

**AFG3000 Series
Arbitrary Function Generators
Service Manual**



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Tektronix

**AFG3000 Series
Arbitrary Function Generators
Service Manual**

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- In North America, call 1-800-833-9200.
- Worldwide, visit www.tektronix.com to find contacts in your area.

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Tektronix warrants that the product will be free from defects in materials and workmanship for a period of three (3) years from the date of original purchase from an authorized Tektronix distributor. If the product proves defective during this warranty period, Tektronix, at its option, either will repair the defective product without charge for parts and labor, or will provide a replacement in exchange for the defective product. Batteries are excluded from this warranty. Parts, modules and replacement products used by Tektronix for warranty work may be new or reconditioned to like new performance. All replaced parts, modules and products become the property of Tektronix.

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This warranty shall not apply to any defect, failure or damage caused by improper use or improper or inadequate maintenance and care. Tektronix shall not be obligated to furnish service under this warranty a) to repair damage resulting from attempts by personnel other than Tektronix representatives to install, repair or service the product; b) to repair damage resulting from improper use or connection to incompatible equipment; c) to repair any damage or malfunction caused by the use of non-Tektronix supplies; or d) to service a product that has been modified or integrated with other products when the effect of such modification or integration increases the time or difficulty of servicing the product.

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General safety summary

Review the following safety precautions to avoid injury and prevent damage to this product or any products connected to it.

To avoid potential hazards, use this product only as specified.

Only qualified personnel should perform service procedures.

To avoid fire or personal injury

Use proper power cord. Use only the power cord specified for this product and certified for the country of use.

Ground the product. This product is grounded through the grounding conductor of the power cord. To avoid electric shock, the grounding conductor must be connected to earth ground. Before making connections to the input or output terminals of the product, ensure that the product is properly grounded.

Observe all terminal ratings. To avoid fire or shock hazard, observe all ratings and markings on the product. Consult the product manual for further ratings information before making connections to the product.

Do not apply a potential to any terminal, including the common terminal, that exceeds the maximum rating of that terminal.

Do not operate without covers. Do not operate this product with covers or panels removed.

Do not operate with suspected failures. If you suspect that there is damage to this product, have it inspected by qualified service personnel.

Avoid exposed circuitry. Do not touch exposed connections and components when power is present.

Do not operate in wet/damp conditions.

Do not operate in an explosive atmosphere.

Keep product surfaces clean and dry.

Provide proper ventilation. Refer to the manual's installation instructions for details on installing the product so it has proper ventilation.

Terms in this manual These terms may appear in this manual:



WARNING. *Warning statements identify conditions or practices that could result in injury or loss of life.*



CAUTION. *Caution statements identify conditions or practices that could result in damage to this product or other property.*

Symbols and terms on the product

These terms may appear on the product:

- DANGER indicates an injury hazard immediately accessible as you read the marking.
- WARNING indicates an injury hazard not immediately accessible as you read the marking.
- CAUTION indicates a hazard to property including the product.

The following symbol(s) may appear on the product:



CAUTION
Refer to Manual



WARNING
High Voltage



Double
Insulated



Protective Ground
(Earth) Terminal

Service safety summary

Only qualified personnel should perform service procedures. Read this *Service Safety Summary* and the *General Safety Summary* before performing any service procedures.

Do not service alone.. Do not perform internal service or adjustments of this product unless another person capable of rendering first aid and resuscitation is present.

Disconnect power. To avoid electric shock, disconnect the mains power by means of the power cord or, if provided, the power switch.

Use care when servicing with power on. Dangerous voltages or currents may exist in this product. Disconnect power, remove battery (if applicable), and disconnect test leads before removing protective panels, soldering, or replacing components.

To avoid electric shock, do not touch exposed connections.

Preface

This manual provides instructions to calibrate, troubleshoot, and repair the Arbitrary Function generators to the module level.

Unless noted otherwise, the term “AFG3000 Series” refers to the models in the AFG3011, AFG3011C, AFG3021B, AFG3021C, AFG3022B, AFG3022C, AFG3051C, AFG3052C, AFG3101, AFG3101C, AFG3102, AFG3102C, AFG3251, AFG3251C, AFG3252, and AFG3252C Arbitrary Function generators.

Manual contents

The manual consists of the following sections:

- *Operating Information* includes general information and operating instructions.
- *Theory of Operation* contains circuit descriptions that support service to the module level.
- *Adjustment Procedures* contains information that you need to manually adjust the *Arbitrary Function generator* so that it meets specifications.
- *Maintenance* contains information and procedures for performing preventive and corrective maintenance of the *Arbitrary Function generator*. These instructions include cleaning, module removal and installation, and fault isolation to the module.
- *Diagrams* contains interconnection diagrams.
- *Replaceable Parts List* includes a table of all replaceable modules, their descriptions, and their Tektronix part numbers.

Manual conventions

This manual uses certain conventions that you should become familiar with.

Some sections of the manual contain procedures for you to perform. To keep those instructions clear and consistent, this manual uses the following conventions:

- Front-panel controls and menu names appear in the same case (initial capitals, all uppercase, and so on) in the manual as is used on the Arbitrary Function generator front-panel and menus. Front-panel labels are all upper case letters (for example, MENU, SELECT, PULSE GEN, and so on).
- Instruction steps are numbered unless there is only one step.

- Modules** Throughout this manual, any replaceable component, assembly, or part of the Arbitrary Function generator is referred to generically as a module. In general, a module is an assembly (like a circuit board), rather than a component (like a resistor or an integrated circuit). Sometimes a single component is a module; for example, the chassis of the Arbitrary Function generator is a module.
- Safety** Symbols and terms related to safety appear in the Safety Summary near the beginning of this manual.

Finding other information

See the following list for other documents supporting the *Arbitrary Function generator*. All documents except the Online Help and the Declassification and Security Instructions are located on the *AFG3000 Series Product Documents CD-ROM* that shipped with instrument. Product documents can also be found on the Tektronix Web site (www.tektronix.com/manuals).

Document name	Description
<i>AFG3000 Series Quick Start User Manual</i>	A quick reference to major features of the instrument and how they operate. It also provides several tutorials to familiarize you with basic instrument features.
<i>AFG3000 Series Specifications and Performance Verification Technical Reference</i>	A source for complete instrument specifications and a procedure for verifying the performance of the instrument.
<i>AFG3000 Series Programmer Manual</i>	An encyclopedia of topics that describe the <i>Arbitrary Function generator</i> interface and features, and gives background information on how to use them. It provides Menu Structures, User Interface, and Programming Information.
<i>AFG3000 Series Online Help</i>	An online help system, integrated with the User Interface application that ships with this product. The online help is preinstalled in the instrument.
<i>AFG3000 Series Declassification and Security Instructions</i>	A source for instructions on how to declassify the instrument.

Introduction

This manual contains information that is needed to properly service the AFG3000 Series Arbitrary Function Generators as well as general information that is critical to safe and effective servicing.

To prevent personal injury or damage to the Arbitrary Function generator, consider the following before attempting service:

- The procedures in this manual should be performed only by a qualified service person.
- Read the *General safety summary* and the *Service safety summary*. (See page v.)
- Read the operating requirements for the instrument. (See page 9, *Operating Requirements*.)

When using this manual for servicing, be sure to follow all of the warnings, cautions, and notes.

Strategy for servicing

This manual contains the information needed for periodic maintenance of the Arbitrary Function generator. Further, it contains information for corrective maintenance down to the module level:

- To isolate a failure to a module, use the troubleshooting procedures found in the *Maintenance* section.
- To remove and replace any failed module, follow the instructions in the *Removal and Installation Procedures* subsection.
- After isolating a faulty module, replace it with a fully-tested module obtained from the factory. The *Replaceable Parts List* section contains part number and ordering information for all replaceable modules.

Tektronix service offerings

Tektronix provides service to cover repair under warranty as well as other services that may provide a cost-effective answer to your service needs.

Tektronix service technicians are well trained to service the Arbitrary Function generator. They have access to the latest information on improvements to the AFG3000 Series as well as new options.

Warranty repair service

Tektronix warrants this product for three years from date of purchase. The warranty appears at the front of this manual. Tektronix technicians provide warranty service at most Tektronix service locations.

Self service Tektronix supports repair to the replaceable part and module level.

For more information Contact your local Tektronix service center or sales engineer for more information on any repair or adjustment service.

Performance verification procedures

The performance check is provided in the *AFG3000 Series Specifications and Performance Verification Technical Reference* manual should be performed every 12 months. In addition, a performance check is recommended after module replacement.

If the AFG3000 Series does not meet the performance criteria, repair is necessary.

Operating basics

This section provides installation and operating information that is necessary for service.

General features

Each AFG3000 Series Arbitrary Function Generators offers the functionality of three generators in one:

- 10 MHz to 240 MHz Function Generator
- 5 MHz to 120 MHz Pulse Generator
- 14 bits Arbitrary Waveform Generator

The following tables describe some of the general features of your instrument. An “X” means the feature is included with the model.

