# F2250 Family of Power System Simulators User Guide

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# Contents

# Figures

# Tables

# Preface

The F2250 family of power system simulators consists of an integrated group of precision test instruments, related options, and associated remote control hardware and software. The F2250 Family of Power System Simulators User's Guide contains detailed information regarding the setup, operation and troubleshooting of the F2250. The F2250 family includes the F2251, F2252 and F2253. The only difference between them is the output power of current **SOURCE 2**.

## Structure of This Manual

This manual consists of seven chapters and five appendices.

Chapter 1. "Overview of Features and Options"

Introduces the features and available options of the F2250 family of power system simulators.

Chapter 2. "Operating Controls, Indicators, and Displays"

Describes the controls and indicators of the power system simulators and the F2010 Minicontroller. It also describes the configuration messages through which an instrument indicates its state and all its installed options.

Chapter 3. "Setup and Operation"

Details the physical installation and configuration of the F2250 family of power system simulators and F2010 Minicontroller.

Chapter 4. "Principles of Operation"

Discusses the theory of operation for the F2250 family, details the operation of its constituent parts, and gives a series of instructions on how to operate the instrument in its various modes.

Chapter 5. "Error Messages"

Lists the error messages the instrument produces and explains error resolution.

Chapter 6. "Troubleshooting"

Contains procedures for troubleshooting F2250 problems.

Appendix A. "Field Replaceable Units"

Gives procedures for performing field replacement of F2250 boards, modules and parts.

Appendix B. "Field Upgrades"

Gives procedures for adding options to and F2250 family unit.

Appendix C. "F2250 Specifications"

Details unit specifications.

Appendix D. "Part Numbers Reference"

Serves as a reference for commonly used parts.

Appendix E. "Drawing Reference"

Contains a set of drawings useful in servicing the instrument.

## Document Conventions

Abbreviations — Frequently referred to items are abbreviated after the first usage in a chapter. For example, the Timing State Generator board is abbreviated TSG.

**NOTE**

**Throughout this manual GND is used as an abbreviation for the ground connection.**

Displays — Items displayed by instrument LEDs are shown in *this text*.

Buttons, Switches, etc.

Items that are operated by the user – switches, buttons, etc. – are shown in **this text**.

Modes — Modes of operation are shown in *this text*.

# 1. Overview of Features and Options

The F2250 family of power system simulators consists of an integrated group of precision test instruments, related options, and associated remote control hardware and software. This chapter introduces all available features and options of the F2250 family of power system simulators.

The F2250 power system simulator is an intelligent instrument that provides the following steady-state, dynamic, transient, manual and automatic tests for protective relays and other control equipment:

- AC and DC voltage and current sources
- Logic sources
- Timing
- Sensing

The F2250 voltage and current source ranges are scaled for the secondary injection of voltages and currents to protective relays, meters, and control apparatus, including tap changers, automatic voltage regulators and governors. High source power ratings allow testing at the highest multiples of settings used in the industry. The intuitive front panel provides convenient control of amplitude, phase, and harmonic frequency (DC and fundamental to the 20th harmonic), for use in steady state calibration and timing applications. Table 1.1 on page 1-2 lists the IEEE relay types that can be tested with the F2250.

The F2010 Minicontroller extends control to include:

- Remote control of F2250
- Variable frequency operations, for performing tests on frequency relays and synchronizers
- Programmable rates of change for dynamic testing

Automated operation using ProTesT™ software, provides access to cycle-by-cycle control for steady-state calibration and dynamic state simulation tests. TRANS2™, transient simulation software, provides reproduction of power system transient records in the IEEE COMTRADE format.

Power system simulators are self-contained units, that contain internal microcomputers used for controlling two Active Sources power amplifiers, the front panel controls and displays. In addition, it has indicators for each source and system control and an integrated digital timer.

Each source display shows its current parameter values (error, or configuration messages), and its controls provide parameter and range control. This same control is provided by a host computer when in *REMOTE* mode.

All necessary manual controls and indicators are located on the unit front panel (See "System Controls and Indicators" on page 2-2). Each simulator provides two independent AC/DC test signals from their internal sources. Up to six power system simulators, of any type, can be connected together to form a single networked system.

***Table 1.1 IEEE Relay Types Tested***

| Relay Type | IEEE Device # | QTY of F2250s | Relay Type | IEEE Device # | QTY of F2250s |
|---|---|---|---|---|---|
| Time-delay starting | 2 | 1 | Instantaneous Overcurrent; (Up to 90 A continuous, 180 A, 1.5 sec. max.) | 50 | 1 |
| Distance; single phase | 21 | 1 | Instantaneous Overcurrent; (Up to 180 A) | 50 | 2 |
| Distance; open delta | 21 | 2 | Time Overcurrent; (Up to 90A continuous, 180 A, 1.5 sec. max.) | 51 | 1 |
| Distance; 3 $\Phi$ wye, voltage & current | 21 | 3 | Directional Overcurrent | 67 | 1 |
| Ground distance | 21G | 2 | Ground Directional Overcurrent | 67N | 1 |
| Volts/Hertz | 24 | 1* | Directional Overcurrent; (Up to 180 A) | 67/51 | 2 |
| Synchronizing/ Autosynch | 25/25G | 2** | Reclosing AC CB | 79 | 2 |

*Table 1.1 IEEE Relay Types Tested*

| Relay Type | IEEE Device # | QTY of F2250s | Relay Type | IEEE Device # | QTY of F2250s |
|---|---|---|---|---|---|
| AC/DC Under/Overvoltage | 27/59 | 1 | Frequency | 81 | 1*** |
| Directional power; single phase | 32 | 1 | Reclosing DC CB | 82 | 1 |
| Directional power (open delta voltage; open wye current) | 32 | 2 | Carrier or Pilot Wire | 85 | 1 |
| DC Under/Overcurrent | 37/76 | 1 | Lockout | 86 | 1 |
| Loss of Field | 40 | 1 | Differential 1 Φ; 2 currents | 87 | 1 |
| Phase Balance | 46 | 2 | Differential 3 Φ; 6 currents | 87 | 3 |
| Negative Sequence Overcurrent | 46N | 2 | Tripping | 94 | 1 |
| Phase Sequence Voltage (open delta) | 47 | 2 | | | |

Options required:

* F2010 Minicontroller

** F2010 Minicontroller and F2920 Precision Autosynch

*** F2010 Minicontroller and F2820 ΔVALUE/ΔTIME

# Plug-in Options

A number of internal options are available that expand or improve the performance of F2250 power system simulators.

These internal options include:

F2810 Fault Rotate

Changes the preset voltage and current phasors to simulate A-N, B-N, C-N, and A-B, B-C, C-A faults without changing interconnecting leads. It speeds up three-phase relay testing by reducing or eliminating the time, hazard, and possible errors in changing the leads each time a different phase is tested. It works with both Y configurations and Open Delta configurations.

With Y configurations, Fault Rotate uses three Y voltage sources, $V_A$, $V_B$, $V_C$, and a single current or three Y currents. It starts with a phase-to-neutral or phase-to-phase fault and each time the control is pressed, changes the amplitudes and phase angles to effectively rotate the fault 120° counter-clockwise into the next phase.

With Open Delta configurations, Fault Rotate uses two voltage sources, $V_A$ and $V_B$, and a single current source, and starts with a phase-to-phase fault. The fault is rotated 120° each time the control is pressed.

F2820 ΔValue /ΔTime

Simulates the rate-of-change of the voltage/current/phase angle and frequency to determine the response of a relay to actual power system excursions. Using this rate of change, the realistic pickup and dropout tests are performed with AutoSensE™. This option is used with the F2010 Minicontroller.

F2825 Multiple Sources

Extends operation to include simultaneous cycle-by-cycle control of up to three voltage or current sources. This simulates three-phase and phase-to-phase faults, power swings, and load change conditions.

F2865 Transient Waveform Generator

Replays COMTRADE format digital fault recorder and relay records, and EMTP or ATP power system simulations. It stores 256 K of 16-bit transient waveform samples per channel. This replaces the standard sine waveform generator board and requires TRANS2 Transient Simulation Software.

This board stores transient data until the instrument is powered down, allowing one relay test plan to simulate tests, without reloading data. It also measures relay operating time by starting the multi-mode timer at any sample number in a transient record for each test.

F2875 Battery Simulator

An internal, high starting current, 60 watt, continuous rating, DC supply used for powering protection relays and auxiliaries. Supplies 48, 125 or 250 VDC controlled manually or remotely using ProTesT.

F2885 Satellite Synchronizing Interface

Synchronizes remotely located power system simulators using GPS or satellite receivers. One interface is required for each three-phase system. The interface uses standard IRIG B and 1 Hz timing signals to achieve synchronized end-to-end tests on unit protection schemes.

F2895 GPS Satellite Synchronizing Interface with Receiver and Antenna

Includes the F2885 as described above, with an integrated GPS Receiver/Antenna, and 100 feet (30 meters) of cable. The F2895 provides a complete solution to satellite synchronization. One set is required for each system.

F2910 ProTesT Software System Starter Kit

Provides communication between simulators and PCs equipped with ProTesT software.

F2920 Precision Autosynchronizer

Automatically tests auto-synchronizing relays; displays circuit breaker advance time in milliseconds. The F2820 ΔVALUE/ΔTIME option is required to verify the response to a rate of change in slip frequency. The F2920 option provides a quick, simple, repeatable, and accurate test for this important relay function (requires two instruments).

## Simulator Automation Options

A number of options that further automate simulator functions exist, including:

ProTesT™ Software System

A menu-driven interactive software system for automated steady-state, dynamic relay tests and database management. Functions include creating, storing and editing relay test plans for any type of relay, running tests automatically, log time and date stamped results, plotting characteristics, overlaying plots for analysis, and generating test reports.

TRANS2

A menu-driven interactive software system that replays power system transient fault records during transient simulation testing of protection relays, power system stabilizers, digital fault recorders, and power system instrumentation and control devices. TRANS2 uses files in the IEEE *COMTRADE* C37.111 - 1991 standard format and controls F2250s to reproduce waveforms at secondary injection levels.

# Features

The F2250 family incorporates a number of unique features. Many are standard in all family members. Others can be added at any time, usually just by plugging in a printed circuit board (PCB) or inserting a module.

Some of the major features of the F2250 family include: Modular Design, Rugged Packaging, Controls and Indicators, the Internal Microcomputer, the Active Sources' amplifiers, AutoRange Mode, and AutoSensE Operation.

### Modular Design

The F2250 family is modular in concept and design to provide only those sources and capabilities that are needed for specific functions. This flexibility allows for capabilities ranging from:

- A single simulator providing two test signals under manual control.

To

- A full system of twelve sources, provided by six units and a remote host computer, capable of simultaneously changing the amplitude and phase angle of up to six voltages and six high power currents.

This modularity also aids portability by dividing the system into easily handled units. Each power system simulator weighs fifty pounds and has sturdy folding handles. The minicontroller is under two pounds.

### Rugged Packaging

The F2250 family is ruggedly designed and constructed for safe transportation by truck over unpaved roads. The F2250 was designed to pass the National Safe Transit Association (NSTA) test #1A, which requires no damage and full operability after 30,000 cycles that bounce the unit off the shake table.

Passing this test requires a light but sturdy welded aluminum chassis with a shockproof case that withstands an impact of greater than 20 G and a compression load of greater than 400 lb. All non-removable components are bolted and locked to the chassis. All printed circuit boards are locked in their cage. Ribbon cables with locking connectors are used instead of wiring harnesses.

A molded two-piece case of high-impact shock-resistant ABS plastic provides protection from dust, dirt, and rain. Molded lands on the top and bottom lock the units together when they are stacked, and rubber feet or optional casters on the back protect the unit when standing up. The top half is easily removed to provide access to the card cage.

A sliding door on the side provides easy access to the **POWER ON/OFF** switch, battery simulator controls, and all cable receptacles. The front cover, also of ABS plastic, clips over the front panel.

A three-position handle folds out of the way under the unit for stacking, and can be slid down to prop the unit up in a tilted position.

## Controls and Displays

The simulators use three types of dual-action switches for their manual controls. Paddle switches change values or states when they are pressed. Rocker switches provide individual on/off control or enable/disable their source, and an indicator **SYSTEM OUTPUT** push button provides simultaneous on/off control of all enabled sources.

In manual mode, pressing a switch interrupts the microcomputer, which senses its new state and performs whatever action it specifies. In remote mode, when under the control of ProTesT, all the switches are disabled: pressing any **SOURCE** or system **ON/OFF** switch causes an abort, turning all sources off.

Light emitting diodes (LEDs) indicate the state of their adjacent switches. A **REMOTE** LED illuminates when the unit is in remote mode, and a **HIGH VOLTAGE** alarm (under the lightning symbol) illuminates whenever a dangerous voltage is present at a source output terminal.

Values and messages are shown by LEDs. The **SOURCE** displays show the present values of their parameters except during startup, when an error occurs, and when the unit configuration is requested. The **TIMER** display is blank when the unit is off, but shows messages during startup and when an error is detected. In the *SENSE* mode, it shows the message *SENSE* when the sense input is asserted. In the *TIME* mode it shows the time values.

Timer and Logic Inputs and Outputs

The F2250 has two sets of dry logic output contacts and two sets of dry and wet contact logic inputs for the multi-mode timer. These inputs serve to start and stop the timer, sense relay operation, and initiate state changes. The outputs trigger or stimulate external events. The logic inputs and logic outputs follow some simple rules under manual control, as shown in Table 4.1 on page 4-13. Manual tests should be designed to take advantage of these operating rules. The timer and logic input and logic output functions are programmable under external computer control from ProTesT, the state SSIMUL of ProTesT, or TRANS2 programs. Computer program control allows for more flexible and complex applications. The logic input and output features allow tests on relays with combinatorial and sequential logic functions.

F2250 timer and logic input functions include:

- Sensing the operation of a relay or other external logical events, such as operation of a contact or a voltage transition
- Timing the response of a relay in response to the change of state of a voltage or current source, or an external logical event
- Measuring the time between two external logical events using the external timer
- Measuring the duration of a single external logical event using the pulse mode
- Changing the state of source outputs in response to an external logical event

The two F2250 logic outputs each provide one normally open, and one normally closed contact output, for stimulating the logical inputs of relays metering and control apparatus. Typical simulations include:

- Circuit breaker auxiliary contact 52a and 52b
- Carrier receive, acceleration, blocking and intertrip
- Reclose initiation, single pole reclose, in progress desensitizing
- External close and trip commands

### Internal Microcomputer

The simulators use an internal microcomputer to control all their operations. The microcomputer uses a high-speed 80186 microprocessor and a data bus to transfer control and status information between the controls, indicators, external communication ports, and an input/output (I/O) controller. All operations are directed by firmware in field programmable memory (FLASH). Random access memory (RAM) provides storage for remote control messages.

### Active Sources™ Amplifiers

All test signals are produced by Active Sources™ power amplifiers. These provide a highly regulated AC or DC output of either voltage or current.

Amplitude accuracy is within ± 0.25% typically, and within ± 0.5% maximum of the specified value. The phase angle accuracy is typically within ± 0.2° and within ± 0.5° maximum of the specified angle. Total harmonic distortion is typically within ± 0.2% and within ± 2% maximum. The frequency is either at the mains frequency or typically within ± 0.0005% of the set frequency controlled by the internal crystal reference. All Doble products have worst case specifications.

### AutoRange Mode

When a source is in *AutoRange* Mode (*Aut* is shown in its **RANGE** display), the lowest range is automatically selected by the amplitude value to provide the highest power signal.

The range is also automatically changed when the amplitude value is changed or ramped into a higher range, or down into a lower range. If a source is on, it is turned off for a few seconds while the internal relays change and the source stabilizes at the new power level.

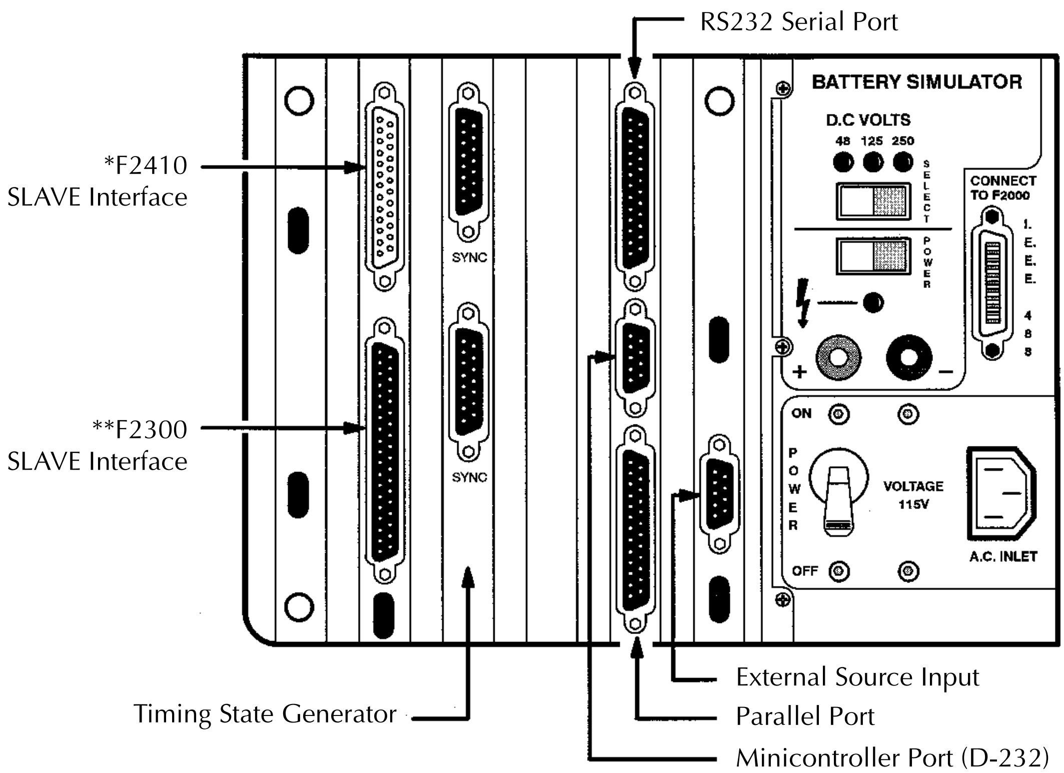
### AutoSensE Operation

AutoSensE finds the pickup, dropout, reach, and maximum torque angle of a relay quickly and easily. It operates in *RAMP* mode when a parameter value is being ramped up or down. When an external signal is sensed in *SENSE/RAMP* mode, AutoSensE freezes the value of the parameter being ramped but leaves the sources on. In *TIME/RAMP* mode, AutoSensE also stops the timer and turns the sources off that were turned on with the **SYSTEM OUTPUT** button. AutoSensE operates with any parameter: amplitude, phase angle, and, with the minicontroller, frequency.

# I/O Interface Panel

An I/O interface panel (Figure 1.1) behind a sliding door on the right side contains:

- On/Off switch
- Mains power receptacle
- Battery simulator controls and connection terminals
- IEEE-488 Bus receptacle
- Two SYNC receptacles (Only one is available when using the F2885 Satellite Synchronizing Interface)
- RS-232 serial port
- D-232 serial port
- Parallel port-transient loading receptacles
- External source interface




*Only used if the Battery Simulator is absent
** See F2000 Instruction Manual

***Figure 1.1 F2250 Battery Simulator Interface Panel***

## Networked Systems

The members of the F2250 family are easily connected together to form a single networked system, with a number of sources for testing multiphase protective relays and system protection schemes. Simulators are connected to each other by two cables (three for parallel download) in a daisy-chain fashion, which forms a multi-drop network. These cables are an IEEE-488 General Purpose Information Bus (GPIB) and a SYNC Bus.

When a networked system comprises only F2250s, the full functionality of the F2250 is available for each simulator in the network. If the networked system contains an instrument that is not an F2250, such as an F2700 or F2150, then the functionality of the F2250s is limited to the level of the F2700 or F2150.

The F2010 Minicontroller plugs directly into the D-232 port of the system MASTER simulator. A host computer plugs into any simulator's RS-232C port (and in a parallel port for parallel download). Figure 1.2 shows how a typical multi-unit system configuration is connected. See "Multi-Unit Systems" on page 3-2 for instructions on the proper connection procedures and power-up sequences for networked systems.

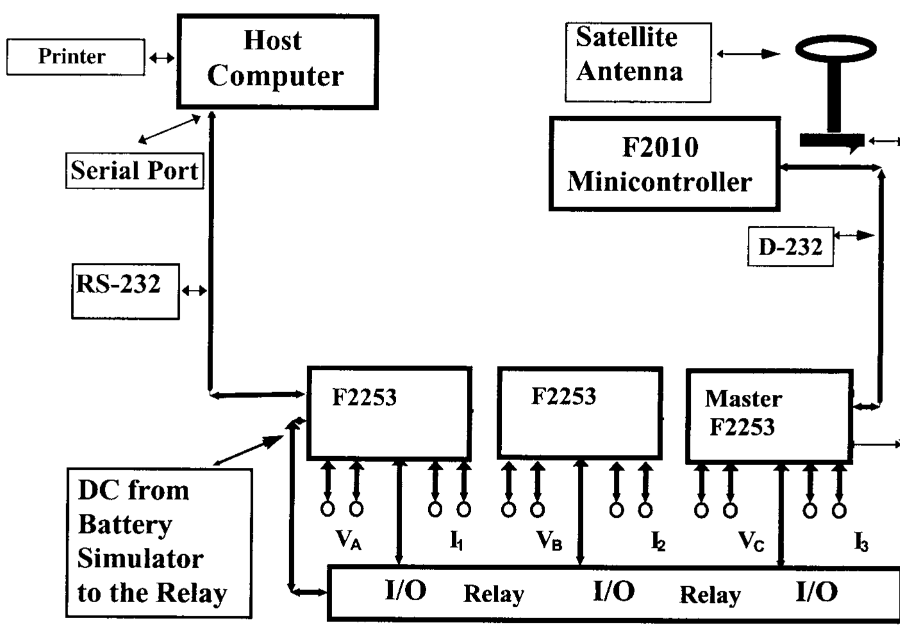



*Figure 1.2 Typical Interconnection*

## System Communication

The firmware used by the microcomputer uses a special language and communications protocol, called DobleCoL, to control communications between the simulators over the IEEE-488 bus. Any simulator may broadcast a message over the IEEE-488 bus to all others, at any time. Only those addressed in the message respond, and perform whatever action is specified or required. The message can:

- Indicate the status of a source or unit
- Inform the other units of an error condition
- Tell a source or sources to change a parameter value
- Set its turn-on mode on or off

One of the simulators must be designated the system MASTER to coordinate and synchronize the actions of the others. To designate a MASTER, power up the simulator that will be the MASTER first. The system MASTER replaces the other units clock signals and timing reference with its own, transmitting these to the other simulators on the SYNC cable. It thus supplies the base frequency and reference signals for the entire system.

## Safety

**WARNING**

**Dangerous and potentially fatal voltages can be developed across the output terminals of any Doble F2250 Power System Simulator. Use extreme caution when turning on or using any F2250. Always turn the source output off and disable the unit before connecting, removing, or touching any output terminal or cable. Never ground any F2250 output connection.**

When connecting the F2250 dry contact sense input to relay internal test points, always connect them in the correct way to prevent damage to the relay in the event of unexpected voltages appearing at the F2250 dry contact sense terminals.

**NOTE**

**Ensure that the solid state, digital, or electronic, relay case is grounded before energizing. Relays contain electronic components that could be damaged by electrostatic discharge currents during handling of the modules. Observe static precautions.**

Remove all sources of potential from the F2250 before removing any modules from the test instrument. Failure to do so can cause damage to the electronic circuitry. Check the rated auxiliary supply voltage before applying the supply.

Always test the relay in its case in a horizontal position. Use the lowest practical source range for best resolution and maximized test power.

### High Voltage Alarm

A **HIGH VOLTAGE** LED under the lightning symbol, blinks whenever more than 20 V are present at a source output terminal.

## Automation and Remote Control

Any single simulator or networked system can be controlled remotely by an F2010 Minicontroller or by a host computer. Remote control is effected by the controlling device transmitting command messages to, and receiving status/data messages from, the unit to which it is connected. In a networked system, this unit rebroadcasts all messages it receives to the other units via the IEEE-488, and retransmits any messages from the other units to the controlling device.

Commands contain values and data that replace the information from the manual controls, or requests for values and status data (which appear in the indicators and displays) for return. The information from the unit or system is interpreted by the controlling device according to its internal program, and used to compose the commands. In the host computer this internal program is either ProTesT or a special application program such as TRANS2.

The unit or system can only be placed in the *REMOTE* mode by the controlling device. When in *REMOTE* mode, under ProTesT all simulator on/off controls are changed to abort switches. Pressing any of them aborts all operations, turns all sources off, and places the unit or system back in *MANUAL* mode.

### F2010 Minicontroller

The minicontroller is a hand-held microcomputer-based remote controller that acts as an extension of the controls for the simulator it is connected to, expanding the unit (or system) frequency range and testing capabilities. The minicontroller performs a number of actions which include:

- Switching the unit/system to *REMOTE* and back to *MANUAL*
- Turning all enabled sources on and off together
- Changing the value of a parameter for a selected source
- Changing the value of two or three similar sources together (requires the F2825 Multiple Sources option)
- Setting two parameter values for a selected source, and switching between them instantaneously. The timer is started at the same time, and stopped when the relay trips.
- Setting a rate of change, and ramping between the two values at this rate. When ramping frequency, the timer can be started when the ramp reaches the second or selected intermediate value, and stopped when the relay trips (requires the F2820 ΔVALUE/ΔTIME option).

## Host Computer

Any MS-DOS or Windows based PC capable of being an F2250 host computer can be used to control one or more F2250 simulators. Control is accomplished by transmitting and receiving messages over an RS-232C cable to a unit's RS-232C port. That simulator relays all messages to and from all other simulators in a networked system over the IEEE-488 bus.

All messages must be in DobleCoL, the Doble command language and communications protocol. If the host computer is running ProTesT, ProTesT performs all message compilation and interpretation in DobleCoL automatically. If the host computer is running some other custom control program, that program must use DobleCoL to compose and interpret all its control and information messages.

### Baud Rate

The user must set the baud rate for use by the system. This is done from the host computer using ProTesT to the specifications in Table 1.2.

***Table 1.2 Host Computer Baud Rate***

| Setting Type | Value |
|---|---|
| Baud Rate | 9600 full-duplex |
| Stop Bit | 1 |
| Parity | None |

On the F2250, the baud rate is set using the dip switches located at the top of the CPUIII board. The six possible settings are given in Table 1.3.

***Table 1.3 Baud Rate Dip Switch Settings***

| 1 | 2 | 3 | 4 | |
|---|---|---|---|---|
| On | On | Off | On | 300 baud |
| On | Off | Off | On | 1200 baud |
| On | On | On | Off | 2400 baud |
| Off | On | On | Off | 4800 baud |
| Off | Off | On | Off | 9600 baud |
| On | On | Off | Off | 19200 baud |

Parity for the F2250 is always set NONE, by setting the thumb wheel located at the top of the CPUIII board to *S*.

## Automatic Protective Relay Testing - ProTesT

The ProTesT Software System is an integrated collection of proprietary programs for creating, running, documenting, and storing a library of automatic protective relay tests. It uses various ProTesTPLANs that contain generic test procedures, called macros, which are easily configured for specific relays. Each ProTesTPLAN contains all the different macros needed to exercise and test all parts of every type of relay in a specific IEEE family or group of related families. Refer to the *ProTesT System Manual* for information about ProTesT, and the various *ProTesTPLAN Reference Manuals* for information about their test macros (Requires F2910 ProTesT starter kit option).

The ProTesT SSIMUL macro performs end-to-end satellite tests that:

- Use standard satellite receiver outputs.
- Synchronize F2250s to IRIG-B *exact second* 1 Hz clock pulse (1PPS). Worst case phase angle accuracy is ±50 µs, between remote test sites under manual control or automation.
- Read time codes from IRIG-B signals and starts a test at user defined test-time-of-day ±5 µs.
- Use SSIMUL™ for dynamic state simulation tests and result database management or use TRANS2 for transient simulations.

ProTesT is organized by IEEE relay functions and supplied as ProTesTPLANs, which are licensed for company-wide use. ProTesTPLANs includes test macros for testing all relay elements by specifying test parameters in standard engineering units of voltage, current amplitude, phase angle, and frequency. ProTesT™ includes sample relay test plans. Each simulator requires a F2910 ProTesT Starter Kit, an MS-DOS or Windows based PC (one per system) with appropriately configured memory and graphics capability, and an RS-232 interface.

See the *Doble End-to-End Satellite Testing Manual*, the *ProTesT Manual, Doble Application Notes, and Test Plans* for more information.

## Transient Testing - TRANS2

TRANS2 is Doble's transient test software for F2250 power system simulators. TRANS2:

- Stores and replays transient files up to 256K samples in length
- Operates the F2860 TWG waveform generator board
- Operates directly from COMTRADE files with multiple sample rates
- Operates in a graphical environment to provide waveform editing for pre/post fault extension and selection of channels for reproduction
- Allows the application of multiple F2250 timers which can be started individually on user assigned sample numbers
- Controls F2250 logical sources to allow simulation of control signals such as single pole reclose, and blocking
- Enables end-to-end satellite testing

IEEE Standard C37.111-1991 Common Format for Transient Data Exchange (COMTRADE) defines a standard file format for transient data so that users of various digital fault recorder, digital relay, or electro-magnetic transient programs can exchange data. Most D.F.R., relay, and transient program manufacturers provide support for import and export of files in this format. Copies of the standard are available from the IEEE.

TRANS2 runs via an RS-232 interface on MS-DOS compatible computers, 386 or better, with at least 4M RAM, an 80 MB hard drive and VGA graphic capability. F2250s must be equipped with the F2865 Transient Waveform Generator (TWG) option, which provides 256 k sample per channel memory, to run TRANS2. TRANS2 provides a fully graphical interface. It provides powerful functions for managing and manipulating transient records, such as the following:

- Transient Set level which allows selection and storage of transient data in binary format.
- Prefault and or Post fault extension of the record which can be added to transient set preserving the original COMTRADE file.
- Transient Test level which allows scaling, selection of channels, zooming and replaying time slices of the transient set record.
- Interpolation of multiple sample rate files which provides seamless replay and application of user defined cut-off frequency.

TRANS2 based test systems have been used in both the laboratory and field for the investigation of protection faults, the evaluation of protection system performance, and the frequency dependence of instrumentation and control devices.

Doble transient software is used for reproducing, via F2250s, transient voltages and currents from sample information stored in COMTRADE standard digital data files.

Sources for the transient data include digital fault recorders, microcomputer/numerical relays, electromagnetic transient programs (ATP/EMTP) or software and hardware power system simulators.

The digital data stored as a COMTRADE computer file is downloaded to F2250s. The F2250 provides digital-to-analog conversion and synchronizing of the data. Test level voltages and current are reproduced by the F2250.

For more information about TRANS2, see the Doble Engineering Company *TRANS2 Software System Manual*.

## DobleCoL

DobleCoL is the control language and communications protocol used by the F2250 family to control their operations and communicate control and status data between test instruments, a minicontroller, and/or a host computer. It is an integral part of the F2250 firmware in every simulator microcomputer.

DobleCoL must be used by any program running in the host computer to communicate with a F2250 simulator or networked system. See the *DobleCoL Manual* for a complete description of how DobleCoL operates, its protocol, its structure, its commands, and its messages.

## Upgrades and Differences from the F2153

The differences between the F2250 and the F2153, which is a modified F2500, are explained below.

Front Panel

The F2250 instrument contains expanded logic inputs and outputs, as well as the Timer front End board. The F2153 front panel and controls are the same as the F2500.

Firmware

The firmware for the F2250 family has been upgraded.

Boards

The F2250 family of instruments contains upgrades to the card cage boards as given in Table 1.4.

***Table 1.4  F2250 Board Upgrades***

| Old F2153 Board | New F2250 Board |
|---|---|
| Timing Generator (TG) | TSG - with or without satellite option |
| I/O Timer | DCT |
| Waveform Generator (WG) | WG2 |
| F2500 Front Panel assembly | F2250 Front Panel assembly |

**NOTE**

**When troubleshooting an F2153:**

- Use this manual to resolve amplifier problems.
- Use the F2500 manual to resolve control logic problems.

# 2. Operating Controls, Indicators, and Displays

The F2250 family of power system simulators can be operated either manually or remotely. Local manual control is provided by front panel controls and indicators. These are divided into three areas:

- System controls and indicators
- Source controls and indicators
- Timer controls and indicators

The indicators show the state of the instrument and its sources, providing all the information needed to direct operations.

Several other topics discussed in this chapter include:

- Minicontroller controls and indicators
- Configuration messages and displays
- Battery Simulator controls and indicators

The simulator state is always shown by its indicators, regardless of the origin of control: front panel, minicontroller, or host computer.

## Powering Up

When the F2250 is powered up, using the **POWER** switch on the side panel, the simulator displays *Pon* while its microprocessor checks its circuits, memory, the high-speed Doble Bus, and the controls and indicators.

All manual controls and functional indicators are on the front control panel, except for the **POWER** switch and Battery Simulator switches, which are located behind the side door with the interface connectors. There are two form C output terminals for each source, and two sets of three input terminals for timer start and stop.

## System Controls and Indicators

The system controls and indicators, as shown in Figure 2.1, determine those parameters that apply to every source in or controlled by the power system simulator, and all other sources in a multi-unit system. Table 2.1 on page 2-3 explains the functions of the controls and indicators**.**

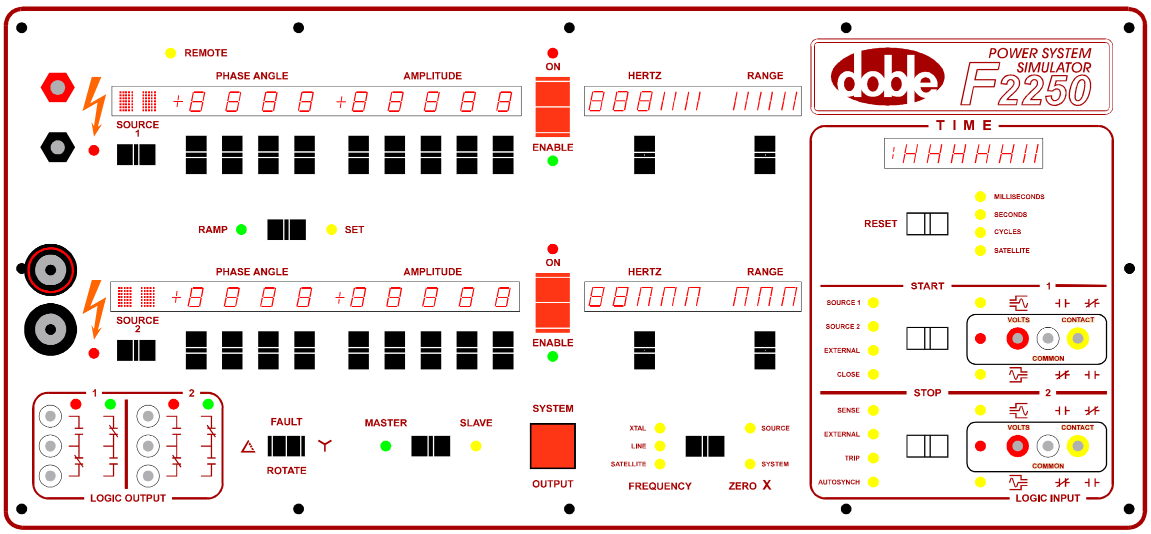



***Figure 2.1  F2250 System Controls and Indicators***

*Table 2.1 Controls and Indicators*

| Control/Indicator | | Function |
|---|---|---|
| **REMOTE** | | A yellow LED in the upper left corner illuminates when the instrument is controlled by a host computer or a minicontroller. When a simulator is under remote control by a host computer running ProTesT, pressing any switch aborts the test in process and turns off the outputs. |
| **RAMP/SET** | | Selects and displays one of the following instrument **AMPLITUDE** and **PHASE ANGLE** control modes. |
| | **SET** | Pressing the lever to the right enables all parameter switches, which increases or decreases the parameter value one unit at a time with carry over. |
| | **RAMP** | Pressing the lever to the left enables any parameter's switches, which increments or decrements the present value one least significant digit at a time, with carry over, at a rate associated with the switch that is pressed. See "Phase Angle" on page 2-8 and "Amplitude" on page 2-9 for ramp rates.<br>In *RAMP/TRIP* mode, the AutoSensE$^{TM}$ function stops the timer and turns all enabled sources off, freezing their values, when an external signal is sensed.<br>In *RAMP/SENSE* mode, the sources are left on (timer is not running in *SENSE*). |
| **SYSTEM OUTPUT** | | Pressing the push-button provides simultaneous on/off control for all enabled sources. When dark (off), pressing the switch turns all enabled sources in a multi-unit system on according to their *ZERO X Turn-On* mode.<br>**SYSTEM OUTPUT** has no control over a source turned on or off by its own **ON/OFF** switch. When off, each **SYSTEM OUTPUT** flashes if any source has been turned on by its own **ON/OFF** switch. Otherwise, it has no control over that source. |

*Table 2.1 Controls and Indicators*

| Control/Indicator | | Function |
|---|---|---|
| **ZERO X** | | This dual-action paddle switch is active only on system MASTER instruments and has two LEDs. Pressing to the right selects and indicates the unit's turn-on mode.<br>Figure 2.2 on page 2-5 show the operational characteristics of these two modes. |
| | **SYSTEM** | Pressing this switch to the right repeatedly until the SYSTEM LED illuminates dictates that all amplitude changes (turn-on, update, and turnoff) occur simultaneously, regardless of the relative phase angles of the sources. |
| | **SOURCE** | Pressing this switch to the right repeatedly until the SOURCE LED illuminates dictates that each source changes at its first positive going zero crossing, with or after the system reference, REF0. If set at zero degrees, the change occurs at REF0. |
| **FREQUENCY** | | This dual action paddle switch selects the system synchronization source. Amber LEDs indicate the selection. Pressing the **FREQUENCY** paddle switch to the left selects one of the following: |
| | **XTAL** | Pressing this switch to the left until the XTAL LED illuminates selects this internal crystal-controlled frequency generator. |
| | **LINE** | Pressing this switch to the left until the LINE LED illuminates selects the frequency generator synchronized to the power line. Tracks line frequency shifts up to 1 Hz of base frequency (50 or 60 Hz). |
| | **SATELLITE** | If the F2885 or F2895 satellite option is installed, and the F2250 is able to acquire enough satellite signals, then pressing this switch to the left repeatedly until the SATELLITE LED illuminates dictates that the frequency generator be synchronized to GPS satellite timing signals and the base frequency (50 or 60 Hz). |

*Table 2.1 Controls and Indicators*

| Control/Indicator | Function |
|---|---|
| **MASTER /SLAVE** | Only one simulator in a multi-unit system can be the system MASTER. The MASTER provides the frequency and timing signals for all other simulators.<br>Pressing the switch left makes that instrument the system MASTER.<br>Pressing the switch to the right with no source on or enabled displays the unit configuration (It does not change the unit to SLAVE).<br>See "Configuration Messages and Displays" on page 2-22. |
| **FAULT ROTATE** | This feature is available only if option F2810 is installed. It is useful in testing three-phase relays in Y or Δ configurations. **FAULT ROTATE** changes the parameters of a simulated fault. It effectively rotates the fault 120° counterclockwise into the next phase. Pressing the switch to the right changes Y configurations (3 voltages and 3 currents). Pressing left changes Open Delta configurations (2 voltages and 1 current). See examples in Table 2.2 and Table 2.3. |

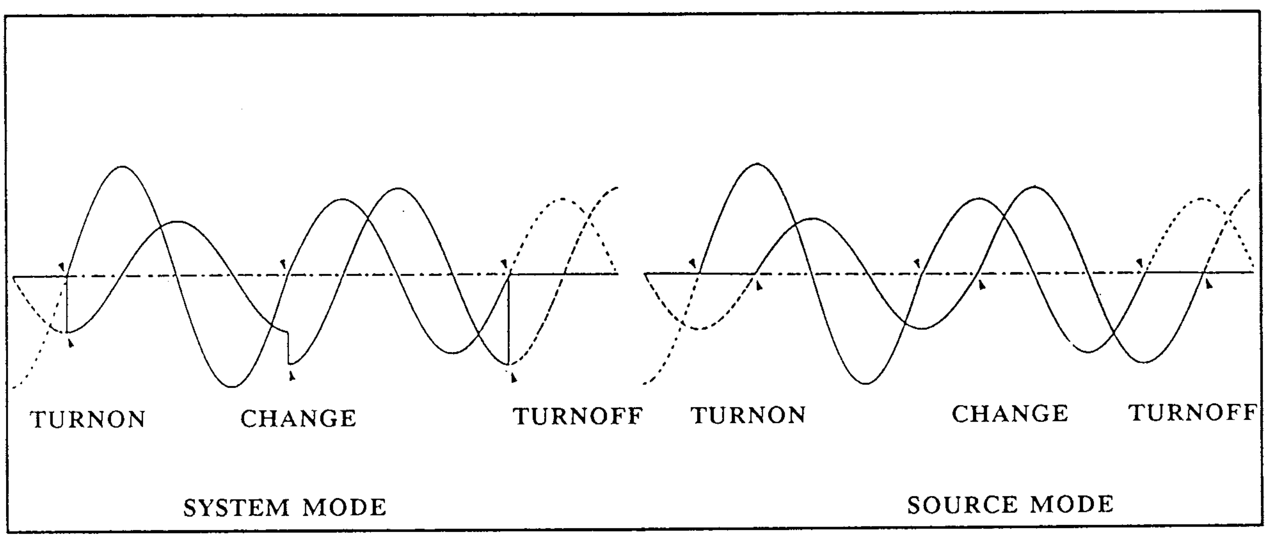



*Figure 2.2 ZERO X Control Operations*

Source designations must be consistent with the convention being used, i.e., $V_A/V_B/V_C$ goes with $I_1/I_2/I_3$, $V_R/V_S/V_T$ with $I_R/I_S/I_T$, $V_R/V_Y/V_B$ with $I_R/I_Y/I_B$. Voltage sources must be on the same range, and multiple current sources must be the same type (I, H, T, or G) and on the same range.

*Table 2.2 Wye Configuration Fault Rotate Operations*

| Source | Initial Values | First Rotation | Second Rotation |
|---|---|---|---|
| $V_A$ | 10.0 V @ 0° | 69.3 V @ 0° | 69.3 V @ 0° |
| $I_1$ | 15.0 A @ –70 | 5.0 A @ 0° | 5.0 A @ 0° |
| $V_B$ | 69.3 V @ –120° | 10.0 V @ –120° | 69.3 V @ –120° |
| $I_2$ | 5.0 A @ –120° | 15.0 A @ –190° | 5.0 A @ –120° |
| $V_C$ | 69.3 V @ –240° | 69.3 V @ –120° | 10.0 V @ –240° |
| $I_3$ | 5.0 A @ –240° | 5.0 A @ –240° | 15.0 A @ –310° |

*Table 2.3 Open Delta Configuration Fault Rotate Operations*

| Source | Initial Values | First Rotation | Second Rotation |
|---|---|---|---|
| $V_A$ | 30.0 V @ 0° | 105.0 V @ 0° | 105.0 V @ 0° |
| $V_B$ | 105.0 V @ 81.8° | 30.0 V @ 81.8° | 105.0 V @ 16.4° |
| I fault | $I_A$ @ –75° | $I_A$ @ –173.2° | $I_A$ @ 23.2° |

## Source Controls, Indicators, and Displays

This section explains the source controls, indicators and displays.

### High Voltage Alarm

The red LED below the lightning symbol blinks when greater than 20 V are present.

### Source 1 and Source 2

Dual action paddle switches control the source mode and designation. Both **SOURCE 1** and **SOURCE 2** have a two-digit display that indicates the source mode and designation.

Pressing the **SOURCE 1** or **SOURCE 2** paddle switch to the left selects and displays one of the modes given in Table 2.4 and Table 2.5.

***Table 2.4 Source Modes***

| Setting | Mode (Left deflection) |
|---|---|
| *V* | Voltage - (Source 1 only) |
| **I, G, H* | Current |
| *T* | High power transient current |

***Table 2.5 Designation Modes***

| Designation | Mode (Right deflection/Digit) |
|---|---|
| Standard | V: A, B,C; I →I/T/G/H/ 1, 2, 3 |
| Extended options | R, S, T; R, Y, B. |
| Multiple sources option | VM/IM/TM/ |

*The “G” current source mode is to be compatible with ProTest.
The “H” current source mode is to be compatible with the F2350 and F2300. Its resolution is reduced by ten.

## Phase Angle

Four decimal digits and dual-action paddle switches display and specify the phase angle as shown in the following example:

*000.0 to ± 359.9×*

+indicates leading angles (with respect to the reference)

–indicates lagging angles (with respect to the reference)

The phase angle display of **SOURCE 1** of the MASTER is blanked when **SOURCE 1** and **SOURCE 2** of the MASTER are running at different frequencies. This is also the case whenever **FREQ** and **SRC1** or **SRC2**, but not both, are selected on minicontrollers, since there is no fixed phase relationship between the sources in this situation.

### Switches

The switches for **PHASE ANGLE** function in a way that depends on the mode selected with the **RAMP/SET** switch, as follows:

SET Mode — Increments and decrements the digit immediately above it with carry over.

RAMP Mode — Increments and decrements the least significant digit at a rate as shown in Table 2.6.

***Table 2.6 Ramp Settings***

| Setting | Ramp Rate |
|---|---|
| tenths (0.1) | 0.1°/second |
| units (1.0) | 0.2°/ second |
| tens (10.0) | 0.5°/ second |
| hundreds (100.0) | 36°/second |

## Amplitude

Dual action paddle switches control the source amplitude. **SOURCE 1** and **SOURCE 2** each have five-digit displays that show the set amplitude.

Table 2.7 gives the range of display values.

***Table 2.7 Source Amplitude***

| Source | Amplitude Range |
|---|---|
| Voltage | 00.00 to 300.0 V. (424.0 V, for DC only) |
| Current | 0.000 to 60.0 A (F2251) |
| | 0.000 to 120.0 A (F2252) |
| | 0.000 to 180 A (F2253) |

Switches

The switches for the **AMPLITUDE** function in a way that is dependent on the mode selected with the **RAMP/SET** switch, as follows:

SET Mode — Increments and decrements the digit above each switch, with a carry over.

RAMP Mode — Increments and decrements the least significant digit, with a carry, at a rate as given in Table 2.8.

***Table 2.8 Ramp Rates***

| Switch Position | Ramp Rate |
|---|---|
| Right | 1 LSD/second |
| Right Center | 5 LSD/second |
| Center | 10 LSD/second |
| Left Center | 100 LSD/second |
| Leftmost | 1000 LSD/second |

## On/Enable

A dual-action paddle switch and indicators display and control the source's ON/OFF state as explained in Table 2.9.

***Table 2.9  ON/ENABLE Switch***

| Switch Position | Source State |
|---|---|
| **ON** | Turns the source on (red LED illuminates) or off (LED dark) directly. Overrides **ENABLE**. |
| **ENABLE** | Enables (green LED on) or disables (LED dark) the **SYSTEM OUTPUT** push-button control of the source (and all other enabled sources). Overrides **ON**.<br>If a source is enabled, pressing **SYSTEM OUTPUT** turns the source on.<br>If a source is not enabled, pressing **SYSTEM OUTPUT** does not turn on the source. |

## Hertz

Dual action paddle switches control the frequency range for AC operation and select DC operation. Both **SOURCE 1** and **SOURCE 2** each have a five-digit display that shows the frequency in Hertz.

Pressing the paddle switch:

- Up selects the next higher frequency range
- Down selects the next lower range
- Down past the lowest AC range selects *DC* and *-DC*

*Base Frequency Mode (Manual Operation Settings)*

This sets the base frequency and frequencies at harmonic intervals up to the 20$^{th}$ harmonic and 100$^{th}$ harmonic as shown in Table 2.10.

***Table 2.10 Base Frequencies and Harmonic Intervals***

| Base Frequency | Harmonic Intervals |
|---|---|
| 50 Hz | 50, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 750, 800, 850, 900, 950, 1000 and 5000 Hz |
| 60 Hz | 60, 120, 180, 240, 300, 360, 420, 480, 540, 600, 660, 720, 780, 840, 900, 960, 1020, 1080, 1140, 1200 and 6000 Hz |

*Variable Frequency Mode - Minicontroller and ProTesT Operation*

**RANGE**: 0.1 to 9999.9 Hz

Range is dependent on the frequency range of the simulator. When the frequency selection on the simulator is 60 (50) Hz, range is 0.1 Hz to 99.999 Hz with 0.001 Hz resolution. When a higher level of harmonic is selected on the simulator, the range is the base range (0.1 to 99.999 Hz) multiplied by the selected level of harmonic, and the resolution is equal to the order of the harmonic times (0.001 Hz).

**Example 1**

If the base frequency selection is 120 (or 100) Hz, which is the second harmonic, then the range is 0.2 Hz to 199.99 Hz with a resolution of 0.002 Hz.

**Example 2**

If the base frequency selection is 300 (or 250) Hz, which is the fifth harmonic, then the range is 0.5 to 499.99 Hz with a resolution of 0.005 Hz.

Table 2.11 gives the frequency ranges as related to particular harmonics.

***Table 2.11 Frequency Ranges***

| Range | Harmonic | 50 Hz | 60 Hz | Min. | Max. |
|---|---|---|---|---|---|
| 1 | Base | 50 | 60 | 0.100 | 99.999 |
| 2 | $2^{nd}$ | 100 | 120 | 0.20 | 199.99 |
| 3 | $3^{rd}$ | 150 | 180 | 0.30 | 299.99 |
| 4 | $4^{th}$ | 200 | 240 | 0.40 | 399.99 |
| 5 | $5^{th}$ | 250 | 300 | 0.50 | 499.99 |
| 6 | $6^{th}$ | 300 | 360 | 0.60 | 599.99 |
| 7 | $7^{th}$ | 350 | 420 | 0.70 | 699.99 |
| 8 | $8^{th}$ | 400 | 480 | 0.80 | 799.99 |
| 9 | $9^{th}$ | 450 | 540 | 0.90 | 899.99 |
| 10 | $10^{th}$ | 500 | 600 | 1.00 | 999.99 |
| 11 | $11^{th}$ | 550 | 660 | 1.1 | 1099.99 |
| 12 | $12^{th}$ | 600 | 720 | 1.2 | 1199.99 |
| 13 | $13^{th}$ | 650 | 780 | 1.3 | 1299.99 |
| 14 | $14^{th}$ | 700 | 840 | 1.4 | 1399.99 |
| 15 | $15^{th}$ | 750 | 900 | 1.5 | 1499.99 |
| 16 | $16^{th}$ | 800 | 960 | 1.6 | 1599.99 |
| 17 | $17^{th}$ | 850 | 1020 | 1.7 | 1699.99 |
| 18 | $18^{th}$ | 900 | 1080 | 1.8 | 1799.99 |
| 19 | $19^{th}$ | 950 | 1140 | 1.9 | 1899.99 |
| 20 | $20^{th}$ | 1000 | 1200 | 2.0 | 1999.99 |
| 21 | $100^{th}$ | 5000 | 6000 | 10.0 | 9999.99 |

## Range

Dual action paddle switches control the **AMPLITUDE** range. Both **SOURCE 1** and **SOURCE 2** have a five-digit display that shows the range setting. The ranges (resolution) available for each model are shown in Table 2.12 through Table 2.17. Ranges are limited to those that include the displayed **AMPLITUDE**. For example: If 7.6 A is shown in the **AMPLITUDE** display, then the 7.5 A range cannot be selected.

The paddle switch:

- Changes the source range to next higher value when pressed up
- Goes to *Aut* then back to the lowest range
- Is disabled when the source is enabled or on

F2253 Voltage and Current Outputs

***Table 2.12 MODE 1: Source 1 Voltage and Source 2 Current***

| | Power | Ranges (Resolution) |
|---|---|---|
| **Source 1 AC Voltage** | | |
| 1.5 second transient | 195 VA-rms | 65, 130 (0.01 V), 260 V-rms (0.1 V) Not available from front panel |
| Continuous power | 150 VA-rms | 75, 150, 300 (0.01 V) |
| **Source 1 DC Voltage** | | |
| Continuous power | 150 Watts | 106, 212, 424 V (0.01 V) |
| **Source 2 AC Current** | | |
| 1.5 second transient | 675 VA-rms | 15, 30, 45, 60, 90 A (0.01 A), 180 A-rms (0.1 A) |
| Continuous power | 450 VA-rms | 7.5, 15, 22.5, 30, 45 A, (0.001 A), 90 A-rms (0.01 A) |
| **Source 2 DC Current** | | |
| 1.5 second transient | 675 Watts | 15, 30 (0.001 A), 45, 60, 90 A (0.01 A), 180 A-dc (0.1 A) |
| Continuous power | 450 Watts | 5, 10, 15, 20 (0.001 A), 30 A, 60 A-dc (0.01 A) |

*Table 2.13 MODE 2: Source 1 Current and Source 2 Current*

| | Power | Ranges (Resolution) |
|---|---|---|
| **Source 1 AC Current** | | |
| 1.5 second transient | 225 VA-rms | 15, 30, 60 A-rms (0.01 A) |
| Continuous power | 150 VA-rms | 7.5, 15, 30 A-rms (0.001 A) |
| **Source 1 DC Current** | | |
| 1.5 second transient | 225 Watts | 15, 30, 60 A-dc (0.01 A) |
| Continuous power | 150 Watts | 5, 10, 20 A-dc (0.001 A) |
| **Source 2 AC Current** | | |
| 1.5 second transient | 450 VA-rms | 15, 30 , 60 (0.01 A), 120 A-rms (0.1 A) |
| Continuous power | 300 VA-rms | 7.5, 15, 30, 60 A-rms (0.001 A) |
| **Source 2 DC Current** | | |
| 1.5 second transient | 450 Watts | 15, 30, 60 (0.01 A), 120 A-dc (0.1 A) |
| Continuous power | 300 Watts | 5, 10, 20, 40 A-dc (0.001 A) |

## F2252Voltage and Current Outputs

***Table 2.14  MODE 1: Source 1 Voltage and Source 2 Current***

| | Power | Ranges (Resolution) |
|---|---|---|
| **Source 1 AC Voltage** | | |
| 1.5 second transient | 195 VA-rms | 65, 130 (0.01 V), 260 V-rms (0.1 V) |
| Continuous power | 150 VA-rms | 75, 150 (0.01 V), 300 V-rms (0.1 V) |
| **Source 1 DC Voltage** | | |
| Continuous power | 150 Watts | 106, 212 V (0.01 V), 424 V-dc (0.1 V) |
| **Source 2 AC Current** | | |
| 1.5 second transient | 450 VA-rms | 15 (0.001 A),30 , 60 (0.01 A), 120 A-rms (0.1 A) |
| Continuous power | 300 VA-rms | 7.5, 15 (0.001 A), 30, 60 A-rms (0.01 A) |
| **Source 2 DC Current** | | |
| 1.5 second transient | 450 Watts | 15 (0.001 A), 30, 60 (0.01 A), 120 A-dc (0.1 A) |
| Continuous power | 300 Watts | 5, 10, 20 (0.001 A), 40 A-dc (0.01 A) |

*Table 2.15 MODE 2: Source 1 Current and Source 2 Current*

| | Power | Ranges (Resolution) |
|---|---|---|
| **Source 1 AC Current** | | |
| 1.5 second transient | 225 VA-rms | 15 (0.001 A), 30, 60 A-rms (0.01A) |
| Continuous power | 150 VA-rms | 7.5, 15 (0.001 A), 30 A-rms (0.01 A) |
| **Source 1 DC Current** | | |
| 1.5 second transient | 225 Watts | 15 (0.001 A), 30, 60 A-dc (0.01 A) |
| Continuous power | 150 Watts | 5, 10, 20 A-dc (0.001 A) |
| **Source 2 AC Current** | | |
| 1.5 second transient | 225 VA-rms | 15 (0.001 A), 30, 60 A-rms (0.01 A) |
| Continuous power | 150 VA-rms | 7.5, 15 (0.001 A), 30 A-rms (0.01 A) |
| **Source 2 DC Current** | | |
| 1.5 second transient | 225 Watts | 15 (0.001 A), 30, 60 A-dc (0.01 A) |
| Continuous power | 150 Watts | 5, 10, 20 A-dc (0.001 A) |

## F2251 Voltage and Current Outputs

***Table 2.16 Source 1 Voltage and Source 2 Current***

| | Power | Ranges (Resolution) |
|---|---|---|
| **Source 1 AC Voltage** | | |
| 1.5 second transient | 195 VA-rms | 65, 130 (0.01 V), 260 V-rms (0.1 V) |
| Continuous power | 150 VA-rms | 75, 150 (0.01 V), 300 V-rms (0.1 V) |
| **Source 1 DC Voltage** | | |
| Continuous power | 150 Watts | 106, 212 V (0.01 V), 424 V-dc (0.1 V) |
| **Source 2 AC Current** | | |
| 1.5 second transient | 225 VA-rms | 15 (0.001 A), 30, 60 A-rms (0.01 A) |
| Continuous power | 150 VA-rms | 7.5, 15 (0.001 A), 30 A-rms (0.01 A) |
| **Source 2 DC Current** | | |
| 1.5 second transient | 225 Watts | 15 (0.001 A), 30, 60 A-dc (0.01 A) |
| Continuous power | 150 Watts | 5, 10, 20 A-dc (0.001 A) |

# Timer Controls, Indicators and Displays

Every F2250 power system simulator has an integrated digital timer for measuring and displaying the time between events. It counts 10-microsecond intervals, and displays the count in milliseconds, seconds, or cycles. It also has a *SENSE* mode for notifying the operator when an untimed event occurs. The timer controls, indicators, and display are on the unit's right side.