Table 1: General features for regular and B models

Feature	AFG3011	AFG3021B/ AFG3022B	AFG3101/ AFG3102		AFG3251/ AFG3252	
Channel	1	1/2	1/2		1/2	
Sine	10 MHz	25 MHz	100 MHz		240 MHz	
Pulse	5 MHz	12.5 MHz	50 MHz		120 MHz	
Memory	2 to 131,072	2 to 131,072	2 to 16,384	>16,384 to 131,072	2 to 16,384	>16,384 to 131,072
Sampling Rate	250 MS/s	250 MS/s	1 GS/s	250 MS/s	2 GS/s	250 MS/s
Amplitude	20 Vp-p	10 Vp-p	10 Vp-p		5 Vp-p	
Display	Color	Monochrome/ Color	Color		Color	
Interface	USB, LAN, GPIB	USB, LAN, GPIB	USB, LAN, GPIB		USB, LAN, GPIB	
Ground isolation	X	X	X		X	
Synchronous operation	X	X	X		X	
Context-sensitive Help system	X	X	X		X	
ArbExpress® Software	X	X	X		X	

Table 2: General features for C models

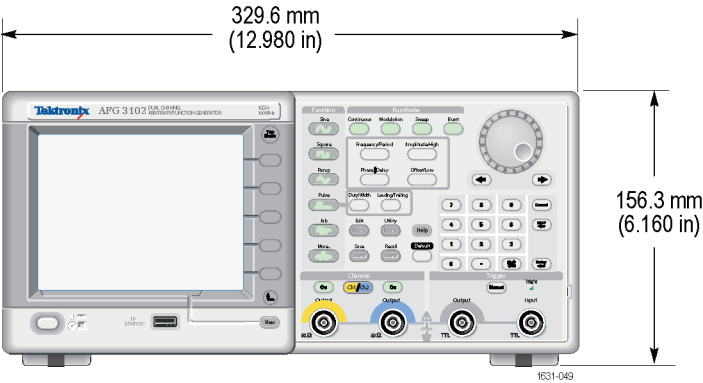
Feature	AFG3011C	AFG3021C/ AFG3022C	AFG3051C/ AFG3052C	AFG3101C / AFG3102C	AFG3251C / AFG3252C
Channel	1	1 / 2	1 / 2	1 / 2	1 / 2
Sine	10 MHz	25 MHz	50 MHz	100 MHz	240 MHz
Pulse	5 MHz	25 MHz	40 MHz	50 MHz	120 MHz
Memory	2 to 131,072	2 to 131,072	2 to 131,072	2 to 16,384 >16,384 to 131,072	2 to 16,384 >16,384 to 131,072
Sampling Rate	250 MS/s	250 MS/s	1 GS/s	1 GS/s	250 MS/s
Amplitude	20 Vp-p	10 Vp-p	10 Vp-p	10 Vp-p	5 Vp-p
Display	Color	Color	Color	Color	Color
Interface	USB, LAN, GPIB	USB, LAN, GPIB	USB, LAN, GPIB	USB, LAN, GPIB	USB, LAN, GPIB
Ground isolation	X	X	X	X	X
Synchronous operation	X	X	X	X	X
Context-sensitive Help system	X	X	X	X	X
ArbExpress® Software	X	X	X	X	X

Operating Requirements

Use the following information to safely install your instrument.

Environmental

- 1. Place the instrument on a cart or bench, observing clearance requirements:
 - Sides: 50 mm (2 in)
 - Rear: 50 mm (2 in)
- 2. Before operating, ensure that the ambient temperature is between 0 °C to +50 °C (+32 °F to +122 °F).



CAUTION. To ensure proper cooling, keep both sides of the instrument clear of obstructions.

Power Supply Requirements



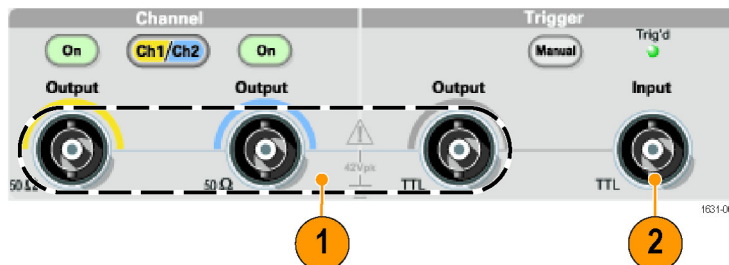
WARNING. To reduce the risk of fire and shock, ensure that the mains supply voltage fluctuations do not exceed 10% of the operating voltage range.

Requirement	AFG3000 series / AFG3000B series / AFG3000C series
Source Voltage and Frequency	100 V to 240 V, 47 Hz to 63 Hz; or 115 V, 360 Hz to 440 Hz
Power Consumption	Less than 120 W

Protect your instrument from misuse

Check input and output connectors

1. Locate the output connectors on the front panel. The image shown here shows the outputs.
2. Locate the input connector on the front panel. Some instrument models have more than one input.



NOTE. When connecting a cable, be sure to distinguish the input connector from the output connectors to avoid making the wrong connection.

The instrument input and output connectors are floating inputs/outputs.



WARNING. To avoid personal injury due to electric shock, do not apply voltages in excess of 42 Vpk to any BNC connector ground or to the chassis ground.



CAUTION. Do not short output pins or apply external voltages to Output connectors. The instrument may be damaged.



CAUTION. Do not apply excessive inputs over +5 V to Trigger Input connector. The instrument may be damaged.

Use fuse adapter

The instrument will be damaged if a large DC or AC voltage is applied to the output or input connectors. To protect the output circuits, a fuse adapter is provided as an optional accessory. When the instrument is used by students or other inexperienced users, always attach the fuse adapter to the output connectors to avoid damage.

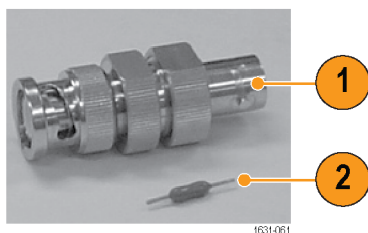


Figure 1: Fuse and fuse adapter

1. Fuse adapter
2. Fuse

Floating ground

Since the common (input and output channel common) of the arbitrary function generator is electrically isolated from the chassis ground (the instrument chassis and ground line of the AC connector), you can make a floating connection between the instrument and other equipment.

All the signal output connectors are connected to the common ground, and the remote interface connector is connected to the chassis ground.



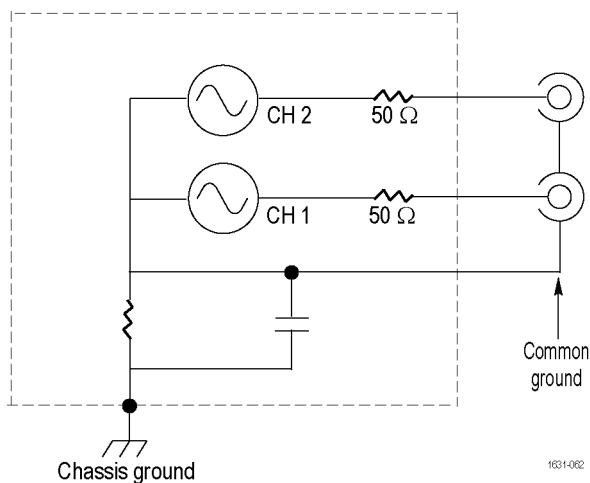
WARNING. To prevent electrical shock, use this product so that the sum of the floating voltage and the output voltage of the instrument does not exceed 42 V_{pk}. Do not touch the center of the BNC while the equipment is in use.



CAUTION. The maximum rated voltage between the chassis ground and common ground is 42 V_{p-p} (DC + peak AC). When the potential voltage between the chassis ground and common ground goes over 42 V_{p-p}, the internal protective circuit will be activated to protect the circuits. However, higher voltage may cause the internal circuits in the instrument to be damaged.

When a potential voltage exists between the chassis ground and common ground, a short circuit from output to ground causes the instrument internal fuse to open and the output is stopped. If the fuse opens, you need to contact your local Tektronix Service Support.

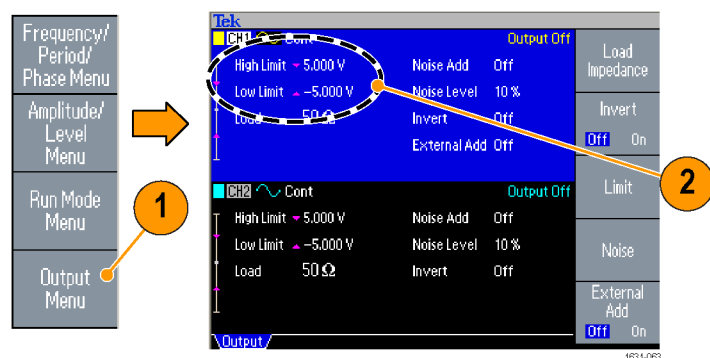
When a potential voltage exists between the common ground and chassis ground, short-circuiting between them may lead to excessive current flow and the internal or external circuits may be damaged.



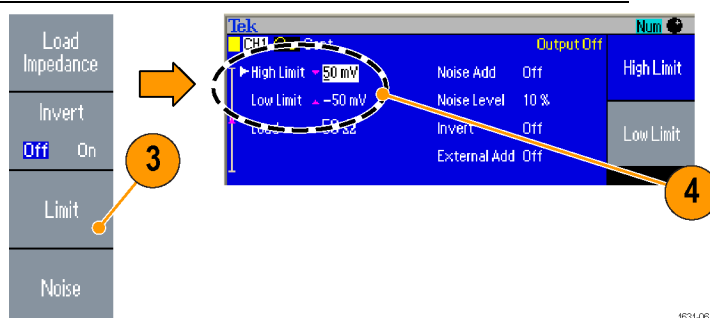
Protect your DUT

Use care when you connect the instrument Channel Output to your DUT (device under test). To avoid damage to your DUT, the following preventive measures are provided. Follow these steps to set the limit values for high level and low level.

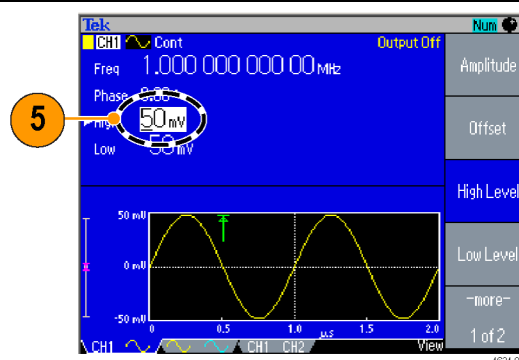
1. Push the front-panel Top Menu button. The Output Menu is displayed at the bottom of the bezel menu. Select Output Menu.
2. In this example, High Limit is set to 5.000 V, and Low Limit is set to -5.000 V.