The *CYCLES* mode of the timer is based on the frequency (50 or 60 Hz), selected by the toggle switch on the Timing State Generator (TSG) board and counts on this basis no matter at what frequency the source is running.

## Time

Time is displayed with six-digit resolution (Figure 2.3). When an event is detected, the display shows the time value or the word *SENSE*.

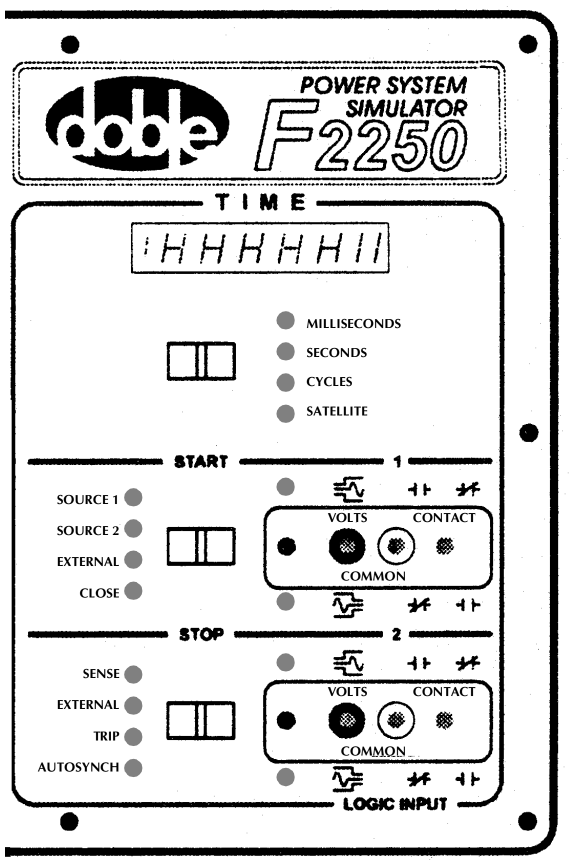



***Figure 2.3 Timer and Logic Input Controls and Indicators***

## Reset

This dual-action paddle switch resets the timer or selects measurement units. Amber LEDs indicate the active selection.

In *TIMER* mode, pressing the switch to the left clears and resets the timer. In *SENSE/RAMP* mode, pressing the switch to the left resets *SENSE*.

Pressing the switch to the right displays time in one of the measurement units given in Table 2.17.

***Table 2.17 TIME Display***

| TIME Selection | Display |
|---|---|
| **MILLISECONDS** | 0 to 999.999 |
| **SECONDS** | 0 to 999999 |
| **CYCLE** | 999.999 (based on a frequency of 50 or 60 Hz) |
| **SATELLITE** | Displays present GPS time F2890 option only |

## Start and Stop

The controls and indicators present in the **STOP** and **START** areas are explained in this section.

START

A dual-action paddle switch selects the functions and the transition type for the **START LOGICAL INPUT**. Amber LEDs indicate the selected functions and transitions. The available **START** functions depend on which **STOP** mode is selected. Refer to Table 4.1 on page 4-13.

Pressing the switch to the:

- Left, selects the function of the **START LOGICAL INPUT**
- Right, selects the transitions that assert the **START LOGICAL INPUT**

A red LED indicates when the logical input is asserted.

STOP

This dual-action paddle switch selects the functions and the transition type of the **STOP LOGICAL INPUT**. Amber LEDs indicate the selected functions and transitions. Certain **START** functions are integrated with **STOP** functions. Refer to Table 4.1 on page 4-13.

Pressing the switch to the:

- Left, selects the function of the **STOP LOGICAL INPUT**. These functions are discussed in the sections that follow
- Right, selects the transitions that assert the **STOP LOGICAL INPUT**

A red LED indicates when the logical input is asserted.

## Timer Logic Inputs and Outputs

This section discusses the characteristics and operations of the timer **LOGIC INPUTS** and **OUTPUTS**.

Logical Input Operation

The F2250 has two independent galvanically isolated inputs. Each input has three terminals: one *voltage*, one *contact*, and a shared *common*. The voltage terminal and the contact terminal are separately conditioned and then connected in logical *OR*.

There are two modes of input signal sensing: *voltage sense* or *contact sense*. The logical input is considered asserted if either of the terminals is in the asserted state. Asserted means that the electrical value presented to the appropriate terminal, matches the polarity setting of the logic input selector.

**NOTE**

**Do not connect external leads to VOLTS and CONTACT terminals at the same time.**

### Voltage Terminal

The input senses the level of the voltage from an external circuit applied between the **VOLTS** and **COMMON** terminal, using a threshold of 1.5 V. The input impedance at low voltages is approximately 100 kohm. The maximum continuous withstand voltage is 300 V rms.

Volts:

- OFF to ON is asserted when the voltage is more than the threshold.
- ON to OFF is asserted when the voltage is less than the threshold.

### Contact Terminal

The input senses the continuity of the external circuit between the **CONTACT** and **COMMON** terminals. A galvanically isolated internal power supply drives the continuity circuit. The threshold is approximately 470 Ohms, with limits of 270 to 640 Ohms. The open circuit voltage is nominally 30 V and the short circuit current is nominally 80 mA.

**WARNING**

**Do not connect external voltages between the CONTACT and COMMON terminals. The circuit is protected by self-resetting fuses, but continual applied voltages can damage internal circuitry.**

To monitor contacts in circuits that are connected to external voltage sources, the **CONTACT** and **COMMON** terminals can be connected to circuits that have a voltage with respect to the voltage input, as long as precautions are taken to ensure that the external voltage can never appear across these two terminals.

- Contact Open to Close is asserted when the resistance of the externally connected circuit is less than 470 Ohms.
- Contact Close to Open is asserted when the resistance of the externally connected circuit is more than 470 Ohms.

## Configuration Messages and Displays

Pressing and holding the **MASTER/SLAVE** switch to the right causes configuration messages to appear in the **SOURCE** and **TIME** displays. These define the unit and its options.

The configuration messages specify the unit's model number, its software revision number, the Base Frequency (selected by a switch on the TSG board), any installed options, and the Doble bus network address. Each message is shown in a specific display area given in Table 2.18.

***Table 2.18 Configuration Messages***

| Display | Message | Meaning |
|---|---|---|
| **SOURCE 1** | *MS* | Multiple Sources option (F2825) |
| **S1 PHASE ANGLE** | *nnnn* | Model number |
| **S1 AMPLITUDE** | *rn.nn* | Firmware revision number |
| **S1 HERTZ** | *50/60* | Base frequency |
| **S1 RANGE** left digit | *t* | TWG board installed (F2860) |
| **SOURCE 2** | *ΔV* | ΔVALUE/ΔTIME option (F2820) |
| **S2 PHASE ANGLE** left | *Fr* | Fault Rotate option (F2810) |
| **S2 PHASE ANGLE** right | *Pc* | Precision frequency (A standard Feature) |
| **S1 RANGE** right digit | *S* | Satellite board Installed (F2885) |
| **S2 AMPLITUDE** right three digits | *PH4* | 4 = Precision Autosynchronizer Advance Time Measurement (F2920) |
| **S2 HERTZ** | *CC.nn* | Network address |
| **S2 RANGE** | *US/EP* | US/Extended Source Designations (An option that offers European source designations) |
| **TIME** | *Prot* | ProTesT Starter Kit (F2910) |

**NOTE**

**The first unit turned on in a multi-unit system automatically becomes the Controller-in-Charge (CC), which directs communications over the IEEE-488 bus. *CC* appears on the SOURCE 2 HERTZ LED of the CC unit. This same LED on SLAVE units displays a two-digit number designating the network bus address of the CC unit. See "Multi-Unit Systems" on page 3-2 for instructions on the proper connection procedures and power-up sequences for networked systems.**

## Minicontroller F2010 Controls and Indicators

This section explains the F2010 Mincontroller controls and indicators.

### Controls

Figure 2.4 identifies the location of each control on the minicontroller.

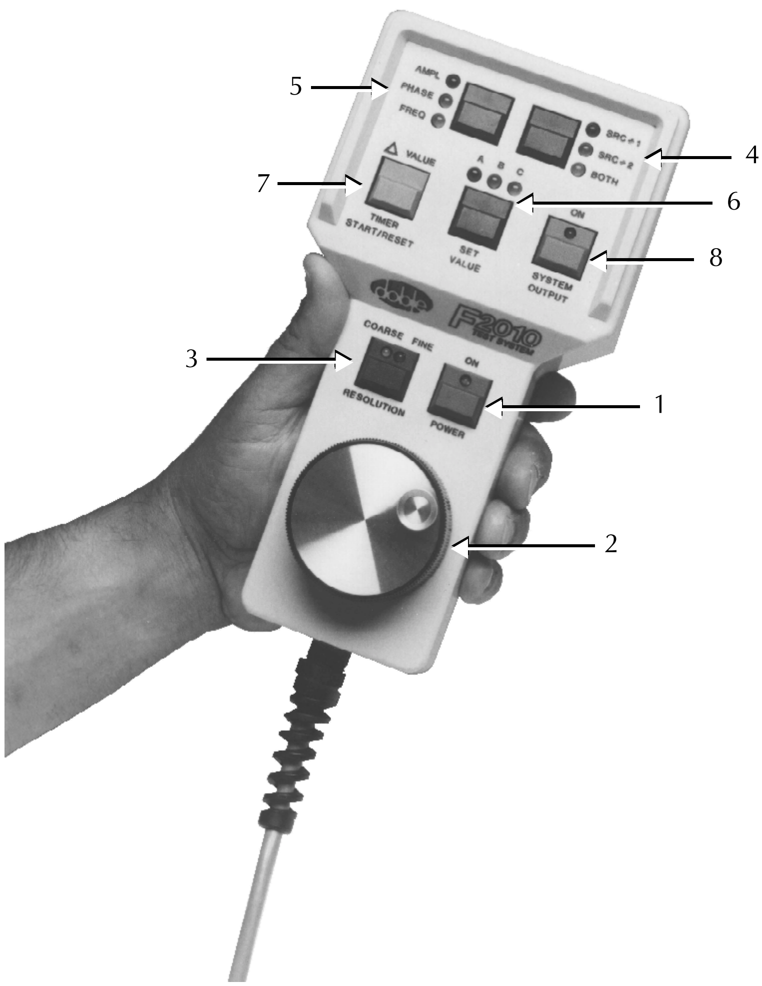



***Figure 2.4  Minicontroller Controller Locations***

1. **POWER ON/OFF**
   - Turns on the F2010
   - Switches the F2250 to *REMOTE*
   - Sets source amplitudes and phase angles to 0.0
   - Sets sources to the base frequency of 50 or 60 Hz

After pressing **POWER ON**, the F2250 displays *REMOTE,* the F2010 displays blink for a few seconds, an audio indicator sounds, then operation can begin.

2. PARAMETER ADJUST KNOB

Continuous rotation varies amplitude, phase angle, or frequency.

Amplitude, or frequency:

- Clockwise: increases value
- Counterclockwise: decreases value

Phase angle

- Clockwise: lagging angles
- Counterclockwise: leading angles

3. **RESOLUTION - COARSE/FINE**

Defines the resolution, or rate-of-change of the voltage, current, phase angle, or frequency vs. rotation of the knob.

- Fine: 24° of rotation = 1 least-significant digit of any parameter
- Coarse: 3° of rotation = 1 least-significant digit of any parameter

When sweeping across a range, or setting an approximate value, rotating the knob more rapidly causes faster parameter changes when using the coarse range. This makes operation easier.

4. SOURCE SELECT: **SRC #1**/**SRC #2**/**BOTH**

Selects which F2250 source is remotely controlled:

**SRC #1** or **SRC #2**

Select any parameter: amplitude, phase or frequency.

**BOTH is available only when FREQ is selected.**

5. PARAMETER SELECT: **AMPL**/**PHASE**/**FREQ**

Selects which parameter is remotely controlled.

- Amplitude can be voltage or current, depending on the type of source, with values ranging from 0 to full-scale
- Phase Angle:

- Clockwise rotation: From 000.0° toward –359.9° to 000.0° (lagging)
- Counterclockwise rotation: From 000.0° toward +359.9° to 000.0° (leading)
- Frequency: From 0.100 to 9999.9 Hz

6. **SET VALUE**: **A/B/C**.

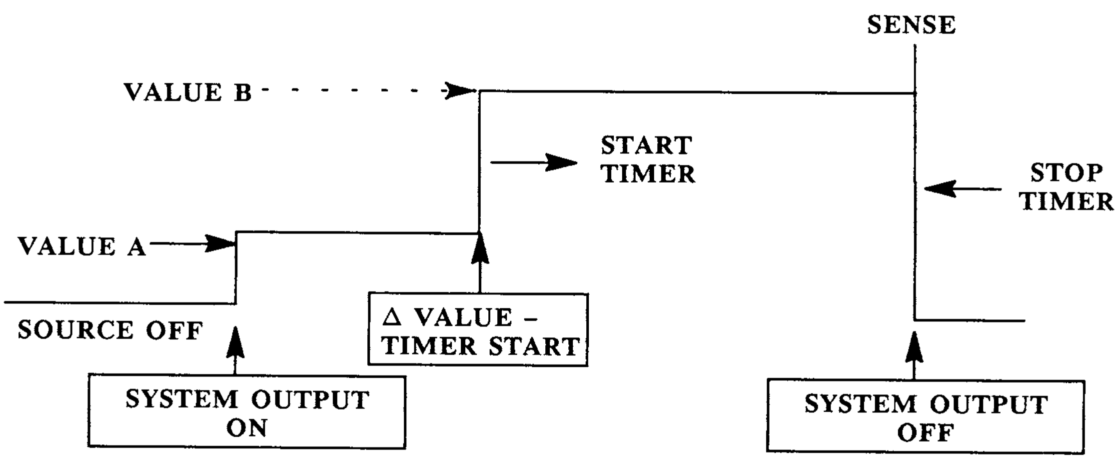



***Figure 2.5 VALUE A/VALUE B***

Two values can be set for a parameter: VALUE A and VALUE B (Figure 2.5). Their size relative to each other makes no difference. Values are set using the knob. The voltage, current, or phase angle changes from VALUE A to B, or VALUE B to A at a zero crossing when the respective **SET VALUE A/B** button is pressed.

The F2250 displays indicate the voltage, current, phase angle, or frequency continuously at all times.

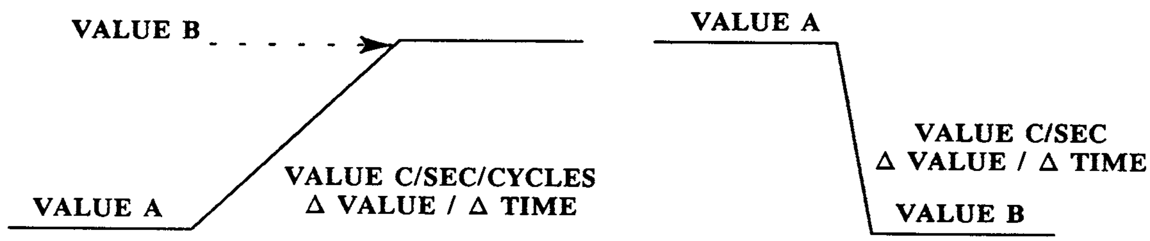



***Figure 2.6 ΔVALUE/ΔTIME***

VALUE C is the Dynamic Test Option (Figure 2.6), which defines the rate-of-change of any parameter between the two limits of VALUE A and VALUE B. Control of VALUE C is provided only when the F2820 ΔVALUE/ΔTime Option is installed in all F2250s which are used in the ΔVALUE/ΔTIME mode.

The value C number is displayed in the respective parameter window (amplitude-phase-frequency) of the controlled source. The amplitude and phase angle window number is designated *CY,* and the frequency number is designated *SEC*. All parameters change by their least-significant digit (L.S.D.). VALUE C for voltage, current, and phase angle is defined as:

$$\Delta\text{VALUE} / \Delta\text{TIME} = \frac{\text{1 Least Significant Digit}}{\text{N Cycles}}$$

For example:

Using the 75 V range, the least-significant digit is 0.01 V; ΔVALUE is always 0.01 V on that range. ΔVALUE for phase angle is always 0.1°. Since amplitude and phase angles change at zero crossings, **TIME** is expressed in *CY*(cles), at the source frequency. A display of *26 CY* in the voltage window defines a rate-of-change of 0.01 V, every 26 cycles. VALUE C for frequency is defined as:

$$\Delta\text{VALUE} / \Delta\text{TIME} = \frac{\text{Hz}}{\text{Second}}$$

A display of *0.008 SEC* in the frequency window defines a frequency rate-of-change of 0.008 Hz per second.

**7. ΔVALUE/TIMER START - RESET**

This control changes the phase, amplitude or frequency, parameter value from **A** to **B**, or **B** to **A** and simultaneously starts the timer. Two different timing start points are used:

| | |
|---|---|
| Step | From **A** to **B** instantaneously at a zero crossing, simultaneously starting the **TIMER** or, if the ΔVALUE/ΔTIME option is installed and **C** is used *RAMP* is available. |
| Ramp | From **A** to **B** at the **C** (rate-of-change) starting the **TIMER**, when **B** is attained. |

When the test is complete, pressing Δ**VALUE** resets the **TIMER**. During a test, pressing Δ**VALUE** aborts the test, returning to the initial value (A or B).

**NOTE**

**The *TRIP* mode must be selected on the F2250 to use the TIMER.**

**8. SYSTEM OUTPUT ON/OFF**

Turns an enabled source on/off. Duplicates the manual operation of the **SYSTEM OUTPUT** push-button on the instrument control panel.

## Battery Simulator Controls and Indicators

The following are the characteristics of the Battery Simulator:

- The **ON\OFF** switch is located on the side I/O panel.
- There are two standard binding posts on the side I/O panel near the **ON\OFF** switch.
- The output is floating.
- The black terminal is negative, and the red is positive.
- The output is short-circuit proof. If the output is shorted or overloaded, the Battery Simulator provides error signals.
- The **POWER** switch for the Battery Simulator has an LED next to it that flashes when power is on.
- The **SELECT** switch that determines whether the unit emulates 48, 125 or 250 V.

# 3. Setup and Operation

The F2250 family of power system simulators can be operated manually using the built-in controls and LEDs on the front panel, with the optional F2010 Minicontroller, or remotely by a host computer.

This chapter describes how to:

- Set up the power system simulator and attach the optional F2010 Minicontroller
- Add additional units to form a multi-unit system
- Start the simulator and set its initial configuration, including:
    - Set the base frequency
    - Assign source designations
    - Change source parameters
    - Configure the timer
- Configure options

## Set Up

To setup the unit:

1. Place the unit close to the relay to be tested.
2. Pull the front cover off and place it to one side.
3. Open the sliding access door on the right side by pushing it in and backwards until it stops.

   This provides access to the:

   - ON/OFF switch
   - AC power cord socket
   - External interface connectors
   - F2410 interface port - for Battery Simulator use only
   - RS-232 port
   - F2300 port
   - Parallel port
   - Minicontroller port
   - Battery Simulator Controls connections
   - Optional BNC connector for IRIG

4. Ensure that the **POWER ON** switch is off (down); then plug the power cord into the socket labeled **AC POWER** and into a 115 V 50/60 Hz AC power source (or 230 V 50/60 Hz if the unit is so labeled).
5. Plug the F2010 Minicontroller cable, , if applicable, into the D-232 connector of the simulator designated as the MASTER.

**NOTE**

**On PHASE or MAGNITUDE, unless all the units in a multi-unit system have the F2825 Multiple Sources option installed, the minicontroller controls only the unit to which it is attached. On FREQUENCY, all SLAVES follow SOURCE 2 of the MASTER.**

6. Repeat steps I through 4 for additional simulators, then connect the units together as described in "Multi-Unit Systems" on page 3-2.
7. Plug in satellite connections, if required.
8. Go to "Turn the simulator on and the following should occur:" on page 3-4.

**WARNING**

**To ensure proper operation, check that all cables are connected before turning on the power.**

## Multi-Unit Systems

Up to six F2250 power system simulators can be connected together to form a single multi-unit system as shown in Figure 3.1. The simulators are connected with two types of cables:

- A SYNC cable transmits the clock pulses and the zero reference signal (REF 0) from the system MASTER to all other simulators to synchronize frequency, phase angles, and operations.
- An IEEE-488 bus transmits commands and data from one simulator to all the others to communicate operating and status information.

**NOTE**

**See the F2000 Series Application Bulletin, IEEE-488 GPIB Cable Connection Serial No. MKT-AB-22, Rev. A, for the procedure to properly install an IEEE 488 GPIB cable to a F2250.**

## Controller-in-Charge

The first unit powered up becomes the Controller-in-Charge (CC) of network communication and the system MASTER. As each subsequent unit is turned on, it is attached to the network and assigned a network address by the Controller-in-Charge. It then waits in the *Pon* state until all the units have powered up. The MASTER waits in *Pon* as well.

NOTE

**Always turn multiple units ON in sequence to avoid contention for position on the bus. Turning units on simultaneously from a common AC main source can result in a Network Error due to bus contention. If this happens, follow the recovery sequence described in "Error Messages" on page 5-1 to restore normal operation.**

Although the **MASTER** switch can be switched ON on another unit (after every unit has been powered up and they are running without errors), the Controller-in-Charge remains the same until the system is restarted, either by a new power-up sequence or by recovery from a network error.

NOTE

**The F2010 Minicontroller must always be networked through the MASTER unit and *connected only after* the MASTER and SLAVES units are successfully powered-up.**

**Be sure to fasten all cables into their connectors securely using the knurled jack screws on the cable connectors.**

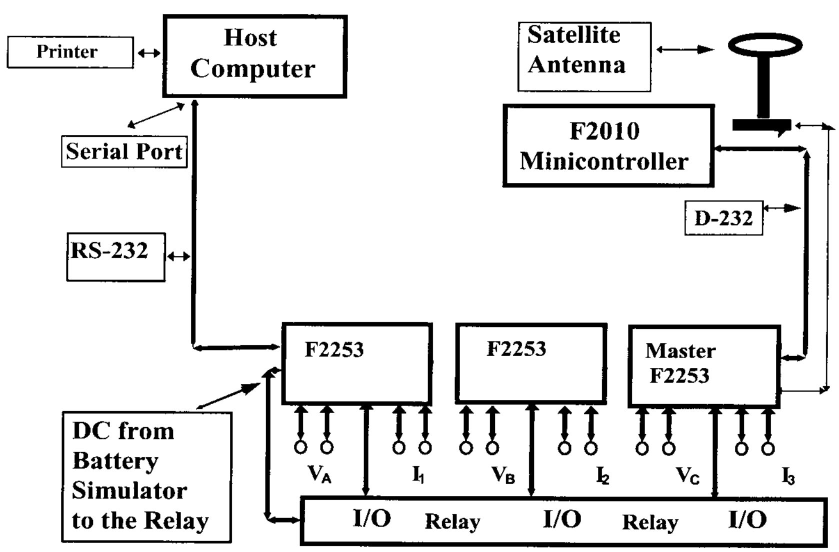



*Figure 3.1 F2250 System Interconnections*

## Connection and Power-Up

To complete connections and power-up the network:

1. Connect the F2250 simulator that is designated as the MASTER to the next simulator in sequence with a SYNC cable and an IEEE-488 bus cable.

   SYNC connectors are wired in parallel internally. The second IEEE-488 bus plugs into the back of the first IEEE-488 bus cable.

2. Connect a host computer to any F2250 simulator RS-232 port.

**NOTE**

**For systems to perform satellite timed triggered tests, configure the simulator with the satellite option as the MASTER, and connect the host computer to the MASTER.**

3. Turn the simulator on and the following should occur:
   - Fan runs
   - Displays flash
   - **TIME** display shows the count down of the transient memory of TWG, if installed, for a few seconds while the self-testing diagnostics run
   - Source(s) initialize and the unit becomes active, if not connected to another simulator
   - All displays reflect default values
   - MASTER (controller-in-charge) displays *Hold* in the phase display of **SOURCE 1** LED until the network is verified

**NOTE**

**The system configures itself as either having full F2250 capabilities, or as having F2000 capabilities, if it is a mixed system consisting of F2250s and other F2000 instruments.**

4. Verify proper control initialization by setting controls as listed in Table 3.1 and confirming that on powering the unit up, the LEDs display the indications listed in Table 3.2.

   If the displays and LEDs are:
   - Correct, the unit is ready to run.
   - Incorrect, refer to "Error Messages" on page 5-1.

   To check on the Firmware version and the options installed, press and hold the **SLAVE** switch to the right. Refer to "Configuration Messages and Displays" on page 2-22 for more information.

**NOTE**

**All F2250s in a network configuration must have the same Firmware version.**

***Table 3.1 Power-On Control Settings***

| Control | Settings |
|---|---|
| **VOLTAGE/CURRENT/PHASE ANGLES** | Set to zero |
| **RANGES** | Set at their lowest setting; V = 75 V, I = 7.5 A |
| **FREQUENCY** | Set to the base frequency (50 or 60 Hz) and XTAL (crystal controlled) |
| **ON/OFF** controls | OFF |
| **RAMP/SET** mode selection | SET |
| **ZERO X** | SYSTEM |
| System is under local control | REMOTE is off |
| Battery Simulator Output Voltage | LED = 48 V, (on I/O plate) |
| Battery Simulator | OUTPUT= OFF |

***Table 3.2 Power-Up Display Indications***

| Indicator | Display |
|---|---|
| *Upper Source (all units)* | |
| **SOURCE 1** | *VA* |
| **PHASE ANGLE** | *000.0* |
| **AMPLITUDE** | *00.00* |
| **ON** | off |
| **ENABLE** | off |
| **HERTZ** | *60* (or 50 as set internally) |
| **RANGE** | *75* |

*Table 3.2 Power-Up Display Indications (Continued)*

| Indicator | Display |
|---|---|
| *Lower Source* | |
| **SOURCE 2** | *I1* |
| **PHASE ANGLE** | *000.0* |
| **AMPLITUDE** | *0.000* |
| **ON** | off |
| **ENABLE** | off |
| **HERTZ** | 60 (or 50 as set internally) |
| **RANGE** | *7.5* |
| *Timer LED Indicators (all units)* | |
| **SEC** | off |
| **MSEC** | off |
| **LINE** | off |
| **SATELLITE** | off |
| **SOURCE I** | off |
| **SOURCE 2** | off |
| **EXTERNAL** | off |
| **CLOSE** | off |
| **SENSE** | illuminated |
| **EXTERNAL** | off |
| **TRIP** | off |
| **AUTOSYNC** | off |
| *Start Logic Input Contacts* | |
| **OFF-TO-ON** | off |
| **ASSERTED** | off |
| **ON-TO-OFF** | off |

*Table 3.2 Power-Up Display Indications (Continued)*

| Indicator | Display |
|---|---|
| *Stop Logic Output Contacts* | |
| **OFF-TO-ON** | illuminated |
| **ASSERTED** | off |
| **ON-TO-OFF** | off |
| *Stop Logic Output Contacts - First Set* | |
| **OPENED** (Green) | illuminated |
| **CLOSED** (Red) | off |
| *Stop Logic Output Contacts - Second Set* | |
| **OPENED** (Green) | illuminated |
| **CLOSED** (Red) | off |
| *System LED Indicators (an units)* | |
| **REMOTE** | off |
| **RAMP** | off |
| **SET** | illuminated |
| **MASTER** | illuminated If set as Controller-in-Charge; off otherwise |
| **SLAVE** | off; if set as slave in network, it will be illuminated |
| **SYSTEM OUTPUT** | off |
| **XTAL** | illuminated |
| **LINE** | off |
| **SATELLITE** | off |
| **SOURCE ZERO X** | off |
| **SYSTEM ZERO X** | illuminated |

**5.** Connect the minicontroller to the MASTER unit and turn it on.

# Configuration

Once the F2250 is powered up, it must be configured before it can be used. Configuration consists of the following:

- Setting the base frequency
- Assigning source designations
- Setting the source parameters
- Configuring the timer

## Base Frequency

The base frequency in *XTAL* mode is determined using the toggle switch, SWI, on the center top edge of the Timing State Generator board in Slot 3. The TSG board has two SYNC connectors and two BNC connectors. The BNC connectors are for IRIG-B use when the satellite option is used.

To change it:

1. Turn off the power and remove the AC cord.
2. Remove the top half of the system MASTER cover by unscrewing the two rubber feet or castors at its rear.
3. Slide the cover back.
4. Set the position of the SWI switch, on the top edge of the TSG board to 60 Hz or 50 Hz.
5. Replace the cover.

If the base frequency is switched to a frequency not provided by the line, switching to **LINE** or **SATELLITE** for the base frequency causes the F2250 to halt and display the error code *8005*.

If a minicontroller or a host computer is used, it can change the base frequency to any value from 0.10 to 9999.9 Hz. In *LINE SYNCH* mode, the base frequency is the same as that for the AC mains. If the mains are at a different base frequency, an error occurs.

In *SATELLITE SYNCH* mode, the base frequency is similar to *XTAL* mode and the positive zero crossing is phase-locked to the 1 Pulse Per Second (PPS) signal from the satellite receiver.

In multi-unit systems, the system MASTER supplies its base frequency to all the other units, overriding the base frequency of the SLAVE regardless of the switch setting on its Timing State Generator board.

## Source Designations

Every source is identified by a two-character designation shown on its **SOURCE** display. Each source is assigned the first appropriate designation by default when its unit is powered up: Source 1 = VA, Source 2 = I1 in all cases. The designation of the source can be changed at any time by pressing the paddle switch to the left of its **SOURCE** display. It is necessary to give each source a unique identifier to facilitate the remote control of sources when using the simulator under PC control.

If the source is OFF and not ENABLED, pressing left cyclically selects the type of source. See Table 3.3.

***Table 3.3  Source Setting and Mode***

| Setting | Mode |
|---|---|
| *V* | AC voltage |
| *I* | AC current |
| *T* | High power transient current |
| *G* | AC current used with ProTest |
| *H* | AC current used with F2300/F2350 with reduced resolution |

Pressing to the right cyclically selects the next available sequence designation. The standard sequence is A/B/C for AC voltage sources and 1/2/3 for AC current sources. An optional extended sequence adds R/S/T and R/Y/B (for red/yellow/blue), which are the European designations. Multiple source designations (VM, IM, HM, TM, GM) are added when the F2825 Multiple Sources option is installed.

**NOTE**

**Changing SOURCE I from V to I can effect the available ranges of SOURCE 2.**

## Source Parameters

After power-up, for each source, the amplitude and phase angle default to zero, frequency defaults to the Base Frequency, range defaults to the lowest available, and its *Ramp/Set* mode defaults to **SET**. Parameters are then changed by pressing the paddle switches associated with the their displayed values. Table 3.4 explains how to change the source parameter settings.

***Table 3.4 Source Parameters***

| Source Parameter | How to change the setting |
|---|---|
| **AMPLITUDE** | Set by repeatedly pressing a switch up or down, which increases (or decreases) the value of the digit immediately above it by one with each press, with a carry. |
| **PHASE ANGLE** | Set by repeatedly pressing a switch up or down, which increases (or decreases) the value of the digit immediately above it by one with each press, with a carry. |
| **FREQUENCY** | Set by pressing the switch below the **HERTZ** display up, which increases it to the next harmonic. After the 20$^{th}$ harmonic, the 100$^{th}$ harmonic is selected. After the100$^{th}$ - DC is selected, followed by DC and finally returning to the Base Frequency. |
| **RANGE** | Set by pressing the switch below the **RANGE** display up, which increases it to the next value. After the highest value, it changes to the *AutoRange* mode (*AUT* shown), which automatically selects the lowest range for the specified amplitude. After AutoRange it returns to the source's lowest range. |

## Ramping

The amplitude and phase angle can also be changed continuously at one of several fixed rates when in *Ramp* mode. Press the **RAMP** switch left to change to *Ramp* mode, then raise (or lower) one of the paddle switches under the parameter to be changed. The output increases (or decreases) at a fixed rate as long as the switch is pressed. The rate depends on which switch is pressed as shown in Figure 3.2.

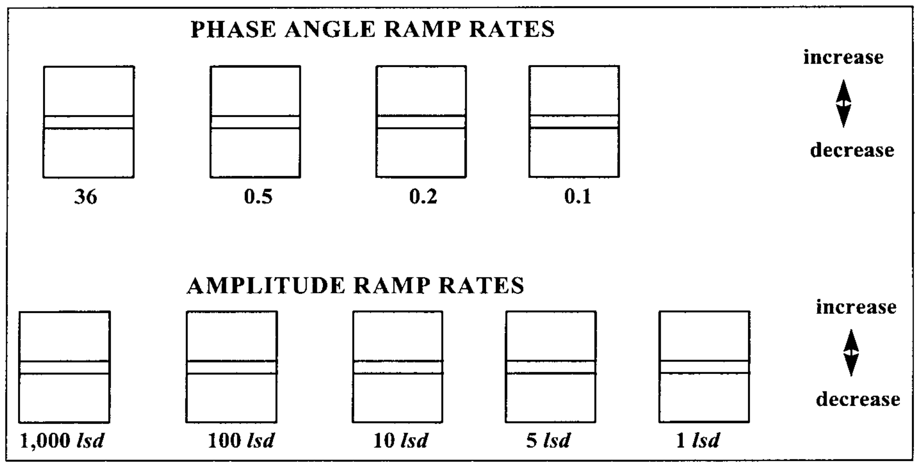



***Figure 3.2  Paddle Switch Ramp Rates - Per Second***

Where lsd = least significant digit

When ramping in *AutoRange*, the output value stops at the end of a range. In *RAMP* mode, for the widest possible range, set the amplitude to the highest value, then range changes (which require the output to be turned off) are not needed.

AutoSensE Tests

An AutoSensE test quickly and easily determines a relay's pickup or dropout setting, reach, or angle of maximum torque. Ramp the appropriate parameter (amplitude, phase angle, or frequency) with the timer in *SENSE* mode, configured for the appropriate signal. When operation is sensed, the beeper sounds, the ramp is stopped, and the sources are left on with their last values shown in the displays.

**NOTE**

In *RAMP* mode, **SENSE** must be manually reset to make it ready for the next test.

## Timer Configuration

After power up, the timer is reset (cleared) and set to *Sense*. In this state it only beeps when the type of signal it is configured for occurs.

Before a timed test can be run, the timer must be activated and configured for the test conditions. This consists of:

- Selecting the desired *START* and *STOP* modes,
- Selecting the type of signal to be sensed
- Setting the timer range

For more information on timer configuration see Table 4.1 on page 4-13.

### ON/OFF Control

Every source can be turned on and off individually at any time using the switch ON side. The source turns on at a zero crossing, with a 1.5 second delay if the source was not already enabled. Its LED lights when the source is on.

Sources are switched into and out of the *ENABLE* mode by alternately pressing the ENABLE side of the switch.

Enabled sources are turned on and off together when the **SYSTEM OUTPUT** push-button on any unit, including the minicontroller, is pressed. There is a 1.5 second delay after enabling.

### Source/System Zero X

Turn-on time depends on the *ZERO X* mode. In *SOURCE ZERO X,* each source turns on at its zero crossing, and in *SYSTEM ZERO* X, they all turn on simultaneously at their respective phase angles when the system MASTER REF 0 occurs. See Figure 2.2 on page 2-5 for more information.

### On/Off Indications

- The **ON** LED above a source switch is illuminated whenever the source is turned on individually.
- All **SYSTEM OUTPUT** switches are illuminated steadily when the enabled sources are on (if no other source has been turned on individually), or blink when any other source has been turned on individually.
- The **High Voltage Alarm** LED of each source (next to its lightning symbol) is ON when the potential at the terminal exceeds 20 V.

# Options

This section explains how to configure system options.

## Fault Rotate - F2810 Option

The fault rotate feature is used when manually testing three-phase distance relays. It rotates simulated faults counterclockwise to the next phase without having to change any source parameters or more than a single connection.

After a test has been run, and the timer reset, just press the **FAULT ROTATE** switch to the appropriate side, change the connection to the relay's next current phase (if only a single current is used), then start to test the next phase.

### Phase-to-Neutral Faults

A simulated phase-to-neutral fault requires three voltage sources and either one or three current sources. Set up the test parameters as shown in Figure 3.3, with one faulted phase.

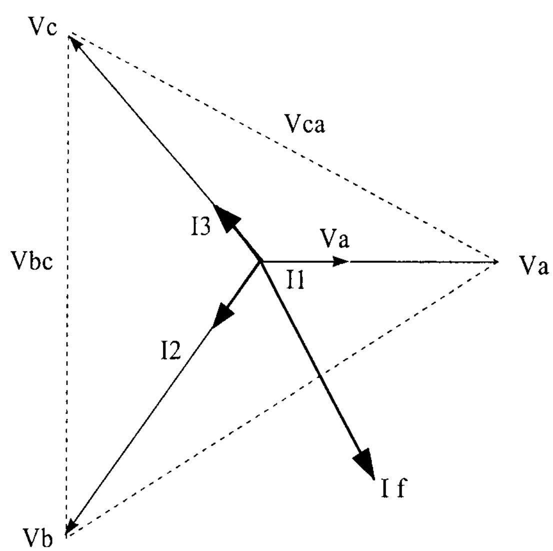



***Figure 3.3  Phase-to-Neutral Faults***

## Phase-to-Phase Faults

In an Open Delta configuration, a simulated phase-to-phase fault requires two voltage sources and one current source setup, as shown in Figure 3.4 and Figure 3.5.

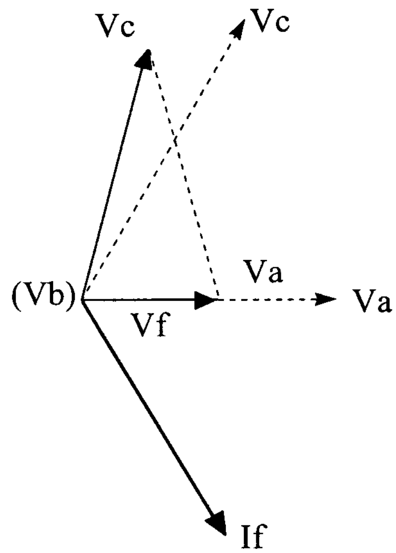



***Figure 3.4 Phase-to-Phase Faults***

In the Open Delta configuration, two voltage phasors are generated directly. These represent two of the three line-to-line potentials in a three phase system; the third voltage is the phasor difference voltage. **Fault Rotate** provides A-B, B-C, C-A rotation of the faulted phase only when the generated phasors truly represent correct power system geometry. All voltage and current sources must be set to the same range.

Examples for fault reduction are given in Table 3.5 for $V_A$ at 0°:

***Table 3.5 Fault Reduction***

| Fault Reduction | 00% | 10% | 20% | 30% | 40% | 50% | 60% |
|---|---|---|---|---|---|---|---|
| $V_A$ ($V_{fault}$) | 120.0 | 108.0 | 96.0 | 84.0 | 72.0 | 60.0 | 48.0 |
| $V_B$ | 120.0 | 117.1 | 114.5 | 112.0 | 110.0 | 108.2 | 106.7 |
| $V_B$ angle | 60.0° | 62.5° | 65.2° | 68.0° | 70.9° | 73.9° | 77.0° |

Using the correct power system phasor values for $V_A$ and $V_B$ results in the following fault rotation for $V_{AB}$-$V_{BC}$,-$V_{CA}$.

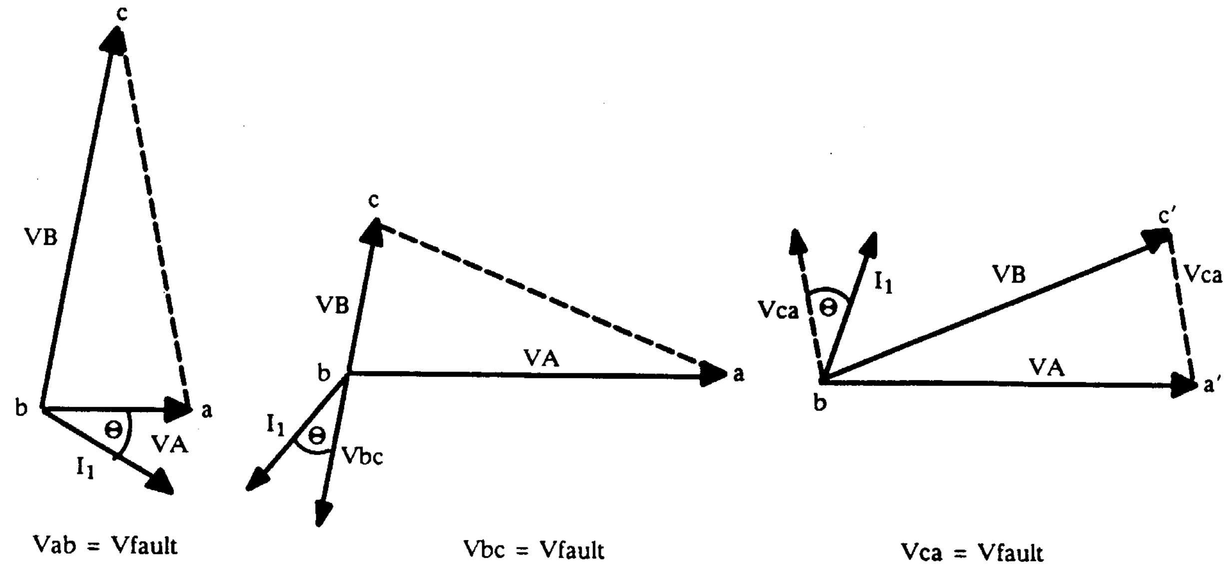



***Figure 3.5 Phase-to-Phase Fault Rotation***

The phase relationship of $I_1 = I_{fault}$ to the faulted phase (regardless of rotation) is constant as shown in Table 3.6.

***Table 3.6 Phase Relationship of $I_1 = I_{fault}$ to the Faulted Phase***

| Test Source | Faulted Phases: AB | Faulted Phases: BC | Faulted Phases: CA |
|---|---|---|---|
| $V_A$ | 40.0 V @ 0.0° | 105.8 V @ 0.0° | 105.8 V @ 0.0° |
| $V_B$ | 105.8 V @ 79.1° | 40.0 V @ 79.1° | 105.8 V @ 21.8° |
| $V_B$-$V_A$ | 105.8 V @ 100.9° | 105.8 V @ 158.2° | 40.0 V @ 100.9° |
| $I_1$ | 1.0 A @ 330.0° | 1.0 A @ 229.1° | 1.0 A @ 70.9° |

## Battery Simulator - F2875 Option

The Battery Simulator is an internal option for the F2251, F2252 or F2253 power system simulator that supplies a selectable DC voltage of 48, 125 or 250 V. This voltage powers the protective relay being tested and simulates the station battery in substations.

### Operation

Select voltage ranges of 48, 125 or 250 V using the momentary switch on the side I/O panel. Three lights on the side l/O panel indicate the selected output voltage

### Remote operation

Remotely select the DC output voltage and turn the Battery Simulator on or off using a computer running programs such as ProTesT.

The Battery Simulator can remotely operate networked F2250 power system simulators provided that at least one of the simulators has the F2875 option installed. Only the simulator with the F2875 option installed, and connected to the PC running ProTesT, responds to commands from remote operation. All other simulators on the network ignore the commands.

## Precision Autosynchronizer - F2920 Option

**NOTE**

**This option requires the F2010 Minicontroller and the F2820 ΔVALUE/ΔTIME option.**

The F2920 Autosynchronizer option is used to test circuit breaker advance time on autosynchronizer relays (See Figure 3.6). The option provides quick, simple, repeatable and accurate tests on this important relay function.

An Autosynchronizer is used to control the closing of circuit breakers connecting an incoming generator to a running system. The Precision Autosynchronizer monitors the voltage from the two sources and initiates circuit breaker closing, providing amplitude and frequency are within pre-set limits, when the two sources are synchronized. Minimum disturbance to the generator and the system occur if the breaker contacts close at exact synchronism.

Because the two sources are normally running at slightly different frequencies the sources are only within the allowable range for a short time. The circuit breaker advance time feature of such relays is intended to initiate closing of the circuit breaker in advance of anticipated synchronization by a time equal to the closing time of the breaker. Breaker contact closure should then occur exactly at synchronism.

The Precision Autosynchronizer automatically tests automatic synchronizing relays and displays circuit breaker advance time in ms/cycles. The F2820 ΔVALUE/ΔTIME option is required to verify response to rate of change in slip frequency.

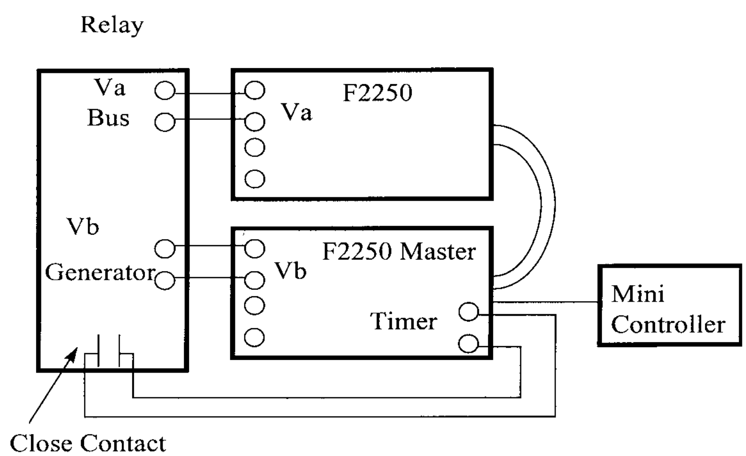



***Figure 3.6  Typical Autosynchronizer Test Setup***

## General

The following are some general characteristics:

- The two F2250 voltage sources are used to supply the relay under test.
- The relay is configured to respond with a close signal in advance of synchronism.
- The F2250 sources are set to slip against each other to simulate running and incoming supplies.
- The **SENSE** input of the F2250 is used to detect relay operation and display the relay circuit breaker advance time.

## Requirements for a F2920 Test Setup

Several conditions must be met before the F2250 performs a phase interface test using the F2920:

- The F2920, F2010 Minicontroller and F2820 options must be installed
- The STOP timer mode must be set to *AUTOSYNCH*
- The minicontroller mode must be set to *FREQUENCY*
- The minicontroller source selection must be *VB*
- The starting frequency must be equal to the base frequency, either 50 or 60 Hz
- The test frequency is Value B, and must be different from the starting Value A (base) frequency
- The initial starting phase difference must be a multiple of 60°. **SOURCE 1** phase is set to zero automatically when the test is run. The phase relationship is set via source $V_B$. Valid source $V_B$ phase settings are: 0, +60°, +120°, +180°, +240°, or +300°.
- If the user sets source $V_B$ to a *non-60°* phase angle the firmware automatically advances the phase angle (and display) to the next 60° multiple, the first time the test is run. For example, if the Source $V_B$ phase is set to –90° the firmware changes the phase to –60°.

## Setting Up for a Precision Autosynchronizer Test

To setup for a test (refer to Figure 3.6):

1. Consult the autosynchronizer relay instructions to determine relay connections and operating requirements. Set up the relay for testing.
2. Connect the F2250 source outputs to the relay inputs.
3. Power up the F2250.
4. Select the *SENSE* input mode to suit the output of the relay (contracts/volts). Connect the F2250 **SENSE** input to the relay **CLOSE** output.
5. Plug the F2010 Minicontroller in to the D-232 socket on left side of the second F2250.
6. Select F2250 sources as voltages
7. Set amplitudes as required by the relay.
8. Power up the relay and make any adjustments required for the test.
9. Turn the F2010 Minicontroller on.

## Running the Test

To run a test:

1. Set source $V_A$ phase to 0°.
2. Set source $V_B$ phase to the desired initial phase, for example 180°.
3. Set source $V_B$, Frequency, **VALUE A**, the starting frequency, to be the same as the base frequency, for example 60 Hz (or 50 Hz).
4. Select source $V_B$, Frequency, **VALUE B**. Set **VALUE B** to the test frequency, for example. 59.96 Hz.
5. Set **VALUE C** to 0°.
6. Select source $V_B$, Frequency, **VALUE A**.
7. Select Frequency for the F2010: **Both**.
8. Reset the relay by switching the auxiliary supply on.
9. Set the F2010 **SYSTEM OUTPUT** to ON.
10. Select the F2010 Frequency, Source $V_B$ (**SOURCE 1**).
11. Initiate the test by pressing **ΔVALUE**. The slip frequency AF = 0.04 Hz is processed by the relay.
12. Ensure that the timer starts counting down from a time equal to a fraction of the slip period. For the phase and frequency given above, this value is 12.5 seconds.
13. Ensure that if the relay does not operate on first synchronization, the timer resets to full slip period time and resumes counting down towards the next synchronism.
14. Ensure that all seven condition LEDs on the relay remain illuminated after 12.5 secs. The **ENABLE** LED goes out as the F2250 timer sense beeper sounds Then the timer starts and then stops.
15. Ensure that the timer stops when the relay operates and displays the time remaining before synchronism. This is the circuit breaker advance time.
16. Record the advance time and calculate the close angle error as described below.

## Calculating the Accuracy of the Relay Under Test

The setting for the relay circuit breaker advance function and the measured response are both times. However, the important factor in synchronizing a generator to a system is the *CloseAngle Error* (CAE), which is the phase difference between the sources when the circuit breaker contacts close. Assume that the circuit breaker advance time exactly matches the circuit breaker time, and that this can only be verified by timing the circuit breaker. The relationship between the error in circuit breaker advance time and close angle error depends on the slip frequency. At low slip rates, a large time error results in only a small close angle error, but at high slip rates even small time errors cause large close angle errors.

CAE = {[ Measured Time - (Set Time - Tl) ] x Slip Frequency x 360]}/1000

Where:

- Measured time = Timer display at the end of the test in mSeconds
- Set Time = Relay advance time setting in mSeconds
- Tl = Time delay of the output relay of the synchronizing relay in mSeconds
- Slip frequency = Frequency difference between the sources in Hz

## F2250 Action During an Autosynchronizing Relay Test

The following events occur:

1. The F2250 checks for a valid test setup. If the test setup is not valid the minicontroller beeps.
2. The F2250 sets the phase relationship which is defined by the source $V_B$ phase display. The phase of source $V_A$ is set to zero. The phase of source $V_B$ must be set to the nearest 60° multiple that is greater than or equal to the set phase.

   For example, if a source $V_B$ phase is set to 45°, then the F2250 changes it to 60°. If the user sets a phase of 150 °, then the F2250 changes it to 120°. The phase of source $V_A$ is simultaneously set to zero.

3. The F2250 sets both sources to the same clock for several cycles to ensure phase update and a known phase relationship.
4. The source selected on the F2010 for changing frequency is set to the variable frequency clock. Note, however, that the variable frequency clock is set to the base frequency, so the phase relationship is maintained.
5. The F2250 calculates the time required for the sources to slip from the initial conditions to synchronism once the test source is moved to the test frequency and preloads this time into the F2250 timer. The initial phase relationship between the sources defines the angular distance to synchronism and the difference between base frequency and test frequency, angular velocity.
6. The F2250 waits for one second to allow the relay to absorb the phase change.
7. The frequency of the test source is changed from the base frequency to the test frequency at a zero crossing. The timer is started, in the downcount mode, at the same zero crossing.
8. The timer uses the predicted time as the starting point, and counts down to synchronism, with zero equaling synchronism. The relay output stops the timer, which then displays the remaining time to synchronism. This is the relay circuit breaker advance time.
9. If the relay does not operate on the first pass through synchronism, i.e., when the timer counts down to zero, the timer is pre-loaded with the full slip period and immediately starts counting down again.
10. If the relay actually stops the timer after coincidence, the timer displays the full slip cycles time, minus the relay retard time.

## Minicontroller - F2010

The F2010 Minicontroller extends the control capabilities of the power system simulator to which it is connected, as well as to other units connected in a multi-unit system providing they all have the F2825 Multiple Sources option. The minicontroller cannot initialize unless it is connected to the system MASTER.

Initialization

Press the minicontroller alternate action **POWER** push-button once to initialize the minicontroller. This illuminates its **ON** LED and the instrument **REMOTE** LED and resets the values of the sources parameters to zero in both A and B Set Value registers.

On/Off Control

Pressing **SYSTEM OUTPUT** turns all enabled sources on and illuminates its LED, or it turns enabled sources and their LEDs off.

Selecting a Source

A source must first be selected before its parameter values can be changed or saved for dynamic testing. Press the **Source** switch to select either **SOURCE 1** (**SRC# 1**), **SOURCE 2** (**SRC# 2**), or **BOTH**. **BOTH** can only be selected when **FREQ** is selected.

Selecting a Parameter

Once a source is selected, its parameter values (shown in its displays) can be changed. Press the parameter switch to select either its amplitude (**AMPL**), phase angle (**PHASE**), or frequency (**FREQ**).

Changing A Parameter Value

The value of the selected source parameter is changed by rotating the knob. Clockwise rotation increases the amplitude, frequency, and the phase angle (in a lagging direction), and vice versa. The present value is always shown in the source displays. The rate of change depends on the source range (automatically set by *AutoRange*) and the **RESOLUTION** control, which selects either **COARSE** or **FINE**. **COARSE** changes the value 128 least significant digits (lsd) per revolution, and **FINE** changes it only 1/8 as much (16 lsd/revolution). In the **COARSE** mode the knob is velocity sensitive; turning the knob faster causes greater change.

## Saving Parameter Values

When the minicontroller is turned on, both Set Value registers A and B are initially loaded with the amplitude, phase angle, and frequency values from both sources, and A is selected. Pressing the **SET VALUE** switch replaces all the values in A with the unit's present values, and selects B. If the F2820 ΔVALUE/ΔTIME option is not installed, pressing **SET VALUE** again replaces all the values in B with the unit's present values and selects A. Thus two sets of parameter values can saved for dynamic testing.

If the F2820 option is installed, pressing **SET VALUE** when B is selected saves the present values then selects C for saving a rate-of-change value. The selected source parameter display also changes; to *N CY* for amplitude and phase angle, where *N* = the number of cycles between single lsd steps, or *N* SEC for frequency, where *N* = number of 0.001 Hz changes per second. The knob changes *N*. Pressing **SET VALUE** saves the rate-of-change value and selects A. The value in C remains available after the minicontroller has been turned off and back on again. Setting *N* to zero produces a step change between values A and B.

On **FREQ** ramps only, an intermediate timer start value can be set. With register C selected, pressing the **HERTZ/RANGE** switch either up or down causes the A and B indications to flash alternately and the **RANGE** display to read *StA* (Start). A value between A and B can now be set via the knob and stored by pressing **SET VALUE** again. When the test is run, the timer starts when the frequency reaches the set value and stop when the relay operates.

## Dynamic Tests

Pressing the **ΔVALUE** push-button initiates a Dynamic Test and disables all the minicontroller's controls except **ΔVALUE**. The test changes the selected parameter of the source from its present value (shown in its display) and stored in A or B (whichever is selected), to the value stored in the other Set Value register. The change occurs instantly (at a zero crossing), or at the rate in C, when the F2820 is installed.

The timer is started when the source value equals the stored value, and stopped when a signal is sensed. Pressing **ΔVALUE** while the test is in process aborts the test and stops the timer. Pressing **ΔVALUE** after the timer stops, resets the timer, reactivates the controls, and restores the Set Value selection.

# 4. Principles of Operation

This chapter describes the organization of F2250 units and how the internal microcomputers that operate them control unit operation from the front panel controls, a F2010 Minicontroller, or a host computer.

This chapter is split into the following sections:

| | |
|---|---|
| *Theory of Operation* | Physical and operational characteristics of the F2250 |
| *Mode Tests* | Tests that can be performed using the F2250 (page 4-18) |
| *Minicontroller Operation* | Physical and operational characteristics of the F2010 Minicontroller and explanations of the tests that can be performed with the unit (page 4-35) |

## Theory of Operation

This section explains the physical structure of the F2250 and the functioning of its various operational modes.

## Organization

Every F2250 power system simulator consists of the following (Figure 4.1 on page 4-3):

- Two or more Active Sources Power Amplifiers that produce precision amplification
- A digital sine wave generator that provides the reference input to each power amplifier
- A timer that senses external events and measures elapsed time or cycles
- A front panel that provides local control and displays the present state of the instrument and its sources
- An F2250 Microcomputer that controls the sine wave generators, the power amplifiers, the timer, logic input and logic output, and the front panel indicators and displays

The microcomputer obtains its control information from one of the following:

- Front panel controls
- External host computer
- F2010 Minicontroller through an RS-232 serial communication port

It also exchanges control and status information with other simulators over an IEEE-488 bus as part of a multi-unit, networked system. Frequency and timing signals are transmitted by the SYNC bus.