3. Push the Limit bezel button.
4. Select High Limit. Use numeric keys or the general purpose knob to enter a value. Enter 50 mV for High Limit, and -50 mV for Low Limit.



5. Push the front-panel Sine button to display the waveform parameter. Confirm that High and Low voltage levels were changed. You cannot enter any values greater than 50 mV for High level.



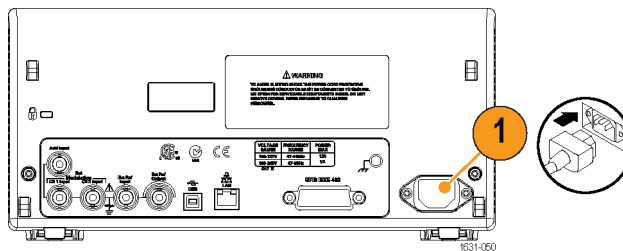
NOTE. When you set limit values using Output Menu, a level indicator is displayed at left end of graph area.

Power the instrument on and off

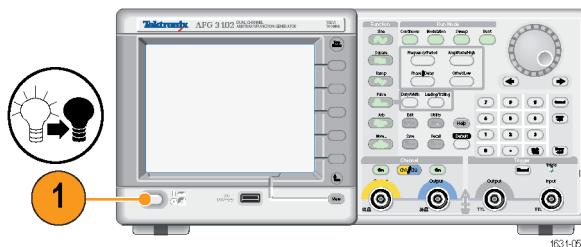
The following procedures show you how to apply power to the instrument and turn it on and off.

Power on

1. Insert the AC power cord into the power receptacle on the rear panel.

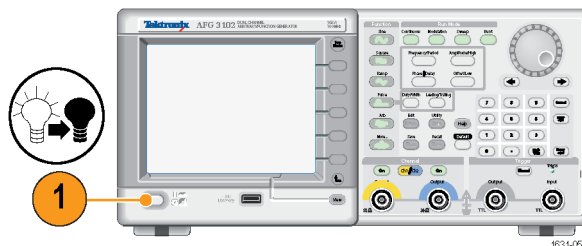


2. Push the front-panel power button to power on the instrument.
Wait until the front panel display shows that the instrument has passed all power-on self tests before using the instrument.



Power off

1. Push the front-panel power button to power off the instrument.



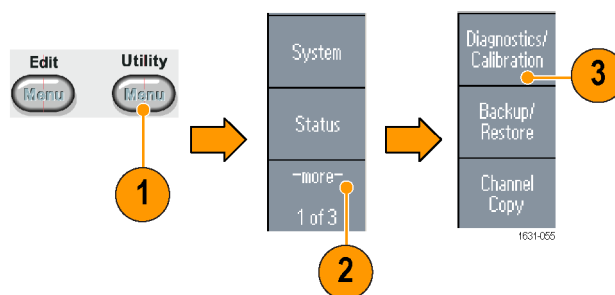
Perform instrument self test and self calibration

The instrument performs a limited set of hardware tests at power-on. You can also perform the following manual diagnostics and/or self calibration using the Utility menu:

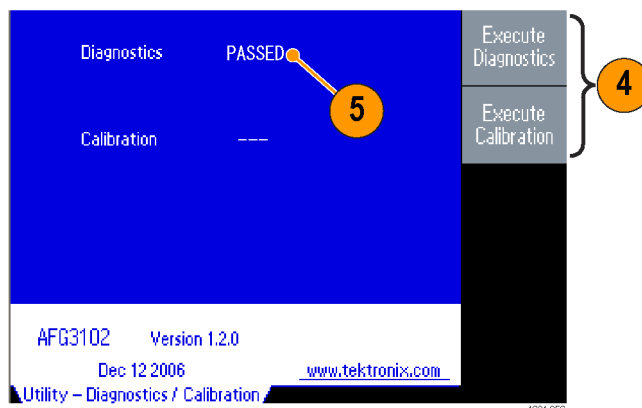
- **Diagnostics (Self test):** Perform the self test to verify that your instrument is operating correctly.
- **Calibration (Self calibration):** The self calibration mainly checks DC accuracy using the internal calibration routines.

NOTE. If you need to verify that the instrument meets the warranted specifications, do the complete set of performance verification procedures provided in the *Specifications and Performance Verification manual*.

1. Push the front-panel Utility button.
2. Push the -more- bezel button.
3. Push the Diagnostics/Calibration bezel button.



4. To execute the instrument diagnostics, push the Execute Diagnostics bezel button.
To execute self calibration, push the Execute Calibration bezel button.
5. If Diagnostics completes without any errors, the message "PASSED" is displayed.



CAUTION. Do not power off the instrument while executing self calibration. If the power is turned off during self calibration, data stored in the internal memory may be lost.

Quick Tips

- Before executing self calibration, ensure that the ambient temperature is between +20 °C and +30 °C (+68 °F to +86 °F). Allow a 20 minute warm-up period before executing self calibration.
- Disconnect all the cables from the instrument when you perform self test or self calibration.
- Perform self calibration at least once a year to maintain DC accuracy. It is recommended that the self calibration should be performed along with a periodic check.

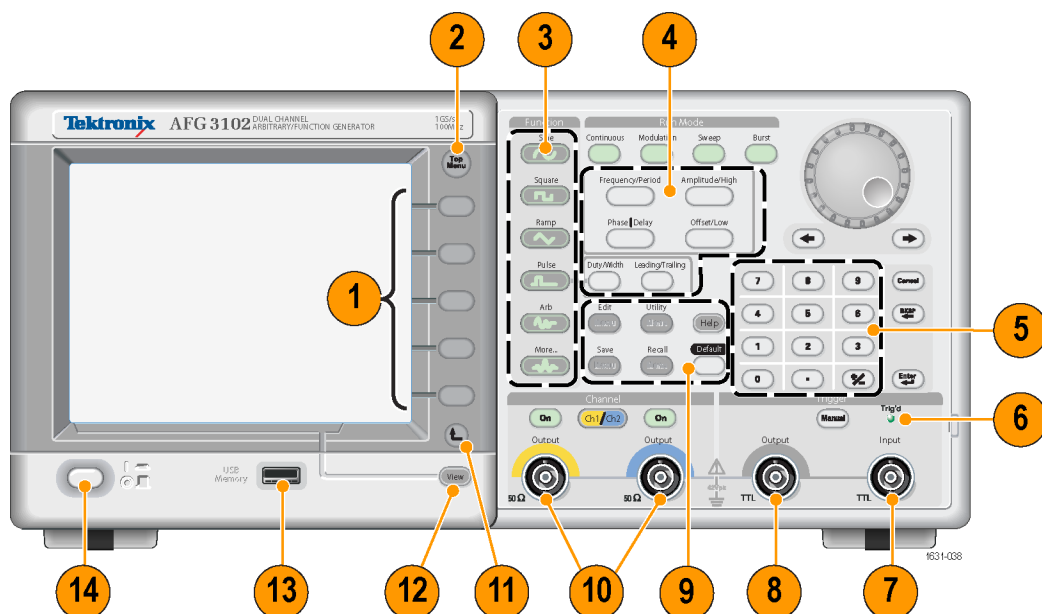
Overheat Protection (AFG3011 / 3011C Only)

The instrument internal temperature is monitored in the AFG3011 and AFG3011C. A warning message will appear if the internal temperature reaches a threshold level, and signal output will automatically turn off. If the warning message appears, check for the following conditions:

- The ambient temperature requirement is being met.
- The required cooling clearance is being met.
- The instrument fan is working properly.

Front panel overview

The front panel is divided into easy-to-use functional areas. This section provides you with a quick overview of the front panel controls and the screen interface. The following figure shows the front panel of the dual-channel model.



1. Bezel menu buttons
2. Top menu button
3. Function buttons
4. Shortcut buttons
5. Numeric keypad
6. Triggered LED is lit when the instrument receives an internal or external trigger
7. Trigger input connector
8. Trigger output connector
9. Menu buttons
10. CH 1 and CH 2 output connectors
11. Return to previous menu button
12. View button
13. USB connector
14. Power on/off switch

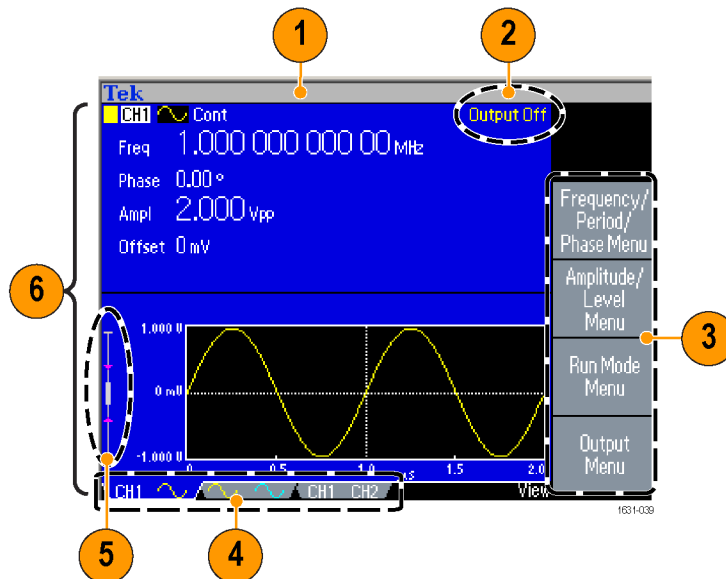
Lock or unlock the front panel controls

If you need to lock the front panel controls, use the following remote command:

- `SYSTem:KLOCK[:STATe]`

To unlock the front panel without using a remote command, push the front-panel Cancel button twice.