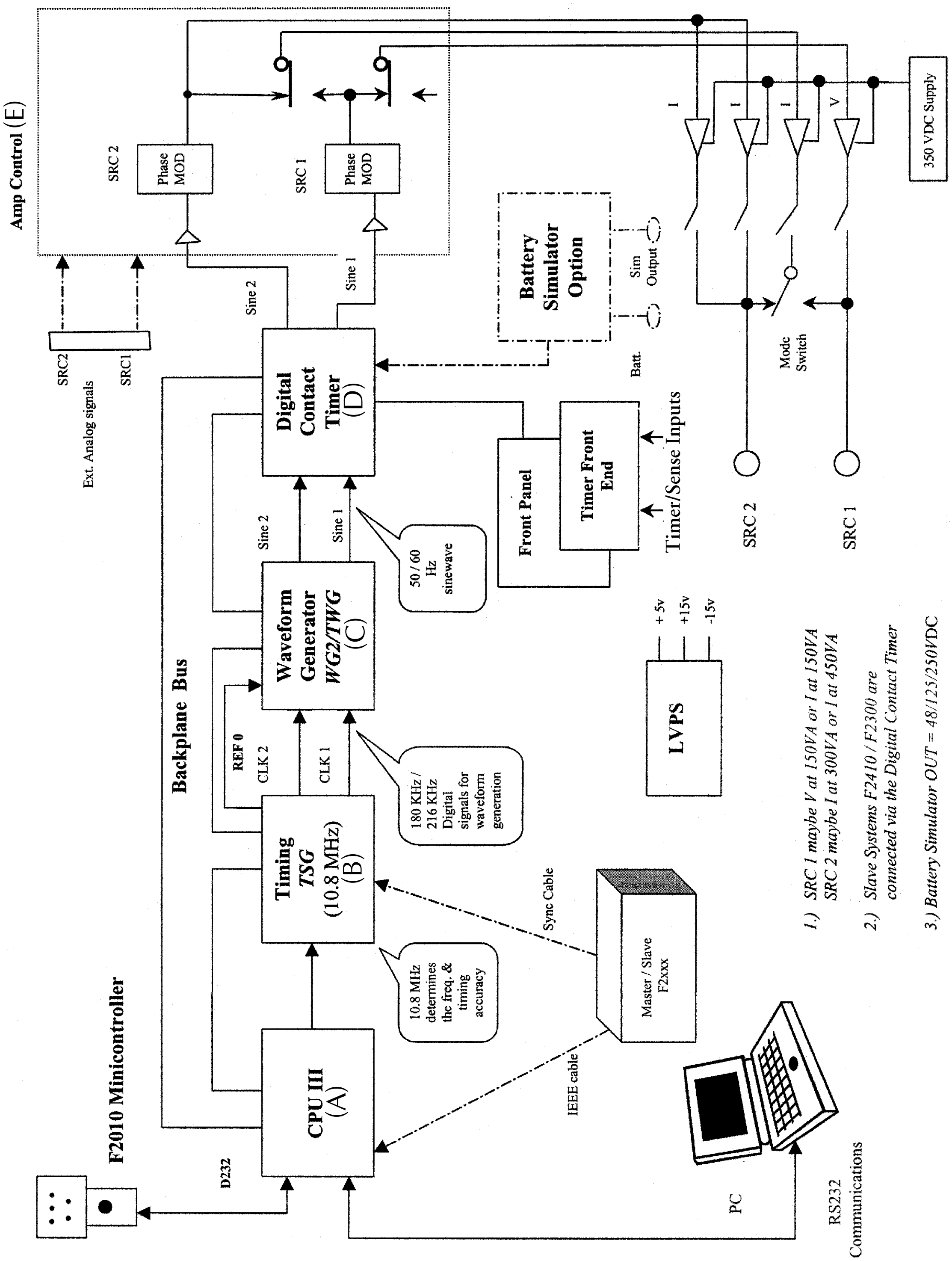



***Figure 4.1 F2250 Functional Block Diagram***

F2250 units have a six-slot card cage that contains up to five standard printed circuit boards (one slot is reserved). A separate adjacent body plane accommodates up to four Active Sources Amplifier modules.

The five standard boards are:

- Central Processing Unit - CPUIII (A in Figure 4.1):
  - Controls and evaluates all communication between other simulators, a minicontroller, a host computer, and the front panel
  - Determines the content of all messages to the other boards that generate and control the test signals
  - Provides external interfaces for communicating with a host computer, and a minicontroller
- Timing State Generator - TSG-01 or TSG-03, used for the F2885 Satellite Synchronizing Interface option (B in Figure 4.1)
  - Produces (or reproduces if resident in a SLAVE unit of a multi-unit system) the system reference (REF0), base frequency, and the timing signals used to generate the test signal, turn the source on and off, and start or stop the timer
  - Provides external SYNC interfaces for synchronizing all operations with other F2250s
- Waveform Generator - WG2 or TWG for the F2865 Transient Waveform Generator option (C in Figure 4.1)
  - Generates two precision test signals for the unit power amplifiers and the amplifier scaling signals
- Digital Contact Timer (DCT) (D in Figure 4.1)
  - Monitors the front panel controls and generates an interrupt whenever a change occurs
  - Provides the signals that operate the displays and indicators
  - Controls ON/OFF and range for both sources
  - Operates the timer
- Amplifier Control (E in Figure 4.1)
  - Controls power amplifier ranging, turn-on, and error correction
  - Monitors amplifier overload and amplifier output errors

# Operation

The Central Processing Unit (CPU) is the heart of the F2250 microcomputer. It contains:

- 80186 microprocessor
- 512 kb flash memory (EEPROM) for non-volatile storage of the firmware that controls the unit
- 256 kb of random-access memory (RAM) that contains buffers for temporary message storage
- Controller and interface to the Doble bus
- Controllers for the IEEE-488, parallel port, RS-232C, and D-232 interfaces

## Turn-on

When first turned on, the firmware performs a memory count down test of the TWG (F2865) board, if installed, and then a power-on (*Pon*) test, that verifies the proper operation of the following:

- Microprocessor and memory
- Waveform generator
- Power amplifiers
- Any other boards that are present
- Phase lock loop operation

If all these tests pass, the firmware initializes the unit and displays *HOLD* in the **SOURCE 1** phase angle display, while it checks to see if it is part of a multi-unit system. If it *is not* part of a multi-unit system, the unit goes into a wait loop until the front panel is activated, or a message is received from the minicontroller or host computer.

If the unit *is* part of a multi-unit system (the IEEE-488 bus cable and SYNC cable are connected to another unit), it either becomes the Controller-in-Charge or requests its bus address from the Controller-in-Charge. The first unit turned on becomes the Controller-in-Charge and automatically receives bus address 00. Once the Controller-in-Charge determines that all the units have been turned on, it activates the system. Until then, all the units go into wait loops.

Upon network verification, the MASTER instrument determines the capability of the network. There is a five second delay while all instruments report their configurations, and *HOLD* is displayed. If all instruments are F2250s, the network is set into full F2250 network mode. If there is a mix of F2250s and other F2000 instruments, the network remains in the F2000 network mode.

## Event Processing

F2250 power system simulators maintain their status quo until an external event occurs. Events occur when:

- The front panel control is changed
- An external operation is sensed, generating a message from the DCT board
- A message is received from another unit, the minicontroller, or a host computer

When an event occurs, the F2250 microcomputer evaluates it to determine what action to take. If an abort is specified, the message buffers are cleared (stopping any action in process) and the source or sources are turned off. Other possible actions include communicating the message over the IEEE-488 bus, storing and/or evaluating, or using the information to change the state of some part of the unit.

# Test Signal Generation and Control

The microcomputer receives source control data and parameter value messages from the front panel controls, the minicontroller, or the host computer. The microcomputer processes this information to develop the required change-of-state messages. It then transmits these messages at the proper time to the appropriate digital sine generator on the Waveform Generator (WG) board and the Timing State Generator (TSG) board.

The combination of the timing state generator and each digital sine generator develop a precision analog sine wave at the specified amplitude, frequency, and phase angle. This is applied to an Active Sources Power Amplifier, which develops the output voltage or current test signal.

The microcomputer also receives status, range, and error messages from the power amplifiers and output controls via the DCT. It uses this data to communicate operating information and error conditions. The microcomputer transmits messages to the DCT that illuminate the appropriate front panel LEDs and/or sound a beeper. It also has the ability to transmit messages to other units in a multi-unit system and to a remote host computer.

## Sine Wave Generation

Incremental values of a sine wave, at every 100$^{th}$ of a degree, are stored in the flash memory of the CPUIII. The microprocessor transfers these coefficients to two random-access memories (RAM), one for each digital sine generator. At the fundamental frequency, each RAM contains the values for every 0.1° at the base frequency. In the second harmonic, every other value is transferred, resulting in values for every 0.2°.

The RAMs are strobed by a chain of clock pulses from the TSG board. Each pulse copies a value from the RAM into an associated digital-to-analog converter (DAC) and increments a pointer to the next succeeding value. Once all values have been transferred to the DAC, the process starts over again.

The DAC changes the digital values to their analog voltage equivalents, producing a stepped approximation of a sine wave. Figure 4.2 shows the typical output of the DAC for every 0.1°.

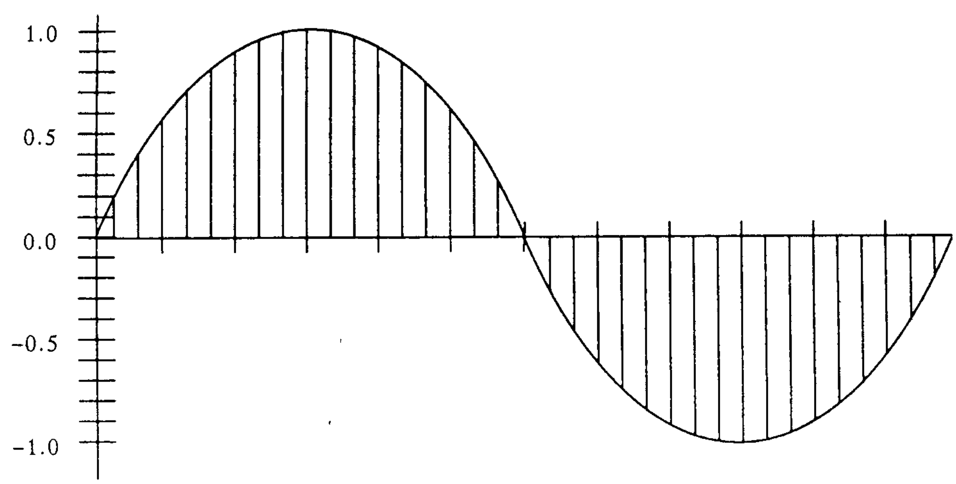



***Figure 4.2 Output of the DAC for Every 0.1° at 50/60 Hz***

## Amplitude Control

The maximum output of each DAC occurs at 90.0°, when the digital value (1.000) equals a precision reference potential. The DAC thus produces a stepped sine wave of constant rms amplitude at the specified frequency and phase angle.

This signal is applied to the reference input of a multiplying DAC converter (XDAC). The desired output amplitude (a percentage of the full scale amplitude at any range) is applied to the XDAC digital input. The output of the XDAC is therefore a stepped sine wave whose rms amplitude equals the specified rms amplitude of the source at its specified range.

The microcomputer calculates the desired amplitude from the type of source, its range, and a specified amplitude. The amplitude can be specified by the source's **AMPLITUDE** switches, a minicontroller, or a host computer. It is always shown in the source's **AMPLITUDE** display.

The output of the XDAC is filtered and applied through an analog switch on the Amplifier Controller board to an Active Sources Power Amplifier. The amplifier's output is directly coupled to the load.

## Turn-on/Turn-off Control

Each source is turned on or off by the microcomputer, which controls an analog switch at the input to the amplifier. The source can be controlled individually by its **ON** switch, or, together with other sources, by the **SYSTEM OUTPUT** push-button in conjunction with each source's **ENABLE** switch. Sources can also be turned on or off by the F2010 Minicontroller or a host computer. Each of these methods starts the turn-on process according to the *ZERO X* mode, either *SOURCE* or *SYSTEM*.

In *SOURCE ZERO X* mode, each source is turned on at its positive zero crossing. If two sources' phase angles are set to 0° and 75°, the second starts 75° after the first. Amplitude changes on each source take place at each sources individual SOURCE ZERO.

In *SYSTEM ZERO X* mode, all enabled sources are turned on simultaneously at the system's 0° reference, REF0. If two sources are set to 90° and 30°, they both start at the same time; the first at its maximum positive amplitude and the second at half its maximum negative amplitude. All amplitude changes occur simultaneously at system REF0.

## Phase Angle Control

Phase angle relationships are obtained by using a specified phase angle to offset the source's RAM pointer. The phase angle is defined by the source's **PHASE ANGLE** switches, an F2010 Minicontroller, or a host computer. The angle is always shown in the source's **PHASE ANGLE** display and represents the offset from the system reference, REF0. Phase angle changes always occur at REF0. If a harmonic frequency is used, then divide the phase angle desired by the number of the harmonic. If a phase angle of 180° is used for the third harmonic, then enter 180°÷3, which is 60°.

## Frequency Control

Frequency is controlled by the rate of the clock pulses that interrogate each source's RAM. The clock pulses are obtained from four references, two fixed and two variable generators.

*XTAL* mode produces 50 or 60 Hz clock pulses, selected by a switch on the TSG board. *LINE SYNCH* mode uses a phase-lock loop to synchronize the reference frequency to the AC power mains. In the *LINE SYNCH* mode, the power mains frequency must be within 4 Hz of the reference frequency.

If the unit is part of a multi-unit system, the system MASTER provides the clock and system reference pulses to all SLAVE units in order to synchronize the frequency and operation of all AC sources. If the frequency of the MASTER is varied, all SLAVE units track the frequency of the MASTER unit.

A crystal controlled oscillator on the TSG board provides variable frequency clock pulses. Its output is divided to produce the correct clock frequency. The nominal base frequency of the system (50/60 Hz) is the default setting of the variable frequency clock. The standard crystal provides an accuracy of +0.0005%.

In *REMOTE* mode either the minicontroller or a host computer can change the MASTER clock frequencies to achieve system frequencies from 0.100 to 9999.9 Hz.

# Active Sources Power Amplifiers

F2250 voltage and current sources use Active Sources Power Amplifiers to produce low-distortion sine waves, with precise amplitude values and phase angle relationships to ensure accurate, repeatable calibration and consistent test results. These waves are produced with better than +0.25% accuracy under normal ambient conditions, and never exceed +0.5% error over the maximum ambient temperature range of 0° to +50° C and AC power mains voltage variations (105 V to 132 V @ 60 Hz or 210 V to 264 V @ 50 Hz) that characterize field testing conditions. Doble's factory acceptance criterion for amplitude accuracy is much tighter: only +0.3% deviation for worst-case conditions of load, line voltage, and ambient temperature combined.

## General Principles

Doble's Active Sources Power Amplifiers consist of wide bandwidth high-power electronic amplifiers connected in a negative feedback configuration. Their input is a low distortion sine wave of precise amplitude from a digital sine generator. Their output is directly coupled to the load.

The output is constantly monitored to provide a negative feedback signal that accurately represents the actual test signal applied to the load. It includes any clipping, phase shift, or distortion introduced by the load.

Voltage sources are monitored by a resistive divider across the output, while current sources are monitored by a series shunt (Figure 4.3 on page 4-11).

The feedback signal is an analog of the output, which is compared to the reference signal at the input or the summing junction of the amplifier. A difference (error) results when the output deviates from the correct value. The error signal drives the amplifier to correct the difference, keeping the output constantly equal to the input. The rate at which the amplifier responds is far greater than the signal frequency. Therefore, error correction is extremely rapid and virtually undetectable when measuring the output. Since the negative feedback signal is obtained from either the output's voltage or its current, it is the parameter that remains constant with respect to the input.

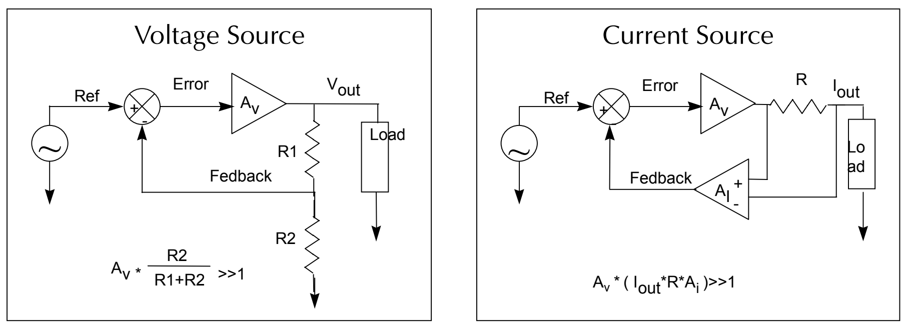



***Figure 4.3 Active Sources™ Power Amplifier Configurations***

The alternate (compliance) parameter varies with the load up to the source's power capacity.

If the load exceeds the rated capacity, the output signal is clipped. If an error, such as clipping, exceeds 1% in amplitude or phase shift, or 2% in distortion, an error detector sounds a beep five times. At that time, *ER* blinks in the source's **SOURCE** display.

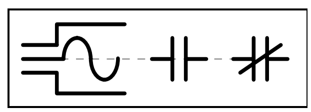
# Start and Stop Logic Input Operation

The operation of the **START** and **STOP** inputs is selected by pressing their respective paddle switches to the right. When the input conditions at the logic input terminals are in the state selected by the paddle switch, the logical input is asserted. In the contact *open to close* mode, the logical input is asserted when a closed contact is connected across the contact terminals. The input is unasserted when the contact is open.

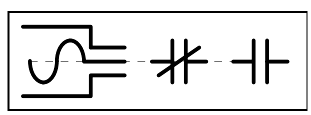
The voltage input is OR'd with the contact input. When contact inputs are wired together in parallel, such as when performing a *WIRED OR* pulse measurement, or tying the inputs between other F2250 units together, sense operation becomes the combined sum of all inputs.

For:

- The logical inputs, pressing the paddle switch to the right toggles between the voltage to and off/open to close modes:
  - *Voltage off to on/contact open to close* mode



  - *Voltage on to off/contact close to open* mode



- Voltage sense, connect the external signal to the **VOLTS** and **COMMON** terminals.
- Contact sense, connect the external signal to the **CONTACT** and **COMMON** terminals.

**NOTE**

**Do not connect external leads to VOLTS and CONTACT terminals at the same time.**

## ProTesT/State Simulator/TRANS2

When using ProTesT, State Simulator, or TRANS2 with the F2250, the input contacts trigger a dynamic state change on the operation of the assigned input, monitor for undesirable contact operation and time test events.

## Manual Mode

**START** and **STOP LOGIC INPUT** operation is described in Table 4.1.

*Table 4.1 Start - Logic 1 and Stop - Logic 2 Manual Modes*

| | **STOP/Logic Input 2 = SENSE** | **STOP Logic Input 2 = EXTERNAL** | **STOP Logic Input 2= TRIP** | **STOP Logic Input 2 = AUTOSYNCH** |
|---|---|---|---|---|
| **START/Logic Input 1= SOURCE 1** | NOT AVAILABLE | Starts on a **SOURCE 1** transition.<br><br>**STOP** on an External signal**.**<br><br>**SYSTEM OUTPUT** not turned off. | **START** on a **SOURCE 1** transition.<br><br>**STOP** on a trip.<br><br>Trip turns the **SYSTEM OUTPUT** off.<br><br>The timer must be reset to turn the **SYSTEM OUTPUT** on. | NOT AVAILABLE |
| **START/Logic Input 1= SOURCE 2** | NOT AVAILABLE | **START SOURCE 2** transition.<br><br>**STOP** on an **EXTERNAL SIGNAL.**<br><br>**SYSTEM** output not turned off. | **START SOURCE 2** transition.<br><br>**STOP** on trip.<br>Trip turns the **SYSTEM OUTPUT** off.<br><br>The timer must be reset to turn the **SYSTEM OUTPUT** on. | NOT AVAILABLE |

*Table 4.1 Start - Logic 1 and Stop - Logic 2 Manual Modes (Continued)*

| | **STOP/Logic Input 2 = SENSE** | **STOP Logic Input 2 = EXTERNAL** | **STOP Logic Input 2= TRIP** | **STOP Logic Input 2 = AUTOSYNCH** |
|---|---|---|---|---|
| **START/Logic Input 1= EXTERNAL** | NOT AVAILABLE | **START** on External signal.<br><br>**STOP** on an External signal.<br><br>Independent *TIMER* mode No effect on **SYSTEM OUTPUT**. | **START** with the **SYSTEM OUTPUT** on.<br><br>Starts timer on an external signal.<br><br>**STOP** on trip. Trip turns the **SYSTEM OUTPUT** off.<br><br>The timer must be reset to turn the **SYSTEM OUTPUT** on. | NOT AVAILABLE |
| **START/Logic Input 1= CLOSE** | NOT AVAILABLE | **SYSTEM OUTPUT** is turned on when a close is asserted.<br><br>Start timer starts when the **SYSTEM OUTPUT** goes on.<br><br>Stop timer stops when an external signal is asserted.<br><br>**SYSTEM OUTPUT** stays on. | Start time starts when the **SYSTEM OUTPUT** goes on.<br><br>Stop timer stops when a trip signal is asserted.<br><br>**SYSTEM OUTPUT** goes off. | NOT AVAILABLE |

*Table 4.1 Start - Logic 1 and Stop - Logic 2 Manual Modes (Continued)*

| | STOP/Logic Input 2 = SENSE | STOP Logic Input 2 = EXTERNAL | STOP Logic Input 2= TRIP | STOP Logic Input 2 = AUTOSYNCH |
|---|---|---|---|---|
| **START/Logic Input 1= ALL LEDs OFF** | Real-time *SENSE* mode. Stop input only.<br><br>**TIME** display shows *SENSE* when asserted. | Pulse single input *SENSE* mode.<br><br>**START** when stop input is asserted.<br><br>**STOP** when stop input is unasserted. | NOT AVAILABLE | Starts MASTER on Delta frequency.<br><br>**STOP** on input.<br><br>2nd F2250 is used as a 2nd voltage source. |

In manual mode, **LOGIC OUTPUT 1** is asserted when **SOURCE 1** is on. **LOGIC OUTPUT 2** is asserted when **SOURCE 2** is on.

The **SENSE** option is used for pickup/dropout Auto Ramp tests. The timer stops on an internal start from **SOURCE 1** or when **SOURCE 2** changes from OFF to ON, or when an ON to OFF condition is used to measure the timing response of the relay for application or removal of analog or logical outputs from the F2250.

The external timer stop and timer start are used for timing externally initiated events, such as circuit breaker trip and close.

# Logic Output Operation

The **LOGIC OUTPUT** operational modes are explained below.

F2010 Minicontroller State Change Mode

The two **LOGIC OUTPUTS** follow a set of rules to simulate circuit breaker auxiliary contact states for Prefault, Fault, and Post Fault conditions. The **LOGIC OUTPUT** contacts change the state on a REF0 transition.

State Change Mode

The two **LOGIC OUTPUTS** simulate states of Prefault, Fault, and Post Fault. Each output is programmed for the next state. The **LOGIC OUTPUT** contacts change the state on a REF0 transition.

Transient Waveform Generation Mode

The **LOGIC OUTPUTS** can be programmed on a sample-by-sample basis, by assigning each to a logical channel in TRANS2 Software. The Transient Waveform Generator memory controls the **LOGIC OUTPUTS**.

Logic Output Operation in Manual Mode and ProTesT (Windows)

The **LOGIC OUTPUTS** follow the state of their associated analog sources.

- **LOGIC OUTPUT 1** is asserted when **SOURCE 1** is on.
- **LOGIC OUTPUT 2** is asserted when **SOURCE 2** is on.

Manual Control Mode

Table 4.2 lists the possibilities for Manual mode configuration and Figure 4.4 shows the output states.

- **OUTPUT 1** is asserted when **SOURCE 1** is on or when **SOURCE 1** is **ENABLED** and **SYSTEM OUTPUT** is on.
- **OUTPUT 2** is asserted when **SOURCE** 2 is on or when **SOURCE 2** is **ENABLED** and **SYSTEM OUTPUT** is on.

*Table 4.2 Manual Control Mode*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **SOURCE 1** | OFF | OFF | OFF | OFF | ON | ON | ON |
| **SOURCE 2** | OFF | OFF | ON | ON | OFF | OFF | ON |
| **SYSTEM OUTPUT** | OFF | ON | OFF | ON | OFF | ON | OFF |
| **LOGIC 1** | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| **LOGIC 2** | 0 | 0 | 1 | 1 | 0 | 0 | 1 |

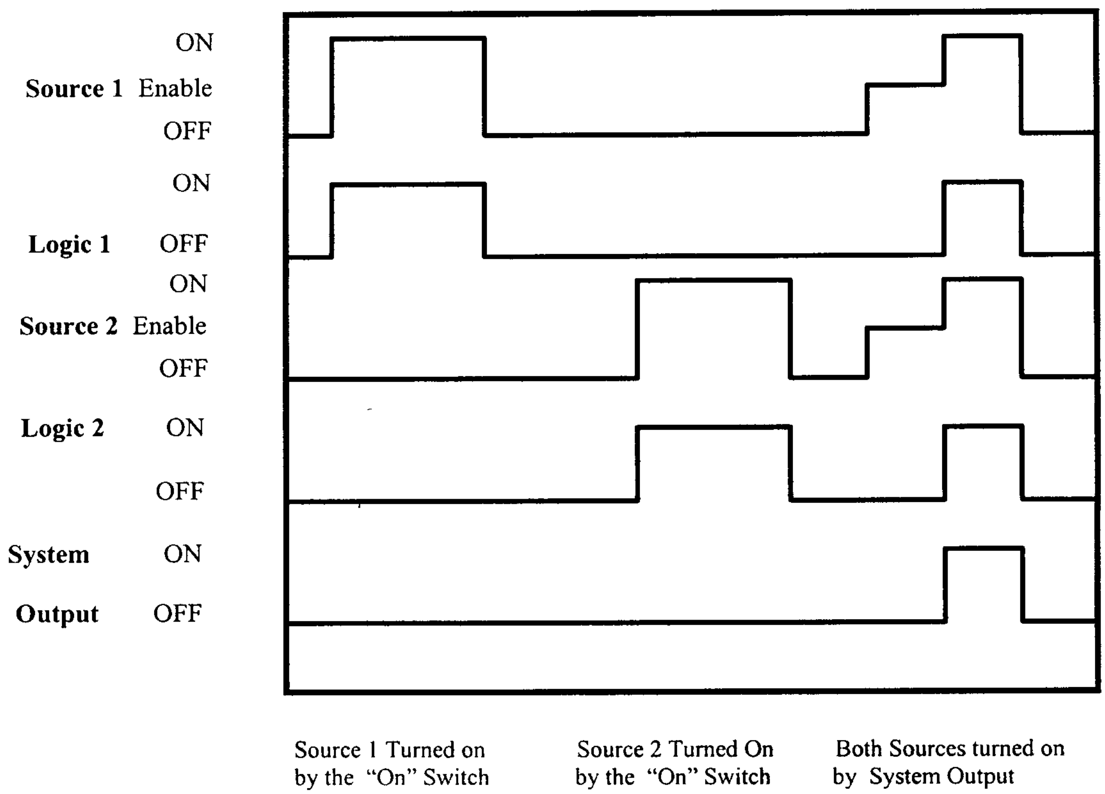



*Figure 4.4 Manual Mode Logic Output States*

## Logic Output Control Mode

For information on ProTesT, SSimul, and TRANS2 Automation Modes, refer to the *ProTesT User's Guide* and the *TRANS2 User's Guide* for information on automation modes.

# Mode Tests

This section discusses the uses of the logical input and gives a series of procedures for validating different modes of operation. Where applicable, applications for the modes are discussed, and followed by a test procedure for the mode.

## Sense Mode

Applications for manual or minicontroller operation include:

- Sensing pick up/drop out of relays output for contacts or voltage outputs
- Single point reach tests
- Continuity tests

### Characteristics

The following are characteristics of the *SENSE* mode:

- Only available on **STOP** input
- Timer does not run
- *RAMP* mode

  When the selected sense condition is achieved, the ramp stops; the **TIME** display indicates *SENSE* (until manually reset), and the buzzer sounds for one second. *SENSE* remains latched until **RESET** is pressed.
- *SET* mode

  **SENSE** tracks input in real time, displays *SENSE* and sounds a buzzer while **SENSE** is asserted.

Test the **SENSE** function in both *RAMP* and *SET* modes, using a push-button switch to simulate relay pickup and dropout with a normally open output contact.

- Connect a normally open push-button switch between the **CONTACT** and **COMMON** terminals of the **STOP** input.
- Select **SENSE**, and perform a Contact Open to Close/Voltage OFF to ON operation as follows:

To select the *SENSE* mode:

1. Press the **STOP** switch to the left repeatedly until the **SENSE** LED illuminates.
2. Press the **STOP** switch to the right repeatedly until the **Contact Open to Close/Voltage** LED illuminates (Figure 4.5).

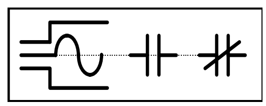


***Figure 4.5  Contact Open to Close/Voltage OFF to ON***

SENSE SET Mode

To perform this test:

1. Select *SET* mode.
2. Close and open the push-button switch repeatedly.
3. Observe that the **TIME** display indicates *SENSE* and that the buzzer sounds only when the switch is closed.

SENSE RAMP Mode

To perform this test:

1. Select *RAMP* mode.
2. Close and open the push-button switch repeatedly.

   Observe that the TIME display indicates *SENSE* and latches. The buzzer sounds briefly when the switch is first closed.
3. Close the push-button, and press **RESET**.

   Observe that the **TIME** display again indicates *SENSE* and latches. The buzzer sounds briefly.
4. Open the push-button, and press **RESET**.

   Observe that the display resets and that the buzzer is silent.

## Interaction of SENSE with RAMP in Progress, Detecting Pickup

To perform this test:

1. Select *RAMP* mode and **STOP SENSE**.
2. Press and hold the right most amplitude paddle switch up.

   Observe the ramp in progress.
3. Close the push-button.

   Observe that **SENSE** is latched, and that the ramp halts and the **AMPLITUDE** display indicates the amplitude reading at the time the switch closed.
4. Release the leftmost amplitude paddle switch, with the push-button still closed.
5. Press and hold the switch up, and observe that the ramp resumes.
6. Release the paddle switch and then release the push-button.

## Interaction of SENSE with RAMP in Progress, Detecting Dropout

To perform this test:

1. Select *RAMP* mode and stop **SENSE**.
2. Press the **STOP** input selector switch to the right repeatedly until the **Contact Close to Open/Voltage ON to OFF** LED (Figure 4.6) illuminates.

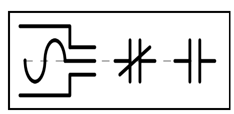


***Figure 4.6 Contact Close to Open/Voltage ON to OFF***

   Observe that the display indicates *SENSE*, latches, and the buzzer sounds briefly.
3. Hold the push-button closed, and press **RESET**.

   Observe that the display is all zeros, and that the buzzer is silent.
4. Press and hold the leftmost amplitude paddle switch up, with the push-button still closed. Observe the ramp in progress.

5. Open the push-button.

   Observe that **SENSE** is latched , that the ramp is halted, and that the display indicates the amplitude reading at the time the switch was opened.

6. Release the leftmost amplitude paddle switch, then press and hold the switch up, with the push-button still open.

   Observe that the ramp resumes, then release the paddle switch.

7. Repeat using **PHASE ANGLE** controls and **SOURCE 2** controls, if desired.

## External Two Input Timer Mode

Applications include the:

- Time between two separate external events, such as the time between an external voltage being applied and a relay picking up.
- Time between two external contact or relay operations.

### Characteristics

The following are characteristics of *the External Two Input Timer* mode (Figure 4.7):

- Timer runs from the first strike of the **START** input to the first strike of the **STOP** input.
- Start input can be asserted continuously during timing, or it can be unasserted after timing starts.
- Operation is not influenced by, nor does it influence, the ON/OFF state of sources or **SYSTEM OUTPUT**.
- Operation is not influenced by the *RAMP/SET* mode selection.

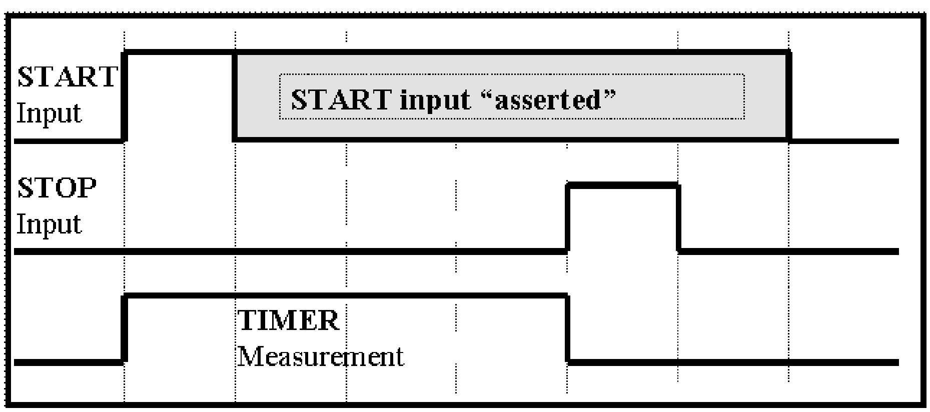



***Figure 4.7  External Two Input Timer Mode***

To select this mode:

- Press the **STOP** input selector switch to the left repeatedly until the **EXTERNAL** LED illuminates.

And

- Press the **START** input selector switch to the left repeatedly until the **EXTERNAL** LED illuminates.

Try the function of the *External Two Input Timer* mode, using a push-button to simulate two external events.

To test this mode:

1. Connect a normally open push-button switch between the **CONTACT** and **COMMON** terminals of the **STOP** input.
2. Connect a normally open push-button switch between the **CONTACT** and **COMMON** terminals of the **START** input.
3. Select the *External Two Input Timer* mode as follows:
   - Press the **STOP** input selector switch to the left repeatedly until the **EXTERNAL** LED illuminates.
   - Press the **START** input selector switch to the left repeatedly until the **EXTERNAL** LED illuminates.
4. Select the *Contact Open to Close/Voltage OFF to ON* mode on both the **STOP** and **START** inputs by pressing the input selector switch to the right repeatedly until this LED (Figure 4.8) illuminates.

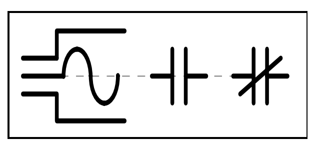


***Figure 4.8  Contact Open to Close/Voltage OFF to ON indicator***

5. Select the **TIMER** milliseconds range by pressing the **RESET** switch to the right repeatedly until the **MILLISECONDS** LED illuminates.
6. Close and hold the **START** push-button switch.

   Observe that the timer changes from *Autoranges* to displaying seconds.

**7.** Close and release the **STOP** push-button switch.

Observe that the display indicates the elapsed time and latches. The buzzer sounds briefly.

**8.** Release the **START** push-button, then press **RESET**.

Observe that the display resets to zero.

## Pulse Mode

Applications include timing the duration of contact dwell or a voltage pulse, such as the dwell time of a carrier send or receive contact, voltage signal, or the duration of a one-shot.

To select this mode:

**1.** Press the **STOP** input selector switch to the left repeatedly until the **EXTERNAL** LED illuminates.

**2.** Press the **START** input selector switch to the left repeatedly until all **START** LED indicators are off.

### Characteristics

The following are characteristics of the *Pulse* mode (Figure 4.9):

- Timer runs during the period that the **STOP** input is asserted. The timer stops when **STOP** is unasserted.
- If **STOP** is reasserted after stopping, the timer **PULSE** mode resets and restarts to display the next event time. Display must be reset before it will time the next event.
- Operation is not influenced by, nor does it influence, the ON/OFF state of sources or by **SYSTEM OUTPUT**.
- Operation is not influenced by the *RAMP/SET* mode selection.

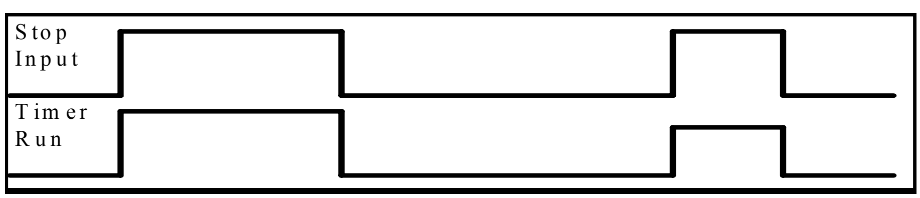



***Figure 4.9  Pulse Mode***

To test this mode:

1. Use a push-button to simulate an external event.
2. Connect a normally open push-button switch between the **CONTACT** and **COMMON** terminals of the **STOP** input.
3. Select the *Independent Pulse* mode:
   - Press the **STOP** input selector switch to the left repeatedly until the **EXTERNAL** LED illuminates.
   - Press the **START** input selector switch to the left repeatedly until all **START** LED indicators are off.
4. Select the *Contact Open to Close/Voltage OFF to ON* mode on the **STOP** input by pressing the input selector switch to the right repeatedly until this LED (Figure 4.10) illuminates.

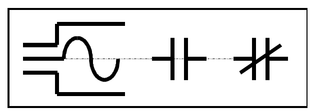


***Figure 4.10 Open to Close/Voltage OFF to ON indicator***

5. Select the **TIMER** milliseconds range by pressing the **RESET** switch to the right repeatedly until the **MILLISECONDS** LED illuminates.
6. Close and hold the **STOP** push-button switch.

   Observe that the timer changes from *Autoranges* to seconds after one second.
7. Release the **STOP** push-button switch.

   Observe that the display indicates the elapsed time and latches. The buzzer sounds briefly.
8. Press **RESET**.

   Observe that the display resets.
9. Close and release the **STOP** push-button.

   Observe that the timer restarts, and stops indicating the time of the second event.

## Pickup/Dropout: Trip Timer Operation with System Output Interaction

The applications for this mode include testing the time pickup or dropout of voltage or current operated relay, and turning the source off after timing is complete. This is especially important to prevent damage to the relay when high per-unit test currents are used.

### Stop Mode

To select this mode:

1. Press the **STOP** input selector switch to the left repeatedly until the **TRIP** LED illuminates.
2. Press the **START** input selector switch to the left repeatedly until either the **SOURCE 1** LED or the **SOURCE 2** LED illuminates.

#### Characteristics

The following are characteristics of the *Stop* mode (Figure 4.11):

- Timer runs from the **SOURCE** turn-on (or turn-off) to the first strike of the **STOP** input.
- Stop turns the **SYSTEM OUTPUT** off.
- **SYSTEM OUTPUT** cannot be turned on again until the timer is reset.
- Operation is not influenced by the *RAMP/SET* mode selection.

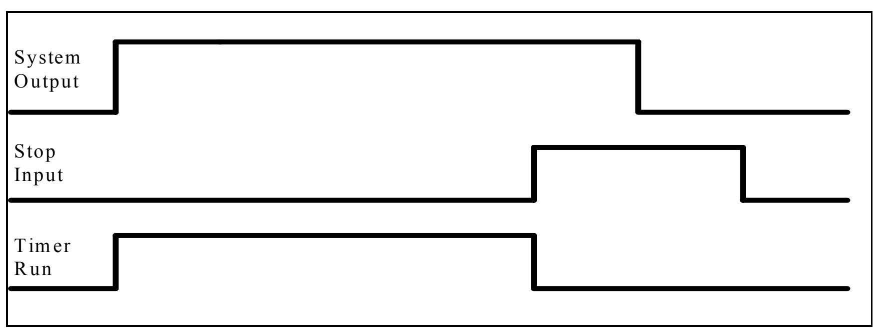



***Figure 4.11 Trip Timer Operation with System Output Interaction***

To test this mode:

1. Use a push-button switch to simulate relay operation.
2. Connect a normally open push-button switch between the **CONTACT** and **COMMON** terminals of the **STOP** input.
3. Select the *Pickup/Dropout - Trip Timer* mode as follows:
   - Press the **STOP** input selector switch to the left repeatedly until the **TRIP** LED illuminates.
   - Press the **START** input selector switch to the left repeatedly until the **SOURCE 1** LED illuminates.
4. Select the *Contact Open to Close/Voltage OFF to ON* mode for both the **STOP** and **START** inputs by pressing the input selector switch to the right repeatedly until this LED (Figure 4.12) illuminates.

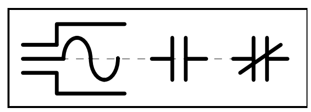


***Figure 4.12 Contact OPEN to CLOSE/Voltage OFF to ON indicator***

5. Select the timer milliseconds range by pressing the **RESET** switch to the right repeatedly until the **MILLISECONDS** LED illuminates.
6. Enable **SOURCE 1**; then turn the **SYSTEM OUTPUT** on.

   Observe that the timer changes from *Autoranges* to seconds after one second.
7. Close and release the external **STOP** push-button switch.

   Observe that the **TIMER** display is latched and indicates the elapsed time. The buzzer sounds briefly. Observe that the **SYSTEM OUTPUT** automatically turns off.
8. Press **RESET**.

   Observe that the display resets.

## Circuit Breaker Simulation Mode

The applications for this mode include the ability to:

- Simulate circuit breaker operation by turning sources on and off in response to external close and trip signals.
- Time multiple iterations of relay trip responses from externally initiated sources onto a relay trip output (such as operations of a feeder relay with auto reclosing).
- Time relay reclose operations.

To select this mode:

- Press the **STOP** input selector switch to the left repeatedly until the **TRIP** LED illuminates.

And

- Press the **START** input selector switch to the left repeatedly until the **CLOSE** LED illuminates.

### Characteristics

The following are characteristics of the *Circuit Breaker Simulation* mode (Figure 4.14 on page 4-29):

- External **CLOSE** input turns the **SYSTEM OUTPUT** on.
  The **SYSTEM OUTPUT** comes on at the next system REF0.
- Timer runs from **SYSTEM OUTPUT** on input to the external **TRIP** input. The tip input turns the **SYSTEM OUTPUT** off.
  The **SYSTEM OUTPUT** goes off at next system REF0.
- Close input can be asserted continuously during a run or can be unasserted after the timer starts. Circuit breaker anti-pumping emulation ensures that a continuously applied close signal does not cause multiple closes.
- Trip input overrides the close input so the **SYSTEM OUTPUT** does not turn on if both the trip and close inputs are asserted.
- A source that is manually turned on, does not affect and is not affected by the timer or **SYSTEM OUTPUT**.
- Operation is not influenced by the *RAMP/SET* mode selection.

To test this mode:

1. Use the push-buttons to simulate close and trip signals.
2. Connect a normally open push-button switch between the **CONTACT** and **COMMON** terminals of the **STOP** input.
3. Connect a normally open push-button switch between the **CONTACT** and **COMMON** terminals of the **START** input.
4. Select the *Circuit Breaker Simulation* mode:

   - Press the **STOP** input selector switch to the left repeatedly until the **TRIP** LED illuminates.

   And

   - Press the **START** input selector switch to the left repeatedly until the **CLOSE** LED illuminates.
5. Turn the *Contact OPEN to CLOSE/Voltage* mode on for both the **STOP** and **START** inputs by pressing the input selector switch to the right repeatedly until this LED (Figure 4.13) illuminates.

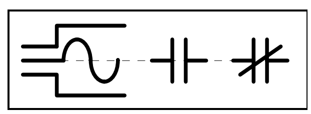


***Figure 4.13 Contact Open to Close/Voltage OFF to ON Indicator***

6. Select the **TIMER** milliseconds range by pressing the **RESET** switch to the right repeatedly until the **MILLISECONDS** LED illuminates.
7. Close and release the **START** push-button switch.

   Observe that the timer *Autoranges* from *milliseconds* to seconds after one second. The **SYSTEM OUTPUT** turns on.
8. Close and release the **STOP** push-button switch.

   Observe that the timer indicates the elapsed time and latches, and that the beeper sounds briefly. The **SYSTEM OUTPUT** turns off.
9. Close and release the **START** push-button switch.

   Observe that the timer resets to zero and restarts, and then changes to *Autoranges* after one second.

10. Close and release the **STOP** push-button switch.

    Observe that the timer indicates the elapsed time and latches, and that the beeper sounds briefly.

11. Repeat as necessary

12. Press **RESET**. Observe that timer clears.

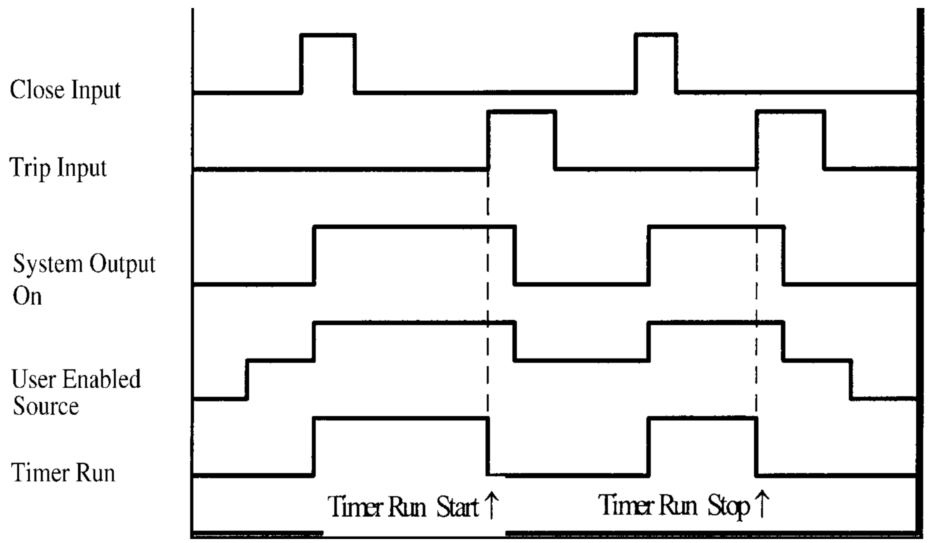



***Figure 4.14 Circuit Breaker Simulation Mode***

## Stop Timer Mode

To select this mode:

1. Select **EXTERNAL** for the **STOP LOGIC** input.
2. Select **SOURCE 1** or **2** for the **START LOGIC** input.
3. Ensure that **SYSTEM OUTPUT** is on.

### Characteristics

The following are characteristics of the *Stop Timer* mode:

- Timer starts when the selected source is turned on.
- Timer stops when the **STOP** input is asserted.
- **SYSTEM OUTPUT** is not turned off and must be turned off manually.

## Trip/External Mode

To select this mode:

1. Select **TRIP** for the **STOP LOGIC** input.
2. Select **EXTERNAL** for the **START LOGIC** input.
3. Begin the test with the **SYSTEM OUTPUT** on.

### Characteristics

The following are characteristics of the *Trip/External* mode:

- Timer runs from the strike of the **START** input to the first strike of the **STOP** input.
- **START** input can be asserted continuously during timing, or it can be unasserted after timer starts.
- **START** is not influenced by, nor does it influence, the **ON/OFF** state of sources or **SYSTEM OUTPUT**.
- **STOP** turns the **SYSTEM OUTPUT** off.

## Close/External Mode

To select this mode:

1. Select **CLOSE** for the **START LOGIC** input.
2. Select **EXTERNAL** for the **STOP LOGIC** input.
3. Begin the test with **SYSTEM OUTPUT** off.

### Characteristics

The following are characteristics of the *Close/External* mode:

- Start/Close sets **SYSTEM OUTPUT** on.
- Timer starts when **SYSTEM OUTPUT** goes on and stops when external stop is asserted. **SYSTEM OUTPUT** does not go off in response to an external stop.
- Measures recloser dwell time after a circuit breaker closes, if inputs are wired in parallel phase opposition.
- Measures trip time after first reclose if Relay Close is wired to Start/Close and Relay Trip is wired to Stop/External.

## Using Conditioning Amplifiers with External Signal Sources

The F2250 conditioning amplifiers can be used with external signal sources such as low voltage analog power system simulators or analog outputs from real time digital simulators. A nine-pin socket on the side panel provides access to the signal and control pins for both amplifiers. The front panel or external RS-232 communications can be used for range selection and amplifier OFF/ON control.

An external user-supplied switch is used to select between internal and external signal sources. The switch is only enabled when the sources are off and not enabled. The external signal required for full scale output on any range is 9.05 V peak (18.1 V peak to peak); for sine wave signals this is 6.4 V rms. The source input is a differential with a ground reference. If the external signal source is single-ended, the external ground and the Source Ref Lo (Src 1 ref lo and or Src 2 ref lo) should be connected to the shell of the nine-pin D connector.

## Input Connector Signal Levels

A nine-pin female D-connector on the Amplifier Control board allows external analog reference input signals as shown in Table 4.3.

***Table 4.3 Input Connector Pin Connections***

| Description | Pin Number | Full Scale Level | Z |
|---|---|---|---|
| Src 1 ref hi | 1 | ± 9.051 V | 25 kohm input Z |
| Src 1 ref lo | 6 | ± 9.051 V | 25 kohm input Z |
| Src 1 ext sel\ | 2 | 5 V HCMOS | 10 kohm pull-up |
| Src 2 ref hi | 4 | ± 9.051 V | 25 kohm input Z |
| Src 2 ref lo | 9 | ± 9.051 V | 25 kohm input Z |
| Src 2 ext sel\ | 5 | 5 V HCMOS | 10 kohm pull-up |
| Src 1 fbk | 7 | ± 9.051 V* | 2.2 kohm output Z |
| Src 2 fbk | 8 | ± 9.051 V* | 2.2 kohm output Z |
| signal common | 3 | | |
| chassis gnd | Shell | | |

* The Src 1 fbk (Pin 7) and Src 2 fbk (Pin 8) lines provide scaled versions of the measured output signals. The Pins 7 and 8 full scale levels for the non-transient mode current source ranges are half those shown in the table.

Pins 1, 2, 4, 5, 6, 7, 8, and 9 are clamped to shell (chassis gnd) with + 15 V (nominal) zener diodes. Pin 3 is clamped with back-to-back silicon diodes to the shell. Pins 2 and 5 (ext sel\) can be externally connected to Pin 3 to activate the external analog input for **SOURCE 1** and **2** respectively. The shell can be used for cable shields and to ground reference an ungrounded external signal source.

## Application

A nine-pin D connection to two switches and connectors suitable for the intended signal source are required to use the amplifiers in manual mode with external signals. Connections from the F2250 to the external source are easily implemented using binding posts mounted on a small plastic box. See Figure 4.15 and Figure 4.16 on page 4-34.

To complete this connection:

1. Connect the external signal source to the F2250 External Input nine-pin D connector as shown in Figure 4.16 (use the specific terminals).
2. Set the Internal/External source selector switches to internal.
3. Connect the F2250 sources to a suitable load.
4. Power up the F2250 and the Signal Generator.
5. Set the desired voltage and or the current range using the F2250 front panel **RANGE** selector switches.
6. Set a test value of a specific amplitude and frequency using the F2250 amplitude and frequency controls.
7. Enable the desired sources and turn the **SYSTEM OUTPUT** on.
8. Ensure that the source is not overloaded and is operating correctly.
9. Set Internal/External source selector switches to external.
10. Set the external signal generator to the desired frequency and amplitude.
11. Enable the desired sources and turn **SYSTEM OUTPUT** on.
12. Ensure that the source is not overloaded and is operating correctly.
13. Turn **SYSTEM OUTPUT** off and disable sources.
14. Disconnect the nine-pin D connector or set the Internal/External selector switches back to internal to enable normal operation.

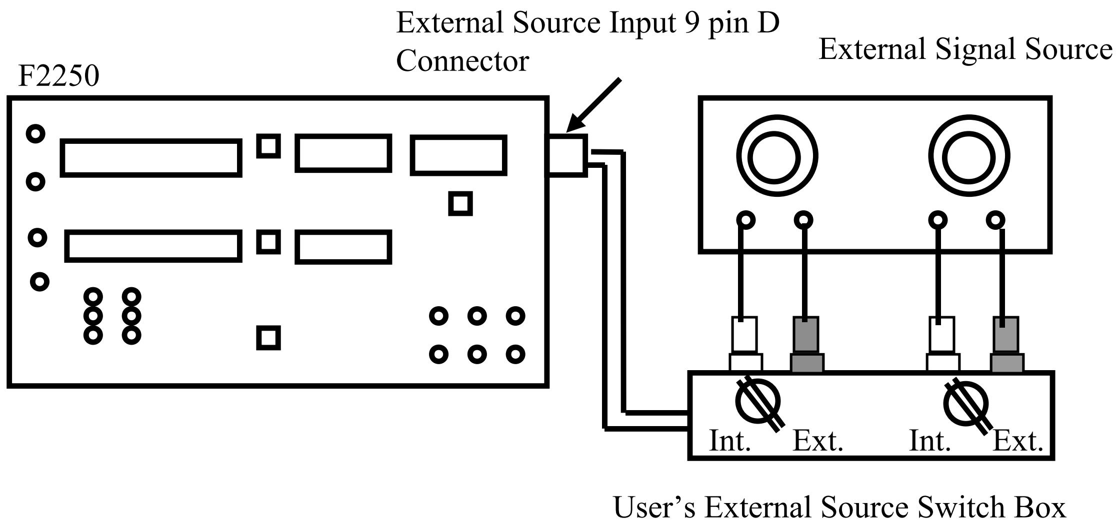



*Figure 4.15 Typical Setup for Use of External Signal Sources*

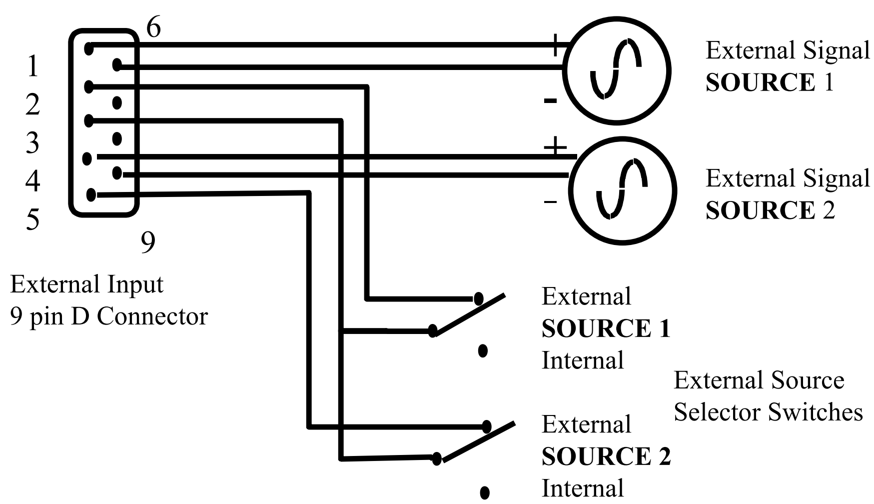



*Figure 4.16 Schematic for Use of External Signal Sources*

# Minicontroller Operation

F2250 front panel controls are engineered for basic, steady-state control of voltage and current phasor quantities. The source control of the F2010 Minicontroller expands the functions of the F2250 to provide dynamic test functions of instantaneous switching and variable-rate changes between two values of voltage, current, phase angle, and frequency for one source. When controlling any F2250 via the D-232 Interface, the minicontroller is easy to use because the F2250 displays indicate phasor quantities of amplitude, phase angle, frequency, ON/OFF status, and Δvalue/Δtime accurately for the parameter whose rate is being controlled.

Minicontroller functions include:

- Continuously variable control of:
  - Voltage or current amplitude from 0 to full scale
  - Frequency from 0.1 to 10 kHz
  - Phase angle, from 0° to +359.9°; 0° to −359.9°
- Setting two test values of amplitude/phase angle/frequency
- Instantaneous switching between two test values
- Location of a value between two test values at variable Δvalue/Δtime rates
- Timing relay operation in response to:
  - Instantaneous changes between two test values
  - Variable rate ramps
- Manual control of any parameter for visual observation of relay operation

Minicontroller functions are used for various test operations including:

- Dynamic tests of any relay measuring function
- Automated: trip frequency, reach, M.T.A., pickup/dropout tests; all without manual adjustments
- Timing relay response
- Generating slip frequencies for automatic synchronizer generator/bus simulation

The F2010 can control the amplitude and phase angle of either **SOURCE 1** or **SOURCE 2** of one F2250. Parameters are voltage, current, phase angle, frequency, and ON/OFF status. The frequency of both sources can also be controlled simultaneously for off-frequency testing. When a group of F2250 family instruments are networked via IEEE-488 and SYNC cables, the frequency of all instruments can be controlled simultaneously.

Two test values can be set for any parameter: under/over frequency, voltage, current; two phase angles can be set for determining M.T.A.

The rate-of-change between the two test values can be controlled if two F2250s in use are equipped with the ΔVALUE/ΔTIME option - F2820. The automatic tests, determining the relay operating point for any parameter can be run, such as pickup/dropout, trip frequency, and reach.

Simultaneous control of one parameter for up to three sources is provided by the Multiple Source option - F2825. You can simulate three-phase faults by varying three voltages, three currents, or rotating the phase angles of three sources - all simultaneously. To determine if your F2250s are equipped with these options, press the **SLAVE** button; the F2250 displays the name of all installed options.

Sensing relay operation and timing responses to these test conditions is easy because the F2250 digital timer is remotely activated by the minicontroller.

## Getting Started

The minicontroller operates with all F2250 instruments. See "Multi-Unit Systems" on page 3-2 for instructions on the proper connection procedures and power-up sequences for networked systems.

To setup the minicontroller:

1. Connect the F2010 cable to the D-232 interface connector on the instrument and tighten the jack screws (Figure 4.17).

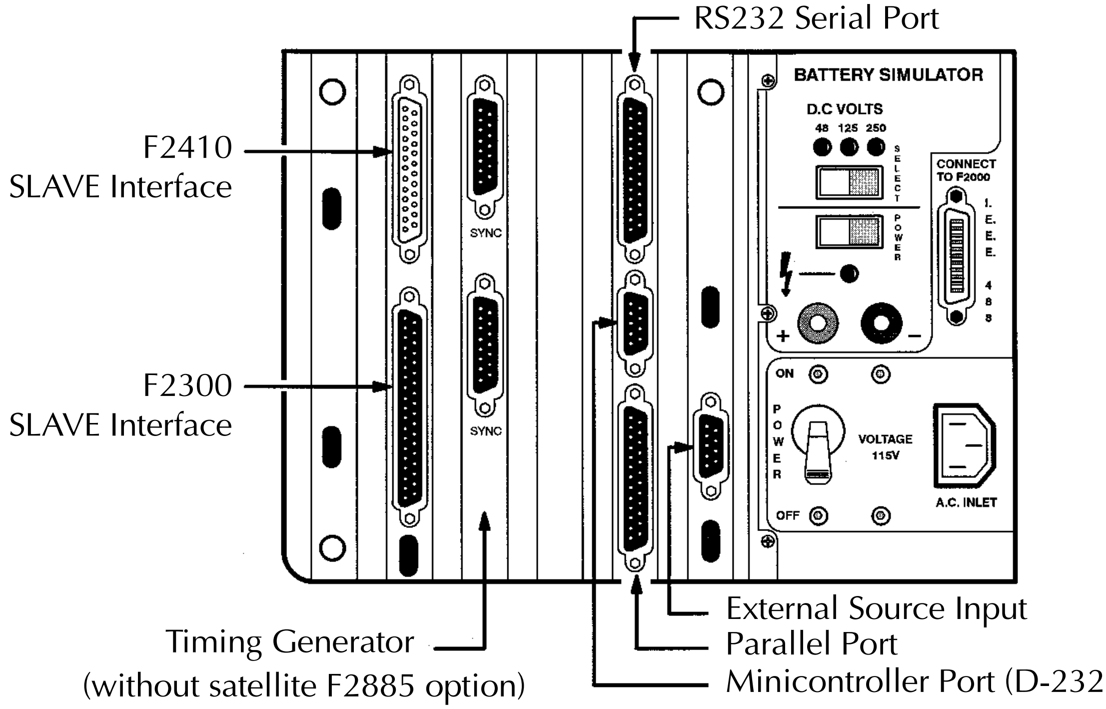



***Figure 4.17 D-232 Interface***

2. Determine the available F2250 options by pressing the **SLAVE** switch on the F2250 control panel.

   $\Delta V$ - Indicates that the VALUE C function - F2820 is available.