Parts of the screen interface



Bezel menu. When you push a front panel button, the instrument displays the corresponding menu on the right side of the screen. The menu shows the options that are available when you push the unlabeled bezel buttons directly to the right of the screen. (Some documentation may also refer to the bezel buttons as option buttons, side-menu buttons, or soft keys.)

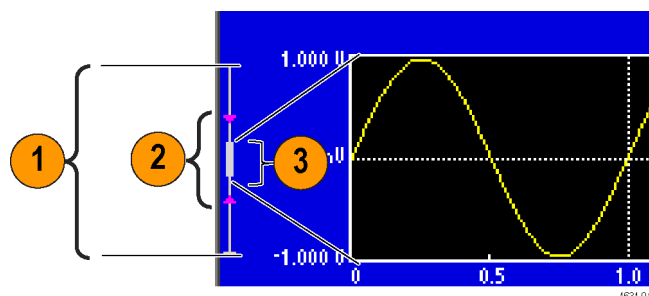
Main display area and View tab. Pushing the front-panel View button toggles through the view format of the main display area. The view tabs correspond with the current view format. The instrument can display three different screen formats.

Output status. If the output is set to disable, Output Off message is displayed in this area. When you push the front panel channel output button to enable the output, the message will disappear.

Message display area. A message that monitors hardware status such as clock or trigger is displayed in this area.

Level meter. Amplitude level is displayed. The following figure describes the level meter.

1. Shows maximum amplitude level of your instrument.
2. Shows the range of high limit and low limit set by the user.
3. Shows the amplitude level that is currently selected.



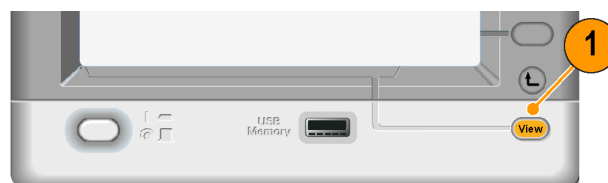
1631-017

View button

The instrument provides the following three screen view formats:

- Waveform parameter and graph display
- Graph comparison
- Waveform parameter comparison

1. To change the screen display format, push the front-panel View button.

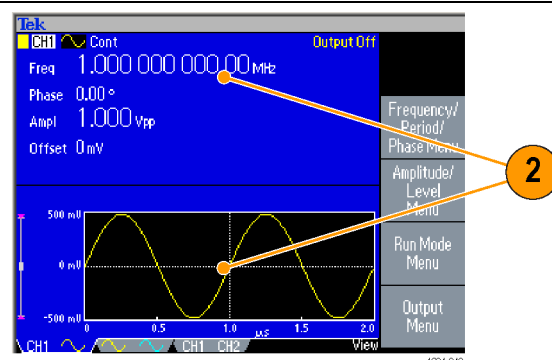


1631-018

2. The first format provides the single channel waveform parameters and graph display. (Dual-channel model only): You can toggle the CH1 and CH2 information by pushing the channel select button.

When you push the View button once, the view format is changed to the graph comparison format.

Push the View button again to display the third format. This view provides the channel parameter comparison.



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Quick Tips

- If the instrument is currently in the Save, Recall, Utility, Help, or Output menu, pushing the View button will have no effect.
- When the instrument is in the Edit menu, pushing the View button will toggle between Edit text and graphical views. This is the only function of the single-channel model view button.

Theory of operation

This section describes the electrical operation of the AFG3000 Series Arbitrary Function Generators to the module level. It describes the basic operation of each functional circuit block shown in the block diagram. (See Figure 2 on page 22.)

The descriptions for the one and two channel units, and the color and monochrome units are slightly different.

Overview

AFG3000 Series Arbitrary Function Generators provide a number of models with different frequencies and numbers of channels. Each model consists of two major sections: the platform section and the generator section. The platform section is common to each model.

The combination of circuit boards in each model is shown below. (See Table 3.)

Table 3: Combination of circuit boards used in each model

Circuit board	AFG3051C / AFG3052C	AFG3021B/C	AFG3022B/C	AFG3101/C	AFG3102/C	AFG3251/C	AFG3252/C	AFG3011/C
A11 Generator with Amp 1ch	1	1						
A12 Generator with Amp 2ch			1					
A31 Generator 1ch				1				
A32 Generator 2ch					1			
A41 Generator High 1ch						1		
A42 Generator High 2ch							1	
A43 Generator								1
A51 Output Amp				1	2			
A61 Output Amp						1	2	
A72 CPU	1	1	1	1	1	1	1	1
A75 Front Panel	1	1	1	1	1	1	1	1
A80 BNC/Peltola			1	1	2	1	2	

Table 3: Combination of circuit boards used in each model (cont.)

Circuit board	AFG3051C / AFG3052C							
	AFG3052C	AFG3021B/C	AFG3022B/C	AFG3101/C	AFG3102/C	AFG3251/C	AFG3252/C	AFG3011/C
A81 Front BNC Insulator	1	1	1	1	1	1	1	1
A82 Rear BNC Insulator	1	1	1	1	1	1	1	1

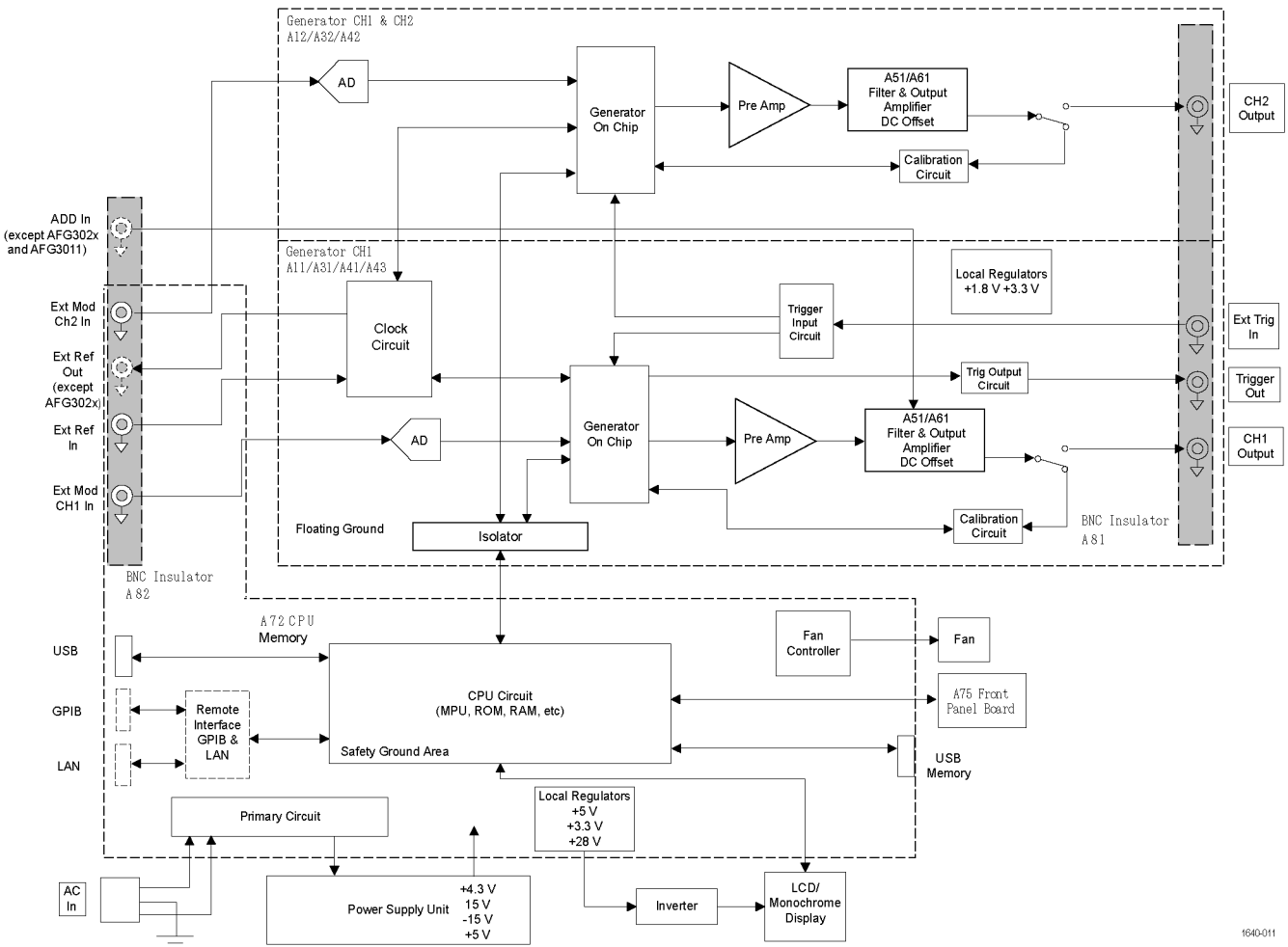


Figure 2: AFG3000 Series block diagram

Platform section

CPU board (A72)

CPU circuit. The CPU Circuit contains an MPU, Flash RAM, and DRAM to control the instrument. The liquid crystal controller and the USB circuit are included in the MPU.

Local regulators. This regulator stabilizes and supplies +3.3 V and +5.0 V for the logic circuit.

Remote interface. The A72 board contains a GPIB and LAN driver circuit.

Fan controller. This circuit controls the speed of the fan.

Primary circuit. Contains the power switch and the filter circuit.

Signal I/O circuit. The Reference Clock Input/Output and the Modulation Input signals are transmitted to the Generator section through this board.

Front panel The Front Panel controls a rubber button matrix, LED, a buzzer, and a rotary encoder.

Power supply The power supply module provides +4.3 V, ± 15 V, and +5 V to the circuit. This power supply module accepts the input voltage within the range of 250 VAC from 90 VAC.

LCD The display is a color/monochrome Quarter VGA (320 x 240) STN LCD display. The high voltage power for LCD is supplied through the inverter. A monochrome display is used in the AFG3021B/C.