   *MS* - Indicates that the multiple source function F2825 is available.

   For all other front panel LED indications refer to Table 2.18 on page 2-22.
3. Press **POWER ON** .

   Wait until the LEDs stop flashing and the **REMOTE** indicator on the F2250 illuminates. Both sources are set at 0 degrees - 0 amplitude, and the base frequency is 50 or 60 Hz. **FREQUENCY** is set to **XTAL**.
4. Examine the operation of all controls.
5. Follow the steps shown in Figure 4.18 on page 4-41 to become familiar with unit operation.

## Minicontroller Functions

This discussion introduces basic F2010 Minicontroller functions and their applications to testing, and also the F2820 ΔVALUE/ΔTIME option. Although the minicontroller is capable of controlling all parameters of a source, one at a time, only single parameter operation for one source is described.

Multiple source control of frequency is included in the basic minicontroller, requiring no additional option. The frequency of all F2250s interconnected via the IEEE-488 network and SYNCH bus can be controlled over the full range of 0.1 to 9,999.9 Hz.

The wide range of steady-state tests performed on protective relays are all based on two straightforward test methods: PRESET and ACTION.

PRESET tests are used to measure the operation time of relays in response to voltages or currents which are accurately PRESET to a value, then turned on. Simultaneously, starting the internal digital timer at the precise zero crossing when the sources turn on provides accurate, repeatable test results. Reversing the process, and timing when the sources turn off is a similar PRESET test.

ACTION tests determine the relay's operating point or setting by varying a phasor quantity. Amplitude, phase angle, or frequency are varied until the relay operates. A more complex form of this test for polyphase relays involves both PRESET and ACTION signals. Polarizing signals is a good example of PRESETs which must be applied prior to varying the action source amplitude, phase angle, or frequency.

Dynamic testing requires two additional levels of control:

- Parameter rate-of-change
- Dual-test values

The F2010 extends control of F2250 instrument sources for dynamic testing by storing two values of a voltage, current, phase angle, or frequency and changing between these values instantaneously, or at variable ΔVALUE/ΔTIME rate-of-change. By integrating timer/sense functions with F2010 controls, dynamic tests can easily be performed.

The rate-of-change (ΔVALUE/ΔTIME) function allows relay tests to more closely simulate actual operating conditions. Measuring the operation time of an overvoltage relay in response to a voltage phasor PRESET to 120 V, then switching instantaneously to 140 V is a representative dynamic timing test. Determining the setting of a frequency relay by first ramping frequency until the relay operates, then timing the operation in response to the variable ΔFrequency/ΔTiming stimulus is an example of a dynamic ACTION test sequence.

## Basic Functions

Basic operation of the F2010 is shown in Figure 4.18 on page 4-41.

Operation involves:

1. Selecting a source

   Either source of an F2250 can be selected for remote control of amplitude or phase angle, or the frequency of both sources can be controlled.

2. Selecting the parameter

   Only one parameter can be controlled at a time, but all parameters of the selected source can be controlled individually.

3. Identifying the value

   Two values can be stored for each parameter - VALUE A and VALUE B. Adjusting the knob sets a value when VALUE A is indicated, then duplicates the process when VALUE B is indicated. Pressing the **SET VALUE A**/**SET VALUE B** buttons controls the value in use.

4. Adjusting a value

   The knob is used to adjust the value of voltage/current/phase angle/frequency. The **SOURCE** display on the F2250 always indicates the value for whichever parameter is selected; the display remains at zero if no amplitude/phase selection is made, and at the 50/60 Hz base frequency if a frequency is not selected.

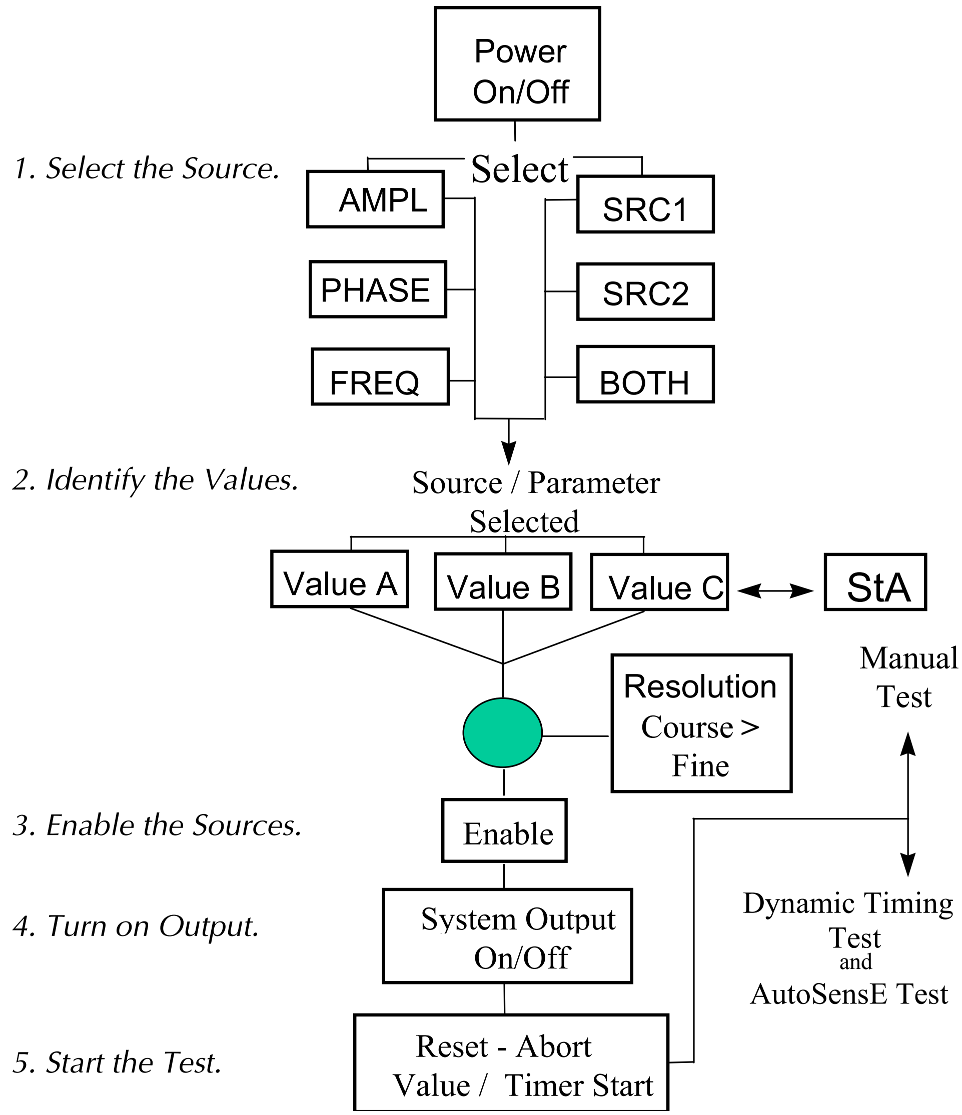



***Figure 4.18 Minicontroller Basic Functions***

# Mode Tests

Turn on the source by using the **SYSTEM OUTPUT** button, which duplicates the front panel control. Remember, **ENABLE** the sources first, just as you would in normal operation.

### Manual Test

To perform this test:

- Continuously vary a parameter.

### Value Timing Test

To perform this test:

1. Set the F2250 **TIMER** to the **STOP** mode.
2. Set the initial parameter for VALUE A.
3. Set the final parameter for VALUE B.
4. Press the **ABC** switch to the A position.
5. Press **SYSTEM OUTPUT** to turn the output on.

   ΔVALUE starts the test and the **TIMER** displays operation time.

### AutoSensE Test

To perform this test:

1. Set the F2250 **TIMER** to **SENSE** mode.
2. Set the initial parameter for VALUE A.
3. Set the final parameter for VALUE B.
4. Set the ΔVALUE/ΔTIME value.
5. Press the **ABC** switch to the A position.
6. Press **SYSTEM OUTPUT**.
7. Press **ΔVALUE** to start the test.
   - **SENSE** stops the test.
   - **DISPLAY** freezes the test at operation value.

### Frequency Timing Test

To perform this test:

1. Set the F2250 **TIMER** to **STOP** mode.
2. Set the initial frequency for VALUE A.
3. Set the final frequency for VALUE B.
4. Set ΔFREQUENCY/ΔTIME for VALUE C.
5. Set the **TIMER START** frequency by pressing the **HERTZ** switch on the F2250 front panel.

   The frequency display of the F2250 changes to: *XX XXX STA*. The minicontroller's A and B indicators flash.
6. Set the start timer frequency with the KNOB on the minicontroller.

   The timer start frequency must be between the initial value and the final value.
7. Set the **ABC** switch to the A position.
8. Press **SYSTEM OUTPUT** to turn sources on.
9. Press **ΔVALUE** to start test.
   - **SENSE** stops the test
   - **DISPLAY** freezes the test at operation value

## PRESET/ACTION Test Modes

Conforming to the PRESET/ACTION test methods, three test modes are available; Manual Operation, Instantaneous timing, and the F2820 ΔVALUE/ΔTIME. Refer to Figure 4.19 for this section.

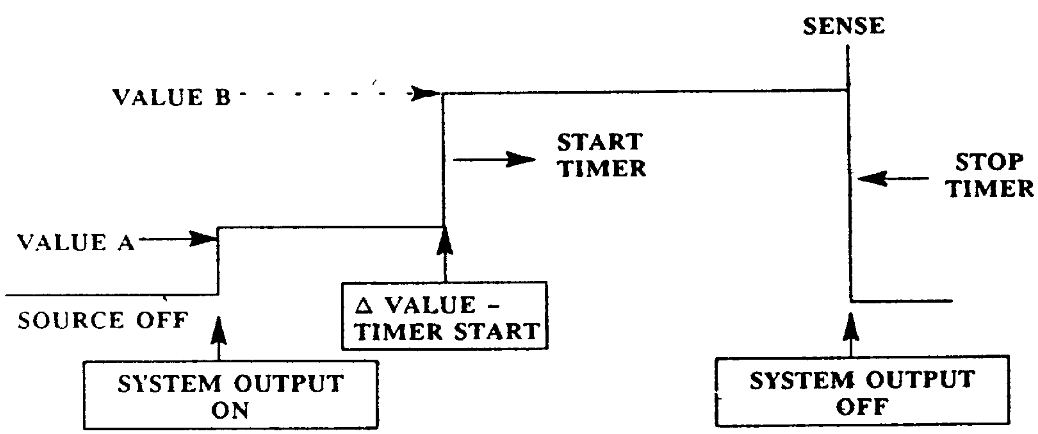



*Figure 4.19 ΔVALUE*

## Manual

To perform this test:

1. Preset or vary any parameter using the KNOB.

   Manual remote control is very useful when the relay is located in a panel, somewhat remote from the test instrument. The 4 meter/12 foot interconnecting cable provides freedom of motion for direct observations.
2. Control the **SOURCE** manually with the F2010.
3. Observe the relay mechanism.

## Instantaneous Timing

To perform this test:

1. Select a source and parameter.
2. **ENABLE** the source.
3. Identify and set VALUE A - the initial value.
4. Identify and set VALUE B - the final value.
5. Set VALUE C = 0 (This means a single step from A to B.)
6. Set the F2250 **TIMER** to **TRIP** mode.
7. Set the **STOP** condition (dry contact - voltage, open to close, etc.)
8. Press **SYSTEM OUTPUT** to turn on the voltage/current at the selected value (A or B).
9. Press **ΔVALUE** to change VALUE A to B/B to A at a zero crossing, simultaneously starting the **TIMER**.
   - The **TIMER** measures operation time beginning at the initial value to the final value zero crossing transition.
   - When **SENSE** occurs, the timer stops, and automatically turns the **SYSTEM OUTPUT** off.
10. Press the ΔVALUE button to reset the F2250 timer.

**NOTE**

**If the TIMER MODE is incorrectly set or if the TIMER condition (Contact: open-to-close/close-to-open; Voltage: OFF-to-ON/ON-to-OFF) is incorrect, the test sequence may progress, but test results will be indeterminate.**

It makes no difference whether the value for A or B is higher. For simplicity, amplitude has been used in these examples. But relay operation time measurements in response to changes in phase angle are equally easy to run using the ΔVALUE method. Phase angle ramps are described in "Advanced Operation" on page 4-54. Operation time vs. frequency measurements also use the ΔVALUE method.

## ΔVALUE/ΔTIME F2820

Automatically varying a parameter with respect to time is a useful ACTION test method. It provides highly repeatable pickup/dropout/reach/M.T.A. results because the rate-of-change in voltage, current, phase angle or frequency is controlled precisely. Under manual control, the rate-of-change may vary, and therefore, results may be incorrect due to the relay measuring circuit response. An AutoSensE test is performed by operating the F2250 TIMER in the *SENSE* mode while using a ΔVALUE/ΔTIME source.

AutoSensE tests automatically determine the relay operating point by stopping the constant-rate ramp when the relay operates, and freezing the display at the operate value. Set point errors due to manual variations are eliminated. Variable ramp-rate timing tests are particularly useful because they more closely simulate actual power system conditions for certain types of faults. Frequency relay operation can be evaluated using decay rates determined by load shedding studies; then, trip settings can be evaluated in light of relay response to actual operating conditions.

The F2250 may be equipped with the F2820 ΔVALUE\ΔTIME option (Figure 4.20). This internal microcomputer program controls source operation in response to commands produced by the F2010 Minicontroller specifying VALUE C, the rate-of-change of any parameter between two limits, specified by VALUE A and VALUE B.

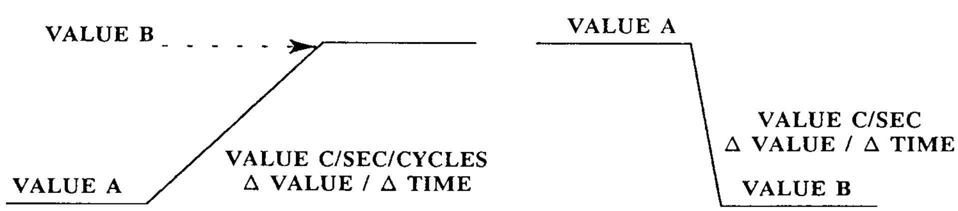



***Figure 4.20 ΔVALUE/ΔTIME***

## Source Resolution

Precise measurements of relay operation require high resolution in test parameters. Stable, Active Sources voltage and currents with a resolution of 0.1% of full scale, minimum, provide meaningful test results. Clearly, a more precise definition of voltage relay pickup is attained with a source resolution of 0.01 V rather than 1 V.

All F2250s change voltage, current, and phase angle incrementally at the least-significant digit (L.S.D.) resolution for any amplitude range. Phase angles always change in 0.1° increments, from 0° to 360°, lead or lag.

F2250 source frequency is established by a single crystal-based time reference. Frequency changes occur asynchronously. The incremental change is 0.005 Hz or 0.1 Hz depending upon the ΔFrequency/ΔTime ramp rate.

Equally important is that amplitude and phase angle changes occur on a cycle-by-cycle basis. The resultant smooth, consistent linear ramp ensures repeatable results for all ACTION tests determining pickup/dropout/reach/M.T.A., etc. "Advanced Operation" on page 4-54 discusses examples of a three-phase fault simulation where three voltage sources decay simultaneously at precisely the same increment on a cycle-by-cycle basis. This simulation of the power system ensures the three relay measuring elements are exposed to a stimulus which closely approximates actual conditions; relay operation is determined precisely. The three relay voltage measuring elements are exposed to the same stimulus.

A ramp function is defined by a beginning value, a limit value, and a slope defined as ΔVALUE/ΔTIME.

The incremental change in parameter value is always one. The incremental change in time is expressed in cycles for amplitude and phase, and in seconds for frequency.

VALUE A and VALUE B define the ramp end points. VALUE C defines the slope.

## Value Test Limits

VALUE A and VALUE B define the limits of all ΔVALUE/ΔTIME ramps. These limits must fall within the range for the particular parameter, such as:

- Amplitude: 0% to 100% of full scale
- Phase Angle: 0° to +359.9° (leading), 0° to −359.9° (lagging)

Since these parameters change on a cycle-to-cycle basis, VALUE C is expressed as:

$$\frac{\Delta\text{VALUE}}{\Delta\text{TIME}} = \frac{\text{1 Least Significant Digit}}{\text{N Cycles}}$$

Frequency ΔVALUE/ΔTIME ramps are expressed in terms of Hz/second. VALUE C is defined as:

$$\text{VALUE C} = \Delta\text{VALUE} / \Delta\text{TIME} = \frac{\text{Hz}}{\text{Second}}$$

The least-significant digit incremental changes in frequency are based on two ramp rates.

Table 4.4 and Table 4.5 explain ΔFREQUENCY/ΔTIME and rates per step size at the base frequencies.

***Table 4.4 ΔFREQUENCY/ΔTIME Ramps***

| ΔFREQUENCY/ΔTIME | L.S.D. |
|---|---|
| From 0.1 Hz/second to 1.999 Hz/second | 0.001 Hz/second |
| From 2.000 Hz/second to 19.99 Hz/second | 0.01 Hz/second |
| From 20.0 Hz/second to 9,999.9 | 0.1Hz/second |

***Table 4.5 Rates per Step Size***

| Rates | Step Size |
|---|---|
| 0.001 Hz/second | 0.0015 |
| 0.002 - 1.999 Hz/second | 0.001 |
| 2.000 - 19.999 Hz/second | 0.010 |
| 20.000 - 99.999 Hz/second | 0.100 |

At other harmonics multiply the range and rate by the harmonic.

One typical application for ΔFREQUENCY/ΔTIME ramps is determining under-frequency relay pickup. The ΔFREQUENCY/ΔTIME ramp is defined by these values:

Upper Limit = VALUE A = 60.00 Hz (line frequency)

Lower Limit = VALUE B = 59.00 Hz (lowest expected trip frequency)

ΔFREQUENCY/ΔTIME = VALUE C = 0.1 Hz/second

This 0.1 Hz/second rate-of-change is executed by 100 x 0.001 Hz incremental changes of frequency every second. Total ramp time is 10 seconds, based on a 1 Hz excursion at 0.1 Hz/second. Using these test conditions, AutoSensE automatically establishes a frequency relay setting in response to an actual power system frequency decay.

Table 4.6 and Table 4.7 show the range of ΔVALUE/ΔTIME ramps based on parameter resolution.

***Table 4.6 Parameter Rate-of-Change per second at 60 Hz***

| No. Cycles | Amplitude & Phase Angle (L.S.D.) | | Resolution |
|---|---|---|---|
| | 0.001 | 0.01 | 0.1 |
| 1 | 0.06/second | 0.6/second | 6/second |
| 2 | 0.03/second | 0.3/second | 3/second |
| 3 | 0.02/second | 0.2/second | 2/second |
| 4 | 0.015/second | 0.15/second | 1.5/second |
| 5 | 0.012/second | 0.12/second | 1.2/second |
| 6 | 0.01/second | 0.1/second | 1.0/second |
| 7 | 0.008/second | 0.085/second | 0.857/second |
| 8 | 0.007/second | 0.075/second | 0.75/second |
| 9 | 0.0066/second | 0.066/second | 0.66/second |
| 10 | 0.006/second | 0.06/second | 0.6/second |
| 20 | 0.003/second | 0.03/second | 0.3/second |
| 30 | 0.002/second | 0.02/second | 0.2/second |
| 40 | 0.0015/second | 0.015/second | 0.15/second |
| 50 | 0.00125/second | 0.0125/second | 0.125/second |
| 60 | 0.001/second | 0.01/second | 0.01/second |
| 70 | 0.0008/second | 0.008/second | 0.085/second |
| 80 | 0.0007/second | 0.0075/second | 0.075/second |
| 90 | 0.00066/second | 0.0066/second | 0.066/second |
| 99 | 0.0006/second | 0.006/second | 0.06/second |

*Table 4.7 Parameter Rate-of-Change per second at 50 Hz*

| No. Cycles | Amplitude & Phase Angle (L.S.D.) | | Resolution |
|---|---|---|---|
| | **0.001** | **0.01** | **0.1** |
| 1 | 0.05/second | 0.5/second | 5/second |
| 2 | 0.025/second | 0.25/second | 2.5/second |
| 3 | 0.016/second | 0.166/second | 1.66/second |
| 4 | 0.012/second | 0.125/second | 1.25/second |
| 5 | 0.01/second | 0.1/second | 1.0/second |
| 6 | 0.008/second | 0.083/second | 0.83/second |
| 7 | 0.007/second | 0.071/second | 0.71/second |
| 8 | 0.006/second | 0.062/second | 0.62/second |
| 9 | 0.0055/second | 0.055/second | 0.55/second |
| 10 | 0.005/second | 0.05/second | 0.5/second |
| 20 | 0.0025/second | 0.025/second | 0.25/second |
| 30 | 0.0016/second | 0.016/second | 0.166/second |
| 40 | 0.0012/second | 0.012/second | 0.125/second |
| 50 | 0.001/second | 0.01/second | 0.1/second |
| 60 | 0.0008/second | 0.008/second | 0.083/second |
| 70 | 0.0007/second | 0.007/second | 0.071/second |
| 80 | 0.0006/second | 0.006/second | 0.06/second |
| 99 | 0.0005/second | 0.0055/second | 0.05/second |

VALUE C is a two-digit number ranging from 01 to 99 cycles; it is displayed in the window of the respective parameter as *N CYCLES*, since the L.S.D. is fixed, and determined by the source range.

Where N ranges from 1 to 99, VALUE C for phase angle is defined below:

$$\text{VALUE C} = \frac{\Delta\ \text{VALUE}}{\Delta\ \text{TIME}} = \frac{\text{1 Least Significant Digit}}{\text{N Cycles}} = \frac{0.1°}{\text{N Cycles}}$$

Changes in phase angle always occur at the system zero degree reference. The F2250 **PHASE ANGLE** window is used to display *PHASE ANGLE* and also to display *N CY* when VALUE C is being set.

For example:

A display of *60 CY* for VALUE C in the **PHASE ANGLE** window, means a value of 0.1° (the L.S.D.) every 60 cycles; a display of *1 CY* indicates a 0.1° (the L.S.D.) change every cycle.

*PHASE ANGLE* is always indicated on the F2250 display.

**NOTE**

**VALUE C can only be set when sources are off, i.e., not on and not enabled. SYSTEM OUTPUT must also be off. When multiple instruments are used, VALUE C is displayed only on the source to which the minicontroller is connected. The other F2250's VALUE C windows continue to display VALUE A, or VALUE B, whichever was the last selected.**

Initial tests should use 60 CYCLES or 50 CYCLES for VALUE C, since it is easy to relate the L.S.D. per-second rate to that achieved when varying parameters manually. For example, 0.1 V/60 cycles is 0.1 V-per-second, a rate typical of manual testing. The rate-of-change should always be well within the measuring capability of the relay. Rates of change exceeding the relay response time result in erroneous test results.

## AutoSensE Tests

This test mode is used to automatically determine the actual setting of a relay in response to a linear incremental ramp of voltage, current, phase angle, or frequency.

The test concept is shown generically in Figure 4.21, demonstrating its simplicity for determining both pickup and dropout settings.

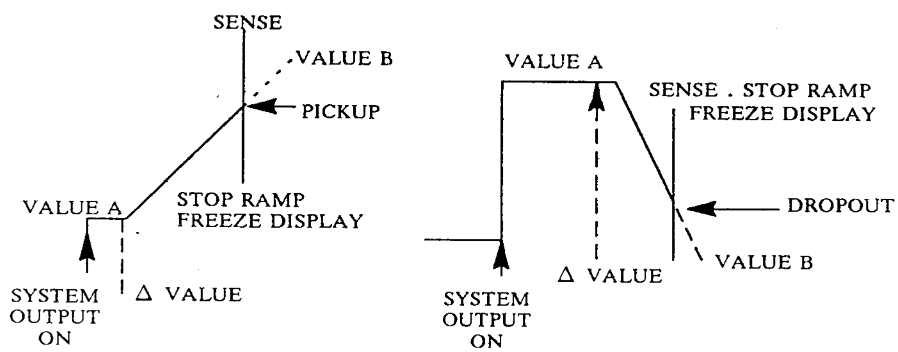



***Figure 4.21 AutoSensE (PU/DO)***

To perform this test:

1. Set the **STOP** condition, with the **TIMER** set to *SENSE* mode.

   The ramp stops when **SENSE** occurs, at which time the display freezes. The **SOURCE** output remains at the pickup/dropout value; *SENSE* is displayed in the **TIMER** window, indicating the test is complete.
2. Turn the **SYSTEM OUTPUT** on and VALUE A occurs.
3. Press **ΔVALUE** to start the ramp.
4. Press **ΔVALUE** again and **SENSE** resets; the output is set to VALUE A, ready to repeat the test.

**NOTE**

**If the TIMER MODE is incorrectly set or if the TIMER condition (Contact: open-to-close/close-to-open; Voltage: OFF-to-ON/ON-to-OFF) is incorrect, the test sequence may progress, but test results will be indeterminate.**

## Frequency Timing Test

Starting a time measurement at any frequency between ramp limits is an important minicontroller function. Frequency relay response can be measured beginning at any frequency on a ΔFrequency/ΔTime ramp.

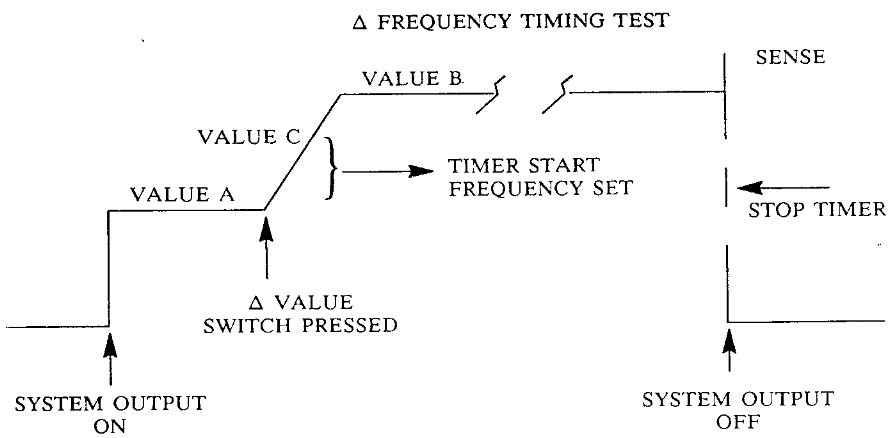



***Figure 4.22  ΔFrequency Timing Test***

Figure 4.22 shows that the **TIMER** can be set to start anywhere along the frequency ramp from VALUE A to VALUE B. VALUE A and VALUE B define the frequency ramp end points; VALUE C defines the *Frequency/Time* slope. If no specific selection of ΔFrequency **TIMER START** frequency is made, then the timer starts at VALUE B. Using the **FREQUENCY** timing mode, the **TIMER START** frequency is selected as follows:

1. Set VALUE A and B as the limits of the frequency ramp.
2. Select VALUE C as the Frequency/Time slope in Hz/Sec.
3. Press the **HERTZ** switch on the F2250 front panel, while in VALUE C.

   The A and B LEDs, above the **SET VALUE** switch, flash alternately. VALUE B is displayed in the **HERTZ** display as *XX.XXX StA*. StA denotes that this is the ΔFrequency **TIMER START** frequency.
4. Select the **TIMER START** frequency with the minicontroller knob.

5. Press the **SET ΔVALUE** button on the minicontroller to store the **TIMER START** frequency.
6. Press the **ΔVALUE** button to start the ramp.

   The timer starts when the frequency reaches the StA value.
   The timer stops when the appropriate sense condition is present.
7. Enter another timer start frequency by pressing the **TIMER START/RESET** button until the *A* LED is lit above the **SET ΔVALUE** switch.
8. Press the **SET ΔVALUE** button until the *C* LED is lit.
9. Repeat Step 3 to set the new **TIMER START** frequency.

## Advanced Operation

Advanced minicontroller functions and their test applications are described in this section.

### Source Frequency Control

F2250 intercommunications require both the IEEE-488 and a SYNC interface. Multiple instruments are interconnected via this communications network to ensure precise, time-related control of all related instrument operations. Settings of multiple phasor quantities, synchronized ΔVALUE changes in all parameters including ON/OFF, and timer functions are communicated via the IEEE-488 network. It makes no difference whether controlled by the front panel at harmonic intervals via ProTesT for automated testing or by minicontroller, when networked, each F2250s can operate at a different frequency. Flexibility in frequency control is necessary for advanced off-frequency relay analysis, common harmonic restraint tests, all frequency measuring relays, and automatic synchronizers requiring both fixed and variable rate slip frequencies.

Using the minicontroller, the frequency of **SOURCE 1**, **SOURCE 2**, or both, can be controlled. Operations this far have demonstrated functions associated with controlling a single source. When F2250s are networked via the IEEE-488 bus, the frequency of all instruments track **SOURCE 2**, similar to selecting BOTH sources within an F2250.

## System Frequency Control

The front panel controls the source frequency at harmonics up to the 20$^{th}$ and 100$^{th}$. Harmonics up to the 20$^{th}$ are selected using the **HERTZ** lever switch on the F2250 front panel. Both sources are independently controlled, with the base frequency of 50 or 60 Hz set internally.

This section describes variable frequency operation when either or both sources are set to the same frequency range. As higher harmonic ranges are selected, the source frequency span expands incrementally to include the full range of instrument operation, from 0.10° to 9999.9 Hz continuously. Since source frequencies are harmonically related, their frequency span under variable minicontroller operation expands as higher harmonics are selected. All minicontroller frequency-related functions are directly applicable regardless of the number of sources. If either or both sources were set to **RANGE 1**, the minicontroller frequency span is 0.10° through 99.999 Hz. If sources were set to **RANGE 3**, the minicontroller frequency span is 0.3 through 299.7 Hz.

This discussion demonstrates the relationship when one source is operating at the base frequency, **RANGE 1**, and the second source range is changed from **RANGE 1** through **RANGE 20** and **RANGE 100**.

A one increment change in the frequency of the first source represents a harmonically related increment for the second source. When one source is set to **RANGE 1** and a second source is set to **RANGE 3** (the third harmonic range), a single L.S.D. change on **SOURCE 1** results in a three L.S.D. change on **SOURCE 2**. This concept is fully applicable to all sources of networked instruments.

## Phase Angle

Phase angle control requires both lag and lead rotation; phase angle definition also requires specification of angles relative to other phasors.

Under KNOB control, the phase angle of a source can be set from an unsigned value of 000.0 degrees in either the lead (+) or lag (–) rotation in increments of 0.1 degree.

The first increment of KNOB adjustment in the lagging (–) clockwise direction signs the display and increments phase angle one L.S.D. to –0.1 degrees. Continuous rotation increments phase angle in 0.1° steps, lagging through –359.9°.

Rotation in the leading (+) counterclockwise direction duplicates the process, starting at unsigned 0.0°, then +0.1°, etc. Phase angles can be set at a ±rotation up to 359.9°; so leading, lagging, or a combination of both rotation conventions can be used to define phasor relationships.

## VALUE - Phase Angle Ramp

The VALUE C implementation for phase angle is similar to that used for amplitude and frequency.

An initial and final value must be stored in both VALUE A and VALUE B. The rate-of-change is stored as VALUE C. AutoSensE tests and Dynamic Timing tests can be run using the same three A, B, and C values. Only the timer mode differs. Instantaneous timing tests need only VALUEs A and B, and C must be set to zero.

The range of control for phase angle ramp is described in Table 4.8. Defining lagging (–) angles with lag (–) ΔPHASE/ΔTIME rotation or leading (+) angles with lead (+) ΔPHASE/ΔTIME rotation provides full 360° phasor rotation.

Defining lagging (–) angles (with the final value being larger than the initial value) using leading (+) rotation, or leading (+) angles (with the final value larger) using negative (–) rotation is also possible. The most useful range of rotation is 180°, as noted. Attempting to run tests using initial and final values (A/B) or rates (C) falling outside these rules results in the error alarm (buzzer) sounding. The values are stored so you can examine them, and correct invalid conditions.

***Table 4.8 Phase Angle Ramp Range***

| **360° Rotation** | |
|---|---|
| **A** | **B** |
| Initial Value (–) degrees | Initial Value (+) degrees |
| Final Value (–) degrees | Final Value (+) degrees |
| Rotation (–) degrees/second | Rotation (+) degrees/second |
| **180° Rotation** | |
| **C** | **D** |
| Final Value (–) degrees | Final Value (+) degrees |
| Initial Value (–) degrees larger number | Initial Value (+) degrees larger number |
| Rotation (+) degrees/second | Rotation (–) degrees/second |

AutoSensE Test

Figure 4.23 is a representative phasor diagram for an A-N fault. An AutoSensE test using the phase angle ramp function can be used to determine M.T.A., by combining two sections as shown in "Basic Functions" on page 4-40 for the pickup/dropout test.

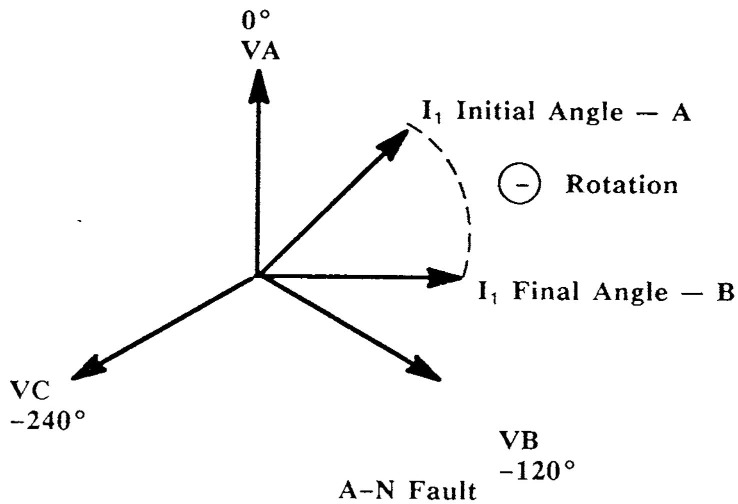



***Figure 4.23 M.T.A. AutoSensE Test***

$V_A$, $V_B$, $V_C$, amplitudes and phase relationships, together with I1 Amplitude, are PRESET using front panel controls to define the A-N fault.

To perform this test:

1. Set the Initial Angle for I1 (VALUE A) at −45°.
2. Set the Final Angle for I1 VALUE B) at −90°.
3. Set VALUE C at −1 degree/second.
4. Ensure that all sources are on (by pressing **SYSTEM OUTPUT** on) and press **ΔVALUE** to start the AutoSensE test sequence.

   As the phase angle of the current rotates, beginning at −45°, pickup occurs at the smaller of the two test result angles. When the rotation stops, the display freezes, and the **SOURCE** remains on.
5. Reverse the **SENSE** condition; start the second section of the test sequence by pressing **VALUE**.

   Rotation stops at the larger of the two test result angles. Their median value is the M.T.A.
6. Set the timer to *SENSE* mode; set **SENSE** condition.

## Multiple Sources - F2825

Simultaneous control of multiple sources is an optional function provided by the F2825. This internal microcomputer program must be installed in all instruments and is used in the multiple source mode. When the minicontroller is on, toggling the Subscript *M* in the F2250 SRC assignment field defines those voltage or current sources which are simultaneously controlled. For example, **SOURCE 1** of an F2250 can be set to either *IM*, or *VM*; **SOURCE 2** can be set for multiple source operation. The minicontroller defines the parameter, limit, and rate values for the F2250 system MASTER. In turn, it communicates control and timing messages to all other F2250s connected to the IEEE-488 network. Up to three voltage sources or three current sources can be simultaneously controlled, however, the sources must be of like type; voltages and currents cannot be mixed.

Precision control is critically important to ensure time-coincident source operation. Whichever parameter is selected, voltage, current, or phase angle, the incremental change in value must occur at precisely the identical instant in time for all sources. This ensures accurate simulation of the power system condition described by the multiple phasors, and correct relay stimulus. If sources do not change precisely in synchronism, relays may respond incorrectly.

Simulating a three-phase fault or power swing by simultaneously collapsing wye-connected voltages is an important test function, which is not otherwise possible. Alternately, the respective phase currents could increase from the balanced value toward the faulted value. Simulation can also include rotating the phase relationship between the three voltage phasors and the three current phasors. By varying the rate-of-change of the three-phase voltage-to-current angular relationship, or the voltage/current amplitude ramps, relay performance can be accurately characterized as follows:

Tripping should occur for fast changing parameters indicating a fault, or inhibited for slower changes representing a power swing. Sensitivity to power swings can be determined by successive tests at varying ΔValue rates.

All previously defined minicontroller functions are usable when controlling multiple sources. However, phase angle relationships must all be defined with the same rotation, i.e., all lagging or all leading. This concept is important for ramping multiple phase relationships. To provide for all forms of three-phase and phase-to-phase faults, source phase angles may be PRESET to any value using the front panel controls. Then, VALUE A and VALUE B define the upper and lower boundaries between which the phase ramp operates for all *M* Sources. In this manner, the $V_A$-$V_B$-$V_C$ relationships and the I1-I2-I3 relationships are maintained, while the V relationships of all sources change as defined by VALUES A, B, and C.

This concept is demonstrated in Figure 4.24.

## Three-Phase Fault Simulation/AutoSensE Reach Test

Figure 4.24 is a representative phasor diagram describing a three-phase system in which the voltages are collapsed to simulate a three-phase fault. The currents and their phase relationships to the voltages are PRESET, and remain constant.

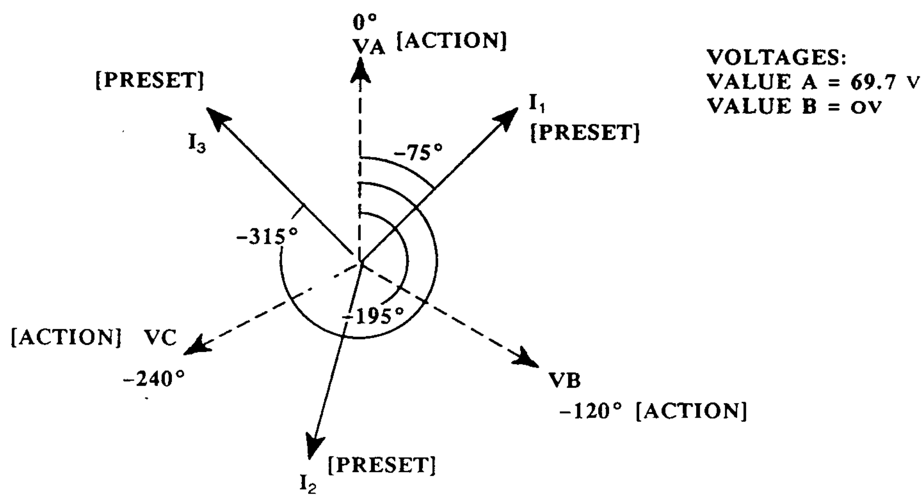



***Figure 4.24 Three-Phase Fault Simulation - Reach Test***

The minicontroller connects to the MASTER F2250, which communicates with all *M* sources providing simultaneous control. SLAVE sources display the value set on the MASTER in their amplitude windows. By assigning the VM designation to three voltage sources, the MASTER sets all three to the same values.

To perform this test:

1. Set an initial amplitude of 69.7 V (VALUE A) and a final amplitude of zero V (VALUE B), using the minicontroller.
2. Individually PRESET the three current source amplitudes to 5A.
3. Preset the current-to-voltage phase angle relationships to 75° lagging using the front panel controls. VALUE C is displayed while being set in the **AMPLITUDE** window of the F2250 to which the minicontroller is connected. Set VALUE C for the three voltages to 1 cycle. This represents a ramp rate of 0.01 V-per-cycle. At 60 Hz, the rate is 0.6 V/second; the 50 Hz rate is 0.5 V/second. Sources can be turned on only when an absolute value (A or B), not rate (C), is displayed.
4. Select **VALUE A** before turning on the sources.
5. **ENABLE** all sources and turn **SYSTEM OUTPUT** on. The PRESET conditions defined by the phasor diagram are applied.
6. Press Δ**VALUE** and the ACTION ramp begins at 69.7 V.

   The sources decrement at the rate of sixty (or fifty), 0.01 V increments per second to attain the specified VALUE C rate. If the source zero crossing is specified, the three sources change amplitude at their respective zero crossings in order of phase angle. If system zero crossing is selected, all sources change amplitude at the system zero degree reference, regardless of their individual phase angle settings. Refer to the *F2000 Operating Manual* for additional information on how sources change value.

   When **SENSE** occurs, the ramp stops and freezes the display at the three-phase reach value; as in previous tests the sources remain on. This test can be repeated in reverse order by starting with VALUE B. By ramping in both directions to examine relay reach settings, the accuracy guard-band of electromagnetic distance relays is accurately established.

## Power Swing Test

For this application (Figure 4.25), either the voltage or current sources can be designated *M*, since the phase angle relationship between all three voltages and all three currents is the ACTION value.

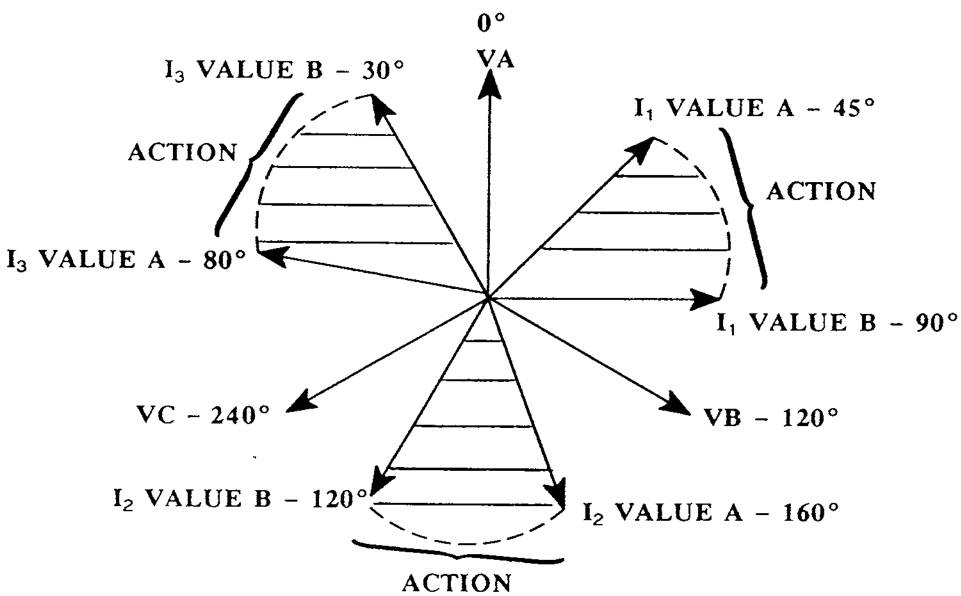



***Figure 4.25  Power Swing - AutoSensE Test***

If current sources are designated *IM:*

1. PRESET the current phasor amplitudes.
2. PRESET the voltage phasor amplitudes.

**3.** PRESET voltage phasor angles using the front panel controls.

Conversely, designating the voltage sources *M*, allows the same basic setup as previously described. The total range over which the (Phase-to-Neutral) current changes phase angle must be established next. For this example:

- VALUE A, the initial current phase angle relationship (to the voltage) is set at –45°
- VALUE B, the final phase angle is set at –90° (current lags voltage)
- ΔPHASE ANGLE/ΔTIME (VALUE C) is set to produce the desired rate-of-change in phase angle with time (see Table 4.6 on page 4-49)

**4.** **ENABLE** the voltage and current sources, and set **SYSTEM OUTPUT** on.

- The three polarizing voltages are applied by pressing the **SYSTEM OUTPUT** button, together with three currents, each lagging its respective voltage phasor by –45°.
- ΔVALUE begins the test sequence.
- The three current phasors rotate simultaneously at the ΔPHASE/ΔTIME ramp rate.
- When either the VALUE B limit is reached or **SENSE** occurs, the phase ramp stops.

  By varying the rate-of-change in the three-phase relationship over a number of tests, the ability of the relays to discriminate between faults and power swings is established.

# 5. Error Messages

The F2250 software system, in addition to controlling all communications that direct unit operations, checks operations for any errors. If an error is discovered, the F2250 software system halts the operation in process and displays an error message that identifies the problem.

This chapter gives an overview of the different types of F2250 error messages (Table 5.1) and lists the most common error messages encountered in the field by type (Table 5.2 through Table 5.6). Refer to "Troubleshooting" on page 6-1 for information regarding corrective actions.

***Table 5.1 General Error Categories***

| General Error Category | Error Cause |
|---|---|
| 1XXX | VRTX (Transmit/Receive) |
| 2XXX | Timer |
| 3XXX | RAM memory |
| 4XXX | RS-232 communications |
| 5XXX | Unexpected CPU interrupts |
| 6XXX | Network and IEEE-488 |
| 7XXX | SYNC or GPS |
| 8XXX | MASTER/SLAVE networking |
| 9XXX | Amplifier |
| AXXX | Message formatting |
| BXXX | Software |
| CXXX | Software |
| DXXX | RS-232 |
| EXXX | Software |

## Network Error Messages

A network error occurs if a problem is detected on the IEEE-488 Bus or SYNC cable. The unit that first detects the problem stops and displays an error code in its **TIME** display, and halts all the other units, which then show *nEt* in their **TIME** displays.

To recover from a network error, press any control on the front panel of each unit. All units go to the power on state (*Pon* shows in their **TIME** display). Once all units are ready, they become active again. Common Network Error Messages are given in Table 5.2.

***Table 5.2 Network Error Messages***

| Error Code | Error Type | Cause |
|---|---|---|
| 8001 | MASTER already present | SYNC cable is attached without the IEEE-488 bus cable, or MASTER/SLAVE transfer has taken too long. |
| 8002 | No MASTER for SLAVE | SYNC cable is disconnected from an operating unit or IEEE-488 bus was attached without a SYNC cable when powered up. |
| 8003 | Invalid Network | MASTER unit was not powered up first in a multiple unit network, and network addressing is incorrect. |
| nEt | Network error | Appears on all other networked units when any unit detects an error or is turned off. |

## Internal Error Messages

Internal errors occur due to hardware or software malfunctions and result in halting the unit and displaying an error code in the **TIME** display of each unit. To recover, press any control on the front panel for each unit. At this point, all units go to the Power On state (*Pon* shows in their **TIME** displays). Once they are all ready, they become active again.

**NOTE**

**Internal errors usually require that the unit be serviced. When reporting problems to Doble, please record all values shown in the error display.**

Common Internal Error Messages are given in Table 5.3.

***Table 5.3 Internal Error Messages***

| Error Code | Error Type | Cause |
|---|---|---|
| 0001 | Watchdog Reset | Software is in an infinite loop, or attempted an operation that takes too much time. |
| 9000 | Amplifier ID Error | No amplifier was detected during initialization (Not an F2250 error code). |
| 9001 | Amplifier error | Power was lost on the TWG board. |
| BUS | Bus Timeout | Missing board or software error was detected. |

## Source Error Messages

Source errors can occur during normal operations for a variety of reasons. When they do, the beeper sounds for five seconds, a two-character error code flashes in the **SOURCE** display. The source can automatically turn off, depending on the type of error. Some of the more common Source Errors are given in Table 5.4. Resolutions for these problems are discussed in "Troubleshooting" on page 6-1; specific pages are cited for each type.

***Table 5.4  SOURCE Error Messages***

| Error Code | Error Type | Cause/Resolution |
|---|---|---|
| 5V | V5 Error | Internal amplifier 5V supply failure.<br>See "Internal Amplifier 5 V Error" on page 6-40. |
| ER | Output Error | Source cannot drive the load at the specified amplitude.<br>Beeps for five seconds and error message flashes for as long as source stays on.<br>See "ER (Output Error)" on page 6-36. |
| OT | Over temperature | The semiconductor heatsink temperature is exceeding 85° C.<br>See "OT (Over-Temperature)" on page 6-39. |
| PS | Power Supply Error | The power supply is exceeding 350 VDC. Maximum allowable is 400 VDC.<br>See "PS (Power Supply)" on page 6-39. |
| TR | TRIP | F2300 Amplifier was tripped.<br>See "TR (Trip)" on page 6-39. |
| TM | Thermal Management | Flashes for up to one minute after the source goes off when output $\leq$ 100 amperes.<br>See "TM (Thermal Management)" on page 6-38. |

Table 5.5 lists the instruction related error codes that occur when running the F22550 with ProTesT. These errors are resolved by resetting the unit.

***Table 5.5 ProTesT Interaction Error Messages***

| Error Code | Error Type | Cause |
|---|---|---|
| 6000 | Error interfacing w/ProTesT | Timeout of request to talk timer. |
| 6001 | Error interfacing w/ProTesT | 488 error was detected. |
| 6002 | Error interfacing w/ProTesT | Timeout of talk timer. |
| 6003 | Error interfacing w/ProTesT | Timeout of listen timer. |
| 6004 | Error interfacing w/ProTesT | F2250 is not ready to talk over 488 network. |
| 6005 | Error interfacing w/ProTesT | Too many devices are on the 488 network. |
| 6006 | Error interfacing w/ProTesT | Error changing the network address, |
| 6007 | Error interfacing w/ProTesT | Bad network address. |
| 7000 | Error interfacing w/ProTesT | 488 SYNC bus error (displayed as *net* by the F2000). |
| 7002 | Error interfacing w/ProTesT | Clkgen gate array was not ready for configuration. |
| 7004 | Error interfacing w/ProTesT | IRIG gate array was not ready for configuration. |
| 7005 | Error interfacing w/ProTesT | GPS time sequence error. |
| 700B | Error interfacing w/ProTesT | No stg board detected. |
| 8001 | Error interfacing w/ProTesT | More than one MASTER. |
| 8002 | Error interfacing w/ProTesT | MASTER is missing. |
| 8003 | Error interfacing w/ProTesT | Incomplete network configuration table. |
| 8004 | Error interfacing w/ProTesT | Inhibit reference error.<br>(F2250 is not the SYNC bus MASTER). |
| 8005 | Error interfacing w/ProTesT | Phase lock loop failure. |
| 8010 | Error interfacing w/ProTesT | Satellite interface II IRIG error. |
| 8040 | Error interfacing w/ProTesT | Satellite interface II 1pps too high error. |
| 8080 | Error interfacing w/ProTesT | Satellite interface II 1pps error. |

## Miscellaneous Error Message List

Table 5.6 lists some miscellaneous error messages. Resolutions for these error messages are given with the causes.

***Table 5.6 Miscellaneous Error Message List***

| Error Code | Error Type | Cause | Corrective Action |
|---|---|---|---|
| 4040 | RS-232 | Framing error. | Reset the unit |
| 500A | Unexpected interrupt | Satellite interrupt error (no ramps or delays active). | Reset the unit |
| 500B | Unexpected interrupt | No satellite board was detected. | Check the board and its connections |

# 6. Troubleshooting

This chapter contains troubleshooting information for the F2250. It is designed to help the user resolve a multitude of troubleshooting situations. If the solutions discussed in this chapter do not resolve the problem, contact Doble Customer Service:

Customer Service Manager (Extension 321)
Doble Engineering Company
85 Walnut Street
Watertown, MA 02472 (USA)

Telephone: 617-926-4900
Fax: 617-926-0528
Email: customerservice@doble.com

NOTE

**Throughout this manual GND is used as an abbreviation for the ground connection.**

The troubleshooting developed in this chapter is based on replacing suspect modules or assemblies with spares or with components from functioning F2250 systems. This exchange allows for the efficient isolation and resolution of problems.

NOTE

**When swapping boards into the CPU backplane, make sure that all the settings of the replacement board match the settings of the board that is being replaced. For example, when testing the TSG board, ensure that the correct PAL chip U28 option is used.**

## Test Equipment

Checking the general condition of the voltage or current source outputs requires the following basic test equipment:

- Digital multimeter
- Oscilloscope for observing logic signals, ripple, or noise

NOTE

**The oscilloscope range should be set to present an easily readable display. For example, if the F2250 is set to a 5 V range the oscilloscope range should be set to 10 V.**

This chapter contains the following sections:

*Instrument Reference*
Graphics used for reference during troubleshooting.

*Basic System Checks*
Provides guidance in making the initial assessment of system operation.

*Flow Charts*
A series of flowcharts that assist in the analysis of more complex unit problems and that provide navigation to the proper procedures for resolution.

*Power-Up and Front Panel Diagnostics*
Explains the power-up sequences and the most common error codes that appear on the F2250 front panel display during system power up and operation.

*System Troubleshooting*
Explains the various symptoms and difficulties most frequently encountered and their probable causes and solutions.

# Instrument Reference

This section contains graphics of the F2250 that are useful in identifying the physical components used in troubleshooting.

## F2250 Configuration Graphics

Figure 6.1 and Figure 6.2 show the F2250 faceplate and a view of the F2250, including notations of its various configurations.

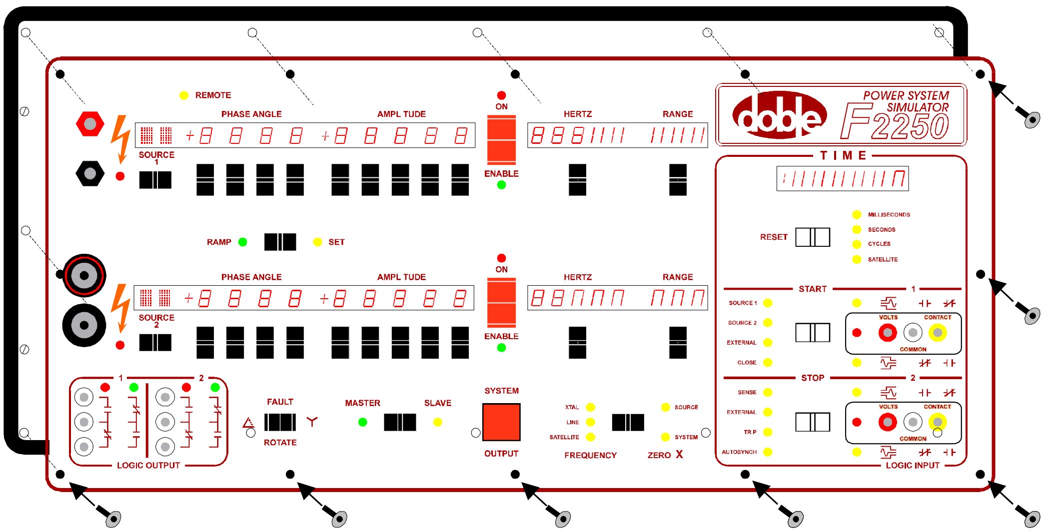



*Figure 6.1  F2250 Faceplate Configuration*

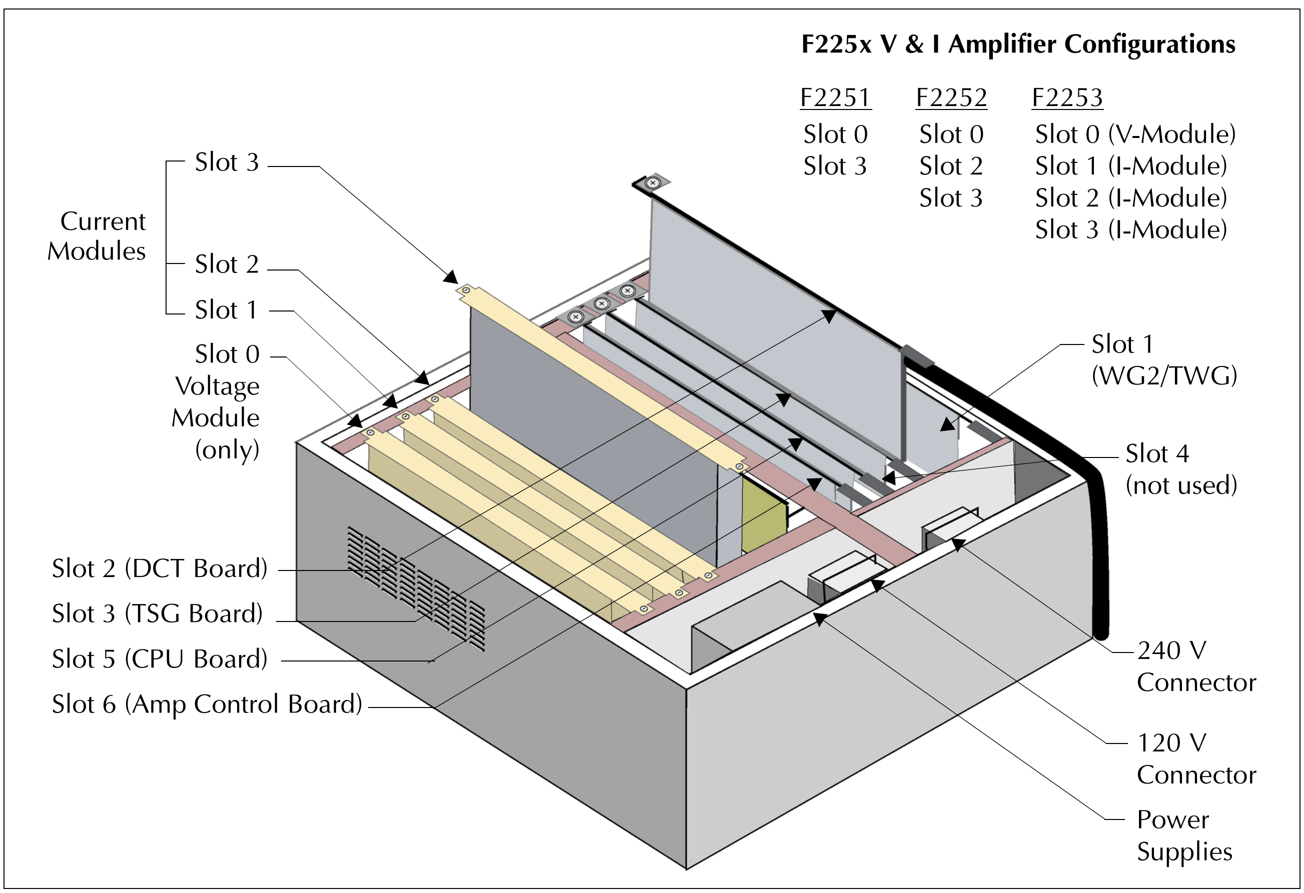



*Figure 6.2  F2250 Configuration*

## F2250 Test Point Graphics

The following graphics call out the test point used for the troubleshooting techniques explained in this chapter:

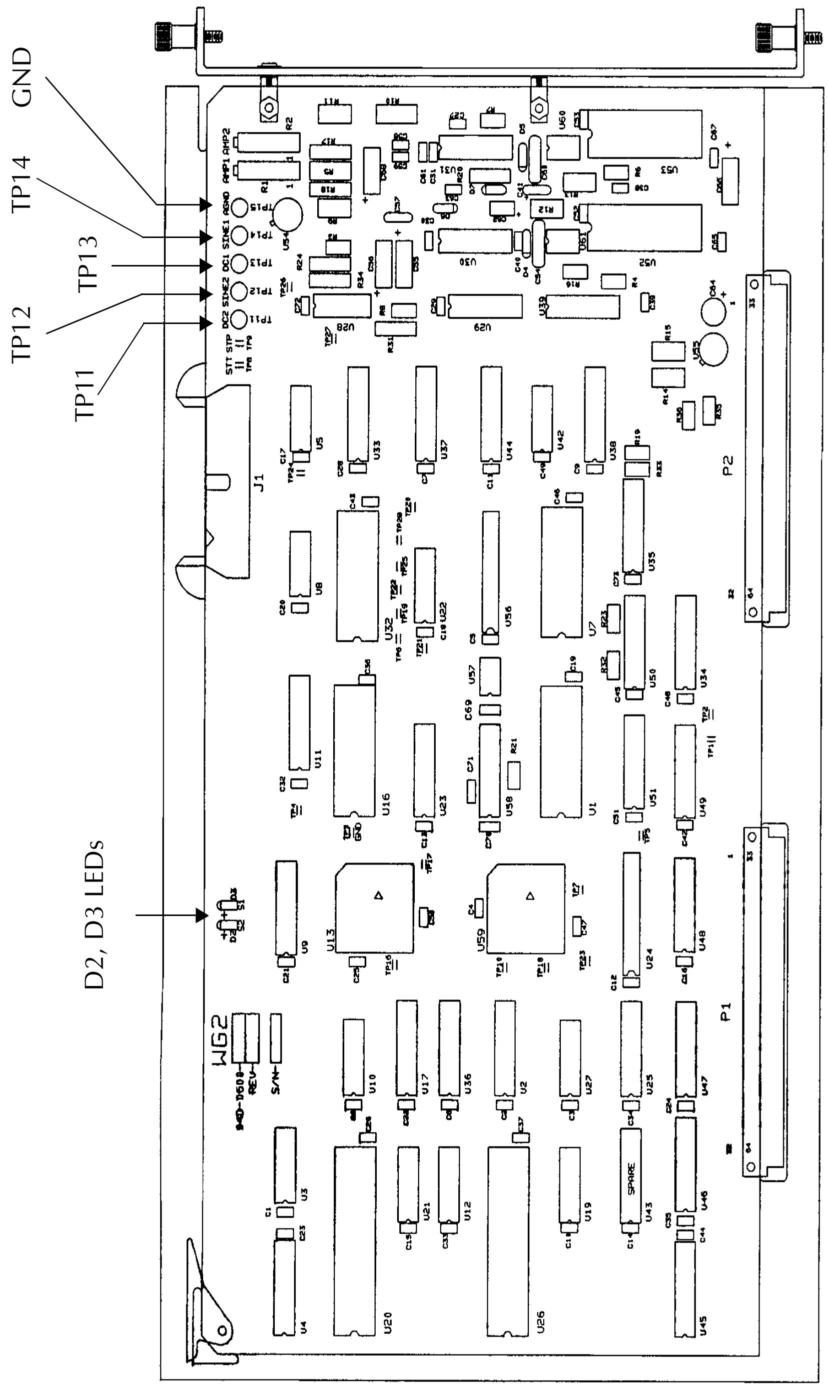



***Figure 6.3  WG2 Board***

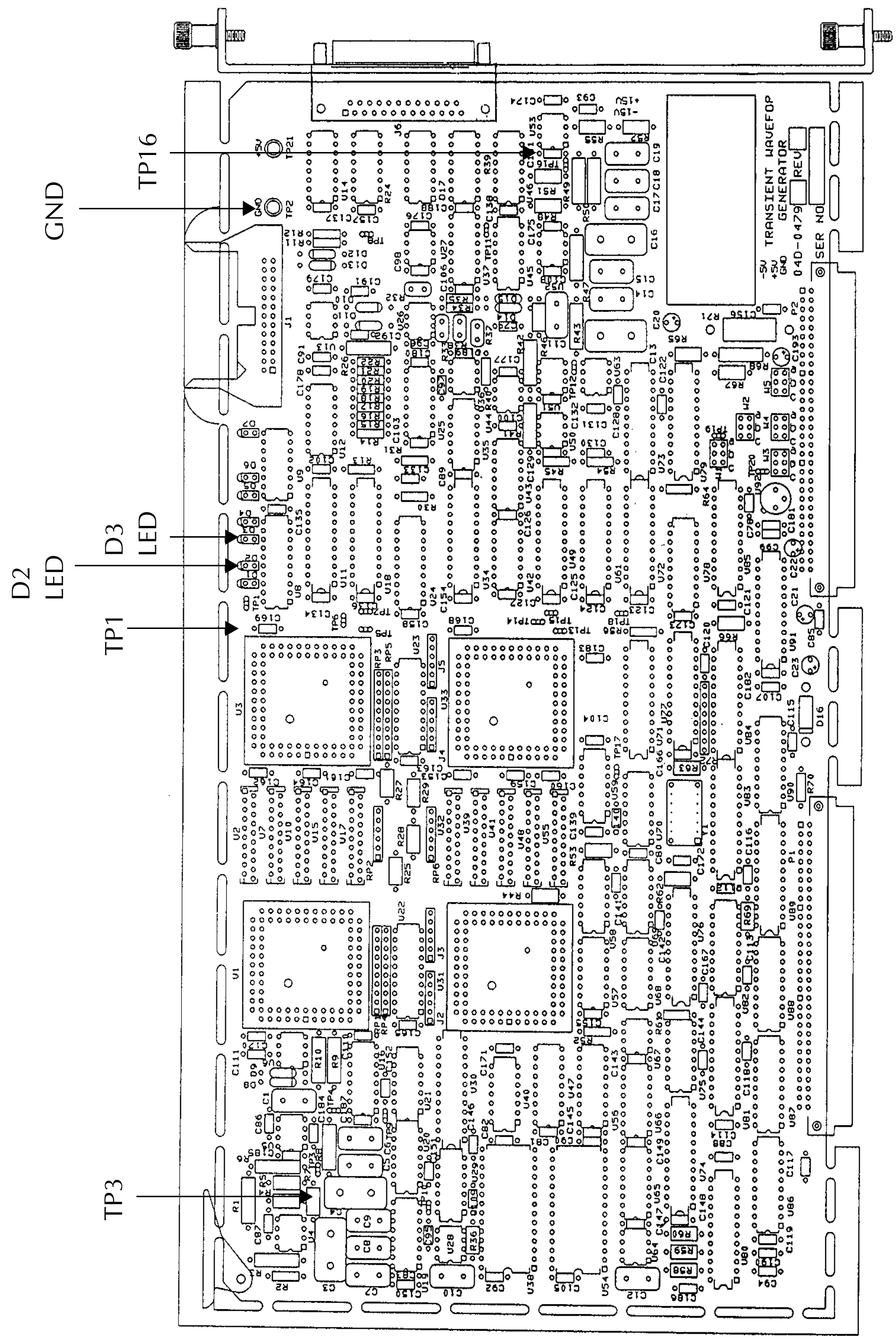



***Figure 6.4 TWG Board***

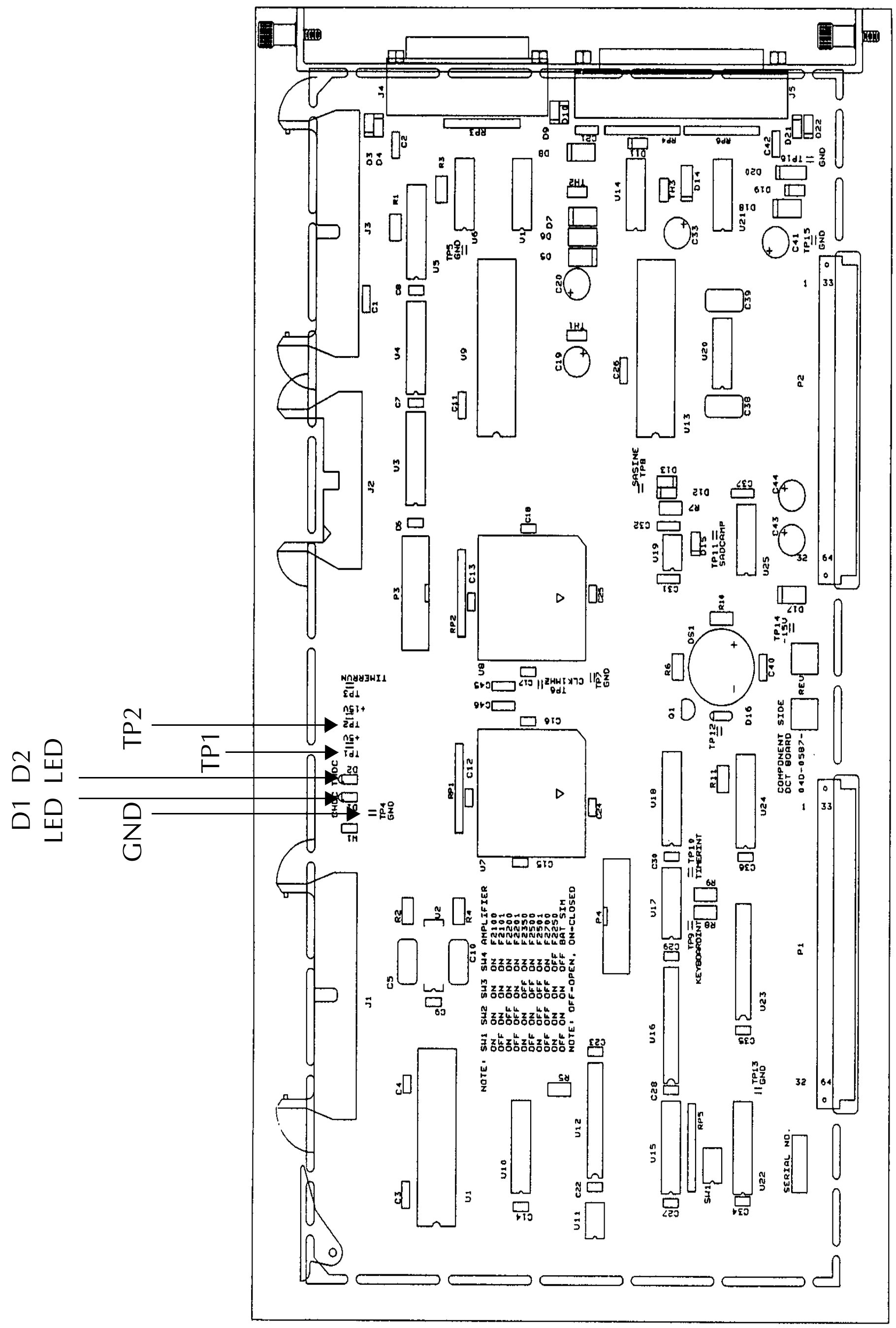



***Figure 6.5 DCT Board***

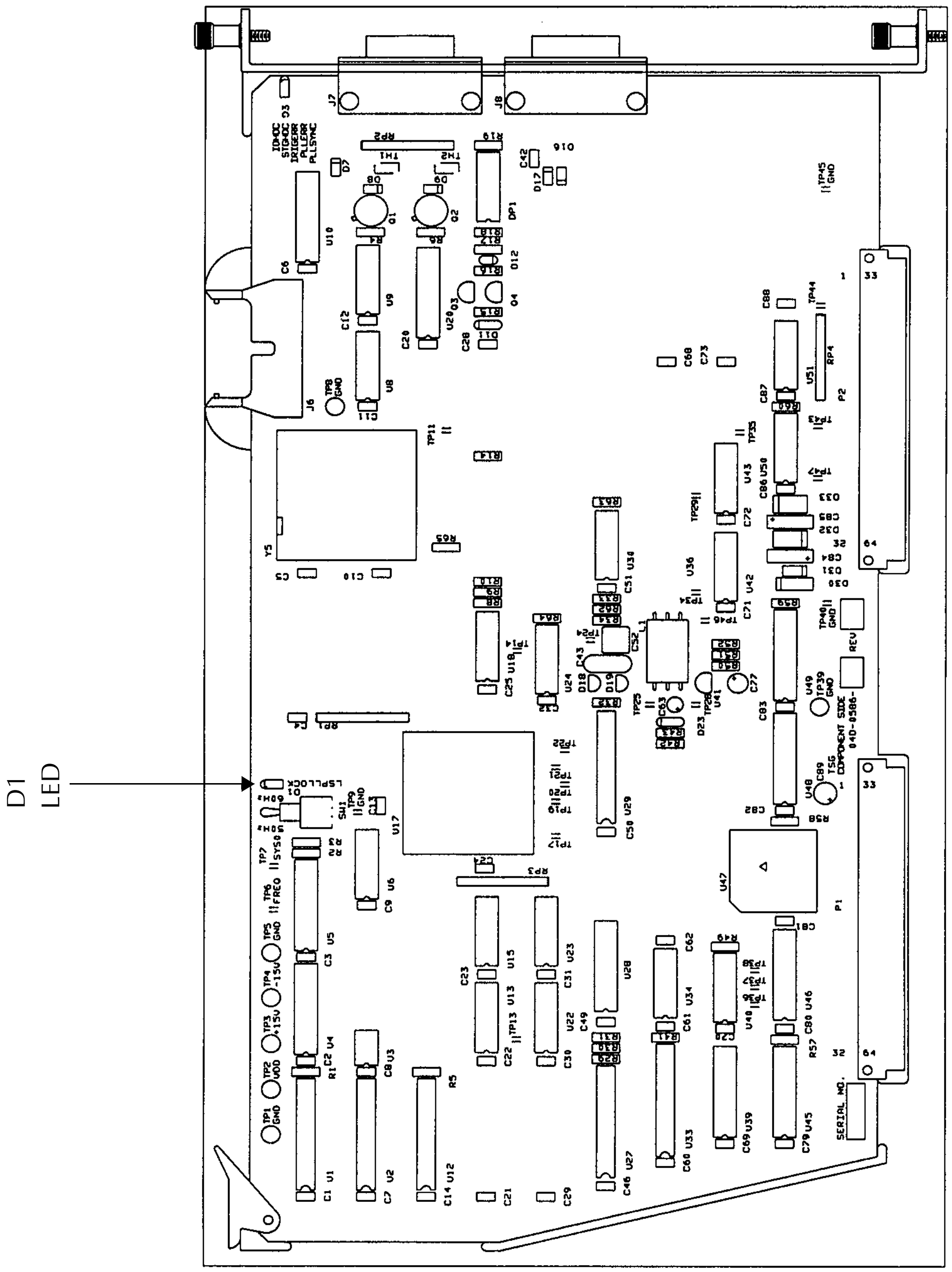



*Figure 6.6 TSG Board*

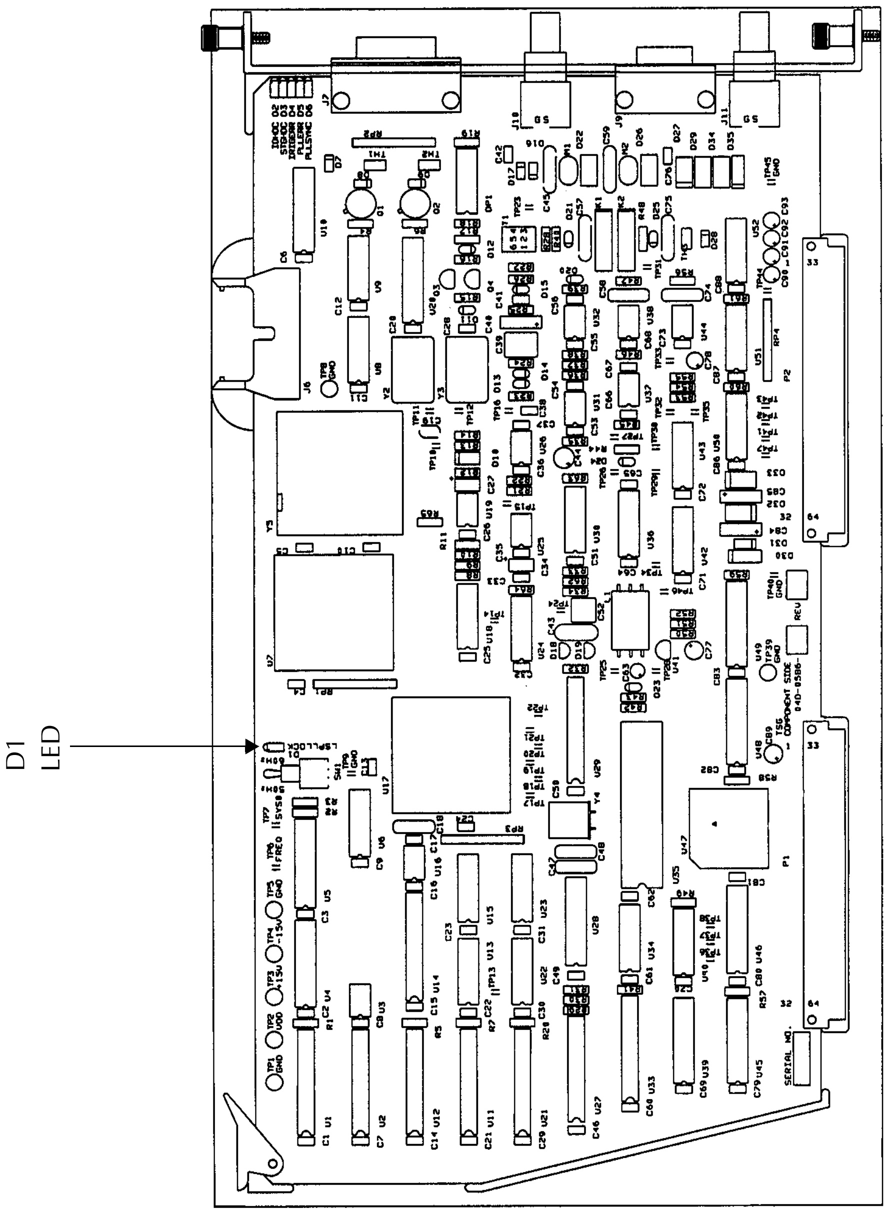



*Figure 6.7  TSG Board with Satellite*

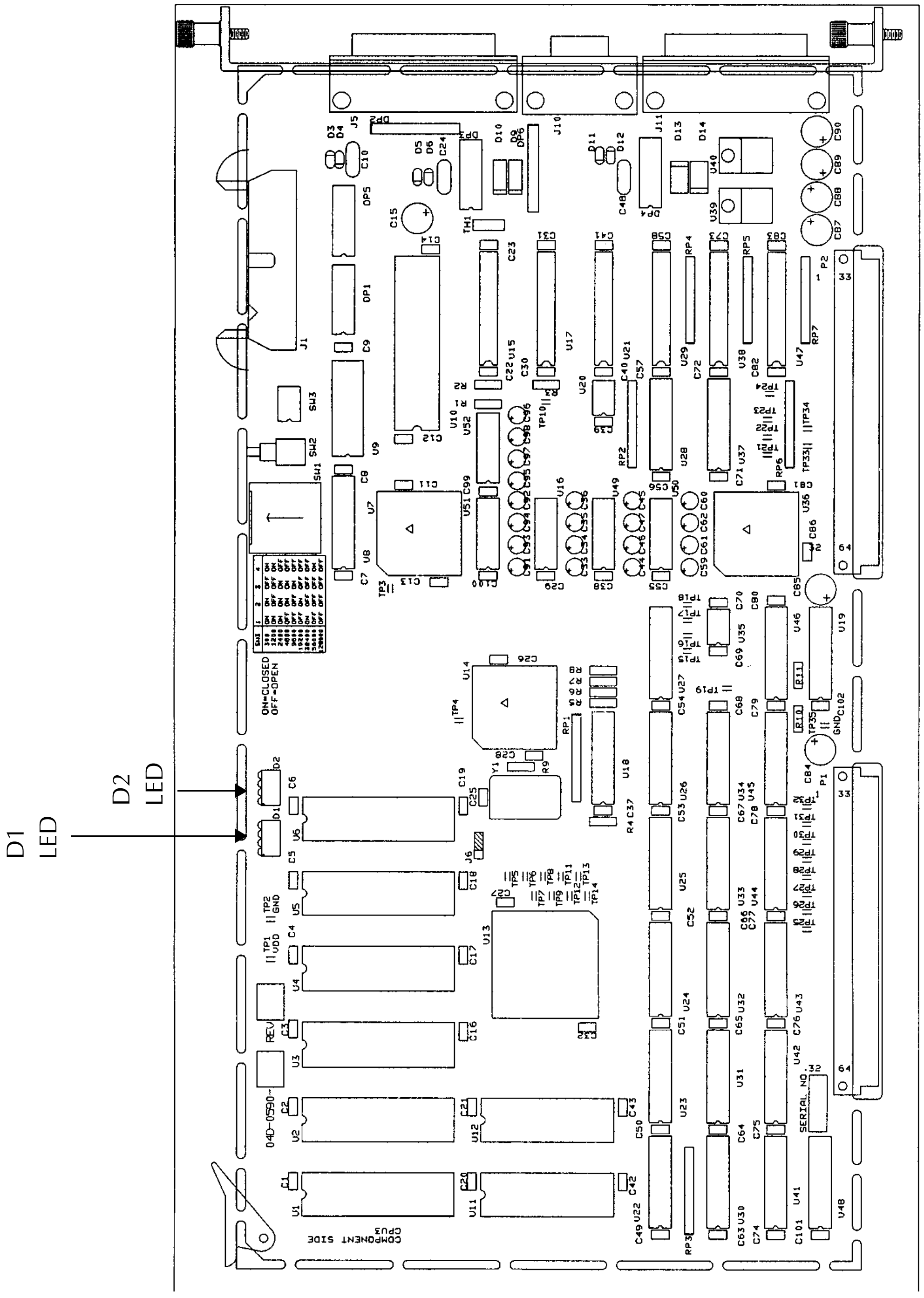



***Figure 6.8 CPUIII Board***

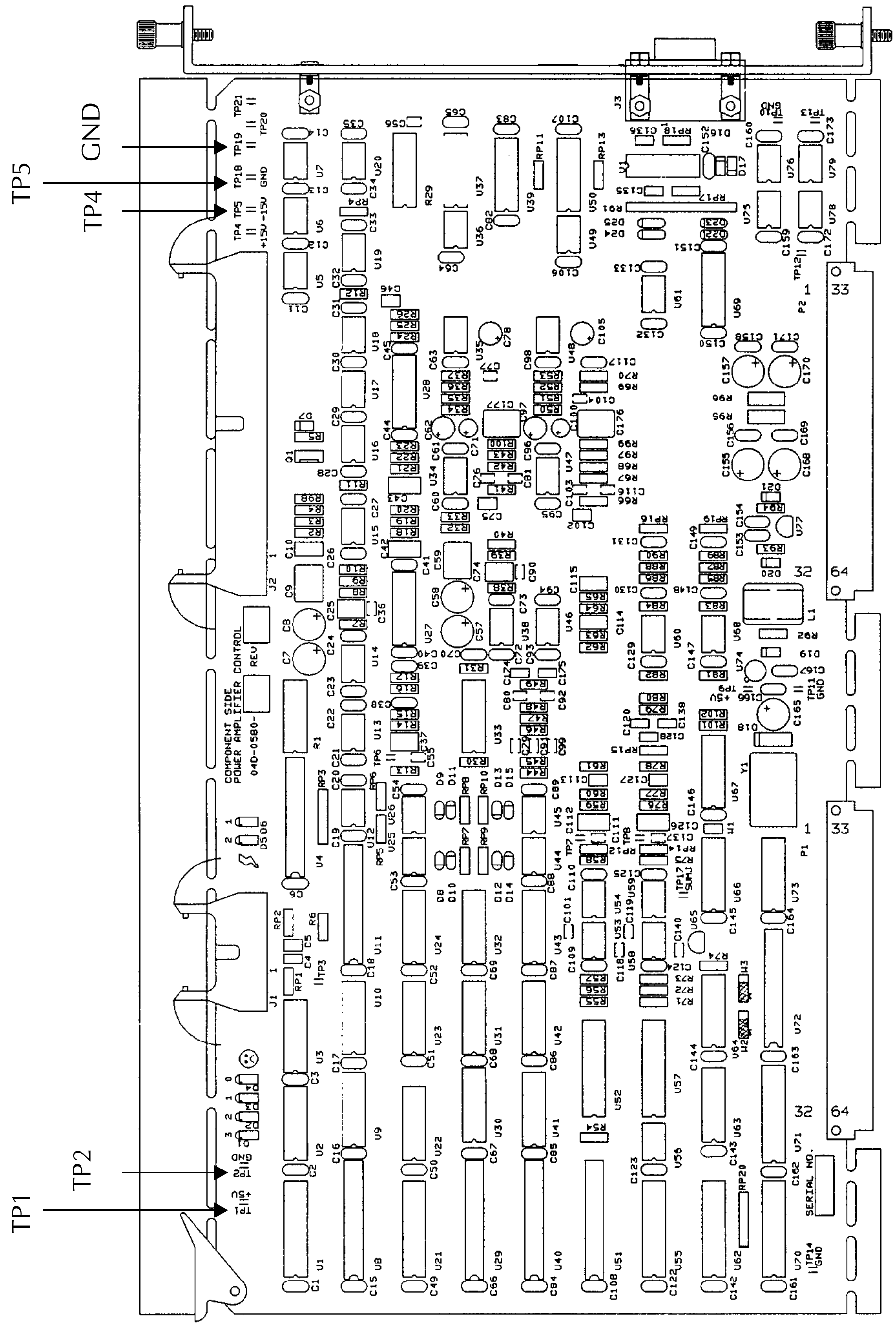



***Figure 6.9  Amplifier Control Board***

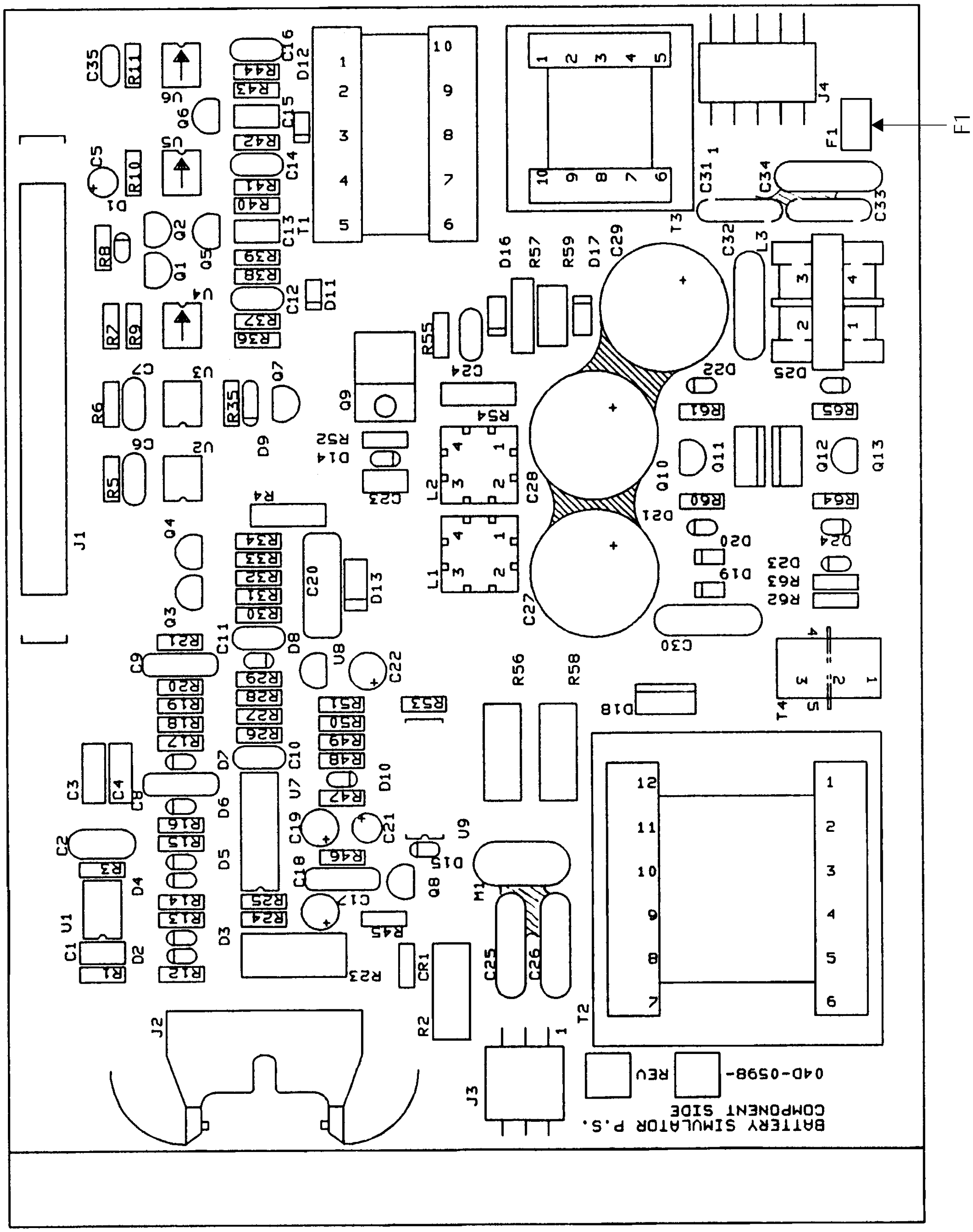



*Figure 6.10  Battery Simulator Board*

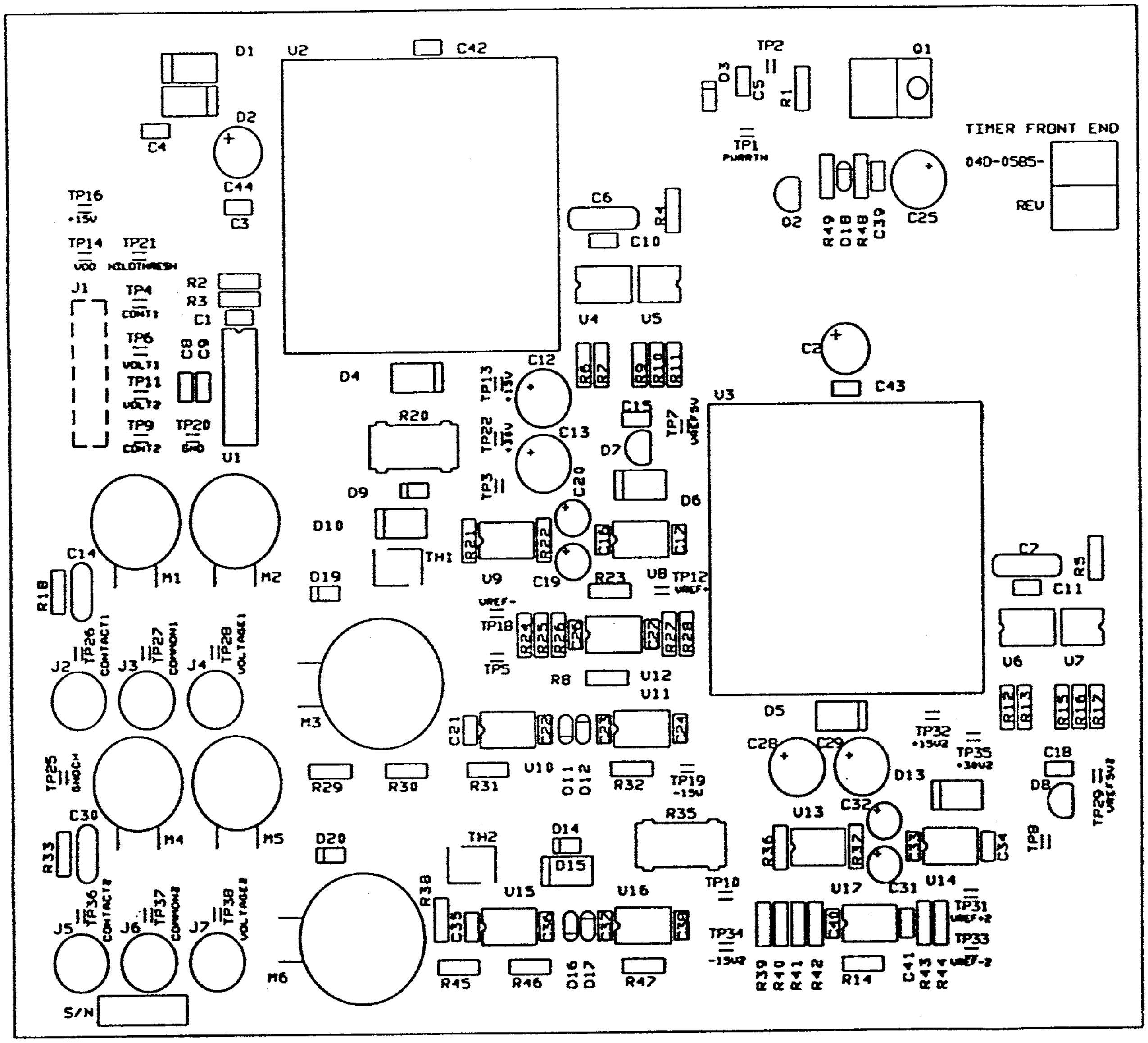



*Figure 6.11 Timer Front End Board*

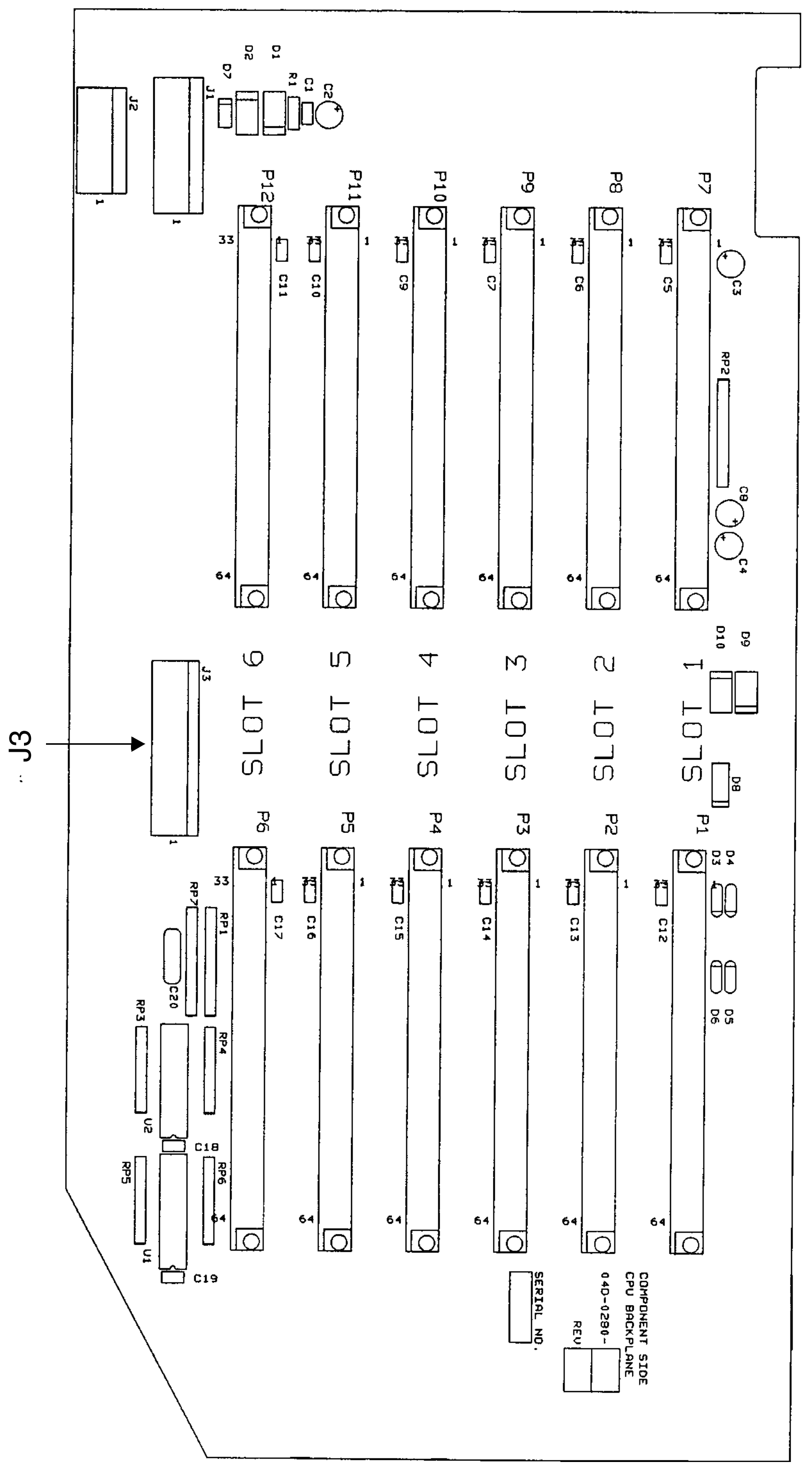



*Figure 6.12 CPU Backplane*

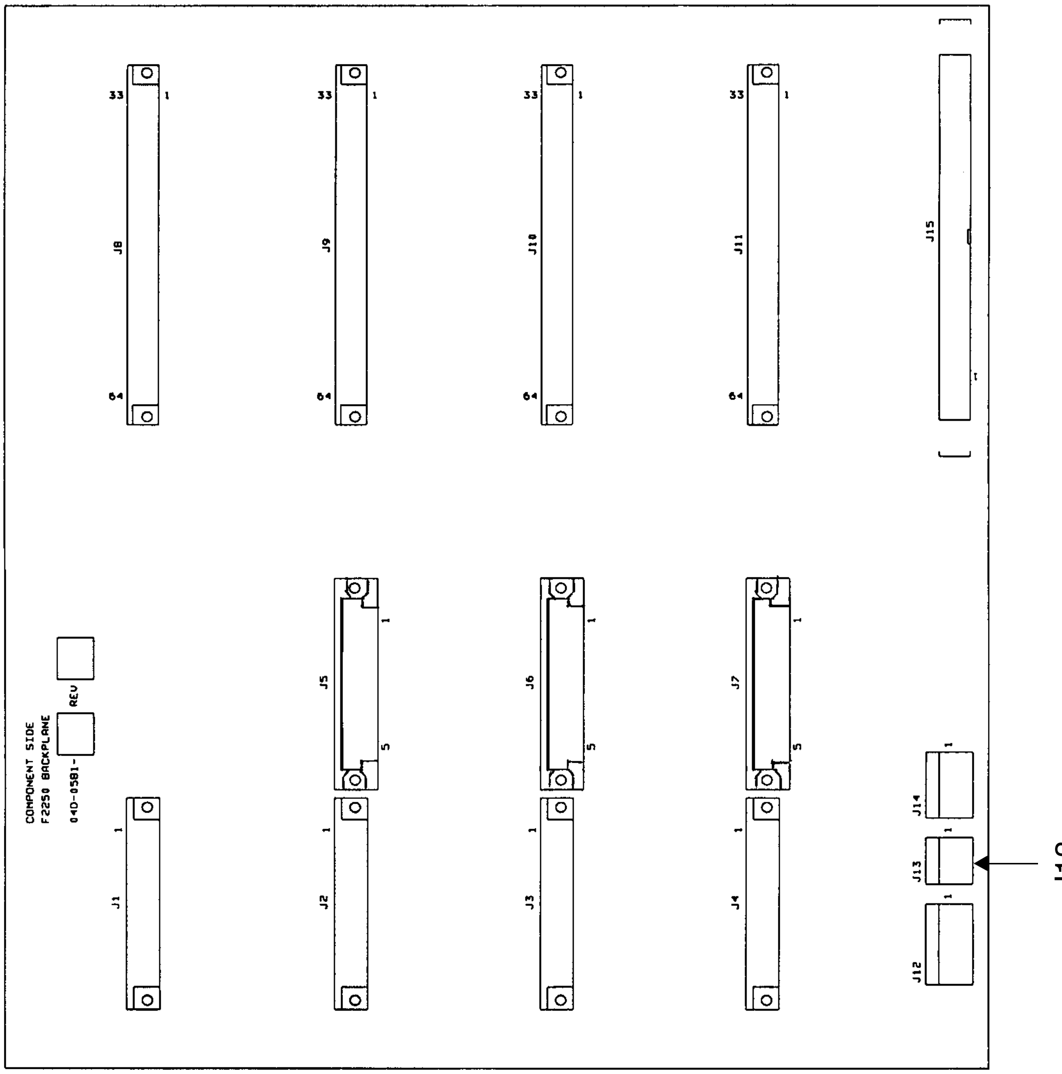



***Figure 6.13 Amplifier Backplane***

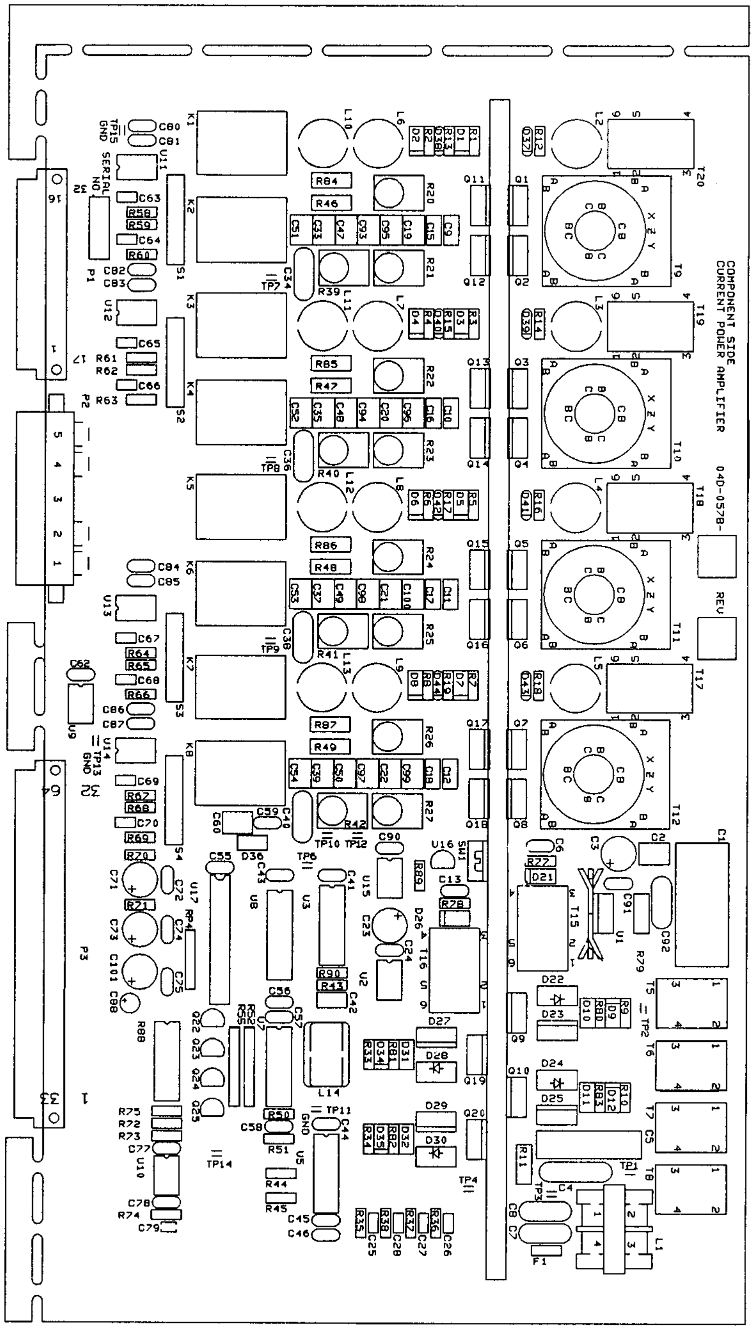


*Figure 6.14 Current Power Amplifier*

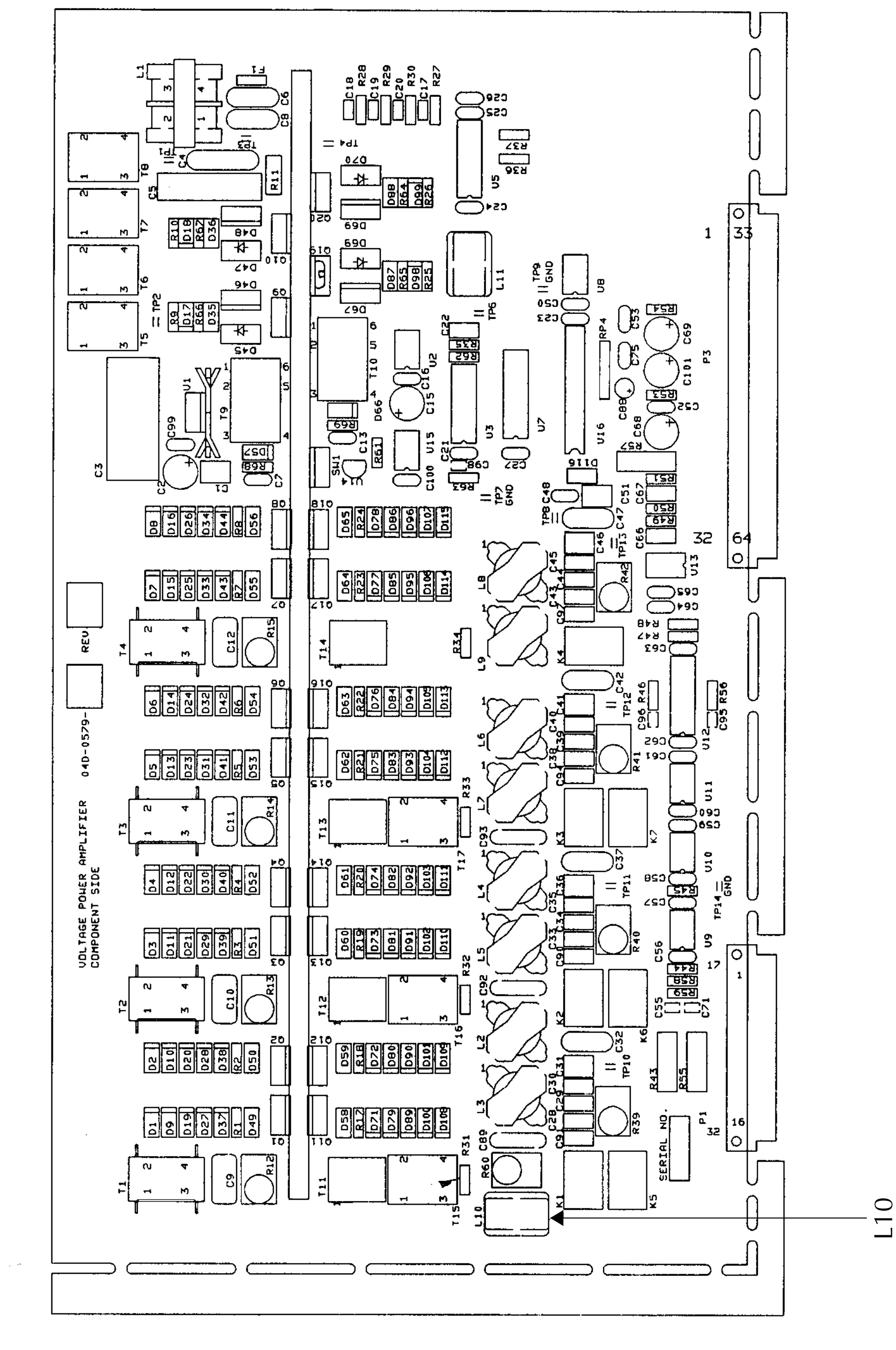



*Figure 6.15 Voltage Power Amplifier*

# Basic System Checks

Before troubleshooting the F2250 instrument, make an initial assessment of system use and operation. Basic system checks allow for problems with simpler causes to be eliminated, before performing more involved troubleshooting of the instrument. Table 6.1 offers a quick guide for basic system checks.

Table 6.1 is followed by:

- "F2250 Unit Validation Test" on page 6-20, which outlines a series of test point tests designed to validate the operation of the F2250.
- "Diagnostic Flow Charts" on page 6-22, which assists in the further diagnosis of problems and, if required, lead to a more complicated level of troubleshooting.

***Table 6.1 Basic System Checks***

| Symptom | Cause | Resolution |
|---|---|---|
| Low output and *ER* or *PS* | The line (mains) voltage being used is insufficient. | Increase the voltage of the line or power mains. Some causes of insufficient voltage include: Generators not providing sufficient voltage or excessive length of the power supply line to F2250. |
| *ER* or *PS* messages | The load or device being tested is outside the volt-ampere rating of the source. | Modify the load or reduce the line level. Higher impedance for the voltage source; lower impedance for the current source. |
| Low output or inability to drive certain loads or relays | Test leads are of insufficient wire size, or are not properly terminated. | Check the test leads. |
| Systems do not power up; no output; no timer stop or sense indications | Internal connectors, printed circuit boards, and cables are not installed properly. | Validate internal connections and ensure that all boards and cables are fully seated. |

*Table 6.1 Basic System Checks (Continued)*

| Symptom | Cause | Resolution |
|---|---|---|
| Systems do not power up together or work with a computer | System interconnections are not present or are not securely fastened. | Verify that external cables are properly connected and that components are seated correctly. |
| No timer stop or sense indication | The DC-to-DC converter is defective. | Verify the following on the **TIME** section of the Front Panel:<br>• **SOURCE 1** and **SOURCE 2** - Measure **COMMON** to **CONTACT** voltage.<br>Both measurements should be between 26 and 28.5 V.<br>• **SOURCE 1** and **SOURCE 2** - Measure **COMMON** to **CONTACT** current.<br>Both measurements should be ≤88 µA.<br>If any of these measurements are out of the expected range *and* there are no other problems with the test set, then replace the Timer Front End (TFE) board. |
| *OT* indication or short source operation times | Improper cooling fan operation. | Ensure that the operating fan is unobstructed and that the filter is clean.<br>Ensure that the unit is not operating in transient mode. |
| Minicontroller is in use: **REMOTE** LED did not illuminate<br><br>Minicontroller does not work<br><br>MASTER/SLAVE sequence is incorrect as seen on front panel LEDS | Minicontroller connection or network power-up sequence. | Ensure that the minicontroller is connected to the MASTER and that the network was powered up as per instructions given in "Multi-Unit Systems" on page 3-2 |

# F2250 Unit Validation Test

The following series of tests, organized by board, comprise a minimal evaluation of F2250 operations. These tests should be performed after power up, or when the F2250 is operating in a questionable manner. They need not be performed in a particular order.

### WG2 Board (PN# 04D-0600)

This test validates the 6.4 V rms measurement. Using test point 15 as GND (See Figure 6.3 on page 6-5):

1. Ensure that the source is enabled (Source set to full amplitude and **SYSTEM OUTPUT**s is ON).
2. Measure Sine 1 wave integrity using test point 14.
3. Measure Sine 2 wave integrity using test point 12.

### TWG Board (PN# 04D-0479)

This measures the +5 VDC and the 6.4 VAC rms for **SOURCE 1** and **SOURCE 2**. Using test point 2 as GND (See Figure 6.5 on page 6-7):

1. Measure for +5 VDC on test point 1.

   Under normal circumstances the multimeter reading should be 4.8 V to 5.2 V.
2. Measure for 6.4 V rms on **SOURCE 1** using test point 16 (Source set to full amplitude and **SYSTEM OUTPUT**s is ON).
3. Measure for 6.4 V rms on **SOURCE 2** using test point 3 (Source set to full amplitude and **SYSTEM OUTPUT**s is ON).

   Under normal circumstances the 6.4 V rms reading should not vary more than ±0.6 V.

### Amplifier Backplane (PN# 04D-0581)

This procedure validates voltage across the amplifier backplane. Tests are performed using the J13 connector (See Figure 6.13 on page 6-15).

- Measure the maximum voltage using pin 1 to 3.

  The maximum voltage should be in the range of 300 VAC to 380 VAC.

Alternately:

- Measure the maximum voltage using pin 1 or 3 of the J4 connector on the AC Front End board (High Voltage Power Supply).

  This requires that probe extenders be used on the meter.

The "Diagnostic Flow Charts" starting on page 6-22 assist in performing a more detailed troubleshooting of the F2250.

## Low Voltage Power Supply

The three tests that follow are used to validate the proper operation of the Low Voltage Power Supply. If any of the results from these three tests are out of the expected range, proceed to "Low Voltage Power Supply" on page 6-21.

### DCT Board (PN# 04D-0587)

This measures the voltage values for the DCT board. Using test point 4 as GND (See Figure 6.5 on page 6-7):

1. Measure the +5 VDC on test point 1.
2. Measure the +15 VDC on test point 2.

### Power Amplifier Control Board (PN# 04D-0580)

This measures the voltage values for the Amplifier Control board (See Figure 6.9 on page 6-11).

1. Connect the meter to test point 18 as GND.
2. Measure the +15 VDC on test point 4.
3. Measure the –15 VDC on test point 5.
4. Connect the meter to test point 2 as GND.
5. Measure the +5 VDC on test point 1.

**NOTE**

**Do not use Test Points 19 to 21. They are used by Doble personnel to check the current balance between amplifiers.**

### CPU Backplane (PN# 04D-0280)

This procedure validates voltage across the CPU backplane. Tests are performed using the J3 connector (See Figure 6.12 on page 6-14).

1. Use pins 4, 5, 6, or 7 as GND.
2. Measure the +5 V on pins 1, 2 and 3.
3. Measure the +15 V on pins 8 and 9.
4. Measure the –15 V on pin 10.

# Diagnostic Flow Charts

This section contains a series of four flow charts. These charts are designed to assist in troubleshooting by guiding the user to the correct information required for problem resolution based on system symptoms.