Fan A 90 mm by 90 mm size, DC 12 V type fan. It is driven by fan controller on the CPU board.

BNC Insulator board (A81/A82) These boards insulate the I/O signal from the chassis. The A81 board is used for the rear-panel connectors and the A82 board is used for the front-panel connectors.

Generator section

Generator with Amp board (A11/A12/A43)

Isolator. Transmit the serial control signal from the CPU board to the following circuits with electrical insulation.

Clock circuit. Generates a 1 GHz high-speed clock necessary for the signal generation from a 10 MHz reference clock by PLL. This circuit has a function of selecting the reference signal source as well.

GoC ASIC. GoC (Generator on Chip) ASIC is a CMOS waveform synthesis IC which includes 2 GS/s DA, Direct Digital Synthesis, waveform SRAM 128 K, x8 MUX, Modulation, Burst and Sweep. So GoC manages most of the generator section.

Trigger circuit. Receives an External Trigger input signal, executes the level conversion, then supplies the level converted trigger signal to the GoC ASIC.

Pre-Amplifier circuit. Converts the differential output signal of the GoC to single ended output, then supplies the single ended output to the Output Amplifier through the Attenuator.

Output amplifier. The output of the pre-amplifier is amplified and output. LPF is used when a sine wave is output.

Trig Out circuit. Sync Out signal from GoC ASIC is level converted to Trigger Out.

ADC. Modulation by an external source is performed by digitally sampling the external input from the Ext Modulation Input connector.

Local regulator. Supplies the necessary +1.8 V, +3.3 V, +15 V, and -15 V power.

On/Off relay. On/Off of the output signal.

Calibration circuit. DC Calibration of the output signal is done by a 16 bit AD Converter.

Generator with Amp board (A31/A32/A41/A42)

The A31/A32/A41/A42 boards are the same as the A11/A12 boards except they have a different Output Amplifier board.

Output Amp board (A51/A61)

Output amplifier. Amplifying the output of the pre-amplifier with the DC offset.

Output filter. LPF is used when a sine wave is output.

Adjustment procedures

This section describes the procedures necessary to manually adjust the AFG3000 Series Arbitrary Function Generators. Perform each adjustment when you exchange a circuit board.

Purpose

This procedure returns the Arbitrary Function generator to compliance with its Warranted Characteristics as listed in the Specification section. It can also be used to optimize the performance of the Arbitrary Function generator.

Adjustment interval Generally, these adjustments should be done every 12 months.

Adjustment after repair After the removal and replacement of a module due to electrical failure, perform the adjustment procedure in this section. The table below lists the adjustment items that should be performed after repair.

Table 4: Adjustments performed after repair

Adjustment	AFG3011, AFG3011C		AFG3021B / C, AFG3022B / C, AFG3051C, AFG3052C		AFG3101, AFG3101C, AFG3102, AFG3102C, AFG3251, AFG3251C, AFG3252, AFG3252C		
	A72 CPU	A43 Generator	A72 CPU	A11, A12 Generator	A72 CPU	A31, A32, A41, A42 Generator	A51, A61 Output
Reference clock	X	X	X	X	X	X	
LF	X	X			X	X	X
Flatness	X	X	X	X	X	X	X
Spurious					X	X	X
Trigger delay	X	X	X	X	X	X	

Equipment required

The following table lists the equipment that is required to complete the adjustment procedures.

Table 5: Test equipment

Description	Minimum requirements	Recommended equipment	Purpose
1. Digital multi meter (DMM)	AC volts, true rms, AC coupled Accuracy: $\pm 0.02\%$ to 1 MHz DC volts Accuracy: 50 ppm, resolution 100 μV Resistance accuracy: $\pm 0.05 \Omega$	Agilent 3458A	Measures voltage. Used in multiple procedures.
2. Power meter	100 kHz to 250 MHz 1 μW to 100 mW (-30 dBm to +20 dBm) Accuracy: 0.02 dB Resolution: 0.01 dB	R&S NRVS	Measures voltage. Used in multiple procedures.
3. Power head	100 kHz to 250 MHz 1 μW to 100 mW (-30 dBm to +20 dBm)	R&S NRV-Z5	Measures voltage. Used in multiple procedures.
4. Frequency counter	50 kHz to 5 GHz, Accuracy: 0.01ppm Phase measurement	Agilent 53132A	Checks clock frequency.
5. Oscilloscope	1 GHz bandwidth 50 Ω input termination	Tektronix TDS5104B	Checks output signals. Used in multiple procedures.
6. Spectrum analyzer	20 kHz to 1.25 GHz	Tektronix RSA3303A	Checks output signals. Harmonics Spurious.
7. BNC coaxial cable (2 required)	50 Ω , male to male BNC connector, 91 cm	Tektronix part number 012-0482-00	Signal interconnection
8. BNC terminator	50 Ω , $\pm 1\Omega$, 2 W, DC to 1 GHz, BNC	Tektronix part number 011-0049-02	Signal termination
9. Adapter dual-banana Plug	BNC (female) to dual banana	Tektronix part number 103-0090-00	Signal interconnection to a DMM
10. Adapter BNC(fe)-N(ma)	BNC (female) to N (male)	Tektronix part number 103-0045-00	Signal interconnection to a Spectrum Analyzer

Performance conditions

The adjustments in this section are an extensive, valid confirmation of performance and functionality when the following requirements are met:

- The cabinet covers must be on the AFG3000 Series.
- The instrument must have been calibrated/adjusted at an ambient temperature between +20 °C and +30 °C.
- The instrument must have had a warm-up period of at least 20 minutes.

Enable the Service mode

You must enable the service mode to perform the adjustment procedure. Do the following steps to enter the service mode:

1. Push the power button to power on the Arbitrary Function generator.
2. After the beep, push the front-panel **Recall** button, and then push the front-panel **7** numeric button.
3. Keep pushing these buttons until the power-on screen is displayed.
4. Release the buttons when the top screen is displayed.
5. Check whether the service mode is available by pushing the **Utility** > **-more-** > **-more-** buttons. The Service menu is displayed in the third page of Utility menu.

Save menu

You can adjust the Reference Clock, LF, Flatness, Spurious, and Trigger Delay parameters on the Manual Calibration that is described in this section. Each of changed parameters is stored in non-volatile memory of the Arbitrary Function generator after you push the Save menu in the first page of Manual Calibration. Previous adjustment parameters will be recalled after a power cycle unless you push the Save menu button.

Clear CAL Data menu

The Clear CAL Data menu in the second page of Manual Calibration clears all the current adjustment parameters and sets them to 0. However, unless you push the Save menu button, the previous adjustment parameters will be recalled after a power cycle.

Reference clock

This procedure adjusts the frequency accuracy of the Arbitrary Function generator. For any model, only one frequency point of channel 1 is adjusted.

1. Connect the Arbitrary Function generator to the frequency counter as shown below.

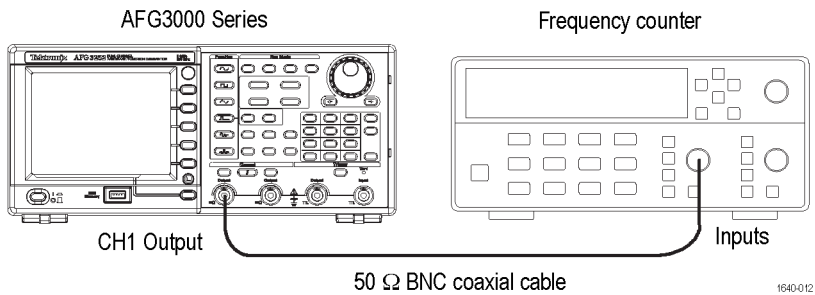


Figure 3: Reference clock adjustment connections

2. Push the **Default** front-panel button and the **OK** menu button to recall the Arbitrary Function generator default setup.
3. Set up the Arbitrary Function generator as shown in the following table:

Select menu	Setting	Operation
Function	Sine	Sine (front)
Frequency	1.000000 MHz	Frequency/Period (front)
Amplitude	1.00 Vpp	Amplitude/High (front)
Channel 1 Output	On	On (front)

4. Select the Ref Clock value by pushing the **Utility** > **-more-** > **-more-** > **Service Menu** > **Manual Calibration** > **-more-** > **Reference Clock** buttons.
5. Adjust the Ref Clock value with the rotary knob so that the frequency counter reading is between 0.999999 MHz and 1.000001 MHz.
6. Push the **Save** menu button to save the adjusted value.

LF adjustment

This procedure adjusts the LF amplitude accuracy of the Arbitrary Function generator. This adjustment is not necessary in the AFG3021B/C and AFG3022B/C.

1. Connect the Arbitrary Function generator to the DMM as shown below.

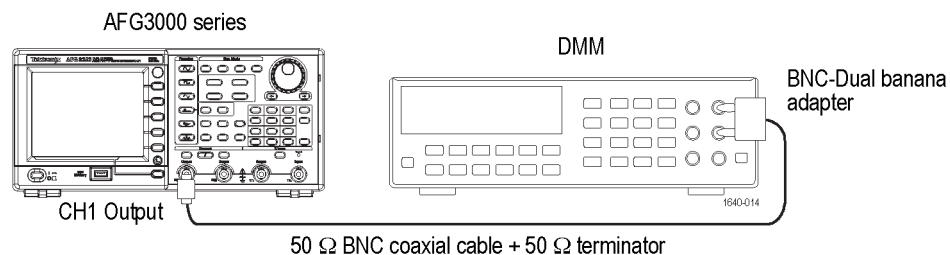


Figure 4: LF adjustment connections

2. Set up the Arbitrary Function generator as shown in the following table:

Select menu	Setting	Operation
Function	Sine	Sine (front)
Frequency	AFG3011x and AFG301xx: 10.00000 kHz AFG325xx: 100.00000 kHz	Frequency/Period (front)
Load Impedance	50 Ω	TopMenu > Output Menu > Load Impedance > 50 Ω
Amplitude	1.00 Vpp	Amplitude/High (front)
Channel 1 Output	On	On (front)

3. Set the DMM voltage unit to VAC (effective voltage).
4. Record the DMM voltage reading in the following table:

AFG	Function	Frequency	DMM reading	
AFG3011x	Sine	10.00000 kHz	CH1:	
AFG310xx	Sine	10.00000 kHz	CH1:	CH2:
AFG325xx	Sine	100.00000 kHz	CH1:	CH2:

5. Set the AFG3000 Series frequency to **100.000 Hz**.
6. Select the LF Adj value by pushing the **Utility > -more- > -more- > Service Menu > Manual Calibration > LF Adjustment > (CH1)** buttons.
7. Adjust the LF Adj value with the rotary knob so that the DMM voltage reading is the same as shown in the table for step 4.