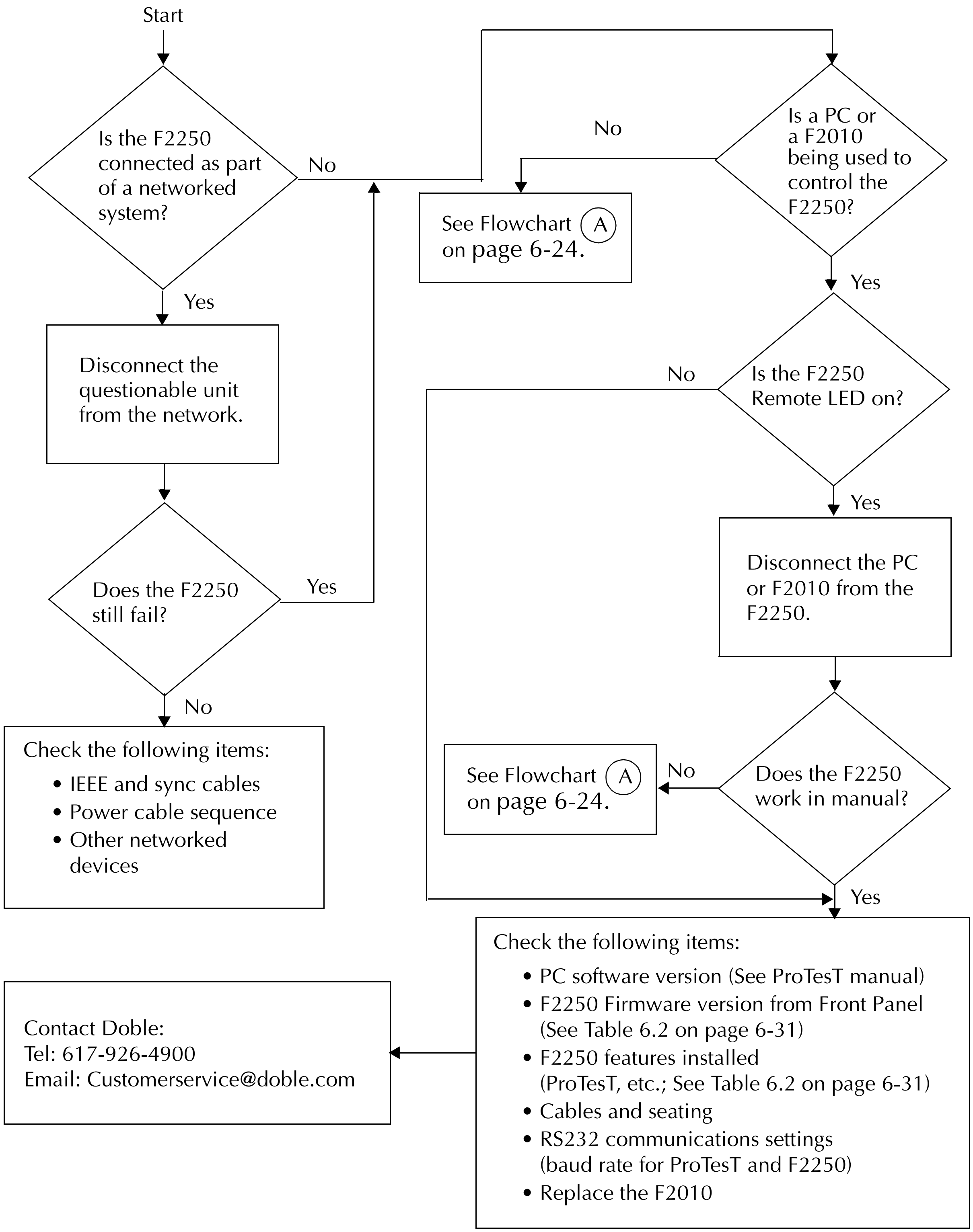



***Figure 6.16  Basic Troubleshooting***

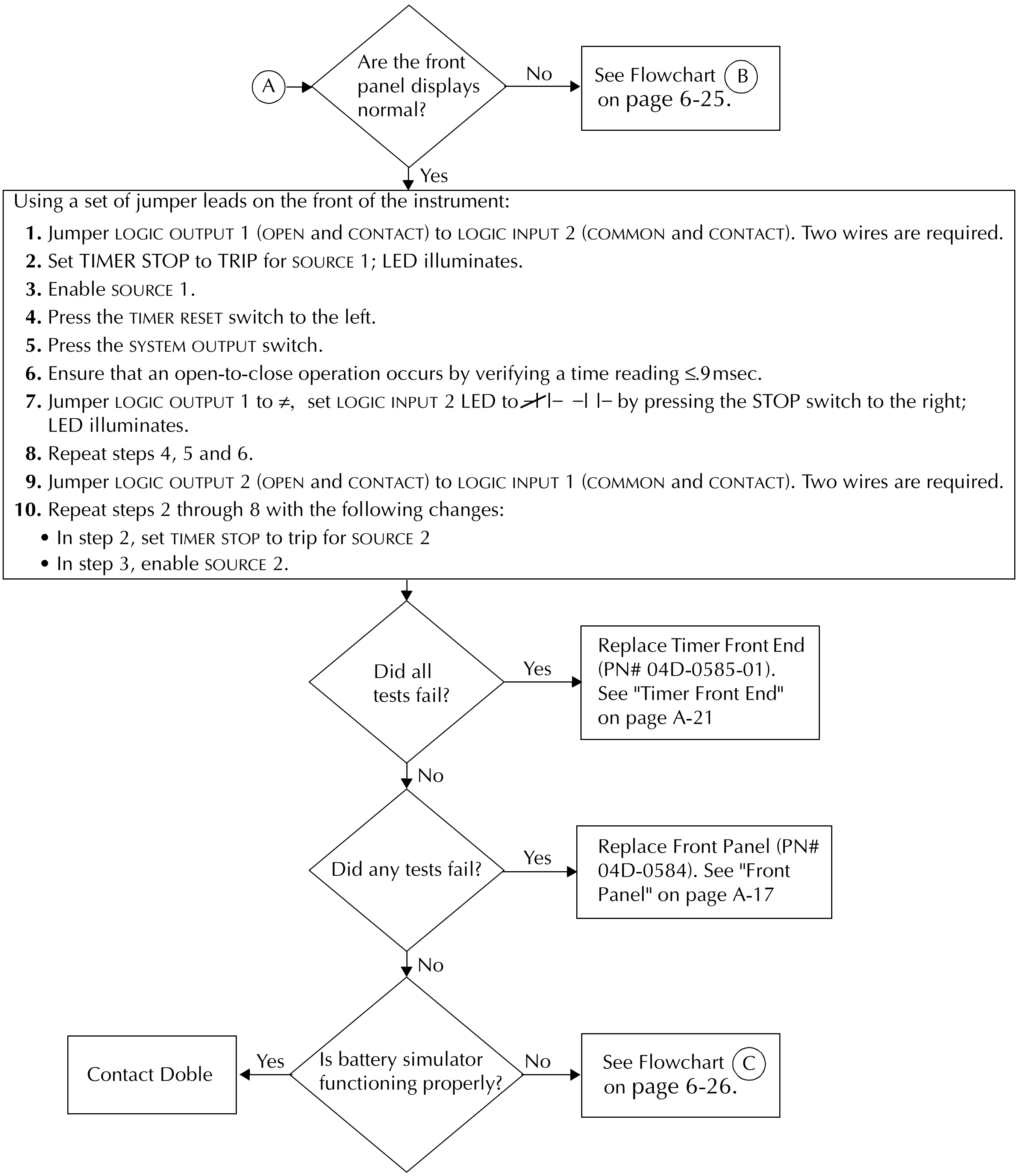



***Figure 6.17  Flowchart A - Jumper Test***

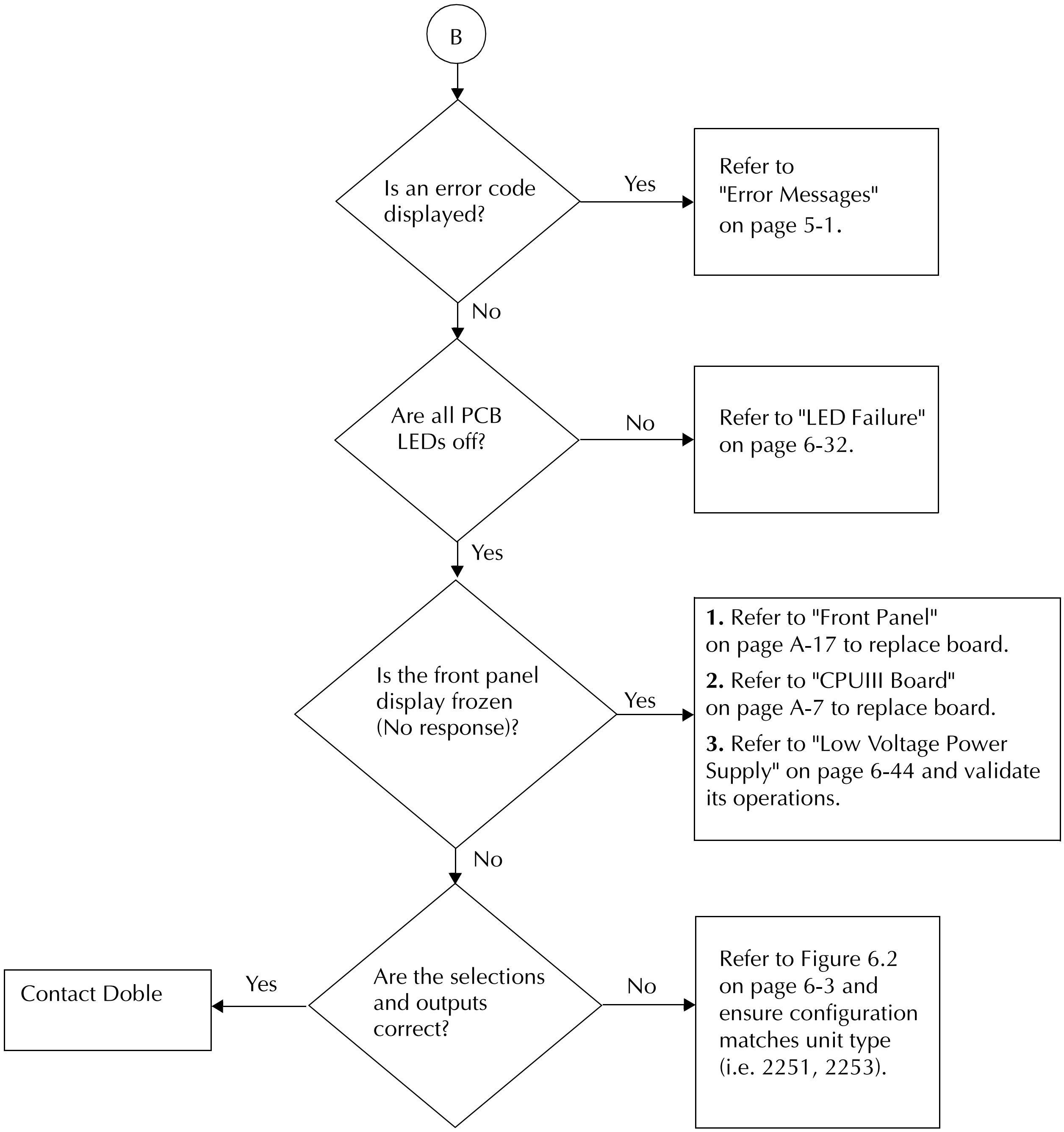



***Figure 6.18 Flow Chart B - Error Codes and LED Display***

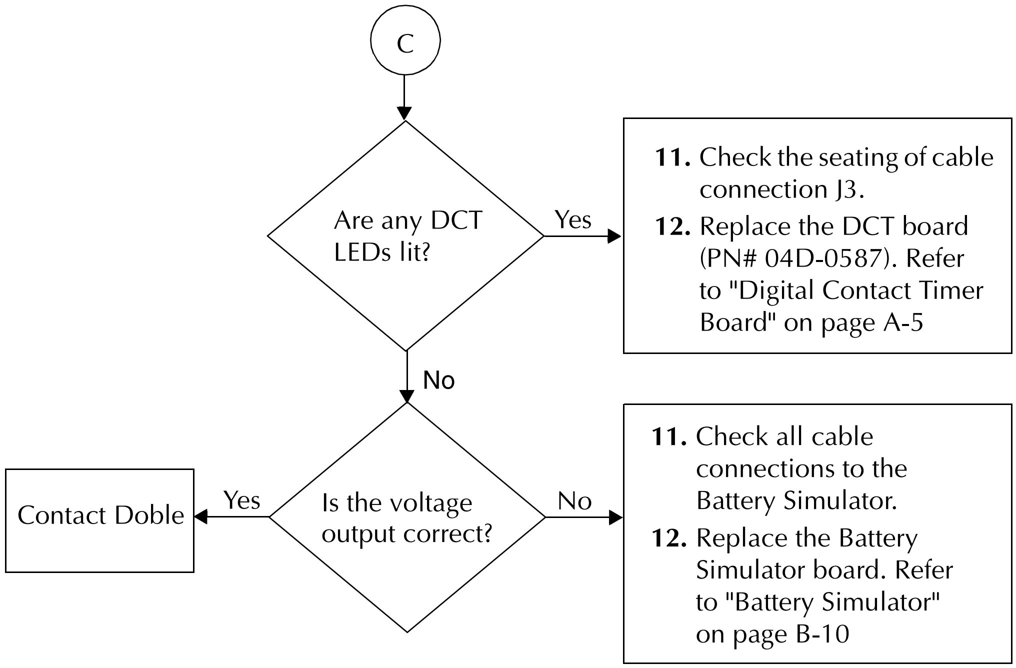



***Figure 6.19  Flow Chart C - DCT Board and Battery Simulator***

# Power-Up and Front Panel Diagnostics

The diagnostics performed by the F2250 can be broken up into two categories:

- *Initialization Diagnostics*

  Occurs during instrument power up while each circuit board is being initialized.

- *Run-Time Diagnostics*

  Occurs when an instrument component or section goes into use.

The analysis of Front Panel LEDs is an integral part of determining system health. The *Error Detection and Handling* discussion that follows explains the various types of error messages that occur.

## Error Detection and Handling

Three types of errors are detected:

- Network Errors (in multi-unit systems)
- Internal Errors (within a unit)
- Source Errors (caused by higher than specified loads, shorted voltage outputs, or open current outputs)

## Network Errors

Network errors are fatal errors (they stop the microcomputer) that occur due to a communication error on either the IEEE-488 Bus or the SYNC Bus. The F2250 that first detects the problem stops, displays an error code that specifies the cause of the error, and then stops all networked F2250s that display a *nEt* error message.

To recover from a network error, press any control on the front panel of each networked unit. All units go into the POWER ON state, show *Pon* in their **TIME** display, and when all units are ready, the network becomes active again.

If this procedure does not clear the error, switch all the F2250s OFF. After five seconds, power up the units in sequence, starting with the MASTER unit.

If the error persists, or if recovery cannot be achieved, record all the error codes and messages. Then attempt to determine which unit is causing the network error by disconnecting one unit at a time from the network until the unit causing the error is isolated. Replace the CPUIII or TSG card in the unit that causes the error. If this does not resolve the error, call Doble. See "Error Messages" on page 5-1 for a listing of network errors and messages.

## Internal Errors

Internal errors are fatal errors caused by a hardware or software malfunction which halts the unit and displays an error code.

Recovery is attempted by pressing any control on the front panel of each networked unit. All units go into the POWER ON state, show *Pon* in their **TIME** display, and when all units are ready, the network becomes active again. Power system simulators on which these errors occur usually require servicing. Be sure to note the error messages and codes before calling Doble.

Figure 6.20 shows a typical display for an internal system error. **SOURCE 1** shows *SY* (for System), followed by an error code and the word *Error*. **SOURCE 2** shows the word *A T*.

Some examples of internal errors are:

- Watchdog Reset/CODE = 0001

  The software is in an infinite loop, or an operation has taken too much time.
- Bus Timeout/CODE = BUS

  There is a software processing error or a PCB board is missing.
- Unexpected Interrupt/CODE = 500 x (x is variable)

  There is too much noise.
- Memory Error/CODE = 300 x

  The software cannot read sine wave values.
- Timer Error/CODE = 200 x

  The timer is not configured correctly.
- Amplifier Error/CODE = 900 x

  The amplifier is not detected during initialization.

See "Error Messages" on page 5-1 for a complete listing of error messages.

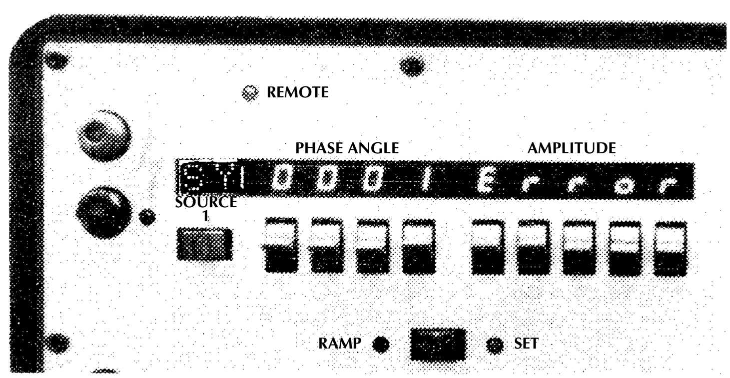



*Figure 6.20 Typical Internal System Error Message Display*

## Source Errors

Source errors are discussed in "Source Diagnostics" on page 6-35.

# Initialization Diagnostics

There are two levels of LEDs that can be used for analysis while the F2250 powers up:

- Configuration status displays
- CPU backplane power-up sequence displays

## Configuration Displays and Messages

Pressing and holding the **MASTER/SLAVE** switch to the right causes configuration messages to appear in the **SOURCE** and **TIME** displays. These define the unit and its options.

The configuration messages specify the unit model number, its software revision number, the Base Frequency (selected by a switch on the Timing State Generator card), any installed options, and the Doble bus network address. Each message is shown in a specific display area identified in Table 6.2. Refer to Table 3.2 on page 3-5 for a list of the LED states that occur during normal power-up.

*Table 6.2 Initial Configuration Messages*

| Display | Message | Meaning |
|---|---|---|
| SOURCE 1 | *MS* | F2825 Multiple Sources option |
| S1 PHASE ANGLE | *nnnn* | Model number |
| S1 AMPLITUDE | *Ern.nn* | Firmware revision number |
| S1 HERTZ | *50/60* | Base Frequency |
| S1 RANGE (left digit) | *t* | TWG board installed (F2860) |
| SOURCE 2 | *DV* | F2820 ΔVALUE/ΔTIME option installed |
| S2 PHASE ANGLE (left) | *Fr* | Fault Rotate option (F2810) installed |
| S2 PHASE ANGLE (right) | *Pc* | Precision Frequency (standard feature) |
| S1 RANGE (eight digit) | *S* | Satellite board installed |
| S2 AMPLITUDE (right three digits) | *PH4* | 4 = F2920 Precision Autosynchronizer Advance Time Measurement |
| S2 HERTZ | *CC.nn* | Network address |
| S2 RANGE | *US/EP* | US/Extended Source Designations |
| TIME | *Prot* | F2910 ProTesT Starter Kit installed |

**NOTE**

**The first unit turned on in a multi-unit system, which automatically becomes the Controller-in-Charge (CC), directs communications over the IEEE-488 Bus. The SOURCE 2 HERTZ display indicates either CC or a two-digit number identifying the network address of the controller in charge of a multi-unit system.**

If any LED displays an error code, refer to "Error Messages" on page 5-1.

## CPU Backplane Boards Power Up LED Sequence

With the cover off, the LEDs on the top edge of the boards are visible. Table 6.3 shows the proper sequence of LED illumination for these boards that occurs during power-up.

***Table 6.3 LED Power Up Sequencing***

| Slot # | LEDs/Board | Sequence On | Description | Sequence Off |
|---|---|---|---|---|
| 2 | D1 and D2/ DCT | 1st | Constant | 3rd |
| 1 | D2 and D3/ WG2 or TWG | 2nd | Constant | 2nd |
| 5 | D1 and D2/CPUIII | 3rd | One flash | 1st |
| 3 | D1/ TSG (If applicable) | 4th | Flashes | N/A |

### LED Failure

If these LEDs do not illuminate or do so out of sequence:

1. Check seating of the boards.
2. Check the ribbon-cable connections.
3. Check the Power Supply test points (See "F2250 Unit Validation Test" on page 6-20).
4. Replace the CPU board to test its validity (See "CPUIII Board" on page A-7).

   After the LED sequence stops, any board with a LED still illuminated is suspect.
5. Replace the suspect board and retest.

If these items are correct, contact Doble Customer Service.

## Run-Time Diagnostics

The error codes in Table 6.4 are indicated by the amplitude, phase, or source designator displays on the instrument front panel. For a complete listing of error codes, refer to "Error Messages" on page 5-1.

***Table 6.4 Run-Time Error Codes***

| Error Code | Error Type | Cause |
|---|---|---|
| 9000 | Amplifier ID check | The amplifier ID is checked to determine which 2250 configuration is in place. This error indicates either that the amplifier cable is not plugged into the DCT timer board, that the amplifier is defective, or that the DCT timer board is defective. |
| 8001 | Master already present | The F2250 did not detect another unit on the IEEE-488 bus, but did detect a MASTER on the SYNC bus. This indicates that an IEEE-488 cable is not plugged in somewhere in the system. |
| 8003 | Invalid network | The Controller-in-Charge could not validate the IEEE-488 network determined from power-up. The invalid network error indicates that the system was not properly powered up. Perhaps two or more units were turned on simultaneously. |
| 6001 | IEEE-488 communication error | If this error occurs frequently, a defective IEEE-488 cable connection exists (not necessarily connected to the instrument with the error); or a defective CPU board exists. |
| bUS | Bus timeout | A board that was previously functioning in the system has stopped functioning. This error can be caused by an intermittent backplane connection. There is no way to determine which board has the problem. |
| 500A* | Unexpected interrupt | This is a satellite interrupt error; the ramps or delays are inactive. |
| 500B* | Unexpected interrupt | Check for a defective or missing satellite board. |

***Table 6.4 Run-Time Error Codes***

| Error Code | Error Type | Cause |
|---|---|---|
| 8005 | Phase Locked Loop detect | This circuit synchronizes the instrument to either the internal crystal reference (XTAL) or the power line frequency (LSYNCH).<br>If this error occurs while the *XTAL* mode is selected, a defective timing generator board is indicated. Check the setting of the SW1 switch on the top edge of the TSG board. Make sure it is set to the correct frequency (50/60 Hz).<br>If this error occurs while the *LSYNCH* mode is selected, a defective amplifier line SYNC circuit is indicated. Replace the Amplifier Control board. |
| 8002 | No MASTER for SLAVE | A slave unit has lost the MASTER signal. This is caused by a SYNC cable being removed or a bad timing board. |
| PS | Power Supply | Indicates that either the power supply is exceeding 350 VDC (400 VDC is the allowable maximum), or that the ten-pin ribbon cable between the Amplifier Control board and the 350 VDC power supply is disconnected or faulty. |
| AcAL | Calibration error | An error has occurred in a Voltage Module, Amplifier Module or Amplifier Control board. The unit is no longer calibrated. Contact Doble Customer Service. |

* Unexpected Interrupts — The software experienced a waveform control interrupt at an unexpected time. The cause of the error could be due to a software problem or a bad board.

# System Troubleshooting

This section lists symptoms of common problems that may be encountered, their associated causes, and the solutions for both single and networked F2250 instruments.

As stated previously, board exchange is the method of choice for diagnosing system problems quickly and is used extensively throughout this section.

## Source Diagnostics

Source errors occur during normal operation for a variety of reasons. The instrument continues operating; however, depending on the type of error, it may turn the source off, or it may just beep and display an error in the associated SOURCE LED.

Source errors are generated by the following conditions:

| | |
|---|---|
| *Overload* | The source cannot drive the load at the specified amplitude |
| *Overtemperature* | An amplifier module is too hot |
| *Power Supply* | The power supply cannot provide the required voltage |

These conditions manifest themselves as LED error indications on the F2250 front panel. The front panel LED display error messages are explained in the following sections:

- ER (Output Error)
- TM (Thermal Management)
- PS (Power Supply)
- OT (Overtemperature)
- TR (Trip)
- Internal Amplifier 5V Error
- No Output

If the F2250 is not operating, and none of the error conditions listed above exist, refer to "F2250 System Checks" on page 6-43.

## ER (Output Error)

The *ER* indicator flashes when the source output signal does not follow its requested input signal. This comparison is performed by the Amplifier Control board. The output error is indicated by the sensitivity ranges given in Appendix C. "F2250 Specifications".

If the external analog signal input feature is being used, then the error detection sensitivity is controlled by the amplitude setting of the source being used. If the amplitude is set to full-scale for the given range, then detection is least sensitive. In this case, the detection threshold is 1% of the full-scale amplitude for the selected range. If the amplitude is set to zero, error detection is most sensitive, responding to errors of 0.1% of the full-scale amplitude.

The most common reason for an *ER* indication is a load burden that the source is incapable of driving (e.g., an open-circuit current source load or a short-circuit voltage source load). Using the lowest voltage and current range that will suffice for a given amplitude and the highest power source available often stops the *ER* indication with high-burden loads.

The combinations of *ER* indications that exist are given in Table 6.5.

***Table 6.5  ER Indications***

| Symptom | Solution |
|---|---|
| *ER* on all **SOURCE**s and ranges | Refer to "F2250 System Checks" on page 6-43. |
| *ER* on **Source 1** voltage source | Run the voltage source output with an open circuit load. If the ER indication continues, then the Voltage Amplifier module is suspect.<br>Refer to "Amplifier Module and Amplifier Control Board Tests" on page 6-47. |
| *ER* on **SOURCE 1** current source | Run the **SOURCE 1** current source output with a short-circuit circuit load.<br>If the ER indication continues, then the Current Amplifier module in Slot 3 and the mode relay are suspect.<br>Refer to the "Amplifier Module and Amplifier Control Board Tests" on page 6-47.<br>This applies to the F2250, F2252, and F2253 models only. |
| *ER* on **SOURCE 2** current source | Run the **SOURCE 2** current source output with a short-circuit circuit load.<br>If the *ER* indication continues, then all the 150 VA Current Amplifier modules are suspect.<br>Refer to the "Amplifier Module and Amplifier Control Board Tests" on page 6-47. |

## TM (Thermal Management)

If the F2250 **SOURCE 1** and **SOURCE 2** LEDs display *TM*, this indicates that one of the amplifier modules is operating too hot. Two *TM* indications exist — Normal and Abnormal.

### Normal TM

If the transient current rating of either source has been exceeded, refer to Table 6.6 for the symptom and solution.

***Table 6.6 Normal TM Indications***

| Symptom | Solution |
|---|---|
| *TM* indication: For current sources at 50/60 Hz, a transient range has been selected (e.g., T1) and the amplitude is greater than 50% of full scale. | Use a higher current range, a lower amplitude, or a non-transient range (e.g., I1). |
| *TM* indication: For current sources at DC, the amplitude is greater than 2/3 of full scale for continuous ranges (e.g., I1). | Use a higher current range or a lower amplitude. |
| *TM* indication: For voltage sources, the load impedance and voltage selected exceeds the continuous rating of the source. | Use a lower voltage range or a lower amplitude for a given load. |
| *TM* indication: The continuous large-amplitude high-frequency (> 2 kHz) rating of a source has been exceeded. | Use a lower current or higher voltage range. The F2250 is not rated for continuous large-signal high-frequency operation. |

### Abnormal TM

If the conditions of a normal TM indication do not apply, then Amplifier Control PCB and the Amplifier Modules are suspect. Refer to the "Amplifier Module and Amplifier Control Board Tests" on page 6-47.

## PS (Power Supply)

If the F2250 **SOURCE 1** and **SOURCE 2** LEDs display *PS*, it indicates one of the following problems:

- The 350 VDC supply is running too high (> 400 VDC). This can occur if the AC mains input is too high or if another source is feeding large amounts of power back into the instrument through the output terminals.
- The ten-pin ribbon cable that connects between the Amplifier Control board and the 350 VDC power supply is disconnected or faulty. Refer to "High Voltage Power Supply" on page 6-46 for further tests.
- The Low Voltage Power Supply is working improperly. Refer to "Low Voltage Power Supply" on page 6-44.

## OT (Over-Temperature)

All OT indications originate from the amplifier modules. The 150 VA amplifier module passes the OT signal to the Amplifier Control board via the sixty-pin ribbon cable whenever its semiconductor heatsink temperature exceeds 85° C.

OT indications should never occur during normal operation. However, if the instrument is operated in a hot environment (> 50° C) or with its air intake and/or exhaust blocked, then OT is a normal protective source shut-down function.

**Solutions:**

- Verify that the above conditions do not apply.
- Verify the seating and connections of the Amplifier Control board.
- Verify that the instrument has not been running with its top cover off and its outputs on.
- Verify that the fan runs when the instrument is turned on. If not, refer to "Circuit Breaker and Fan" on page 6-43.

If none of these solve the problem, the Current and Voltage Amplifier modules are suspect.

## TR (Trip)

A networked F2300 SLAVE unit has detected an error and tripped.

**Solution**

- Examine the front display for the error indicator and refer to the F2300 manual for troubleshooting solutions.

## Internal Amplifier 5 V Error

If the Front Panel displays the *5 V* error on either **SOURCE** LED:

**DANGER**

**Disconnect the power cord and wait at least two minutes before removing or installing any amplifier module.**

1. Remove the Slot 0 (Voltage Amplifier) module.
2. Power up the instrument and determine if the indication persists.
   - If no, then replace the module.
   - If yes, proceed to Step 3.
3. Power down (removing the power cord and waiting two minutes) and repeat Steps 1 and 2 for the remaining modules in the following order until the condition is resolved:
   - Slot 1 (current, F2250, F2253 only)
   - Slot 2 (current, F2250, F2252, F2253 only)
   - Slot 3 (current)

**NOTE**

**Return all modules to their original slots.**

If removing all the Voltage and Current Amplifier modules does not eliminate the indication, then the Amplifier Control board, sixty-pin ribbon cable, or Amplifier backplane is suspect.

To determine which is defective:

1. Turn the power off and wait two minutes.
2. Disconnect the sixty-pin ribbon cable.
3. Turn the power on.
   - If the indication *persists*, the Amplifier Control board may be defective. Proceed to Step 4.
   - If the indication *ceases*, the sixty-pin ribbon cable or the Amplifier backplane is probably defective. Proceed to Step 5.
4. Replace the Amplifier Control board (See "Amplifier Control Board" on page A-6).
5. Refer to "Amplifier Backplane (PN# 04D-0581)" on page 6-20, which explains how to validate the voltage across the backplane. If the voltage is within expectations the cable is bad.

## No Output

If a *no source output* problem is associated with an ER, TM, PS, or OT front panel indication, then refer to these sections first.

If no source output is available on all sources and ranges, and no front panel ER, OT, TM, or PS indication is present, then refer to "Low Voltage Power Supply" on page 6-44.

If neither of these conditions applies, then a problem exists in the printed circuit card cage. Perform board contact cleaning below.

### Board Contact Cleaning

Depending on the options purchased with the instrument, it may have either a WG2 or a TWG board.

To clean the board contacts:

1. Turn the power off and disconnect the power cable.
2. Remove and insert the board into its connectors to clear dirty contacts.

   If any large IC packages are present in sockets, push down on them to ensure they are fully seated.
3. Power-up the unit.

   If replacing the board does not restore the outputs, then all the printed circuit boards in the card cage are suspect.
4. Turn the power off and remove the power cord.
5. Remove and insert each board in the CPU backplane.

   If any large IC packages are present in sockets, push down on them to make sure they are fully seated.
6. If this does not restore the outputs, contact Doble Customer Service.

## Battery Simulator Diagnostics

If the rest of the instrument functions normally, but the Battery Simulator is not operating correctly, there is an improper voltage output, or an *ER* error message appears, do the following:

1. Check cable connections, especially the W37 cable.

   It is also possible that the DCT board is at fault. This is connected to the Battery Simulator board assembly with a W36 ribbon cable. Measure the voltage values for the DCT board.

   Using test point 4 as GND (see Figure 6.5 on page 6-7):

2. Measure the +5 V on test point 1.
3. Measure the +15 V on test point 2.

   If these values are:

   - Valid, proceed to Step 4.
   - Not valid, replace the board as explained in "Digital Contact Timer Board" on page A-5.

4. Power-down the unit.

**WARNING** **Attempting to perform operations inside the unit before two minutes has expired poses a serious shock hazard to the user and can result in equipment damage.**

5. Remove the Current Amplifiers in Slots 2 and 3.
6. Loosen the four Phillips head screws at the four corners of the Battery Simulator board and gently pull the board out.
7. Power-up the unit.
8. Measure the resistance across the Battery Simulator board fuse, position F1, by placing an ohmmeter on its contacts on the back of the board (See Figure 6.10 on page 6-12).

   If the position is:

   - Not shorted, then proceed to Step 9.
   - Shorted, then contact Customer Service.

9. Refer to "Battery Simulator" on page B-10 for instructions on how to replace the simulator.

# F2250 System Checks

Remove the top cover of the instrument. Refer to Figure 6.2 on page 6-3 during the following tests.

## Circuit Breaker and Fan

If the fan is not operating:

1. Turn on the F2250.
2. Determine whether any front panel or internal lights are illuminated.

   If any illuminate the circuit breaker is OK.
3. Disconnect the plug (120 V or 240 V) mounted directly over the fan.
4. Verify the AC voltages are in range by inserting voltmeter probes into the pins of the 120V or 240V connector from Wire Color 1 to Wire Color 2 as indicated in Table 6.7.

***Table 6.7 Circuit Breaker and Fan Voltage Test***

| Wire Color 1 | Wire Color 2 |
|---|---|
| Blue | Black |
| Brown | Gray |

Expected voltages are:

| | |
|---|---|
| 120 V Connection | 115 VAC to 120 VAC |
| 240 V Connection | 235 VAC to 240 VAC |

If these voltages are:

| | |
|---|---|
| Out of range | The wiring or connector may be faulty.<br>Replace connector and wiring. |
| In range | The fan has failed; replace the unit.<br>Refer to "Fan" on page A-16 for a replacement procedure. |

## Low Voltage Power Supply

If there is an error indication for the Low Voltage Power Supply:

1. Turn on the F2250.
2. Using test point 2 of the Amplifier Control board as GND, verify the DC voltages as in Table 6.8.

***Table 6.8 Low-Voltage Power Supply Test***

| Test Point on the Amplifier Control Board (Slot 6) | Expected Voltage Range for Low Voltage Power Supply |
|---|---|
| TP1 | +4.75 to +5.25 VDC |
| TP4 | +14.5 to +15.5 VDC |
| TP5 | –14.5 to –15.5 VDC |

If any of the voltages are out of range, then the cable and connector assembly between the +5/+15/–15 VDC power supply and the CPU backplane is suspect.

3. Disconnect the power cord and wait two minutes.
4. Disconnect the W7 cable from the backplane at connector J3.
5. Reconnect the power cord and turn the F2250 on.

6. Check the voltages using the disconnected end of the cable from Step 4, and compare them with the expected values given in Table 6.9.

***Table 6.9 Low Voltage Power Supply Test***

| Test Point | Expected Voltage |
|---|---|
| Pin 1 to Pin 4 | +5 V |
| Pin 8 to Pin 4 | +15 V |
| Pin 10 to Pin 4 | −15 V |

If:

- All voltages are valid, proceed to Step 7.
- Any voltage is incorrect, proceed to Step 8.

7. Replace each PC board in any sequence, return to Step 2 and repeat the procedure until the bad board is found.
8. Swap another Low Voltage Power Supply into the unit and retest the value in Table 6.8. Refer to "Low Voltage Power Supply" on page A-11 for the replacement procedure.

**NOTE**

**Check all cables for burn or other damage.**

## High Voltage Power Supply

If there is an error indication for the High Voltage Power Supply:

1. Turn on the F2250.
2. Verify the DC voltage given in Table 6.10 using the three-pin connector J13 on the Amplifier backplane (Figure 6.13 on page 6-15):

***Table 6.10 High Voltage Power Supply Test***

| Test Point | Expected Voltage Range |
|---|---|
| Blue wire to yellow wire | +295 to +375 VDC |

If this voltage is out of range, the AC input line voltage is either too high or too low.

3. Verify the AC input as given in Table 6.11.

   Refer to drawing 03D-1151 in Appendix E.

***Table 6.11 High Voltage Power Supply AC Input Test***

| Voltage Configuration | Test Point on AC Front End Board | Expected Voltage Range |
|---|---|---|
| 115 VAC | W8 to W10 | 105 to 132 VAC |
| 230 VAC | W8 to W10 | 210 to 264 VAC |

If this voltage is within range, the 350 VDC power supply is suspect. See "AC Front End (High Voltage Power Supply)" on page A-13.

## Amplifier Module and Amplifier Control Board Tests

This procedure is split into two sub-sections:

*Part 1* A test that validates the amplifier system for using a voltage and current configuration

*Part 2* A test that validates the amplifier system for using a current configuration

To perform an amplifier module and control board test:

*Part 1*

1. Set up the conditions indicated in Table 6.12.

***Table 6.12 Amplifier Module and Control Board Test - Part 1***

| Source | Source Design | Phase | Amplitude | Range | Hz | Output | Load |
|---|---|---|---|---|---|---|---|
| 1 | VA | 0 | 75 V | 75 V | FL | On | Open |
| 2 | I1 | 0 | 7.5 A | 7.5 A | FL | On | Short |

2. Verify that the *source on* LEDs on the Amplifier Control board illuminate one second after the front panel **ON/ENABLE** button is set to *on*.
   - If this does not occur, then the problem is most likely the Amplifier Control or CPU board, though any of the card cage boards could be at fault.

     Proceed to Step 3.
   - If any of the overcurrent indicator LEDs on the Amplifier Control board come on during this test, then a problem may exist with one or more of the amplifier modules.

     Proceed to Step 3.
   - If no problems occur, proceed to Step 4.
3. Swap a spare module or board into the unit until no problems occur. Proceed to Step 4.

**DANGER**

**Always power-off the instrument and wait two minutes before inserting or removing any of the printed circuit boards or amplifier modules.**

*Part 2*

4. Set up the conditions indicated in Table 6.13 and repeat Step 2 (Models F2250,F2252,F2253 only):

***Table 6.13 Amplifier Module and Control PCB Test - Part 2***

| Source | Source Design | Phase | Amplitude | Range | Hz | Output | Load |
|---|---|---|---|---|---|---|---|
| 1 | I1 | 0 | 7.5 A | 7.5 A | FL | On | Short |
| 2 | I2 | 0 | 7.5 A | 7.5 A | FL | On | Short |

If there is an error indication on the **I1** LED, such as an *ER* or a *TM* indication, then the mode relay is suspect.

The mode relay coil control signal originates on the Amplifier Control board, then travels down the W5 ribbon-cable to the Amplifier backplane, then through a four-pin connector to a wire cable to the relay.

5. Set **SOURCE 1** to the *Current* mode and measure the voltage from pin 1 to pin 4 of the J14 connector on the Amplifier backplane.

   If 14 VDC is:

   - Present, then the mode relay is good. Proceed to Step 6.
   - Not present, then the mode relay is bad. Replace the mode relay and retest from Step 4.

**NOTE**

**If the Battery Simulator option is installed the J14 connector is inacessible. Perform the alternate Step 5 given below:**

**Alternate Step 5: Swap a mode relay from another unit into the F2250 and return to Step 4.**

6. Swap a W5 cable from another unit into the F2250 and return to Step 4.

   If none of the above are successful, call Doble Customer Service.

**NOTE**

**After swapping assemblies between instruments, the highest level of source output accuracy will be maintained if non-defective modules are returned to their original instrument and slot location after troubleshooting.**

# Appendix A. Field Replaceable Units

The F2250 family of instruments is comprised of the combination of board configurations shown in Figure A.2. The procedures that follow explain the module replacement procedures to reconfigure the following F2250 field replaceable units (FRUs):

| | |
|---|---|
| V-amp | See "Voltage Amplifier Module" on page A-3. |
| I-amp | See "Current Amplifier Module" on page A-4. |
| Digital Contact Timer | See "Digital Contact Timer Board" on page A-5. |
| Amplifier Control | See "Amplifier Control Board" on page A-6. |
| CPUIII | See "CPUIII Board" on page A-7. |
| Waveform Generator | See "Waveform Generator Board (WG2) or TWG" on page A-8. |
| Timing State Generator | See "Timing State Generator Board (TSG)" on page A-9. |
| Low Voltage Power Supply | See "Low Voltage Power Supply" on page A-11. |
| Fan | See "Fan" on page A-16. |
| AC Front End (High Voltage Power Supply) | See "AC Front End (High Voltage Power Supply)" on page A-13. |
| Front Panel | See "Front Panel" on page A-17. |
| Timer Front End | See "Timer Front End" on page A-21. |

## F2250 Configuration Graphics

Figure A.1 and Figure A.2 show the F2250 faceplate and a view of the F2250, including notations of its various configurations.

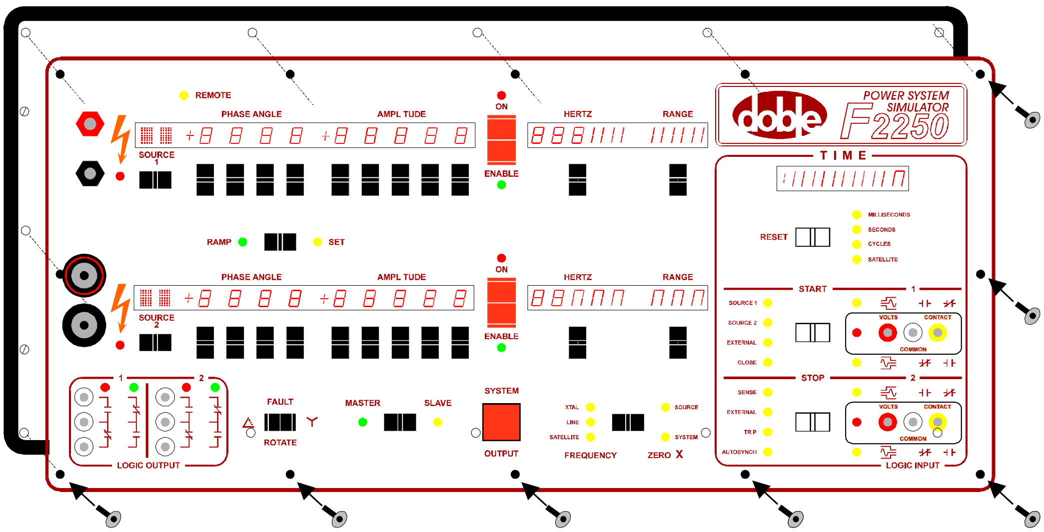



*Figure A.1  F2250 Faceplate Configuration*

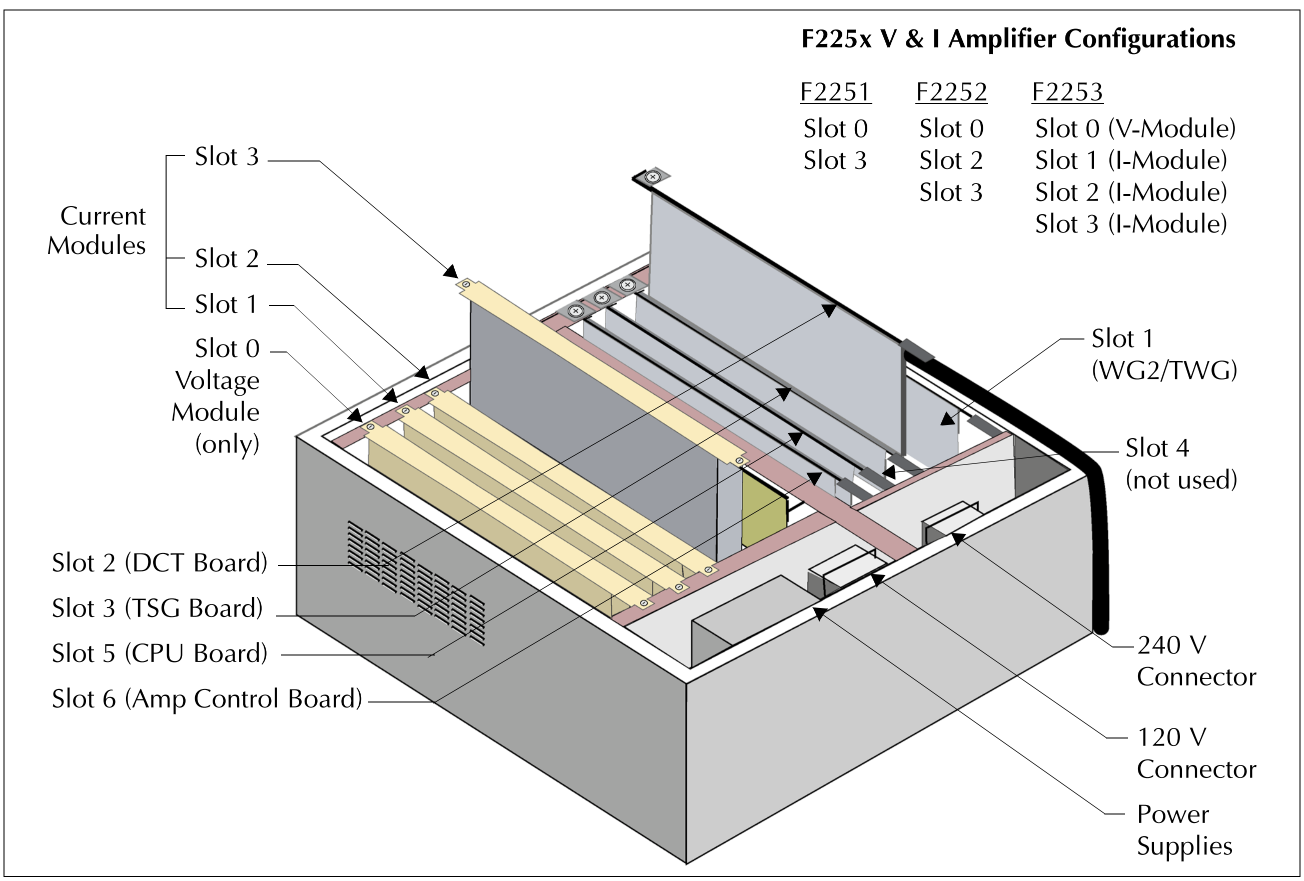



*Figure A.2  F2250 Configuration*

## Voltage Amplifier Module

Important features of the Voltage Amplifier module (PN# 04D-0579) are:

- Thirty-two pin and a sixty-four pin connectors that seat into Slot 0 of the amplifier backplane
- Separator nut, unique to the Voltage Amplifier module, is provided to ensure that the Voltage Amplifier module is not installed into a current slot

**NOTE**

**Modules temporarily removed during maintenance must be replaced in their original positions. Doble provides adhesive labels for use in marking amplifier positions. To ensure that modules are replaced properly, install these labels as soon as the unit is put into service.**

To replace the Voltage Amplifier module:

1. Turn the **POWER** switch off and remove the power cord.
2. Wait a minimum of two minutes so that the voltage present in the system can bleed off.

**WARNING**

**Attempting to remove the module before two minutes has expired poses a serious shock hazard to the user and can cause damage to equipment.**

3. Unscrew the two knurled nut screws located in the right and lefthand corners of the module.

**NOTE**

**Be careful when removing or installing this module. The coil located at position L10, (See Figure 6.15 on page 6-17) on the lower left side of the module, is close to the edge of the board and is easily dislodged.**

4. Pull the module straight up and out.
5. Position the sides of the replacement module PCB board into the brown slides provided, and push straight down. Gently adjust the module until the two multi-pin connectors on the bottom of the module board click into their respective positions.
6. Tighten the two knurled nut screws loosened in Step 3.

## Current Amplifier Module

The Current Amplifier module (PN# 04D-0578) connects to the amplifier backplane using a thirty-two pin connector, a sixty-four pin connector, and a five pin connector. Current Amplifier modules seat into Slots 1 to 3.

NOTE

**Modules temporarily removed during maintenance must be replaced in their original positions. Doble provides adhesive labels for use in marking amplifier positions. To ensure that modules are replaced properly, install these labels as soon as the unit is put into service.**

To replace a Current Amplifier module:

1. Turn the **POWER** switch off and remove the power cord.
2. Wait a minimum of two minutes so that the voltage present in the system can bleed off.

WARNING

**Attempting to remove the module before two minutes has expired poses a serious shock hazard to the user and can cause damage to equipment.**

3. Unscrew the two knurled nut screws located in the right and lefthand corners of the module.
4. Pull the module straight up and out.
5. Position the sides of the replacement module PCB board into the brown slides provided and push straight down. Gently adjust the module until the multi-pin connectors on the bottom of the module board click into their respective positions.
6. Tighten the two knurled nut screws loosened in Step 3.

## Digital Contact Timer Board

The Digital Contact Timer (DCT) board (PN# 04D-0587) connects to the CPUIII backplane using two sixty-four pin connectors and must be located in Slot 2.

To replace the DCT board:

1. Turn the **POWER** switch off and remove the power cord.
2. Remove the center bar by removing the two Phillips head screws.
3. Disconnect the W36 (if the Battery Simulator is present), W28 and W29 cables from the DCT board.
4. Loosen the two knurled nut screws located on bottom and top of the righthand side of the board.
5. Pull the board ejector to unlock the board and pull the board straight up and out.
6. Position the left side of the replacement PCB board into the slide provided and push straight down. Gently adjust the module until the two multi-pin connectors on the bottom of the module board click into their respective positions.
7. Tighten the two screws loosened in Step 4.
8. Reconnect the W36 (if the Battery Simulator is present), W28 and W29 cables to the DCT board.
9. Re-install the center bar.

## Amplifier Control Board

The Amplifier Control board (PN# 04D-0580) connects to the CPUIII backplane using two sixty-four pin connectors that must be seated in Slot 6.

To replace the Amplifier Control board:

1. Turn the **POWER** switch off and remove the power cord.
2. Remove the center bar by removing the two Phillips head screws.
3. Disconnect the W36 cable (if the Battery Simulator is present) from the DCT board in Slot 2.
4. Disconnect the W5 cable from the Amplifier Control board.
5. Disconnect the W1 cable from the CPUIII board in Slot 5.
6. Loosen the two knurled nut screws located on bottom and top of the righthand side of the board.
7. Pull the board ejector to unlock the board and pull the board straight up and out.
8. Position the left side of the replacement PCB board into the slide provided and push straight down. Gently adjust the module until the two multi-pin connectors on the bottom of the module board click into their respective positions.
9. Tighten the two screws loosened in Step 6.
10. Reconnect the W5 cable to the Amplifier Control board.
11. Reconnect the W36 cable (if the Battery Simulator is present) to the DCT board.
12. Reconnect the W1 cable to the CPUIII board.
13. Re-install the center bar.

## CPUIII Board

The CPUIII board (PN# 04D-0590) connects to the CPUIII backplane using two sixty-four pin connectors and must be seated in Slot 5.

To replace the CPUIII board:

1. Turn the **POWER** switch off and remove the power cord.
2. Remove the center bar by removing the two Phillips head screws.
3. Disconnect the W36 cable (if the Battery Simulator is present) from the DCT board.
4. Disconnect the W1 cable from the CPUIII board.
5. Loosen the two knurled nut screws located on bottom and top of the righthand side of the board.
6. Pull the board ejector to unlock the board and pull the board straight up and out.
7. Position the left side of the replacement PCB board into the slide provided and push straight down. Gently adjust the module until the two multi-pin connectors on the bottom of the module board click into their respective positions.
8. Tighten the two screws loosened in Step 5.
9. Reconnect the W36 cable (if the Battery Simulator is present) to the DCT board.
10. Reconnect the W1 cable to the CPUIII board.
11. Re-install the center bar.

## Waveform Generator Board (WG2) or TWG

The WG2 board (PN# 04D-0600) or TWG (PN# 04D-0479) connects to the CPUIII backplane using two sixty-four pin connectors and must be seated in Slot 1.

To replace this board:

1. Turn the **POWER** switch off and remove the power cord.
2. Remove the center bar by removing the two Phillips head screws.
3. Disconnect the W29 cable from the DCT board in Slot 2.
4. Disconnect the W28 cable from the WG board in Slot 1.
5. Loosen the two knurled nut screws located on bottom and top of the righthand side of the board.
6. Pull the board ejector to unlock the board and pull the board straight up and out.
7. Position the left side of the replacement PCB board into the slide provided and push straight down. Gently adjust the module until the two multi-pin connectors on the bottom of the module board click into their respective positions.
8. Tighten the two screws loosened in Step 5.
9. Reconnect the W29 cable to the DCT board.
10. Reconnect the W28 cable to the WG board.
11. Re-install the center bar

## Timing State Generator Board (TSG)

The TSG board (PN# 04D-0586-01 or 03) connects to the CPUIII backplane using two sixty-four pin connectors and must be seated in Slot 3.

**NOTE**

**The TSG board denoted by PN 04D-0586-03 is the only TSG board with satellite capability.**

The procedure for replacing this board also includes swapping the PAL chip onto the replacement board. Refer to "Timing State Generator Board (TSG) Upgrade" on page B-3 for test procedures to validate its performance. Installation consists of the following sub-procedures:

To replace the TSG board:

1. Turn the **POWER** switch off and remove the power cord.
2. Remove the center bar by removing the two Phillips head screws.
3. Disconnect the W36 (if the Battery Simulator present) cable from the DCT board in Slot 2.
4. Loosen the two knurled nut screws located on bottom and top of the righthand side of the board.
5. Pull the board ejector to unlock the board and pull the board straight up and out.
6. Locate Options PAL chip in location U28 (See Figure A.3 on page A-10) and use an IC extractor or small flathead screwdriver to remove the PAL chip.

**NOTE**

**The new chip must be installed in the same orientation on the TSG board as the original chip. This notched end of the PAL chip must point towards the lefthand side of the PC board. Make sure that all pins are in good condition.**

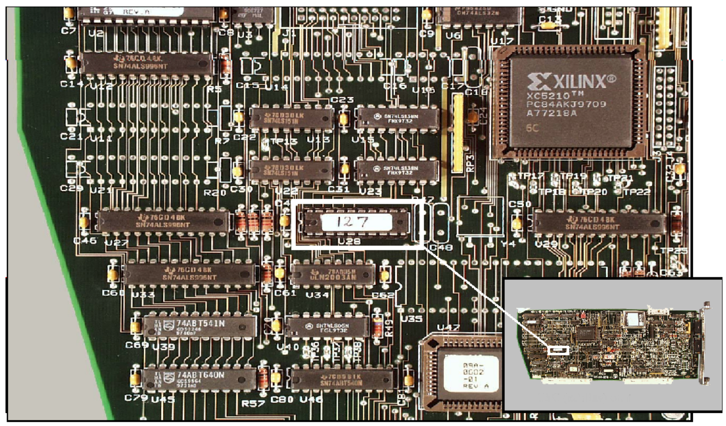



***Figure A.3  TSG Board - PAL Chip Location***

Store the removed TSG board in a safe location. This board can be used as a spare in other F2250 instruments.

7. Install the new PAL chip.
8. Position the left side of the replacement PCB board into the slide provided and push straight down. Gently adjust the module until the two multi-pin connectors on the bottom of the module board click into their respective positions.
9. Tighten the two screws loosened in Step 4.
10. Reconnect the W36 cable (if the Battery Simulator is present) to the DCT board.

## Low Voltage Power Supply

To replace the Low Voltage Power Supply (PN# 03D-1151-01):

**WARNING**

**Attempting to remove the module before two minutes has expired poses a serious shock hazard to the user and can cause damage to equipment.**

1. Turn the **POWER** switch off and remove the power cord.
2. Wait a minimum of two minutes so that the voltage present in the system can bleed off.
3. Unscrew the two knurled nut screws located at the top of the Voltage Amplifier Module residing in Slot 0 and remove the module (refer to "Voltage Amplifier Module" on page A-3).

**NOTE**

**Modules must replaced to their original slots.**

4. Repeat Step 3 for each of the Current Amplifier Modules residing in Slots 1 to 3 (Refer to "Current Amplifier Module" on page A-4).
5. Remove the module slide rail by removing the six screws shown in Figure A.4.

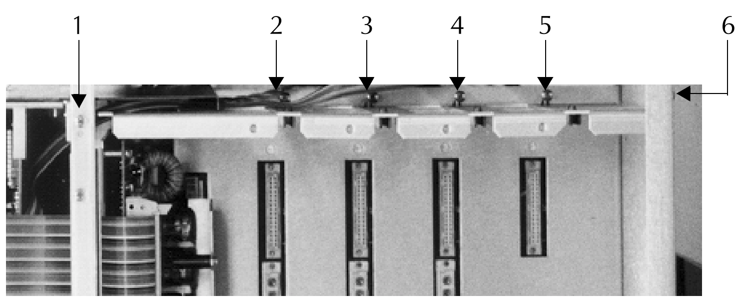



***Figure A.4 Mounting Rail Screws***

6. Disconnect the five-position plug from the J1 connector.
7. Disconnect the thirteen-position plug from the J2 connector.
8. Remove the four Phillips head screws in the four corners of the board and remove the Low Voltage Power Supply assembly.
9. Place the replacement assembly in to position and secure using the four screws from Step 8.
10. Reconnect the five-position plug into the J1 connector.
11. Reconnect the thirteen-position plug into the J2 connector.
12. Re-install the module slide rail by securing the six screws shown in Figure A.4.

13. Plug the unit in and turn the power on.

14. Perform a test point check to validate operation. See "F2250 Unit Validation Test" on page 6-20.

15. Turn the **POWER** switch off and remove the power cord.

16. Wait two minutes for the voltage in the system to bleed off.

17. Return the Current Amplifier and Voltage Amplifier Modules to their correct positions.

## AC Front End (High Voltage Power Supply)

To replace the AC Front End:

**WARNING**

**Attempting to remove the module before two minutes has expired poses a serious shock hazard to the user and can cause damage to equipment.**

1. Turn the **POWER** switch off and remove the power cord.
2. Wait a minimum of two minutes so that the voltage present in the system can bleed off.
3. Unscrew the two knurled nut screws located at the top of the Voltage Amplifier Module residing in Slot 0 and remove the module (refer to "Voltage Amplifier Module" on page A-3).
4. Repeat Step 2 for each of the Current Amplifier Modules residing in Slots 1 to 3 (Refer to "Current Amplifier Module" on page A-4).
5. Remove the module slide rail by removing the six screws shown in Figure A.5.

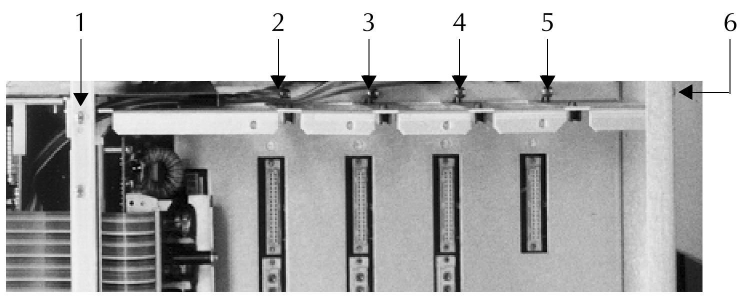



***Figure A.5 Mounting Rail Screws***

6. Remove the Low Voltage Power Assembly using the procedure explained in "AC Front End (High Voltage Power Supply)" on page A-13.
7. Disconnect the W6 ribbon cable from the AC Front End assembly.
8. Disconnect the three-position plug from position J1 of the AC Front End assembly.
9. Disconnect the five-position plug from J4 of the AC Front End assembly.

10. Disconnect the following wires from the AC Front End assembly:
   - W1
   - W2
   - W5
   - W7
   - W8
   - W9
   - W10
11. Remove the four Phillips head screws in the four corners of the board and remove the AC Front End assembly.
12. Place the replacement assembly into position and secure it using the four screws from Step 10.
13. Reconnect the W6 ribbon cable to the AC Front End assembly.
14. Reconnect the three-position plug to position J1 of the AC Front End assembly.
15. Reconnect the five-position plug to J4 of the AC Front End assembly.
16. Reconnect the wires to the indicated position on the AC Front End assembly as shown in Table A.1.

***Table A.1 AC Front End Wire Connections***

| Wire Color | From | To (AC Front End) |
|---|---|---|
| Black | Diode Bridge DC– | W1 |
| White | Diode Bridge AC (top right) | W2 |
| Red | Diode Bridge DC+ | W5 |
| Red | E1 / AC Front End board | W7 |
| Brown | Input RFI Filter (lower right side) | W8 |
| White/Blue | Diode Bridge AC (bottom left) | W9 |
| Blue | Input RFI Filter (lower left side) | W10 |

17. Re-install the module slide rail by securing the six screws shown in Figure A.5.
18. Plug the unit in and turn the power on.
19. Perform a test point check to validate operation. See "F2250 Unit Validation Test" on page 6-20.
20. Turn the **POWER** switch off and remove the power cord.
21. Wait two minutes for the voltage in the system to bleed off.
22. Return the Current Amplifier and Voltage Amplifier Modules to their correct positions.

# Fan

To replace the fan assembly:

**WARNING**

**Attempting to remove the fan before two minutes has expired poses a serious shock hazard to the user and can result in equipment damage.**

1. Turn the **POWER** switch off and remove the power cord.
2. Wait a minimum of two minutes so that the voltage present in the system can bleed off.
3. Remove the top rail by removing the five screws shown in Figure A.6.

**NOTE**

**The sixth screw is present only if the Battery Simulator option is installed. This additional screw mounts the Battery Simulator to the top rail.**

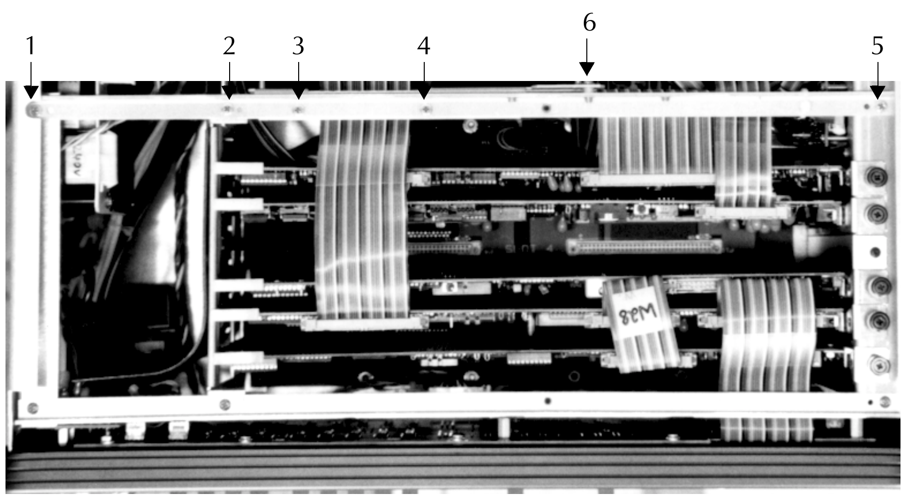



*Figure A.6 Mounting Rail Screws*

4. Disconnect the 120 V or 240 V plug.
5. Remove the four nuts and screws on the exterior of the unit that mount the fan assembly to the exhaust vent.
6. Slip the entire unit to the left and pull straight up.
7. Insert and mount the new unit (PN# 05C-0530).
8. Re-install the top rail bar using the screws removed in Step 3.

## Front Panel

To replace the Front Panel board:

1. Turn the **POWER** switch off and remove the power cord.
2. Remove the twelve hex screws on the front of the unit and lift off the faceplate.
3. Remove the center bar by removing the two Phillips head screws.
4. Disconnect the:
   - W29 cable from the Front Panel board.
   - Eight-position plug from the back of the Front Panel board. This is position J13 on the front of the board.
   - Four-prong plugs connected to positions J3 and J4 on the back of the Front Panel board.
5. Remove the four flathead screws around the periphery of the front cover that mount it to the unit (Figure A.7).
6. Remove ground screw on left side of panel.

   The Front Panel board, Timer Front End board and front cover pull forward as a unit.

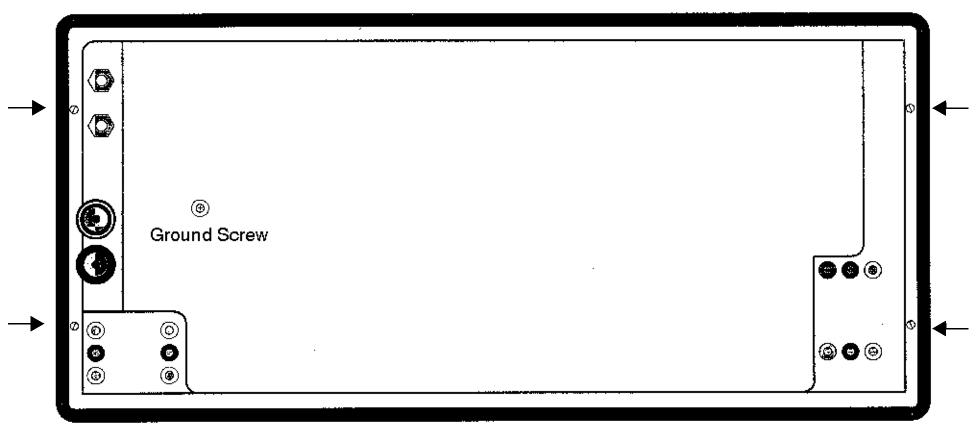



***Figure A.7 Front Cover***

7. Disconnect the Timer Front End board by unscrewing the four Phillips head screws shown in Figure A.8. Each of these screws has an accompanying hex spacer that mounts between the Timer Front End board and the Front Panel board.

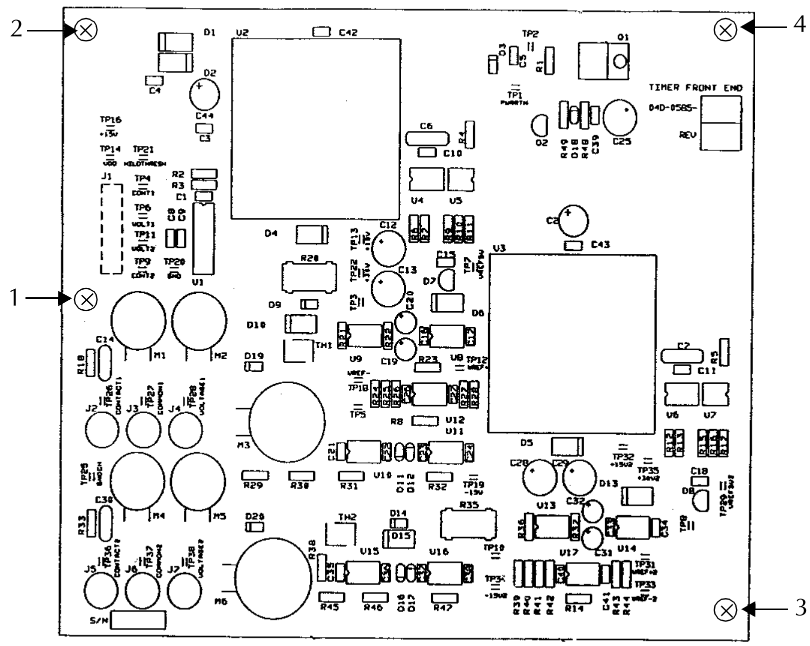



*Figure A.8 Timer Front End Board - Back View*

8. Unscrew the six Phillips head screws on the back of the Timer Front End board that secure the **VOLTS**, **COMMON** and **CONTACT** inputs to the front of the unit. Each of these screws has an accompanying hex spacer that mounts between the Timer Front End board and the Front Panel board.

9. Unscrew the six Phillips head screws on the back of the Front Panel board that secure the **LOGIC OUTPUT** contacts to the front of the unit.

**10.** Unscrew the following:

- Bottom of the board
  (four hex nuts and two Phillips head screws)
- Top of board
  (three Phillips head screws and one hex nut)
- Left side of board
  (one Phillips head screw accessed on the front of the board)

Each of these items has an accompanying hex spacer that mounts between the Front Panel board and the front of the unit.

**11.** Remove the old board and position the new board.

**12.** Secure the new Front Panel board using the:

- Four hex nuts and two Phillips head screws on the bottom of the board.
- Three Phillips head screws and one hex nut on the top of the board.
- One Phillips Head screw from the left side of the board accessed on the front of the board.

Each of these items has an accompanying hex spacer that mounts between the Front Panel board and the front of the unit.

**13.** Secure the **LOGIC OUTPUT** contacts to the front of the unit, via the back of the Front Panel board, using six Phillips head screws.

**14.** Reconnect the Timer Front End board using the four Phillips head screws removed in Step 7. Each of these screws has an accompanying hex spacer that mounts between the Timer Front End board and the Front Panel board.

**15.** Secure the **VOLTS**, **COMMON** and **CONTACT** inputs to the front of the unit, via the back of the Timer Front End board, using six Phillips head screws. Each of these screws has an accompanying hex spacer that mounts between the Timer Front End board and the Front Panel board.

**16.** Replace the ground screw removed in Step 6.

**17.** Reconnect the front plate to the unit using the four flathead screws (Figure A.7).

**18.** Reconnect the:

- Eight-position plug to the back of the Front Panel board, which is position J13 on the front of the board.
- W29 cable from the Front Panel board.
- Four prong plugs connected to positions J3 and J4 on the back of the Front Panel board.

**19.** Replace the faceplate and screw in the twelve hex screws on the front of the unit.

**NOTE**

**Be careful in replacing the faceplate to not strip any of the hex screw mounting holes. Do not over-torque the screws.**

**20.** Re-install the center bar.

## Timer Front End

To replace the timer front end board:

1. Turn the **POWER** switch off and remove the power cord.
2. Remove the twelve hex screws on the front of the unit and lift off the faceplate.
3. Remove the center bar by removing the two Phillips head screws.
4. Disconnect the:
    - W29 cable from the Front Panel board.
    - Eight-position plug from the back of the Front Panel board, which is position J13 on the front of the board.
    - Four-prong plugs connected to positions J3 and J4 on the back of the Front Panel board.
5. Remove the four flathead screws around the periphery of the front cover that mount it to the unit (Figure A.9).

   The Front Panel board, Timer Front End board and front plate pull forward as a unit.
6. Remove Phillips head ground screw on left side of panel.

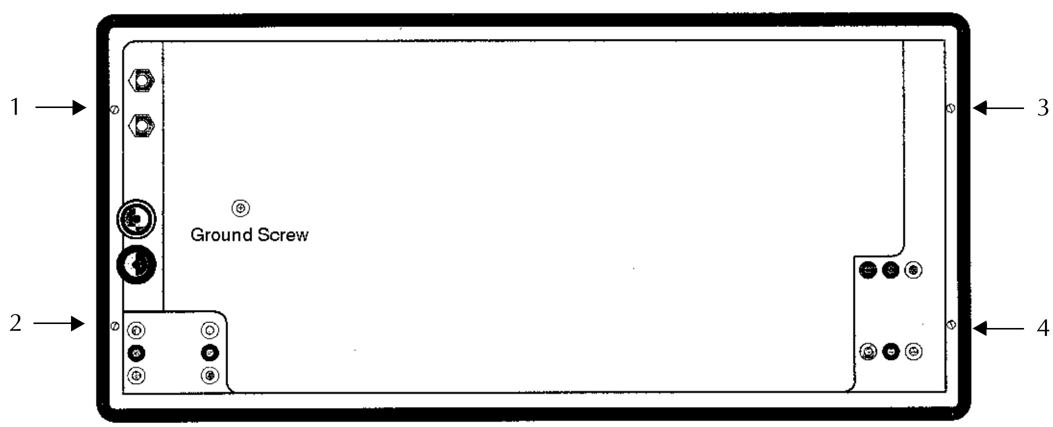



***Figure A.9 Front Cover***

7. Disconnect the Timer Front End board by unscrewing the four Phillips head screws as shown in Figure A.10. Each of these screws has an accompanying hex spacer that mounts between the Timer Front End board and the Front Panel board.
8. Unscrew the six Phillips head screws on the back of the Timer Front End board that secure the **VOLTS**, **COMMON** and **CONTACT** inputs to the front of the unit. Each of these screws has an accompanying hex spacer that mounts between the Timer Front End board and the Front Panel board.

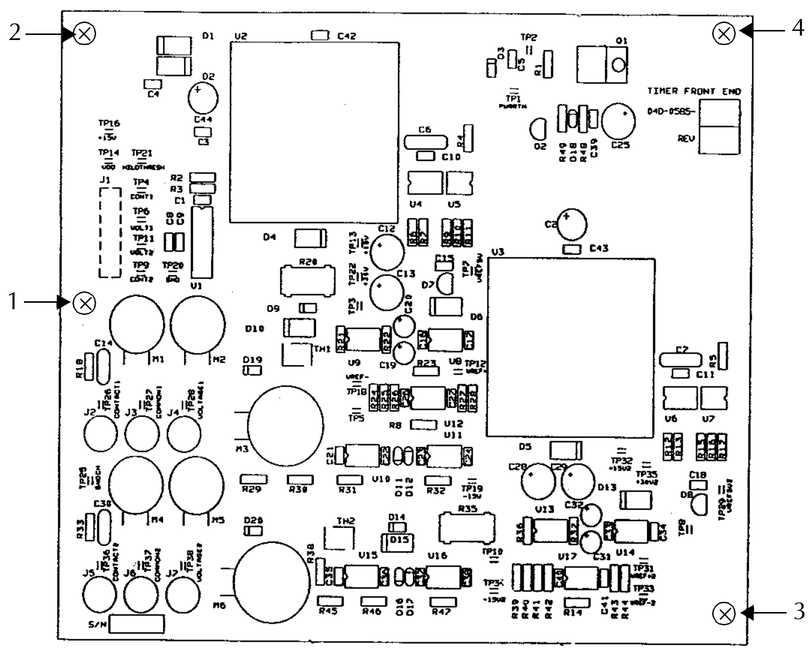



***Figure A.10 Timer Front End Board - Back View***

**9.** Remove the old board and position the new board.

**10.** Reconnect the Timer Front End board using the four Phillips head screws as shown in Figure A.10. Each of these screws has an accompanying hex spacer that mounts between the Timer Front End board and the Front Panel board.

**11.** Secure the **VOLTS**, **COMMON** and **CONTACT** inputs to the front of the unit, via the back of the Timer Front End board, using six Phillips head screws. Each of these screws has an accompanying hex spacer that mounts between the Timer Front End board and the Front Panel board.

**12.** Reconnect the front plate to the unit using the four flathead screws (Figure A.9).

**13.** Reconnect the:

- Eight-position plug to the back of the Front Panel board, which is position J13 on the front of the board.
- W29 cable from the Front Panel board.
- Four-prong plugs connected to positions J3 and J4 on the back of the Front Panel board.

**14.** Replace the ground screw removed in Step 6.

**15.** Replace the faceplate and screw in the twelve hex screws on the front of the unit.

**NOTE**

**Be careful in replacing the faceplate to not strip any of the hex screw mounting holes. Do not over-torque the screws.**

**16.** Re-install the center bar.

# Appendix B. Field Upgrades

The F2250 family of instruments is comprised of the combination of board configurations shown in "F2250 Configuration" on page B-2. The procedures that follow explain the procedures for adding upgrade options to the F2250. These options include:

- Timing State Generator
  (See "Timing State Generator Board (TSG) Upgrade" on page B-3)
- Battery Simulator
  (See "Battery Simulator" on page B-10)
- 120 V to 240 V Conversion
  (See "120 V to 240 V Conversion and Base Frequency from 60 Hz to 50 Hz" on page B-25)
- Flash Firmware Update
  (See "F2250 Family Firmware Updates" on page B-25)

## F2250 Configuration Graphics

Figure B.1 and Figure B.2 show the F2250 faceplate and a view of the F2250, including notations of its various configurations.

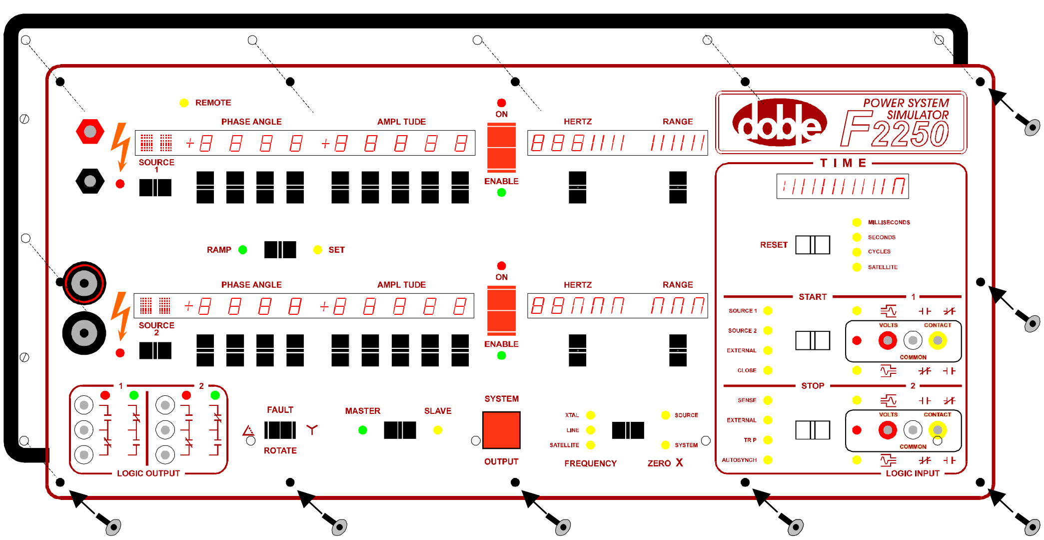



***Figure B.1 F2250 Faceplate Configuration***

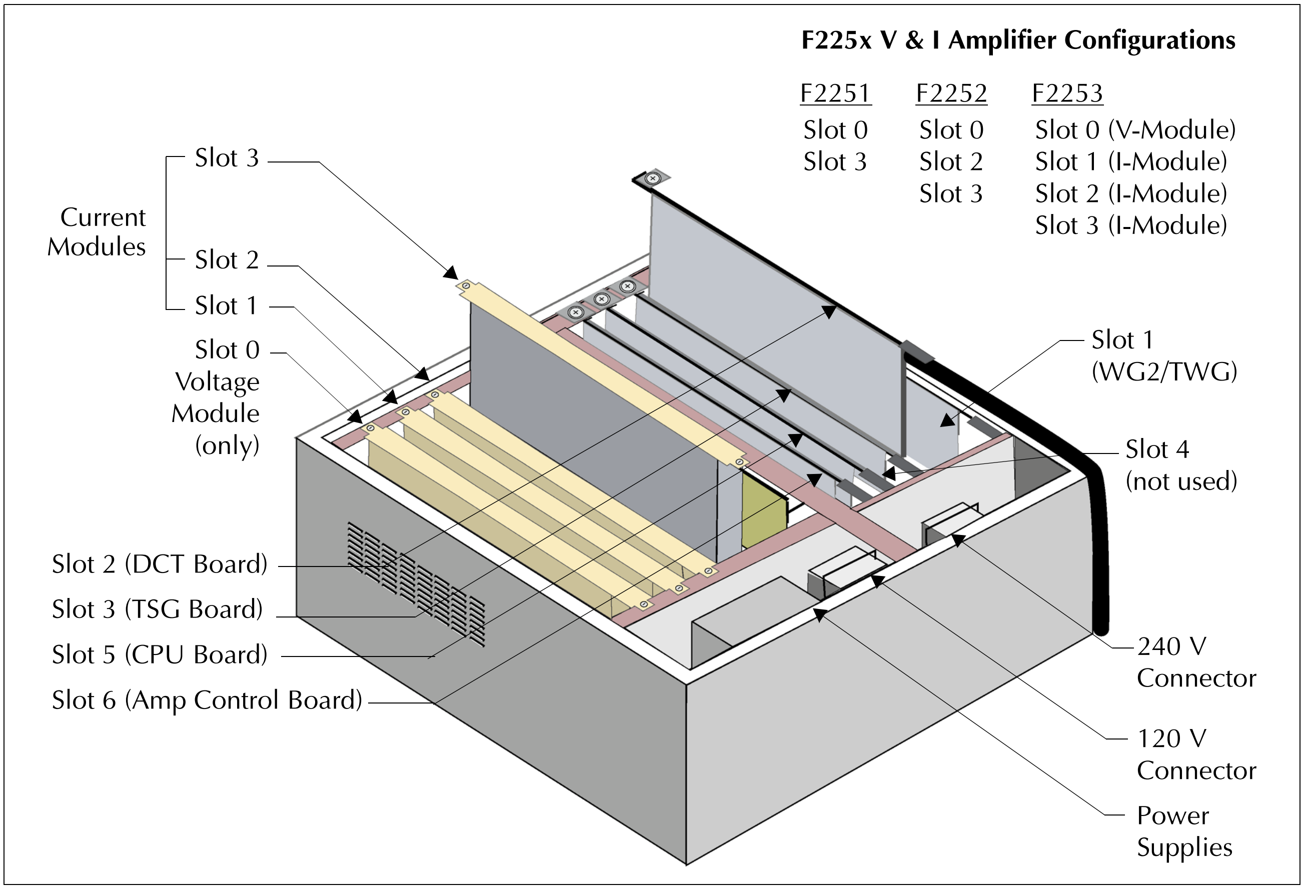



***Figure B.2  F2250 Configuration***

# Timing State Generator Board (TSG) Upgrade

The TSG board connects to the CPUIII backplane using two sixty-four pin connectors and must seat into Slot 3. This procedure assumes that the TSG board is not being replaced; but rather, that a new PAL chip is being installed.

NOTE

**The TSG board denoted by PN 04D-0586-03 is the only TSG board with satellite capability.**

The procedure for upgrading this board also includes several test procedures to fully validate its performance. Installation consists of the following sub-procedures:

- TSG Board PAL Chip Upgrade
- Quick Test for the F2885 Satellite Option
- Testing the TSG Board BNC Inputs
- Testing the TSG Satellite Input

## TSG Board PAL Chip Upgrade

To upgrade the PAL chip:

1. Turn the **POWER** switch off and remove the power cord.
2. Remove the center bar by removing the two Phillips head screws.
3. Disconnect the W36 cable (if Battery Simulator present) from the DCT board in Slot 2.
4. Loosen the two knurled nut screws located on bottom and top of the right side of the board.
5. Pull the card ejector to unlock the board and pull the board straight up and out.
6. Locate the options PAL chip in location U28 (See Figure B.3 on page B-4) and use an IC extractor or small flat-head screwdriver to remove the PAL chip.

**DANGER** **The new chip must be installed in the same orientation on the TSG board as the original chip. This notched end of the PAL chip must point towards the left-hand side of the PC board. Make sure that all pins are in good condition.**

Please see the Important User Information sheet on page B-9.

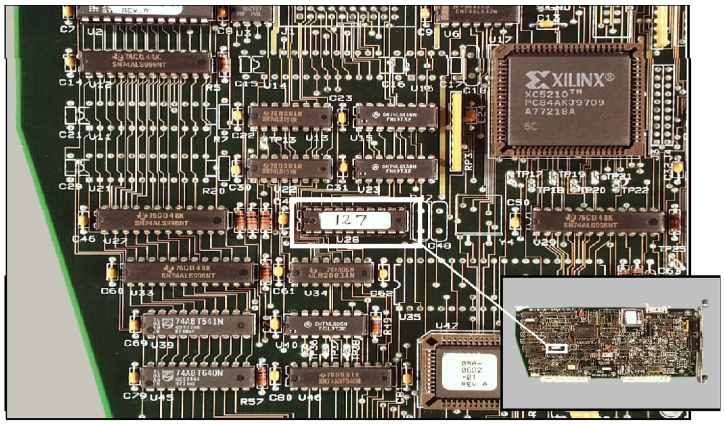


*Figure B.3  TSG Board - PAL Chip Location*

**NOTE** **If replacing the TSG board, store the removed TSG board in a safe location. This board can be used as a spare in other F2250 instruments.**

**7.** Install the new PAL chip.

**8.** Position the left side of the PCB board into the slide provided and push straight down. Gently adjust the module until the two multi-pin connectors on the bottom of the module board click into their respective positions.

**9.** Tighten the two screws loosened in Step 4.

**10.** Reconnect the W36 cable (if Battery Simulator is present) to the DCT board.

## Quick Test for the F2885 Satellite Option

Once the board has been installed, use the following procedure to verify installation:

1. Re-install the power cord and turn the instrument on.

   Wait until the LEDs on front panel of the instrument indicate that it is operational.
2. Hold the **MASTER/SLAVE** switch on the front panel of the instrument in the **SLAVE** position. The right hand side of the **SOURCE 1 RANGE** LED should display a capital *S* for satellite. Release the switch.
3. If the instrument:
   - Displays *S*. Turn the instrument off, remove the power cord and proceed to the Step 4.
   - Does not display *S*. Turn the instrument off, remove the power cord and board. Check to ensure proper alignment and installation of the TSG board and the options PAL chip. If the board and the options PAL chip are installed properly, contact Doble Customer Service.
4. Re-install the center bar.
5. Re-install the top cover.

## Testing the TSG Board BNC Inputs

Once the Quick Test is successfully completed, the BNC inputs must be tested.

**NOTE**

**Testing the F2885 Satellite option requires a satellite controlled clock or Time Code generator with an IRIG-B output and a 1 pulse per second (PPS) output.**

To test these inputs:

1. Install the power cord and turn the instrument on.
2. Press the **STOP** paddle switch to the left once to light the **EXTERNAL** LED.
3. Press the **RESET** paddle switch three times to the right to light the **SATELLITE** LED.

   The **TIME** display should read *No TOD*, which means No Time of Day.

4. Press the **FREQUENCY** paddle switch several times.

   The **SATELLITE** LED should not illuminate.

5. Connect the **IRIG-B** output to the top **BNC** connector and the **1PPS** output connects to the lower **BNC** connector (Figure B.4).

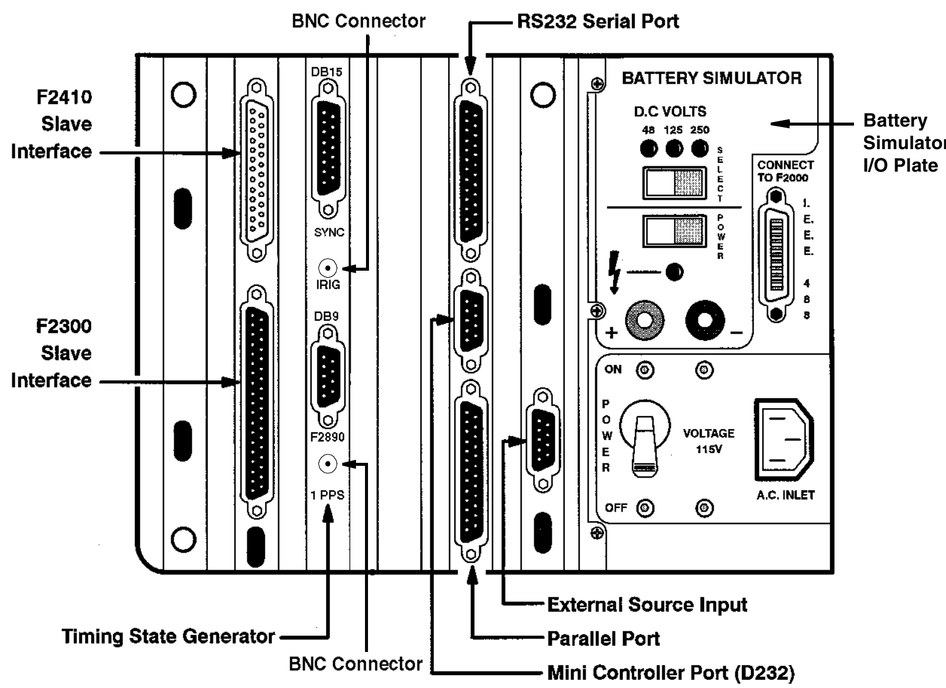



***Figure B.4 Interface Panel with Satellite Option***

6. Apply a test signal. After a short period of time, the **TIME** display should read the same time as the satellite clock.

7. Press the **FREQUENCY** paddle switch three times.

   The **SATELLITE** LED illuminates. When the **FREQUENCY** LED is lit, the frequency generator of the instrument is synchronized to the GPS satellite signals and the base frequency (50 or 60 HZ).

8. Turn the instrument off and disconnect the **1PPS** and **IRIG-B** signals.

## Testing the TSG Satellite Input

The satellite antenna/receiver supplies IRIG-B and position information back to the TSG board via a RS-232 communications link. A separate wire supplies the 1PPS signal. The antenna/receiver must first determine its position in order to supply the correct time. The average time it takes to acquire enough satellites (five) to start supplying IRIG-B and 1PPS is about 15 minutes. Once the position has been determined, only one satellite is required to maintain time.

The antenna/receiver looks directly up and to the side for satellites. Therefore, these areas must be kept clear of obstructions. The clearer the receiving area, the faster the unit acquires satellites.

NOTE

**If the antenna/receiver becomes disconnected or the instrument is powered off, the antenna/receiver will require another 15 minutes to acquire the correct number of satellites again.**

To test the actual satellite input:

1. Turn off the instrument before connecting the satellite receiver.

WARNING

**Since the F2250 powers the satellite receiver via the interconnection cable, failure to turn the instrument off before proceeding can result in damage to the satellite receiver or the TSG board.**

2. Connect the:
   - Round connector of the 100-foot (30-Meter) interconnection cable provided with the F2895 satellite option to the connector on the bottom of the satellite antenna/receiver.
   - DB9 connector of this same cable to the TSG board. See Figure B.4 for connection locations.
3. Place the antenna/receiver in a clear location, connect the antenna/receiver to the instrument and turn the power on.
4. Press the **STOP** paddle switch to the left once to illuminate the **EXTERNAL** LED.

5. Press the **RESET** paddle switch three times to the right to illuminate the **SATELLITE** LED. The **TIME** display should read *No TOD*.
6. Press the **FREQUENCY** paddle switch three times. The **SATELLITE** LED should not illuminate.

   When the antenna/receiver acquires the correct number of satellites, the instrument displays Greenwich Mean Time.
7. Press the **FREQUENCY** paddle switch three times and the **SATELLITE** LED illuminates. When the **FREQUENCY** LED illuminates, the frequency generator of the instrument is synchronized to GPS 1 PPS satellite signals and the base frequency (50 or 60 HZ).
8. Turn the instrument off and disconnect the antenna/receiver.

   Installation is complete.

## User Information Sheet

The user information sheet (Figure B.5) explains Doble procedures for returning PAL chips and provides a written record of the PAL upgrade procedure.

### ***! IMPORTANT USER INFORMATION !***

**INSTALLATION OF NEW OPTIONS IN F2250**
**POWER SYSTEM SIMULATORS OF INSTRUMENTS**

New F2000 options are installed by replacing the original "PAL" integrated circuit labeled "U28" on the Timing State Generator PC Board with the new PAL enclosed with these instructions.

The Timing State Generator Board is the **third** plug-in PC Board, as viewed from the front of the instrument.

In order to install the new option(s) and retain the previously installed option(s), the *correct PAL number* must be installed in the appropriate instrument:

Install PAL Number:

F____ S/N .............................. ________________

F____ S/N .............................. ________________

F____ S/N .............................. ________________

F____ S/N .............................. ________________

***** IMPORTANT *****

**The "notched" end of the PAL must point towards the left-hand side of the PC Board, identical to integrated circuits U22, U23, U15, etc...etc. (See enclosed drawing).**

**When installing the new PAL, ensure that none of the pins are bent or inserted improperly. Then reinstall the board.**

To confirm correct installation of the new and any original options, power up the system, then hold the Master/Slave Switch in the **Slave** position. Consult the F2000 Operating Manual to determine the correct front panel displays for various options.

After installation is complete, all original PALS must be returned in the special antistatic containers, prepaid via UPS Ground or First Class mail to:

Doble Engineering Company
85 Walnut Street
Watertown, MA 02172
Attn: Customer Service

**PLEASE NOTE!**

Original PAL devices not returned within the 10 day period will be considered as unreturned F2000 Options, which will be invoiced at the current list price for each option originally ordered.

Your cooperation is greatly appreciated.

Doble Customer Service

ISO_MKT_145 REV. 01 10/25/96

DOBLE ENGINEERING COMPANY 85 WALNUT STREET WATERTOWN MA 02172

*Figure B.5 User Information Sheet*

# Battery Simulator

This procedure describes how to install a Battery Simulator into the F2250. This procedure is comprised of the following sub-procedures:

- Preparation Work
- Pre-Installation Cabling
- Installing the Battery Simulator Plate
- Restoration Work
- Manually Testing
- Testing with ProTesT

The estimated time to complete this upgrade is 45 minutes.

## Tools Required for Installation

Table B.1 lists the tools required to install the Battery Simulator.

***Table B.1 Tools Required for Installation***

| Type | Size |
|---|---|
| Slotted Screwdriver | N/A |
| Hex Key Wrench | 5/64" |
| Phillips Screwdriver | #2 |
| Open End Wrenches | 1/4"<br>3/16" |
| Nutdrivers | 1/4"<br>3/16"<br>9/32<br>5/16" |
| Long slotted and<br>Phillips head screwdrivers | 10" |
| Loctite® 290 Thread Locker | N/A |

## Field Installation Kit

The items shown in Figure B.6 comprise the Field Installation Kit (PN# 030-1110). The kit is comprised of:

| | |
|---|---|
| **A** | Battery Simulator Plate (PN# 04D-0598) |
| **B** | I/O Plate (PN# 04D-0599) |
| **C** | W14Y Power cable (PN# 05B-0519-02) |
| **D** | W33K Power cable (PN# 05B-0571-01) |
| **E** | W37 cable (PN# 05B-0569) |
| **F** | W30 cable (PN# 05B-0543) |
| **G** | External Load cable (PN# 2FB-1075-07) |

**NOTE**

**If the unit serial number is provided when the replacement kit order is placed, only the power cable required (W14Y or W33K) for that unit type is included with the kit.**

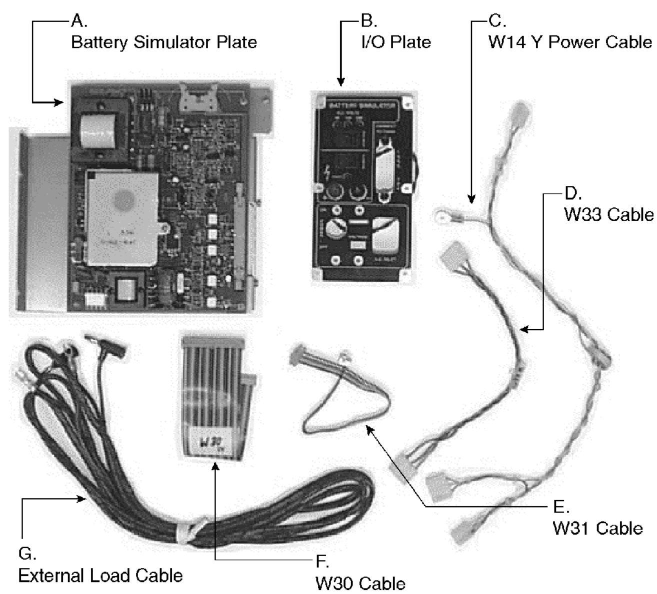



***Figure B.6 Parts Included in the Battery Simulator Field Install Kit***

Before installation, examine all components in the Field Installation Kit for any damage or loosening during shipping.

## Preparation Work

This procedure explains how to prepare the F2250 so that installing or replacing the Battery Simulator unit is easily accomplished. Refer to Figure B.7 for reference during installation.

Preparation work is comprised of two sub-procedures:

- Cover and Module Removal
- I/O Plate Removal

### Cover and Module Removal

To remove the cover and modules:

1. Turn the power **OFF** and remove the power cord.

**WARNING**

**Attempting to remove the module before two minutes has expired poses a serious shock hazard to the user and can cause damage to equipment.**

**Proper antistatic handling procedures must be observed when removing or installing PC boards. Minimum handling procedures require wearing an antistatic wrist strap to dissipate any accumulated static charges to ground that might otherwise cause permanent damage to a PC board.**

2. Remove the top cover of the F2250 unit with a slotted screwdriver. The screw location depends on whether the F2250 instrument has caster wheels or rubber feet.

   If the unit has:

| | |
|---|---|
| Caster wheels | The slotted screw is located on the wheel plate of each wheel. The other three devices are nuts with lock washers. To remove the top cover, only the screws from the top two wheels need to be removed. |
| Rubber feet | The screw is located in the middle of the rubber foot. To remove the top cover, remove the two top rubber feet. |

3. Remove the center bar by removing the two Phillips head screws.
4. Disconnect the W1 ribbon-cable from the CPUIII board.

5. Disconnect the W5 ribbon-cable from the Amplifier Control board and the Amplifier backplane.
6. Mark the Current Amplifier modules in Slots 2 and 3 so they are returned to the same slot.
7. Loosen the knurled nut screws holding the Current Amplifier modules in Slots 3 and 4 and remove the modules.

   Temporarily store the modules in a safe location.

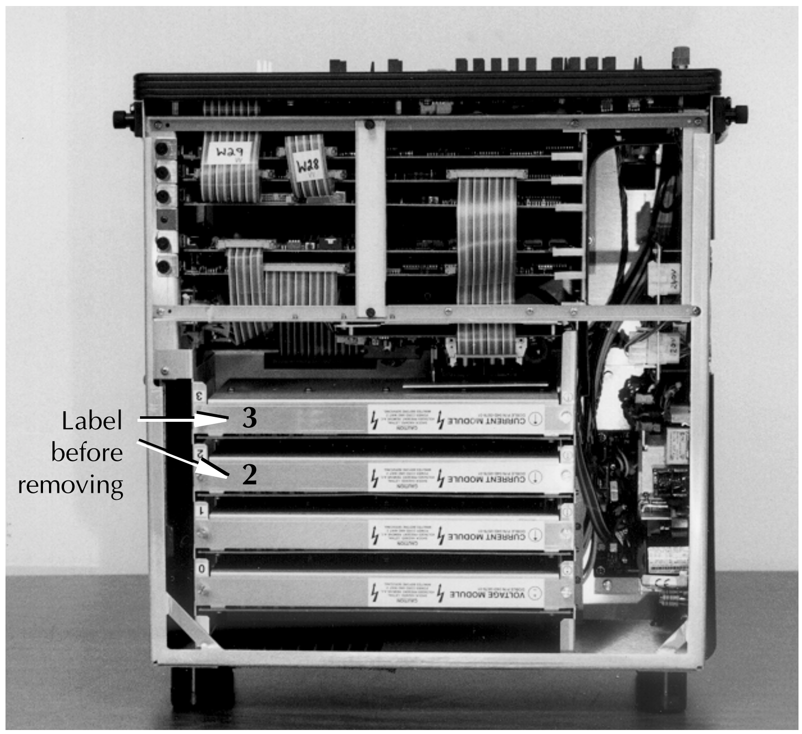



***Figure B.7 F2250 Unit-Current Module Nos. 2 & 3 Labeled for Removal***

**NOTE**

**Not all F2250 configurations require a module in Slot 2.**

## I/O Plate Removal

To remove the existing I/O plate (See Figure B.4 on page B-6):

1. Slide the side door open until the door handle is against the back stop.
2. Gently pull out and hold the end of the black cover guide. Simultaneously, push back on the sliding door and push in on the back of the door until the three screws on the right side of the I/O plate are exposed.
3. Remove the six screws holding the old I/O Plate to the instrument chassis using a 5/64" Hex Key wrench or a #2 Phillips screwdriver.

   These screws are used to attach the new I/O plate to the chassis.
4. Remove the four screws securing the power circuit breaker to the I/O plate with a 5/64" Hex Key wrench. Reserve these screws to re-attach the circuit breaker to the new I/O plate.
5. Remove the power receptacle from the I/O plate by removing the two hex nuts on the back of the unit with a 1/4" nutdriver. Reserve these nuts to reattach the power receptacle to the new I/O plate.
6. Pull the old I/O plate clear of the instrument chassis.
7. Disconnect the IEEE-488 connector using a 9/32 nutdriver to turn the head on the front of the I/O plate while holding the 3/16" nut on the back side secure with the 3/16 open end wrench.

**NOTE**

**The jacksocket may break while attempting to remove it. Two new IEEE jacksockets are provided in the event that the old ones break.**

## Install the I/O Plate with Battery Simulator Options

To install the new I/O plate with the Battery Simulator options:

1. Insert the existing IEEE-488 connector into the new I/O plate.
2. Remove the nuts and two washers, a flat washer and a lock washer, from the back of the IEEE jacksockets on the I/O plate.
3. Install the jacksockets through the I/O plate so that the head is on the front side of the I/O plate and the tail is on the back of the I/O plate. On the front side of the jacksockets, there is a spacer between the jacksocket head and the front face of the I/O socket; *this spacer is critical*.
4. Hold the jacksockets in place and slip the IEEE connector onto the tails of the jacksockets on the back of the I/O plate. Apply a drop of Loctite 290 Thread Locker to the threads.
5. Place a flat washer, followed by a lock washer, then the 3/16" nut onto the tail to secure the connector. Hold the nut in place with a 3/16" wrench and tighten the jacketsocket by turning the head with a 9/32 nutdriver.
6. Hold the new I/O plate near the I/O plate cutout on the chassis of the instrument, with the back facing the instrument. Place the power receptacle into the AC INLET cutout; guided by the threaded studs. Use a 1/4" nutdriver to secure the power receptacle using the nuts saved from the old I/O plate.
7. Place the power circuit breaker switch through the POWER cutout. Use a 5/64" Hex Key wrench to secure the power circuit breaker, through the front of the plate, using the Hex Key head screws saved from the old I/O plate.
8. Align the screw holes on the I/O plate to the screw holes on the I/O plate cutout of the instrument chassis. Secure I/O plate using the six 5/64" or Phillips screws removed from the old I/O plate.

**NOTE**

**DO NOT connect any cables at this time.**

## Pre-Installation Cabling

Before installing the battery simulator plate, the correct power cable to use with the instrument must be determined: W33 K cable or W14 Y. Find the J4 connector, located next to the red MOV V1 disk, on the AC Front End (High Voltage Power Supply) power supply. If the J4 connector has:

- Three pins, then proceed to Step 1 (W33K cable).
- Two pins, then proceed to Step 2 (W14Y cable).

**1.** Install the new W33 K cable, routing it from the battery simulator board J4 connector to the AC Front End J4 connector.

Run the W33 K cable along the bottom of the instrument chassis and thread it between the outside of the card cage and the black air baffle. Do not use cable tie wraps to secure this cable.

Once the cable is installed, proceed to "Installing the Battery Simulator Plate" on page B-18.

**NOTE**

**Both ends of the cable are identical.**

**2.** Install the new W14 Y power cable by replacing the existing W14 cable that runs between the J1 connector on the power supply and the J13 connector on the amplifier backplane. The existing W14 cable consists of a twisted blue and yellow pair of wires with a toroid wrapped in the middle.

a. Disconnect the cable and board connectors by prying back the white tabs on the board connector while gently pulling up on the cable connector (See Figure B.8).

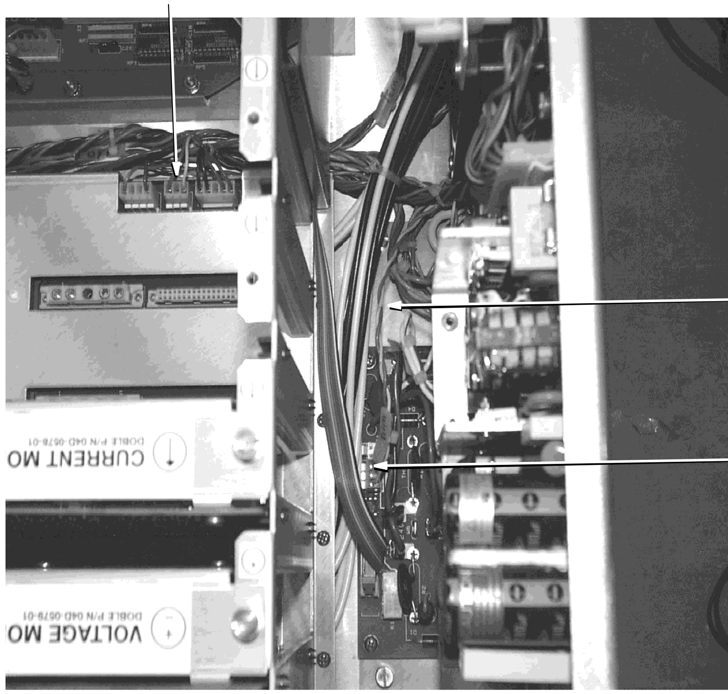



*Figure B.8 Pre-Installation Cabling*

b. Note exactly how the existing cable runs from the power supply to the amplifier backplane and where the toroid and slack are tied off before cutting the cable ties to remove the W14 cable.

c. Cut the tie wraps securing the W14 cable and remove it.

**NOTE**

**The cable may be secured to the instrument chassis with a cable clamp mounted on a stud near the J12 Connector of the amplifier backplane. Remove this cable clamp by removing the 5/16" kep nut. The cable clamp must be removed to install the battery simulator plate. Discard the cable clamp and loosely reinstall the 5/16" kep nut.**

d. Route the W14 Y power cable along the same path as the W14 cable.

One end of the cable has a connector for the power supply and the other end has two connectors: a green ground wire and a three-pin connector for the J13 connector on the amplifier backplane. Secure the slack and toroid with the supplied wire ties in the same manner as the old cable.

e. Connect the single-connector side of the W14 Y power cable to the J1 connector on the power supply. The yellow wire goes to pin number one of the J4 connector on the power supply.
f. Connect the three-pin connector on the W14 Y power cable to J13 connector on the amplifier backplane. The yellow wire goes to pin number one of the J12 connector on the amplifier backplane.
g. Route the green ground wire to where the five studs are located below the power receptacle on the I/O plate. Place the ring lug of the ground wire onto one of the free studs. Secure the ring lug with the supplied 8-32 kep nut using a 5/16 nutdriver.

## Installing the Battery Simulator Plate

The Battery Simulator Plate is installed in the space between the CPUIII backplane and the amplifier backplane. The component side of the plate faces the amplifier backplane (See Figure B.9).

Before installing the Battery Simulator Plate, the studs located on the instrument chassis must be prepared. The studs are located next to the J12 and J14 connectors on the amplifier backplane.

**NOTE**

**The stud next to the J12 connector may have a cable clamp mounted on it. This cable clamp must be removed before installing the Battery Simulator Plate. To remove this cable clamp, remove the kep nut with a 5/16 nutdriver. Discard the clamp and loosely reinstall the kep nut. The bottom of the Battery Simulator Plate is slotted, so the kep nut must be loosely reinstalled.**

To install the Battery Simulator plate (See Figure B.9):

**1.** Loosen both the J12 and J14 connector kep nuts using a 5/16" nut driver, until the nuts are held on by the top threads only.

On the vertical tab at the top of the Battery Simulator Plate there is a SEMS screw (a screw with an attached lock washer), a spacer and a nut. The spacer sits between the nut and the back faceplate.

**2.** Remove the nut and then the screw.

This nut is not used to install the Battery Simulator Plate.

**3.** Insert the screw from Step 2 into a pem fastener on the side of the cross rail with the spacer going between the cross rail and the back face of the Battery Simulator Plate.

**4.** Remove the screws from the horizontal tab at the top of the plate.

Make sure that the instrument chassis is clear of wires and cables in the area between the mounting studs and the CPUIII backplane, as the bottom of the Battery Simulator Plate must rest flush against the instrument's chassis. The wires that run over the top of the mounting studs will go over the top of the *foot* of the Battery Simulator Plate.

**5.** Make a mark with a felt tip pen on the top of the CPUIII backplane and on the instrument chassis bottom across from the mounting studs.

**6.** Lower the Battery Simulator Plate at an angle until the bottom of the plate rests against the CPUIII backplane.

**7.** Connect the W33 cable connector or the five-pin connector of the W14 Y power cable to the J4 connector on the Battery Simulator, as shown in Figure B.10.

The J4 connector is located in the lower right corner on the component side of the Battery Simulator Plate.

**8.** Align the marks on the back of the plate with the marks made in the previous set.

**9.** Rotate the top of the plate toward the cross rail.

The foot on the bottom of the Battery Simulator Plate should slide under the wires.

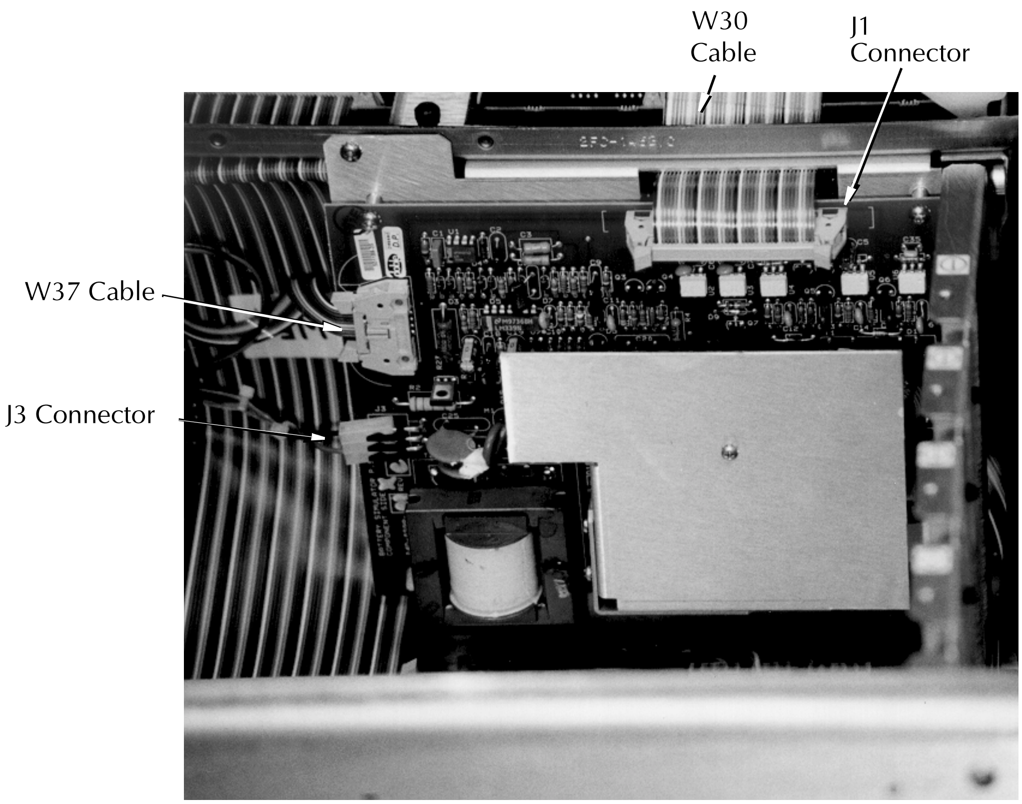



***Figure B.9 Battery Simulator Plate***

**10.** Place the spacer between the cross rail pem and the screw hole on the vertical tab of the plate and insert the 6-32 screw with a Phillips screw driver. Do not tighten the screw at this time.

**11.** Align the screw holes on the cross rail with the pems on the horizontal tab of the plate.

**12.** Insert the 6-32 screws through cross rail holes using a Phillips screwdriver. Do not tighten the screws at this time.

**13.** Use a 5/16" nutdriver on a ten-inch extension to tighten the kep nuts on the mounting studs at the bottom of the plate.

**14.** Tighten the three screws at the top of the plate with a #2 Phillips screwdriver.

**15.** Connect the W32 cable to the J3 connector on the Battery Simulator Plate, located in the middle of the left side of the board.

**16.** Connect one end of the W37 cable to the connector on the top of the newly installed I/O Plate.

**NOTE**

**Both ends of this cable are identical.**

**17.** Connect the free end of the W37 cable to the J2 connector on the Battery Simulator.

**18.** Connect one end of the W30 cable to the J1 connector of the Battery Simulator.

**19.** Connect the other end of the W30 cable to the J1 connector on the Digital Contact Timer (DCT) board, as shown in Figure B.10.


***Figure B.10 Battery Simulator Cabling***

## Restoration Work

To restore the F2250 to operational condition:

1. Re-install the W5 cable between the Amplifier Control board and the Amplifier backplane. The cable should be routed under the cross rail.
2. Re-install the IEEE-488 W1 cable between the IEEE-488 connector on the I/O plate to the J1 connector on the CPUIII board.
3. Re-install the Current Amplifier modules into the appropriate slots.
4. Return the door back to its normal position.
5. Re-install the center bar.
6. Re-install the top cover with a slotted screwdriver. The screw location depends on whether the F2250 instrument has caster wheels or rubber feet.

If the unit has:

| | |
|---|---|
| Caster wheels | The screw is located on the wheel plate. Re-install the flathead screws on the top two wheels. |
| Rubber feet | The screw is located in the middle of the rubber foot. The two top rubber feet are used to re-install the top cover. |

## Manually Testing

Once the unit is installed, test the unit as follows:

1. Install the power cord and turn on the instrument.

   When the instrument is ready, the **48 Volt** LED should illuminate.
2. Connect a DC voltmeter to the Red (+) and Black (-) output terminals of the Battery Simulator. The voltmeter should read 0 V.
   a. Push the Battery Simulator **SELECT** switch once.
   The **48 Volt** LED should go out and the **125 Volt** LED should illuminate. The voltmeter should read 0 V.
   b. Push the Battery Simulator **SELECT** switch again.
   The **125 Volt** LED should go out and the **250 Volt** LED should illuminate. The voltmeter should read 0 V.

c. Push the Battery Simulator **SELECT** switch again.
The **250 Volt** LED should go out and the **48 Volt** LED should illuminate. The voltmeter should read 0 V.

d. Push the Battery Simulator **POWER** switch once.
The voltmeter should read approximately 48 V.

e. Push the Battery Simulator **SELECT** switch once.
The **48 Volt** LED should stay illuminated.

f. Push the Battery Simulator **POWER** switch once.
The voltmeter should go to zero.

g. Push the Battery Simulator **SELECT** switch once.
The **48 Volt** LED should go out and the **125** Volt LED should illuminate.

h. Push the Battery Simulator **POWER** switch once.
The voltmeter should read approximately 125 V.

i. Push the Battery Simulator **SELECT** switch once.
The **125 Volt** LED should stay illuminated.

j. Push the Battery Simulator **POWER** switch once.
The voltmeter should go to zero.

k. Push the Battery Simulator **SELECT** switch once.
The **125 Volt** LED should go out and the **250** Volt LED should illuminate.

l. Push the Battery Simulator **POWER** switch once.
The 250 Volt meter should read approximately 250 V.

m. Push the Battery Simulator **SELECT** switch once.
The **250 Volt** LED should stay illuminated.

n. Push the Battery Simulator **POWER** switch once.
The voltmeter should go to zero.

**3.** Turn the F2250 off and remove the voltmeter.

## Testing With ProTesT

To test the system with ProTesT:

**1.** Install the RS-232 communication cable between the instrument and the computer.

**2.** Turn on the instrument.

**3.** Start ProTesT and open a *POWER* macro.

   a. Set the *POWER* macro to 48 V and run the macro.

   b. Connect a DC voltmeter to the Red (+) and Black (-) output terminals of the Battery Simulator. The voltmeter should read 48 V.

   c. Stop the *POWER* macro. The voltmeter should read 0 V.

   d. Set the *POWER* macro to 125 V and run the macro. The voltmeter should read 125 V.

   e. Stop the *POWER* macro. The voltmeter should read 0 V.

   f. Set the *POWER* macro to 250 V and run the macro. The voltmeter should read 250 V.

   g. Stop the *POWER* Macro. The voltmeter should read 0 V.

**4.** Turn the instrument off and remove the voltmeter. Disconnect the RS-232 communication cable.

The Battery Simulator installation is complete.

## 120 V to 240 V Conversion and Base Frequency from 60 Hz to 50 Hz

To change the power supply voltage from 110 VAC to 220 VAC:

1. Remove the top cover as detailed in "Preparation Work" on page B-12.
2. Remove the terminal lug on the AC Front End board (on the jumper wire) from W7(120V) and connect it to W6 (240V).
3. Move the cable on the fan assembly from the 120V connector to the 240V connector.
4. Locate the double pole switch on the right side of the AC input circuit breaker.
5. Move the terminal lug from the bottom lug (**HI**) to the middle lug (**LO**).
6. Repeat Step 5 for the second lug on the switch.
7. Change the position of the SW1 switch, on the top edge of the TSG board, from 60Hz to 50 Hz.
8. Locate the power label, next to AC circuit breaker on the outside right side of the F2250.
9. Pull out the power label (with needle nose pliers), positioning it so that 230 V is showing.

## F2250 Family Firmware Updates

NOTE

**The power management functions on certain laptops can interfere with communications between the laptop and the F2250 during the loading process. If this occurs, disable the power management software.**

These instructions describe how to install revised firmware onto a Doble F2250, F2251, F2252, or F2253 power system simulator with a CPUIII central processor unit. The CPUIII board is equipped with a re-writeable non-volatile memory *Flash ROM* to which revised firmware is loaded using a flash loader program. Normal installation does not require changing integrated circuits or opening the instrument.

Firmware is supplied on a 3.5" floppy disk and is loaded from a PC via a RS-232 connection. The flash loader program, *floaddos,* is run from the DOS prompt using command line arguments.

NOTE

**The RS-232 cable must have handshaking lines connected as described in the next section.**

## Hardware Considerations and Firmware Revision Levels

### RS-232 Cable

The cable used for the flash loader program must be have a 9-to-25 pin or 25-to-25 pin connector, depending on the computer connector. Homemade or minimum configuration three-wire cables will not work with the flash loader, even though they may work with ProTesT or other Doble software.