8. AFG3102x and AFG3252x only:
 - a. Connect the AFG3000 Series CH2 Output to the DMM.
 - b. Repeat steps 2 through 7 for the channel 2 output.
9. Push the  button and the **Save** menu button to save the adjusted value.

Flatness adjustment

To obtain the flatness of sine waveform relative to the 100 kHz sine waveform, compensate the output level of the sine waveform at 5 MHz interval with the power meter.

1. Connect the Arbitrary Function generator to the power meter with a power head as shown below.

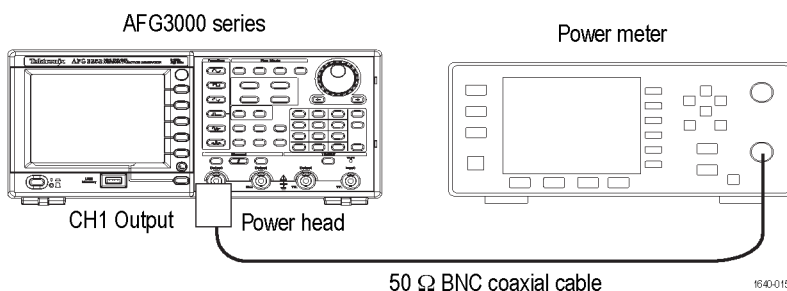


Figure 5: Flatness adjustment connections

2. Set up the Arbitrary Function generator as shown in the following table:

Select menu	Setting	Operation
Amplitude Units	Vpp	TopMenu > Amplitude/Level Menu > -more- > Units > Vpp
Amplitude	1.0 Vpp	Amplitude/High (front)
Offset	0 V	Offset/Low (front)
Channel 1 Output	On	On (front)

3. Push the **Utility > -more- > -more- > Service Menu > Manual Calibration > Flatness > CH1-Flatness Next Frequency** buttons. The setting of the first frequency of the Arbitrary Function generator is 100 kHz.
4. Set the frequency parameter of the power meter to 100 kHz, and compensate the power meter so that the reading value at 100 kHz may become 0 dB with the frequency dependent offset function. Then set up the power meter to the relative measurement mode.
5. Push the **CH1-Flatness Next Frequency** button. The setting of next frequency of the Arbitrary Function generator becomes 5 MHz.

6. Change the frequency of the power meter setting to 5 MHz so that it is the same as the Arbitrary Function generator frequency.
7. The power meter shows the value difference from the reference value. Set this value to the **Flatness** field of the Arbitrary Function generator.
8. Repeat steps 5 through 7 until the setting of the Arbitrary Function generator is as follows:
 - AFG3011x: 10 MHz
 - AFG302xx: 25 MHz
 - AFG310xx: 100 MHz
 - AFG325xx: 240 MHz

The output signal frequency of the Arbitrary Function generator increases in 5 MHz steps (1 MHz steps for the AFG3011x) every time you push the CH1-Flatness Next Frequency button. Set the frequency of the power meter to the same frequency of the Arbitrary Function generator in step 6. Pushing the CH1-Flatness Previous Frequency button decreases the output frequency of the Arbitrary Function generator.

9. Push the **CH1-Flatness Apply Parameters** button to enable the input data for flatness correction.
10. **AFG3xx2x only:** Repeat steps 2 through 9 for the channel 2 output.
11. Push the  button and the **Save** menu button to save the adjusted value.

Spurious adjustment

This adjustment minimizes spurious of the output signal by adjusting spurious in the frequency of several points. This adjustment is not necessary in the AFG3011/C, AFG3021B/C, and AFG3022B/C.

1. Connect the Arbitrary Function generator to the spectrum analyzer as shown below.

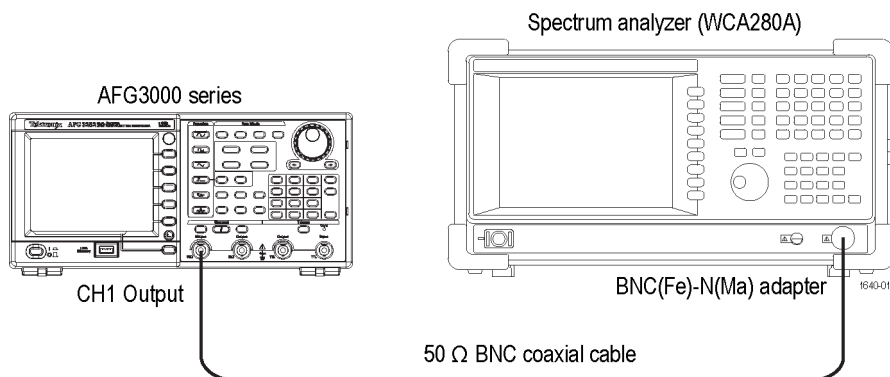


Figure 6: Spurious adjustment connections

2. Set up the Arbitrary Function generator as shown in the following table:

Select menu	Setting	Operation
Function	Sine	Sine (front)
Amplitude Units	Vpp	TopMenu > Amplitude/Level Menu > -more- > Units > Vpp
Amplitude	1.0 Vpp	Amplitude/High (front)
Channel 1 Output	On	On (front)

3. Access the Spurious Adjustment menu:

- AFG310xx only: Push the **Utility** > **-more-** > **-more-** > **Service Menu** > **Manual Calibration** > **Spurious Adjustment** > **CH1 Pulse 2.7 MHz** buttons.
- AFG325xx only: Push the **Utility** > **-more-** > **-more-** > **Service Menu** > **Manual Calibration** > **Spurious Adjustment** > **CH1 Sine 0.1 MHz** buttons.

4. Set up the spectrum analyzer according to the Spurious adjust setup of your AFG3000 Series instrument:

AFG3000 Series	Spectrum analyzer		
Spurious adjust	Center frequency	Span	Spurious frequency
AFG310xx			
Pulse 2.7 MHz	247.3 MHz	100 kHz	247.3 MHz
AFG325xx			
Sine 0.1 MHz	249.9 MHz	100 kHz	249.9 MHz
Sine 50 MHz	200 MHz	100 kHz	200 MHz
Sine 200 MHz	50 MHz	100 kHz	50 MHz
Pulse 2.7 MHz	247.3 MHz	100 kHz	247.3 MHz

5. Push the **CH1-Sine (Pulse) x.x MHz Gain** menu button.
6. Adjust the **Spurious Gain** value with the rotary knob to minimize the spurious display on the spectrum analyzer screen.
7. Push the **CH1-Sine x.x MHz Phase** menu button.
8. Adjust the **Spurious Phase** value with the rotary knob to minimize the spurious display on the spectrum analyzer screen.
9. Push the  button. Repeat steps 4 through 8 to minimize the spurious display on the spectrum analyzer screen for each frequency of the Sine (Pulse) x.x MHz.
10. AFG3xx2x only: Repeat steps 2 through 9 for the channel 2 output.
11. Push the  button and the **Save** menu button to save the adjusted value.

Trigger delay adjustment

This procedure adjusts trigger timing of two channels. This adjustment is not necessary in the AFG3011/C, AFG3021B/C, AFG3101/C, and AFG3251/C.

1. Connect the Arbitrary Function generator to the oscilloscope as shown below.

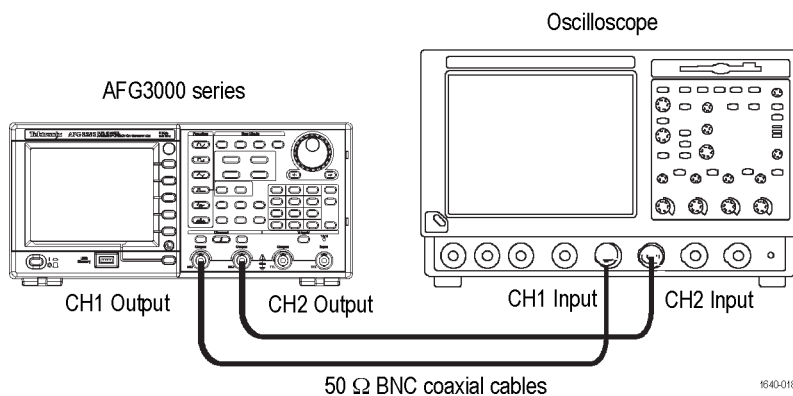


Figure 7: Trigger delay adjustment connections

2. Push the **Default** front-panel button and the **OK** menu button to recall the Arbitrary Function generator default setup.
3. Set up the Arbitrary Function generator as shown in the following table:

Select menu	Setting	Operation
Function (CH1)	Pulse	Pulse (front)
Leading (CH1)	AFG3022x: 18 ns AFG3102x: 5 ns AFG3252x: 2.5 ns	Pulse Parameter Menu (menu) > Leading Edge
Delay (CH1)	0.00 ns	Delay (front)
Function (CH2)	Pulse	CH1/CH2 > Pulse (front)
Leading (CH2)	AFG3022Bx: 18 ns AFG3102x: 5 ns AFG3252x: 2.5 ns	Pulse Parameter Menu (menu) > Leading Edge
Delay (CH2)	0.00 ns	Delay (front)
Run Mode (CH2)	Burst	Burst (front)
Trigger Delay	0.0 ns	more (menu) > Delay
Run Mode (CH2)	Continuous	Continuous (front)
Channel 1 Output	On	On (front)
Channel 2 Output	On	On (front)

4. Set up the oscilloscope as shown in the following table:

Select menu	Setting	Operation
Horizontal	200 ns/div	Sec/div knob
Vertical (CH1 and CH2)	200 mV/div	Volts/div knob
Vertical position	Align the baseline of each channel	CH1 and CH2 Vertical position knob

5. Push the **Utility** > **-more-** > **-more-** > **Service Menu** > **Manual Calibration** > **-more-** > **Trigger Delay** buttons.
6. Change the value of the **Trigger Delay** in the Service menu to a value other than 0.0 ns, and then return the value to 0.0 ns.
7. Push the **CH1/CH2** button to activate the CH1 screen.
8. Push the **Burst** > **-more-** > **Delay** buttons to change the CH1 Run mode to Burst mode.
9. Change the value of the **Trigger Delay** in the Burst menu to a value other than 0.0 ns, and then return the value to 0.0 ns.
10. Push the **Continuous** button to change the CH1 Run mode to Continuous mode.
11. Push the **Phase | Delay** > **Recover Lead Delay** buttons.
12. Change the Horizontal setting of the oscilloscope to 1 ns/div.
13. Make a note of the skew time of the two signals from the oscilloscope screen.
14. Push the **Utility** > **-more-** > **-more-** > **Service Menu** > **Manual Calibration** > **-more-** > **Trigger Delay** buttons.
15. Set the **Trigger Delay** to the value noted in step 13.
16. Push the **-more-** > **Save** > **OK** buttons.
17. Push the **Burst** > **-more-** > **Delay** buttons to change the CH1 Run mode to Burst mode.
18. Change the value of the **Trigger Delay** in Burst menu to a value other than 0.0 ns, then return the value to 0.0 ns.
19. Push the **Continuous** button to change the CH1 Run mode to Continuous mode.
20. Push the **Phase | Delay** > **Recover Lead Delay** buttons.
21. Check that the skew time of the two signals on the oscilloscope screen is less than 1 ns.

Resetting the serial number

When you replace the A72 CPU board, you must set the serial number. Perform the following procedure to set the serial number:

1. Enable the Service mode. (See page 27, *Enable the Service mode.*)
2. Push the **Utility** > **-more-** > **-more-** buttons.
3. Push the **Service Menu** > **Factory Initialize** > **Serial Number** buttons.
4. Enter the serial number using the numeric keys and Function buttons.

NOTE. Use the Function buttons to enter alphabetical characters. The *Sine to More...* button corresponds to A through F.

5. Push the **OK** button.

Resetting the MAC address

The MAC Address is set at the factory and usually does not need to be reset. When a new MAC address setup is required, perform the following procedure:

1. Enable the Service mode. (See page 27, *Enable the Service mode.*)
2. Push the **Utility** > **-more-** > **-more-** buttons.
3. Push the **Service Menu** > **Factory Initialize** > **MAC Address** buttons.
4. Enter the MAC address using the numeric keys and Function buttons.

NOTE. Use the Function buttons to enter alphabetical characters. The *Sine to More...* button corresponds to A through F. Use the +/- key to enter hyphens.

5. Push the **OK** button.

Maintenance

This section contains the information needed to do periodic and corrective maintenance on the Arbitrary Function generator. The following subsections are included:

- *Preparation* – Tells you how to get ready to do Arbitrary Function generator maintenance.
- *Preventing ESD* – Provides general information on preventing damage to internal modules when doing maintenance.
- *Inspection and Cleaning* – Information and procedures for inspecting the Arbitrary Function generator and cleaning its external and internal modules.
- *Removal and Installation Procedures* – Procedures for the removal of defective modules and replacement of new or repaired modules.
- *Troubleshooting* – Information for isolating failed modules. Included are instructions for operating the internal diagnostic routines of the Arbitrary Function generator and troubleshooting trees.

Service preparation

Only qualified persons should perform service procedures. Before performing any service procedures, read the *General Safety Summary* and *Service Safety Summary* sections of this manual and the preventing ESD information below.

Refer to the *Operating Information* section and your Arbitrary Function generator user manual for information about using the Arbitrary Function generator.

Preventing ESD

When performing any service that requires internal access to the Arbitrary Function generator, adhere to the precautions on page 6-2. These precautions will help you avoid damaging internal modules and their components due to electrostatic discharge (ESD).



CAUTION. *Static discharge can damage any semiconductor component in this Arbitrary Function generator.*

- Minimize handling of static-sensitive modules.
- Transport and store static-sensitive modules in their static protected containers or on a metal rail. Label any package that contains static-sensitive modules.

- Discharge the static voltage from your body by wearing a grounded antistatic wrist strap while handling these modules. Service static-sensitive modules only at a static-free work station.
- Do not allow anything capable of generating or holding a static charge on the work station surface.
- Handle circuit boards by the edges when possible.
- Do not slide the modules over any surface.
- Avoid handling modules in areas that have a floor or work-surface covering that is capable of generating a static charge.

Preventive maintenance

Preventive maintenance consists of visually inspecting and cleaning the Arbitrary Function generator, and using general care when operating it. Perform preventive maintenance more often if you operate the Arbitrary Function generator in a severe environment. A good time to perform preventive maintenance is just before adjustment of the Arbitrary Function generator.

General care

For optimum performance, follow these recommendations:

- Protect the Arbitrary Function generator from adverse weather conditions. The Arbitrary Function generator is not waterproof.
- Do not store or leave the Arbitrary Function generator whether the liquid crystal display (LCD) will be exposed to direct sunlight or high humidity for long periods of time.
- The front and rear cases help keep dust out of the Arbitrary Function generator and must be in place during normal operation.
- To avoid damage to the Arbitrary Function generator, do not expose them to any sprays, liquids, or solvents.

Inspection and cleaning

This section describes how to inspect for dirt and damage, and how to clean the exterior and interior of the Arbitrary Function generator. Inspection and cleaning are done as preventive maintenance. Preventive maintenance, when done regularly, may prevent malfunctions and enhance reliability. (See page 38, *Preventive maintenance*.)

The collection of dirt on internal components can cause them to overheat and fail. Dirt also provides an electrical conduction path that could cause an Arbitrary Function generator failure, especially under high-humidity conditions. Inspect the Arbitrary Function generator as often as operating conditions require.



CAUTION. *Avoid the use of chemical cleaning agents which might damage the plastics used in this AFG3000 Series Arbitrary Function generator. Use only deionized water when cleaning the front panel buttons. Use an ethyl alcohol solution as a cleaner and rinse with deionized water.*

Exterior inspection

Inspect the outside of the Arbitrary Function generator for damage, wear, and missing parts, using the following check list as a guide. An Arbitrary Function generator that appears to have been dropped or otherwise abused should be checked thoroughly to verify correct operation and performance. Immediately repair defects that could cause personal injury or cause further damage to the Arbitrary Function generator.

Table 6: External inspection check list

Item	Inspect for	Repair action
Cabinet, front panel, and cover	Cracks, scratches, deformations, damaged hardware or gaskets.	Repair or replace the defective module.
Front-panel knobs	Missing, damaged, or loose knobs.	Repair or replace missing or defective knobs.
Connectors	Broken shells, cracked insulation, and deformed contacts. Dirt in connectors.	Repair or replace the defective modules. Clear or wash out dirt.
Carrying handle, bail, cabinet feet	Correct operation.	Repair or replace the defective module.

Exterior cleaning

Perform the following steps to clean the exterior of the Arbitrary Function generator:

1. Remove loose dust on the outside of the Arbitrary Function generator with a lint-free cloth. Use care to avoid scratching the clear glass display shield.
2. Remove remaining dirt with a lint free cloth dampened in a general purpose detergent-and-water solution. Do not use abrasive cleaners.



CAUTION. *To prevent getting moisture inside the Arbitrary Function generator during external cleaning, use only enough liquid to dampen the cloth or applicator.*

To avoid damage to the surface of the Arbitrary Function generator, do not use any abrasive or chemical cleaning agents.

Flat panel display cleaning

The display is a soft plastic display and must be treated with care during cleaning.



CAUTION. *Imported cleaning agents or methods can damage the flat panel display.*

Avoid using abrasive cleaners or commercial cleaners to clean the display surface.

Avoid scrubbing the display with excessive force.

Avoid spraying liquids on the display surface.

1. Clean the flat panel display surface by gently rubbing the display with a clean-room wipe (such as Wypall Medium Duty Wipes, #05701, available from Kimberly-Clark Corporation).
2. If the display is very dirty, moisten the wipe with distilled water or a 75% isopropyl alcohol solution and gently rub the display surface. Avoid using excess force or you may damage the plastic display surface.



CAUTION. *To prevent getting moisture inside the Arbitrary Function generator during external cleaning, use only enough liquid to dampen the cloth or applicator.*

Interior inspection

Inspect and clean the interior if it appears that the Arbitrary Function generator may have been damaged or exposed to an unusually dirty environment.

To access the inside of the Arbitrary Function generator for inspection and cleaning, refer to the removal and installation procedures. (See page 43, *Removal and installation procedures*.)

Inspect the internal portions of the AFG3000 Series Arbitrary Function generator for damage and wear, using the check list below as a guide. Defects should be repaired immediately.



CAUTION. To prevent damage from electrical arcing, ensure that circuit boards and components are dry before applying power to the Arbitrary Function generator.