ProTesT presently uses only the minimum configuration pins: Transmit, Receive and Ground. The flash loader program uses two hardware handshaking connections, RTS and CTS, in the RS-232 cable that are not used by ProTesT.

### Hardware Type and Firmware Revision Level

Ensure that the CPU board in use is the CPUIII board. The flash loader cannot be used on earlier CPU boards. The CPUIII board is differentiated from the earlier CPUII board by the edge connectors as follows:

- The CPUIII board has *two* 25-pin and one nine-pin D connectors on the edge connector. The top 25-pin connector is the serial connection. The bottom 25-pin connector is for the TRANS2 high speed parallel download option.
- The CPUII board has *one* 25-pin and one nine-pin D connector.

**NOTE**

**The bottom 25-pin connector is covered by a blanking plate. Unless the parallel option is in use, the blanking plate should be left in place to prevent inadvertent connection to the wrong connector when connecting to the RS-232 25-pin socket. If the CPUIII board was supplied without a blanking plate, contact Customer Service for a replacement.**

To check the version of firmware presently installed in simulator:

1. Turn on the simulator.
2. Allow the simulator to warm up.
3. Check the firmware version by pressing **MASTER/SLAVE** switch to **SLAVE**.

   The firmware version appears in the **SOURCE 1 AMPLITUDE** display. Do not load firmware with a lower revision number than the firmware presently installed in the simulator. Contact Customer Service and speak to Bob Beyer (Extension 321).

## Loading New Firmware

To guard against loss of power during loading, make sure that the computer and the simulator have reliable power supplies. If the power supply is interrupted during the loading process, the firmware installation could be incomplete or corrupted, and the process must be repeated. In some cases, reloading after such an event requires opening the simulator to reset an internal switch (See "Unsuccessful Load and Failed Reboot" on page B-31).

Loading firmware consists of the following sub-procedures:

- Preparing to load
- Copying the Distribution Disk to the Hard Drive
- User Interaction During the Flash Load Process
- The Loading Process

### Preparing to Load

To prepare to load new firmware:

1. Ensure that all simulators are OFF.
2. Disconnect any IEEE-488 and SYNCH cables from the simulators so that each simulator can operate in the stand-alone mode.
3. Connect *one* simulator to the computer, using a normal RS-232 connection, via the top 25-pin D connector of the CPUIII board.
4. Turn the simulator and the computer on. There is no need to turn the computer off before connecting to the simulator or between loads for multiple simulators.
5. Place the distribution disk in the A or B drive and select that drive as the default drive by entering *A:* or *B:* at the DOS prompt.

If desired, the file complement can be checked by comparing a directory (dir) list of files on the disk with the file list shown in the *readme.txt* file on the disk. See the section "Documentation on Distribution Disk" on page B-32 for further information about the distribution disk.

## Copying the Distribution Disk Files to the Hard Drive

To copy the contents of the distribution disk to a hard drive:

1. Run the install batch file, *install.bat,* included on the distribution disk.
2. Select the drive containing the distribution disk as the default drive.
3. Enter *install* and press **Enter**.

   The files are loaded into the program-created directory *c:\floaddos*. The install batch file does not provide an option for installation into any other directory.

   To store the contents of the distribution disk in another directory, copy the files to the desired directory using the DOS copy command.
4. Select the drive and directory in which the files are installed as the default drive and directory.

## Running the Flash Loader Program

To run the loader program from the DOS command line:

1. Enter the program name *floaddos* and press **Enter**.

**NOTE**

**It is recommended that COM1 be used as the communications port and that the baud rate be set to 9600 baud.**

To run the flash loader at a different baud rate or from another COM port, add the necessary command line arguments as follows:

*floaddos [port] [baud]*

A space is required between the arguments.

*Example*

To load from COM2 at 2400 baud, use the command line:

*floaddos 2 2400*

When the program runs, status messages appear as the program opens the computer communications port and then starts the flash loader. At 9600 baud, this process takes about 10 seconds.

Once the program establishes communication with the flash loader, a prompt appears to select between a *Normal* or a *Custom Flash Load.*

## User Interaction During the Flash Load Process

The flash load program has two modes of operation:

| | |
|---|---|
| Normal Upgrade | This mode loads only the files necessary to perform an upgrade from the presently installed version to the new version. |
| Custom Install | This mode reports the version of each module of the firmware and prompts as to whether or not to load that module.<br>The Custom Install mode should only be used if problems are experienced and only after consultation with Doble. |

Once the program has established communication with the instrument, a load menu appears as follows:

*For Normal Upgrade Load, press 'Return' key*

*For Custom Install, press '1' (Return)*

- To perform a
  - Normal Upgrade, press **Enter**.
  - Custom Install, press **1**, and then **Enter**.

The program then interrogates the instrument to determine which files require updating, and a status message is displayed *File load list being generated, please stand by...* The program compares the unit configuration file (*.cfg*) and the program (*.hex*) files. Status messages appear as the respective files are found and compared. If either the configuration file or a *.hex* file is not found, the load is terminated and the user is advised to reboot the F2250.

### Normal Upgrade Mode

If the Normal Upgrade mode is selected, the loader examines the modules presently in the instrument, determines which need to be upgraded, and then loads the required modules without further user interaction. Status messages are displayed as the modules load and when loading is finished. See "The Loading Process" on page B-30.

### Custom Install Mode

If the Custom Install mode is selected, the loader prompts for a confirmation before loading each module. In this mode, the following messages appear for each *.hex* file called for loading:

*Checking Current Rev Level: FILENAME.HEX*

*Hex file Rev: 01.00.00, 10/31/95, 17:00:00*

*F2250 Rev: 01.00.00, 10/31/95, 17:00:00*

*Do you wish to load .hex file? Y/N/ESC*

- Pressing:
  - **Y** or **y** puts the file on the load list
  - **N** or **n** skips the file
  - **Esc** terminates the load

In the Custom Install mode, an informational message appears if the *.hex* file specified will overwrite an entirely different file already residing at the same address (different Partition ID). For example, *APFILLER.HEX* and *F2K.HEX* both load at C000:0000. Similarly, a warning is issued if no file header can be read starting at the specified address, as is the case if an application is to be loaded starting at a memory location which currently contains only fill characters. As noted above, Normal Upgrade mode treats such files as upgrades and loads them in the usual fashion.

## The Loading Process

When loading commences the simulator displays *FLASH* in the **TIMER** window. The flash loader displays status messages as it progresses and when loading is complete.

If the unit flash load module (*FLOAD.HEX*) is in the load list, it is loaded first and a prompt appears which requires that the machine be rebooted before proceeding. Loading progress messages appear as follows:

*New Flash Loader module has loaded successfully.*

*Turn off F2250.*

*Re-power F2250, then press 'Return' on computer.*

*Attempting to restart instrument's Flash Loader...*

When all the modules are loaded, the program displays a list of the files loaded successfully and any files that failed to load. A message prompting for the reboot of the F2250 appears. At this point the simulator is locked up and FLASH is displayed in **TIMER** window.

If:

- All files load successfully, proceed with Step 1.
- Some files fail, proceed to "Incorrect Firmware Loading" on page B-31.

1. Reboot the simulator by turning the simulator OFF and then ON.
2. Allow the simulator to warm up.
3. Check the firmware version by pressing the **MASTER/SLAVE** switch to **SLAVE**.

   The firmware version appears in the **SOURCE 1 AMPLITUDE** display.
4. Ensure that the revision level matches that on the distribution disk.

### Incorrect Firmware Loading

If any files fail to load correctly:

1. Leave the simulator ON.
2. Write down a list of the files that did not load and any error description or code that appears.
3. Restart the loading process as described in "Running the Flash Loader Program" on page B-28.
4. If the load fails again, contact Doble.

### Power Failure During Load

If the loading process is interrupted by computer or power failure:

1. Turn the simulator OFF then ON.
2. Restart the loading process as described in "Running the Flash Loader Program" on page B-28. The loading process is then repeated.

### Unsuccessful Load and Failed Reboot

If the simulator fails to reboot after an unsuccessful load, the simulator can be forced into the flash load mode by setting an internal switch. In such cases:

1. Turn OFF the simulator.
2. Remove the simulator top cover by removing the screw holding each of the two rubber feet or castors at the rear of the top cover.
3. Locate the CPUIII board by finding the rotary switch in the middle of the top edge of the board.

   This switch is normally set to *S*.

4. Set the rotary switch to *L*.
5. Exchange the U2 and U6 chips on the CPU board. See Figure 6.8 on page 6-10.
6. Turn ON the simulator.
7. Observe that the status LEDs on the CPUIII board top edge flash as the CPU cycles through a start up sequence. All the LEDs should then go out.

   The simulator is now ready to load. The front panel LEDs remain OFF.
8. Repeat the installation by running the flash loader program as described in "Running the Flash Loader Program" on page B-28

**NOTE**

***Flash* is not displayed when loading with the rotary selector in the *L* position.**

   The program reports when loading is complete and prompts for a reboot.
9. Turn OFF the simulator.
10. Set the rotary switch back to the *S* position to allow normal operation.
11. Turn ON the simulator.
12. Allow the simulator to warm up.
13. Check firmware version by pressing the **MASTER/SLAVE** switch to **SLAVE**.

    The firmware version appears in the **SOURCE 1 AMPLITUDE** display.
14. Ensure that the revision level matches that on the distribution disk.
15. Turn OFF the simulator, replace the top cover and secure it by replacing the screw holding each of the two rubber feet or castors at the rear of the top cover.

In case of questions or problems, contact Doble Engineering and speak to Bob Beyer (Ext. 321).

## Documentation on Distribution Disk

The distribution disk contains several utility files which are not usually required for normal operation, but are provided for the convenience of the customer to assist in troubleshooting. Running any of these programs, other than *floaddos*, does not permanently interfere with the operation of the simulator. The programs are described in the file *readme.txt*, which also contains a list of the application files on the distribution disk.

# Appendix C.  F2250 Specifications

This chapter details the following specifications:

- Frequency
- Voltage and current outputs
- Logic outputs and inputs
- Multi-mode digital timer
- Battery simulator
- F2250 general specifications
- F2010 Minicontroller automation resolution
- External interface connectors
- Internal options
- Physical specifications

## Frequency

Table C.1 describes the frequency characteristics of the F2250.

***Table C.1  Frequency***

| Characteristic | Description |
|---|---|
| Base Frequency | 50 or 60 Hz, crystal, line or satellite synchronized |
| Selectable Frequencies | 2nd through 20th and 100th harmonic of base frequency; DC |
| Accuracy | Standard crystal = +0.0005% of base frequency; at 60 Hz frequency accuracy is + 0.003 Hz |
| Line Synchronization | Signal frequency tracks line frequency for variations of + 1 Hz on nominal base frequency (50 or 60 Hz) |

*Table C.1 Frequency (Continued)*

| Characteristic | Description |
|---|---|
| Variable Frequency Options | F2010 Minicontroller, ProTesT 0.1 to 99.99 at base frequency |
| Resolution | 0.001 Hz from 0.100 to 99.999 Hz at base frequency; 0.00l Hz from 100.0 Hz to 999.9 Hz; 0.1 Hz from 1,000 to 9,999.9 |

## Voltage And Current Outputs

Table C.2 describes the voltage and current characteristics of the F2250.

*Table C.2 Voltage and Current Output*

| Model | | F2251 | | F2252 | | F2253 | |
|---|---|---|---|---|---|---|---|
| | | Power | Ranges | Power | Ranges | Power | Ranges |
| Mode 1: Source 1 Voltage Source 2 Current | | | | | | | |
| Source 1 AC Voltage | Continuous power | 150 VA rms | 75, 150 V rms (0.01 V); 300V rms (0.1 V) | 150 VA rms | 75, 150 V rms (0.01 V); 300 V rms (0.1 V) | 150 VA rms | 75, 150 V rms (0.01 V); 300 V-rms (0.1 V) |
| | 1.5 sec transient* | 195 VA rms | 65, 130 V rms (0.01 V); 260V rms (0.1 V) | 195 VA rms | 65, 130 V rms (0.01 V); 260 V rms (0.1 V) | 195 VA-rms | 65, 130 V rms (0.01 V); 260V rms(0.1 V) |
| | | | | | | | |
| Source 1 DC Voltage | Continuous power | 150 Watts | 106, 212 VDC (0.01 V); 424 VDC (0.1 V) | 150 Watts | 106, 212 VDC (0.01 V); 424 VDC (0.1 V) | 150 Watts | 106, 212 VDC (0.01 V); 424 VDC (0.1 V) |

*Table C.2 Voltage and Current Output (Continued)*

| Model | | F2251 | | F2252 | | F2253 | |
|---|---|---|---|---|---|---|---|
| Source 2 AC Current | Continuous power | 150 VA rms | 7.5, 15, 30A rms (0.001 A) | 300 VA rms | 7.5, 15, 30, 60 A rms (0.001 A) | 450 VA rms | 7.5, 15, 22.5, 30, 45, 60 A rms (0.001 A); 90 A rms (0.01 A); 15,30, 45, 60, 90, 120 A rms (0.01 A); 180 A rms (0.1 A) |
| | 1.5 sec transient* | 225 VA rms | 15, 30, 60 A rms (0.01 A) | 450 VA rms | 15, 30, 60, 120 A rms (0.01 A) | 675 VA rms | 15, 30, 45, 60, 90, 120 A rms (0.01 A); 180 A rms (0.1 A) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Source 2 DC Current | Continuous power | 150 Watts | 5, 10, 20 ADC (0.001 A) | 300 Watts | 5, 10, 20, 40 ADC (0.001 A) | 450 Watts | 5, 10, 15, 20, 30 ADC (0.001 A); 60 ADC (0.01 A) |
| | 1.5 sec transient* | 225 Watts | 15, 30, 60 ADC (0.01 A) | 450 Watts | 15, 30, 60, 120 ADC (0.01 A) | 675 Watts | 15, 30, 45, 60, 90 ADC (0.01 A); 180 ADC (0.1 A) |

*Table C.2 Voltage and Current Output (Continued)*

| Model | | F2251 | | F2252 | | F2253 | |
|---|---|---|---|---|---|---|---|
| Mode 2: Source 1 Current<br>Source 2 Current | | | | | | | |
| Source 1<br>AC Current | Continuous power | | | 150 VA rms | 7.5, 15,<br>30 A rms<br>(0.001 A) | 150 VA rms | 7.5, 15,<br>30 A rms<br>(0.001 A) |
| | 1.5 sec transient* | | | 225 VA rms | 15, 30,<br>60 A rms<br>(0.01 A) | 225 VA rms | 15, 30,<br>60 A rms<br>(0.01 A) |
| Source 1<br>DC Current | Continuous power | | | 150 Watts | 5, 10,<br>20 ADC<br>(0.001 A) | 150 Watts | 5, 10,<br>20 ADC<br>(0.001 A) |
| | 1.5 sec transient* | | | 225 Watts | 15, 30,<br>60 ADC<br>(0.01 A) | 225 Watts | 15, 30,<br>60 ADC<br>(0.01 A) |
| Source 2<br>AC Current | Continuous power | | | 150 VA rms | 7.5, 15,<br>30 A rms<br>(0.001 A) | 300 VA rms | 7.5, 15, 30,<br>60 A rms<br>(0.001 A) |
| | 1.5 sec transient* | | | 225 VA rms | 15, 30,<br>60 A rms<br>(0.01 A) | 450 VA rms | 15, 30,<br>60, 120 A rms<br>(0.01 A) |
| Source 2<br>DC Current | Continuous power | | | 150 Watts | 5, 10,<br>20 ADC<br>(0.001 A) | 300 Watts | 5, 10, 20,<br>40 ADC<br>(0.001 A) |
| | 1.5 sec transient* | | | 225 Watts | 15, 30, 60 ADC<br>(0.01 A) | 450 Watts | 15, 30, 60,<br>120 ADC<br>(0.01 A) |

*Transient operation of AC voltage sources is limited to the voltage shown, for each of the continuous power ranges.

## Logic Outputs and Inputs

This section explains the **LOGIC OUTPUT**s and **LOGIC** and **SIGNAL INPUT**s.

### Logic Output

Each output has three terminals: normally open, common, and normally closed. Green and red LEDs indicate the *unasserted* and *asserted* states, respectively. Table C.3 describes the characteristics of the **LOGIC OUTPUT**s.

***Table C.3 LOGIC OUTPUT***

| Characteristic | Explanation |
|---|---|
| Switching power | 10 Watts maximum |
| Input voltage | 300 V DC and or AC peak maximum suppressed @ 400 V |
| Switching current | 0.2 A make or break maximum |
| Carry current | 0.3 A maximum |
| Operate time | 1 millisecond maximum |

### Logic Input

Each input has three terminals: **VOLTAGE**, **COMMON**, and **CONTACT**. Each input has a galvanically isolated supply common to all three terminals. The F2250 does not differentiate between the voltage and contact terminals of the same logic input; they are *OR'd* together. Input polarity/contact transition selection controls both terminals simultaneously. An input becomes asserted when it moves between states, as shown in graphic beside amber phase selection LED.

OFF to ON = open to close

ON to OFF = close to open

OFF/ON also serves to indicate source transition in the source 1/2 mode.

Table C.4 discusses **LOGIC INPUT** characteristics.

***Table C.4 Logic Input***

| Characteristic | Description |
|---|---|
| Voltage terminal input rating | 300 V AC/DC. Threshold 1 V suppressed to nominal F2250 levels (300V) |
| Contact terminal rating | 30 V open circuit, 100 mA short circuit, threshold limits 200 to 600 Ohms |
| *Logic input contact sense mode* | |
| Open circuit test voltage | 30 V nominal |
| Short circuit test current | 90 mA nominal |
| Threshold | 460 Ohms nominal |
| *Logic input voltage sense mode* | |
| Input voltage | 420 V DC and (or) peak AC maximum |
| Input impedance | 100 kOhms nominal |
| Threshold | 1.5 V nominal |

## Multi-Mode Digital Timer

Table C.5 discusses the characteristics of the timer.

***Table C.5 Multi-Mode Digital Timer***

| Characteristic | Description |
|---|---|
| Accuracy | 0.0005% of reading, ± least significant digit, ± 50 microseconds |
| Resolution | 10 microseconds (1 least significant digit) |
| Ranges | 0 - 999.99 milliseconds<br>0 - 999999 seconds<br>0 - 999999 cycles<br>GPS time of day<br>(with F2895 GPS Option) |

## Battery Simulator

Table C.6 discusses the characteristics of the Battery Simulator.

***Table C.6 Battery Simulator***

| Characteristic | Description |
|---|---|
| Output voltage | 48, 125 and 250 V DC |
| Amplitude | Accuracy: ±10% of setting, including line and load regulation over the temperature range, typically ±5% |
| Output power | 60 Watts maximum, continuous. Peak output power at 48 V is 75 Watts, and is 100 Watts at 125 and 250 V |
| Peak output power | 48 V range: 75 Watts<br>125, 250 V ranges: 100 Watts |
| Output current | 1.25 A at 48 V, 0.48 A at 125 V and 0.24 A at 250 V, DC, nominal. The Battery Simulator is able to drive circuits with capacitor input filters that have high peak inrush currents greater than the nominal value and recover |

*Table C.6 Battery Simulator*

| Characteristic | Description |
|---|---|
| Maximum output current | 1.5 A, DC |
| Short circuit capability | Short circuit current 1.5 A; indefinite with no damage |
| Short circuit recovery | Immediate |
| AC ripple voltage, rms | At line frequency is less than 0.2% of setting |
| Switching noise | 5% peak to peak of setting at switching frequency |
| Voltage overshoot | 5% maximum |
| Input power | 350 VDC, unregulated, supplied from the amplifier power supply not isolated from the AC power line |
| Temperature range | 0° to +50° C |
| AC line voltage requirements | 105 –132 V, or 210 –264 V, 47 to 63 Hz |

# General Specifications

Table C.7 discusses F2250 general specifications.

*Table C.7 General Specifications*

| Characteristic | Description |
|---|---|
| Source operation | Worst-case accuracy specifications include all errors contributed by variations in power line voltage, load regulation, stability, and temperature, up to full output power. Stable source operation in four quadrants: load power factor from 1 to 0, leading or lagging. The F2250 is supplied with Certificate of Calibration traceable to the National Institute of Standards and Technology. |
| Electrostatic discharge immunity | Meets IEC 801A at 20 kV |
| Surge withstand capability | ANSI/IEEE C37.90. The F2250 functions as a source during surge withstand capability tests, when the specified isolating circuit is interposed between the F2250 and the test relay. |
| Amplitude accuracy | ± 0.5% of value at 50/60 Hz |
| Distortion | Low distortion sine waves; total harmonic distortion: 0.2% typical; 2% maximum at 50/60 Hz |
| Operating temperature | 0° to 50° C |
| Storage temperature | −25° to 70° C |
| Voltage and current source conditioning amplifier noise | −80 dB of range |
| Phase Angle range | 0 to 359.9° / 0 to −359.9° |
| Phase Angle resolution | ± 0.1° at 50/60 Hz |
| Phase Angle accuracy | ± 0.25° at 50/60 Hz |

*Table C.7 General Specifications*

| Characteristic | Description |
|---|---|
| Frequency range | DC to 10 kHz |
| Frequency accuracy | 0.001% |
| Frequency manual ranges | DC; AC: Base Frequency to 20th harmonic at harmonic intervals, and the 100th harmonic |
| Mains power voltage | 105 –132 V or 210 –264 V (field selectable) |
| Mains power frequency | 47 - 63 Hz |
| Audible noise | Measured at 2 meters;<br>ANSI Type 2<br>Typically:<br>Front: 52.5 dBA Rear: 55 dBA<br>L.H.:54 dBA R.H.:52.5 dBA |

## F2010 Minicontroller Automation Resolution

Table C.8 discusses minicontroller resolution.

*Table C.8 Minicontroller Resolution*

| Range | Resolution |
|---|---|
| 0.001 to 99.999 Hz | 0.001 Hz |
| 100 to 999.99 Hz | 0.01 Hz |
| 1,000 to 9,999.9 Hz | 0.1 Hz |

## External Interface Connections

Table C.9 discusses the external interface connections found on the I/O plate.

*Table C.9 External Interface Connections*

| Connection | Description |
|---|---|
| IEEE-488 | General Purpose Instrument Bus (GPIB). Provides a high speed communication link with other F2000 units. |
| RS-232 | Provides RS-232C serial communications with an external computer for remote control. |
| D-232 | Doble serial communication port for the F2010 Minicontroller. |
| SYNC | Provides clock and reference pulses from the system MASTER to synchronize frequency and control of SLAVEs. |
| AC POWER | Receptacle for line power. |

## Physical Specifications

Table C.10 discusses F2250 physical specifications.

*Table C.10 F2250 Physical Specifications*

| Characteristic | Description |
|---|---|
| Enclosure | High impact, molded, flame retardant ABS.<br>Meets National Safe Transit Association testing specification No. 1A for immunity to severe shock and vibration. |
| Dimensions | 9.5 h x 19.75 w x 22 inches d (24 x 50 x 55.8 cm) |
| Weight | 50 lbs. (22.7 kg) |

# Appendix D.  Part Numbers Reference

The part numbers for F2250 components appear in the tables that follow grouped by type.

Table D.1 gives the part numbers for individual boards and modules.

***Table D.1  Boards/Modules***

| Board | PN# |
|---|---|
| CPUIII board | 04D-0590 |
| Amplifier Control board | 04D-0580 |
| Timing State Generator (TSG) board | 04D-0586-01 |
| Timing State Generator (TSG) board with Satellite option | 04D-0586-03 |
| Transient Waveform Generator (TWG) board | 04D-0277 |
| Waveform Generator (WG2) board | 04D-0600 |
| Digital Contact Timer (DCT) board | 04D-0587 |
| Front Panel board | 04D-0364 |
| Timer Front End board | 04D-0342 |
| 150 VA Current Power Module | 04D-0578 |
| 150 VA Voltage Power Module | 04D-0579 |
| Battery Simulator board | 04D-0598 |
| AC Front End (High Voltage Power Supply) board | 04D-0577 |

Table D.2 gives the part numbers for assemblies.

*Table D.2  Assemblies*

| Assemblies | PN# |
|---|---|
| Low Voltage Power Supply | 03D-1151-01 |
| Battery Simulator | 03D-1110 |
| Fan | 05C-0530 |
| Battery Simulator User Interface (I/O plate) | 04D-0599 |

Table D.3 gives the part numbers for ribbon cables and other connectors.

***Table D.3 Cables and Connectors***

| Cable/Connector | PN# |
|---|---|
| W1 | 05B-0217 |
| W5 | 05B-0510 |
| W6 | 05B-0511 |
| W7 | 05B-0512 |
| W8 | 05B-0513 |
| W12 | 05B-0517 |
| W13 | 05B-0518 |
| W14 | 05B-0519 |
| W15 | 05B-0520 |
| W18 | 05B-0521 |
| W19 | 05B-0522 |
| W21 | 05B-0524 |
| W22 | 05B-0525 |
| W27 | 05B-0530 |
| W28 | 05B-0534 |
| W30 | 05B-0543 |
| W32 | 05B-0570 |
| W33 | 05B-0571 |
| W36 | 05B-0568 |
| W37 | 05B-0569 |
| SYNCH Bus | 05B-0565 |

# Appendix E. Drawing Reference

This appendix contains drawings which can be used for reference purposes while servicing the unit. Table E.1 lists the drawing name, and number.

***Table E.1 Drawing Reference***

| Drawing Name | Drawing # |
|---|---|
| Cabling Diagram F2151 Series | 76D-0220 |
| Block Diagram F2250 Power Amplifier | 76D-0272 |
| F2250 Low Voltage Power Supply Assembly | 03D-1151 |
| F2250 AC Front End Assembly (High Voltage Power Supply) | 04D-0577 |
| F2250 Cable, Adapters and Accessories | 79D-0096-01 - Pages 2,3 and 4 of the 4 page set |

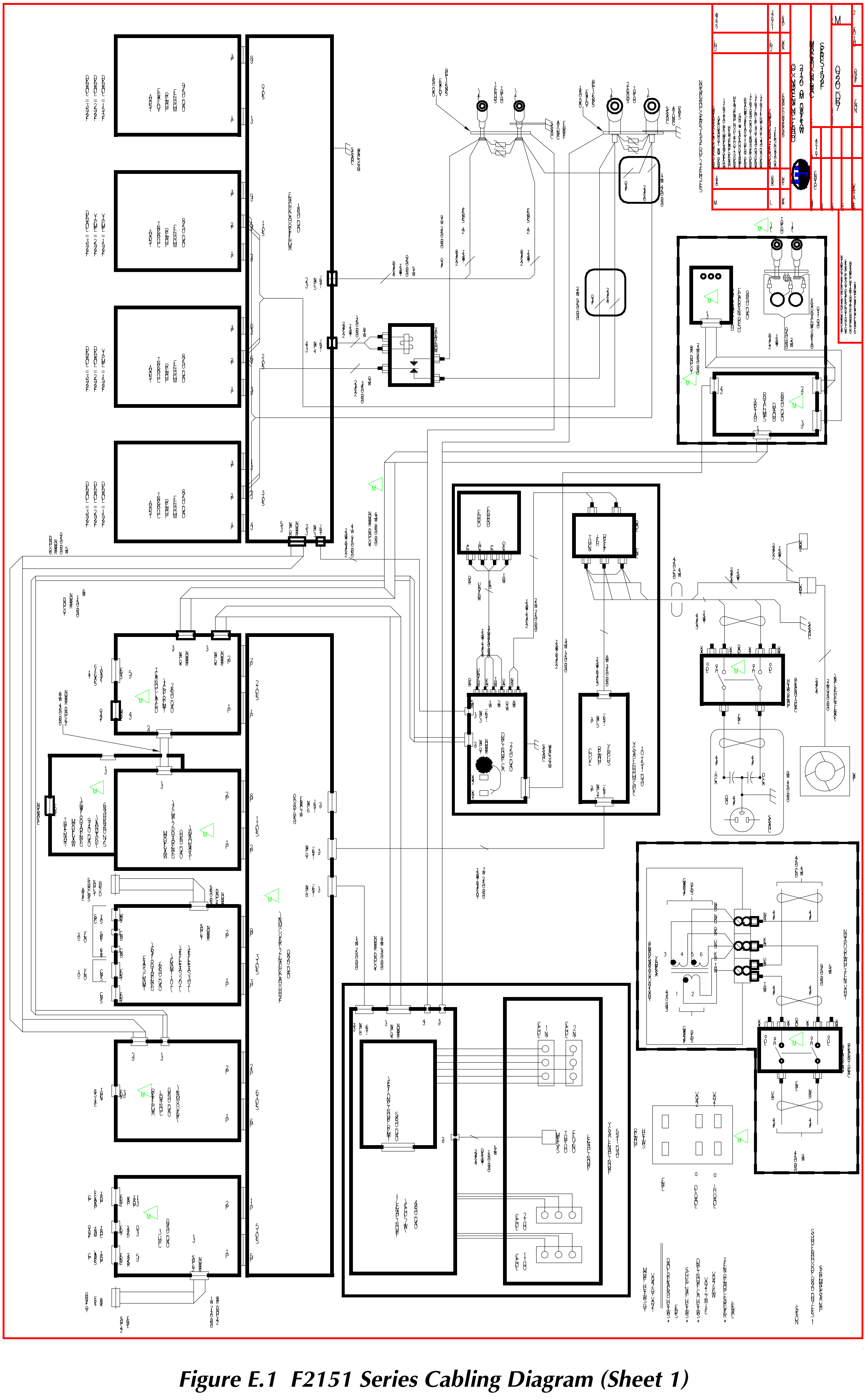


*Figure E.1  F2151 Series Cabling Diagram (Sheet 1)*

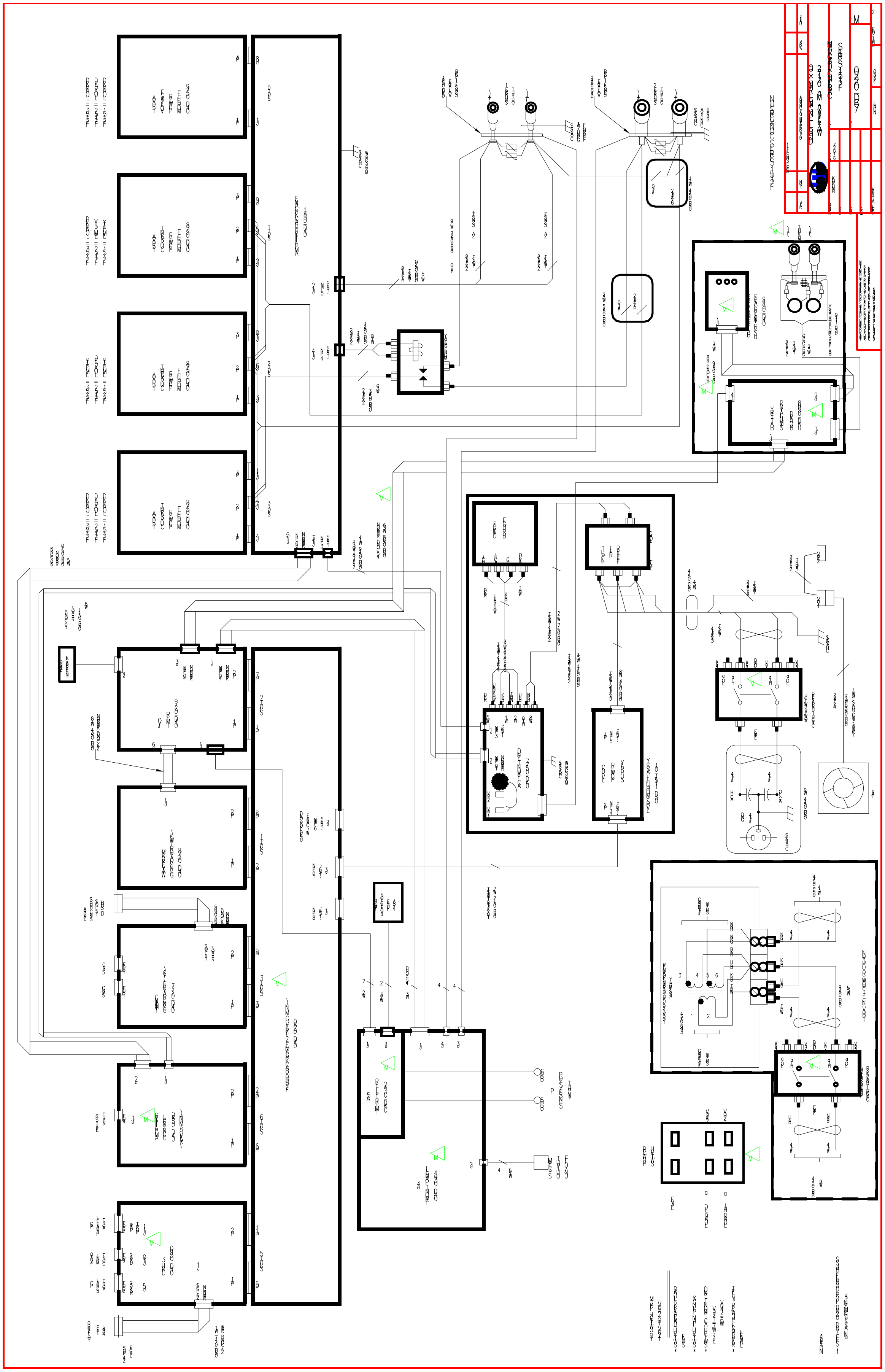


*Figure E.2  F2151 Series Cabling Diagram (Sheet 2)*

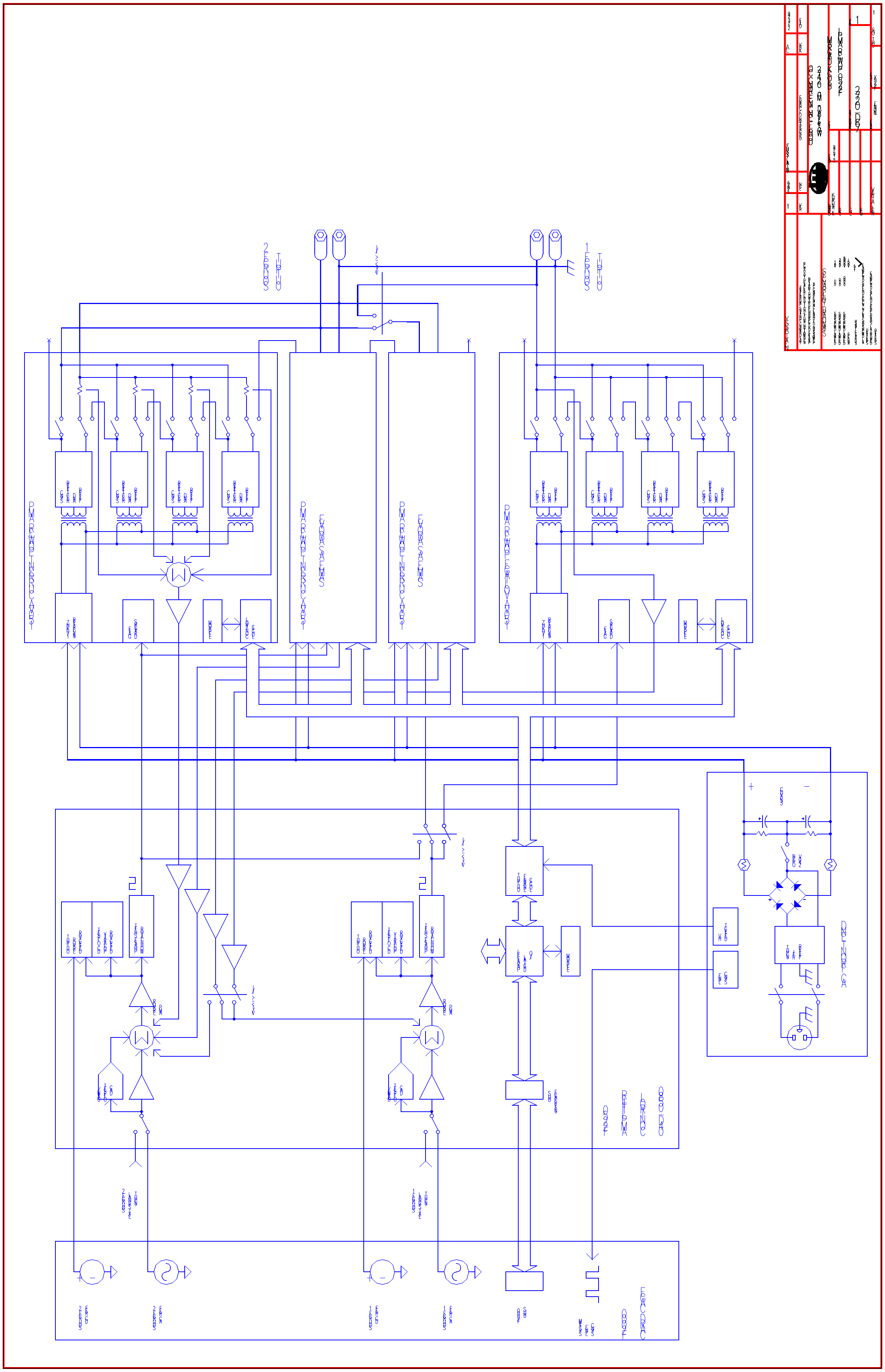


*Figure E.3  F2250 Power Amplifier Block Diagram*

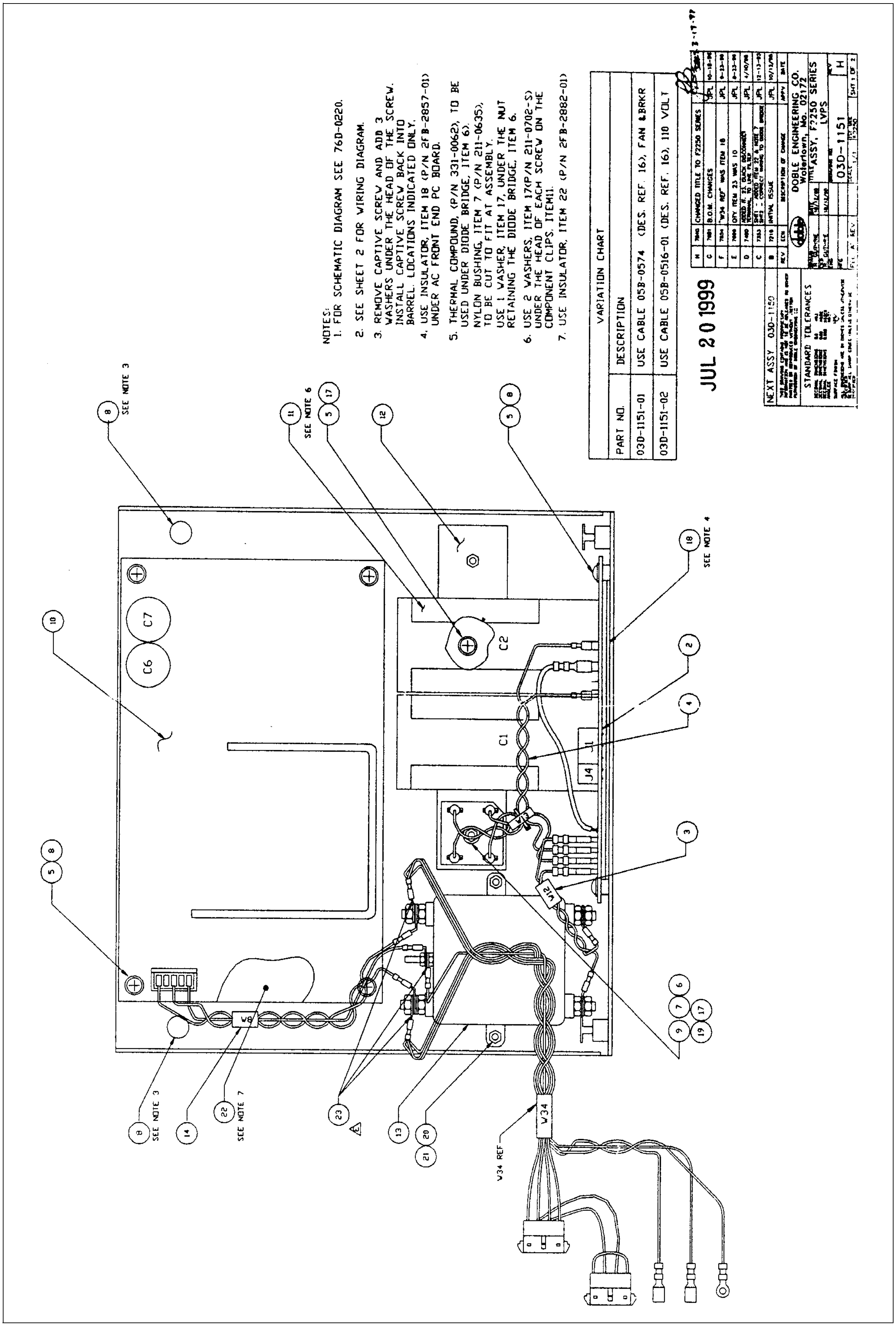



*Figure E.4 F2250 Low Voltage Power Supply Assembly (Sheet 1)*

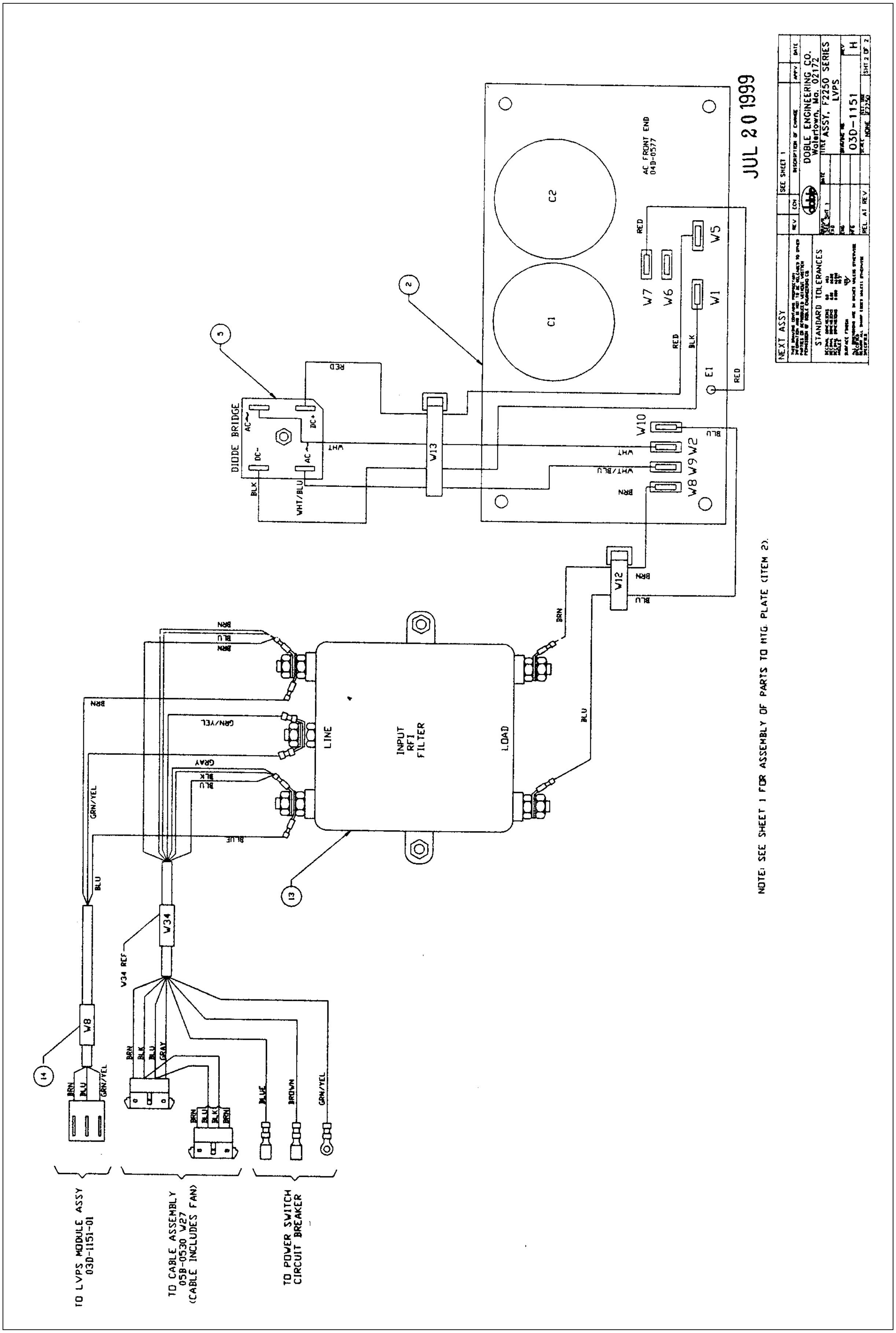



*Figure E.5 F2250 Low Voltage Power Supply Assembly (Sheet 2)*

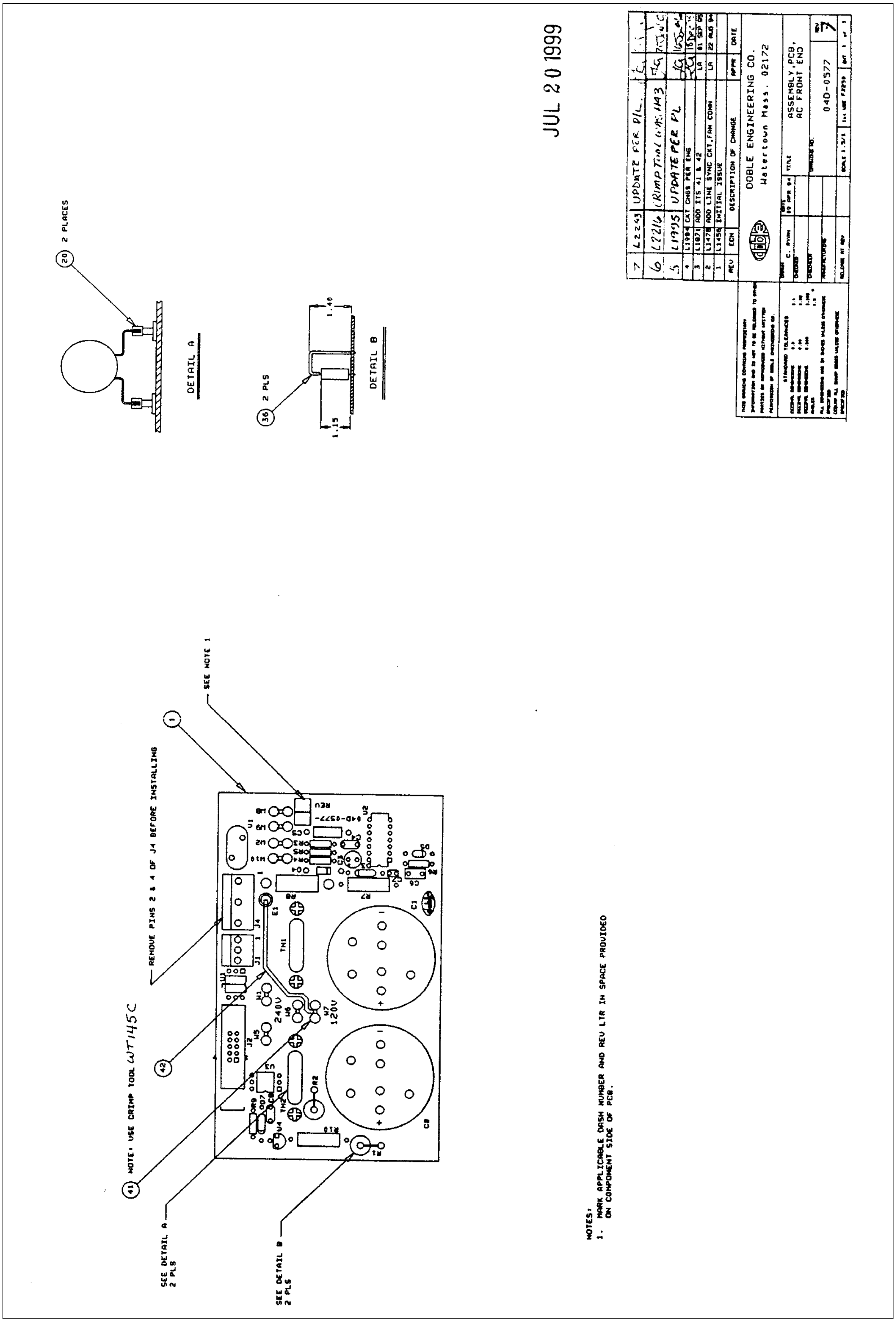



*Figure E.6 F2250 AC Front End Assembly (High Voltage Power Supply)*

## F2000 SERIES CABLES, ADAPTERS, AND ACCESSORIES

| WHERE USED | DESCRIPTION | PART NUMBER | COST | M.R.P. DESCRIPTION |
|---|---|---|---|---|
| CURRENTLY IN CABLE SET | 5 FT, 4 AWG, BLACK | 05B-0531-01 | | CABLE, 90 AMP, BLK, F2250 |
| CURRENTLY IN CABLE SET | 5 FT, 4 AWG, RED | 05B-0531-02 | | CABLE, 90 AMP, RED, F2250 |
| OPTIONAL PR2250 | 15 FT, 4 AWG, BLACK | 05B-0531-03 | | CBL, HI CURR, BLK, 15' PR2250 |
| OPTIONAL PR2250 | 15 FT, 4 AWG, RED | 05B-0531-04 | | CBL, HI CURR, RED, 15' PR2250 |
| OPTIONAL MEXICO | 10 FT, 4 AWG, RED | 05B-0575-01 | | CABLE, OUTPUT, 4 AWG F2700 |
| OPTIONAL MEXICO | 10 FT, 4 AWG, BLACK | 05B-0575-02 | | CABLE, OUTPUT, 4 AWG F2700 |
| OPTIONAL 10 AWG OUTPUT POWER | 10 FT, 10 AWG | 05B-0576-01 | | P/A, CBL, OTPT, 10 AWG F2700 |
| CURRENTLY IN CABLE SET | 10 FT, 14 AWG, POWER CORD | 181-0088 | | CORD, PWR, 14AWG X 3, USA PLUG |
| CURRENTLY IN CABLE SET | 5 FT, DB15 DATA CABLE | 401-0042 | | CABLE, MOLDED, 5FT, 15P, SYNC |
| CURRENTLY IN CABLE SET | 3 FT, IEEE GPIB CABLE | 401-0035 | | CABLE, MOLDED, 3 FT. IEEE |
| OPTIONAL | 7 IN, 15 PIN RIBBON CABLE | 05B-0565-01 | | CABLE, XTRA SYN BUS F2250 |
| CURRENTLY IN CABLE SET QTY ONE | 10 FT, 14 AWG, LARGE/LARGE SPADE BLACK BODY/RED TRACE POWER TEST | 2FB-1075-01 | | TEST LEAD, R/B, LG.LG F21/22 |
| CURRENTLY IN FOPR SOURCE ONE CABLE SET | 10 FT, 14 AWG, LARGE/LARGE SPADE BLACK BODY/RED TRACE POWER TEST | 2FB-1075-01 | | TEST LEAD, R/B, LG.LG F21/22 |
| IN CABLE SET FOR F2000 SOURCE TWO | 10 FT, 14 AWG, LARGE/LARGE SPADE BLACK BODY/BLUE TRACE POWER TEST | 2FB-1075-02 | | TEST LEAD, BLUE/BLK F2,PRT,F3D |
| OPTIONAL LONG SPECIAL | 16 FT, 14 AWG, LARGE/LARGE SPADE BLACK BODY/RED TRACE POWER TEST | 2FB-1075-03 | | LEAD, TEST, RED 16 FT |

| REV | ECN | DESCRIPTION OF CHANGE | APPR | DATE |
|---|---|---|---|---|
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TITLE: DOCUMENT TREE, F2251

| DRAWING NO. | SHEET | OF | REV |
|---|---|---|---|
| 79D-0096-01 | 2 | 4 | Y |

*Figure E.7 F2250 Cable, Adapters and Accessories (Part I)*

F2000 SERIES CABLES, ADAPTERS, AND ACCESSORIES

| WHERE USED | DESCRIPTION | PART NUMBER | COST | M.R.P. DESCRIPTION |
|---|---|---|---|---|
| OPTIONAL LONG SPECIAL | 16 FT, 14 AWG, LARGE/LARGE SPADE BLACK BODY/BLUE TRACE POWER TEST | 2FB-1075-04 | | LEAD, TEST, BLUE 16 FT |
| NO WHERE USED | 10 FT, 14 AWG, SMALL/LARGE SPADE BLACK BODY/RED TRACE POWER TEST | 2FB-1075-05 | | TEST LEAD, R/B, SM.LG F2250 |
| NO WHERE USED | 10 FT, 14 AWG, SMALL/LARGE SPADE BLACK BODY/BLUE TRACE POWER TEST | 2FB-1075-06 | | TEST LEAD, B/B, SM.LG F2250 |
| IN THE BATTERY SIMULATOR KIT | 10 FT, 14 AWG, SMALL SPADE/BANANA RED BODY/BLACK TRACE BATTERY SIMULATOR | 2FB-1075-07 | | TEST LEAD, R/B, R/B, SM.LG F2250 |
| CURRENTLY IN BINDING POST TYPE CABLE SET | 10 FT, 18 AWG, SMALL/SMALL SPADE BLUE BODY/RED TRACE TIMER | 2FB-1075-08 | | TEST LEAD, BLUE/BLK, BLUE BLK |
| CURRENTLY IN BINDING POST TYPE CABLE SET | 10 FT, 18 AWG, SMALL/SMALL SPADE BLUE BODY/BLACK TRACE CONTACT | 2FB-1075-09 | | TEST LEAD, RED/BLK, BLUE BLK |
| OPTIONAL TIMER DAISY CHAIN | 10/2/2 FT, 18 AWG, SMALL/SMALL SPADE BLUE BODY/BLACK TRACE TIMER CONTACT | 2FB-1075-10 | | TEST LEAD, BLUE/BLK DAISY CHAIN |
| NEW FOR BANANA JACK TYPE PANEL | 10 FT, 18 AWG, BANANA/SMALL SPADE BLUE BODY/RED TRACE TIMER | 2FB-1075-11 | | TEST LEAD, RED/BLK, BLUE RED |
| NEW FOR BANANA JACK TYPE PANEL | 10 FT, 18 AWG, BANANA/SMALL SPADE BLUE BODY/BLACK TRACE CONTACT | 2FB-1075-12 | | TEST LEAD, BLU/BLK, BLUE BLK |
| CURRENTLY IN ACCESSORY KIT | 5 FT DUAL BANANA BLACK TEST LEAD | 220-0895 | | TEST LEAD, BLK, 60IN, MINI PLUG |
| CURRENTLY IN ACCESSORY KIT | 5 FT DUAL BANANA RED TEST LEAD | 220-0896 | | TEST LEAD, RED, 60IN,MINI PLUG |
| CURRENTLY IN ACCESSORY KIT | DOUBLE BANANA JACK | 220-0897 | | JACK, BANANA, DOUBLE, MINI |
| CURRENTLY IN ACCESSORY KIT | SINGLE BANANA JACK | 220-0898 | | JACK, BANANA, SINGLE, MINI |

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*Figure E.8 F2250 Cable, Adapters and Accessories (Part II)*

## ZF2000 SERIES CABLES, ADAPTERS, AND ACCESSORIES

| WHERE USED | DESCRIPTION | PART NUMBER | COST | M.R.P. DESCRIPTION |
|---|---|---|---|---|
| CURRENTLY IN ACCESSORY KIT | SINGLE BANANA JACK W/ TERMINAL | 220-0899 | | PLUG,BANANA,SOLDERLESS,STACKUP |
| IN ACCESSORY KIT FOR BANANA JACK TYPE PANEL | SINGLE BANANA JACK W/ TERMINAL | 220-0915 | | PLUG,BANANA,STACKUP,BLACK |
| IN ACCESSORY KIT FOR BANANA JACK TYPE PANEL | 5 FT DUAL STD BANANA BLACK TEST LEAD | 220-1018 | | LEAD,TEST,60IN.STD/STD BLACK |
| IN ACCESSORY KIT FOR BANANA JACK TYPE PANEL | 5 FT DUAL STD BANANA RED TEST LEAD | 220-1019 | | LEAD,TEST,60IN.STD/STD RED |
| IN ACCESSORY KIT FOR BANANA JACK TYPE PANEL | SINGLE BANANA PLUG | 220-1021 | | PLUG,BANANA.STD,BLACK |
| CURRENTLY IN CABLE SET | 30 AMP ADAPTER, BLACK | 09B-0691-01 | | P/A, ADPTR, HI.C, BLK F2250 |
| CURRENTLY IN CABLE SET | 30 AMP ADAPTER, RED | 09B-0691-02 | | P/A, ADPTR, HI.C, RED F2250 |
| OPTIONAL | 90 AMP DUAL STUD ADAPTER | 03B-1197-01 | | P/A, STUD, ADAPTER 2250F2250 |
| CURRENTLY IN CABLE SET | 3" X 12" X 18" BROWN CABLE BAG | 2FD-1545-01 | | BAG, CBLE, EXTRNL, BRN F2000 |
| CURRENTLY IN ACCESSORY KIT | 8" X 10" ZIP LOCK BAG | 903-0011 | | BAG, ZIP ALL, 10.5 X 8.0 |
| CURRENTLY IN CABLE SET | VELCRO STRAP | 903-0016 | | TIE, CABLE, VELCRO, BLUE |
| CURRENTLY IN CABLE SET | DOBLE LOGO SCREWDRIVER | 09B-0696-01 | | REWORK, SCREWDRIVER INSITE |
| OPTIONAL | PCB CLAMP KIT | 030-1342-01 | | KIT, PCB CLAMP |

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*Figure E.9 F2250 Cable, Adapters and Accessories (Part III)*

# Index

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