Table 7: Internal inspection check list

Item	Inspect for	Repair action
Front and rear case	Cracks or deformations. Scratched lettering or display filter. Loose connectors or labels.	Repair or replace defective hardware.
Circuit boards	Loose, broken, or corroded solder connections. Burned circuit boards. Burned, broken, or cracked circuit-run plating.	Remove failed module and replace with a new module.
Solder connections	Cold solder or rosin joints.	Resolder joint and clean with ethyl alcohol.
Wiring and cables	Loose plugs or connectors. Burned, broken, or frayed wiring.	Firmly seat connectors. Repair or replace modules with defective wires or cables.
Chassis	Dents, deformations, and damaged hardware.	Straighten, repair, or replace defective hardware.

Interior cleaning

Perform the following steps to clean the interior of the instrument:

1. Blow off dust with dry, low-pressure, deionized air (approximately 9 psi).
2. Remove any remaining dust with a lint-free cloth dampened in isopropyl alcohol (75% solution) and rinse with warm deionized water. (A cotton-tipped applicator is useful for cleaning in narrow spaces and on circuit boards.)

NOTE. If these steps do not remove all of the dust or dirt, please contact Tektronix for assistance. (See *Contacting Tektronix at the front of this manual*.)

Lubrication

There is no periodic lubrication required for this instrument.

Removal and installation procedures

This section describes how to remove and install the major mechanical and electrical modules. Any electrical or mechanical module, assembly, or part listed in the parts list is referred to as a module.

See the *Replaceable parts* section for a list of all the replaceable modules and diagrams showing their location in the instrument. (See page 77.)



WARNING. *Only qualified personnel should perform service procedures. Before doing this or any other procedure in this manual, read the General Safety Summary and Service Safety Summary found at beginning of this manual.*

Always disconnect the power cord before disassembling any portion of the Arbitrary Function generator.

To prevent damage to electrical components, follow the instructions for preventing ESD. (See page 37, Preventing ESD.)

The following subsections are included:

- *After repair adjustments* – Describes when to perform the adjustment procedures after a repair.
- *Before disassembly* – Describes what you should do before you disassemble the instrument.
- *Equipment required for disassembly* – Lists the equipment required to remove and install modules.
- *Order of disassembly* – Provides a diagram showing the proper order in which to remove and install modules.
- Removal procedures for each of the replaceable modules.

NOTE. *If you are disassembling the Arbitrary Function generator for cleaning, refer to the inspection and cleaning instructions. (See page 39, Inspection and cleaning.)*

After repair adjustments

After the removal and replacement of a module due to electrical failure, perform the adjustment procedures. (See page 25, *Adjustment procedures*.)

Before disassembly

Before you disassemble the instrument, do the following:

- Review how to prevent ESD damage. (See page 37, *Preventing ESD*.)
- Review the exploded view diagrams in the *Replaceable parts* section for an overview of how the entire Arbitrary Function generator is assembled. (See page 77.)
- Review the order of disassembly diagram to understand which procedure(s) must be performed to access a given module. (See Figure 8 on page 45.)
- Review the required equipment list to verify that you have the necessary tools to remove and install modules in the Arbitrary Function generator. (See page 44, *Equipment required for disassembly*.)

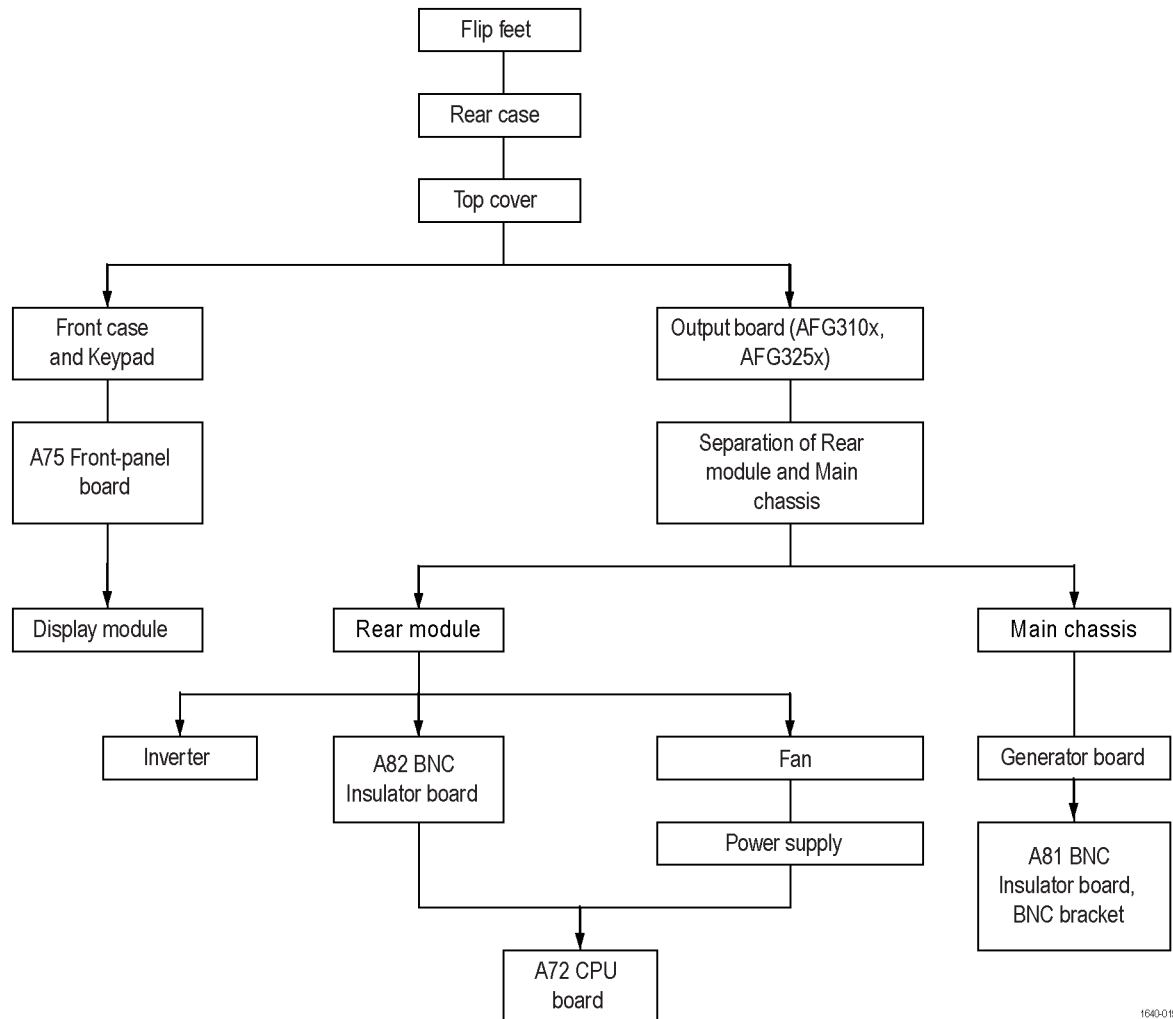
Equipment required for disassembly

Use the following tools to remove and replace all modules:

- Torque-limiting screwdriver, long shank, 8 lb-in (0.85 N m) range with Torx T15 tip
- 16 mm (5/8 inch) deep socket with wide center hole
- 7 mm (9/32 inch) socket
- Torque wrench to 30 in-lb (3.3 N m)
- Screwdriver with 1/4 inch flat blade
- Phillips head screwdriver
- Pliers (all-purpose and needle-nose)
- Tweezers

Order of instrument disassembly

Disassembly for replacement is best achieved by removing and replacing the modules in a specific order. Complete disassembly is best achieved by performing the removal procedures in the order shown in the following figure.



1640-019

Figure 8: Order of instrument disassembly

Flip feet removal/installation

Required equipment. You will need needle-nose pliers to remove the flip feet.

Removal. To remove the flip feet, refer to the figure below and perform the following steps:

1. Place the Arbitrary Function generator top down on a soft surface such as an antistatic mat.
2. Grip the flip foot with the pliers as close to the notches as possible and squeeze gently on the foot.
3. Twist slightly to swing one hinge free of the slot.

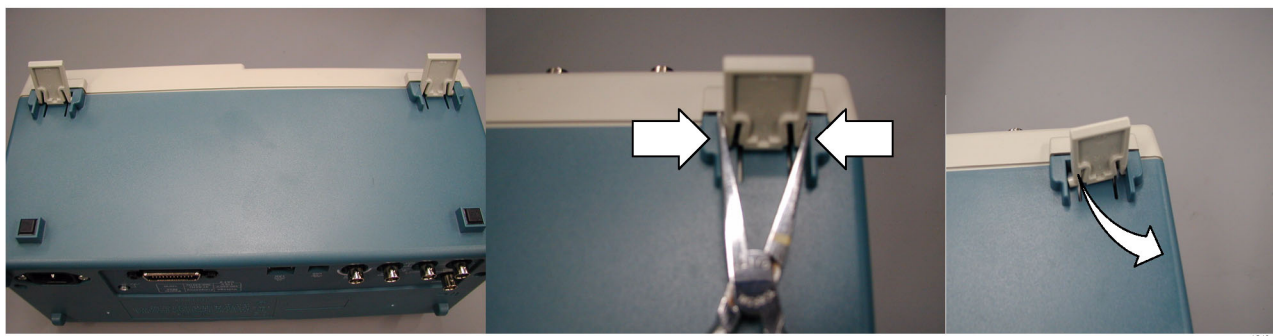


Figure 9: Removing and installing the flip feet

Installation. To install the flip feet, perform these steps:

1. Place the Arbitrary Function generator top down on a soft surface such as an antistatic mat.
2. Hold the flip foot with the smooth side facing down.
3. Gently squeeze the foot so that the hinge on one side fits into the slot, and twist slightly to snap into the slot on the other side.

Front panel knob removal/installation

Required equipment. None.

Removal. Firmly grasp the knob and pull it away from the shaft.

Installation. Align the keyed knob with the shaft and press the knob onto the shaft.

Rear case removal/installation

Required equipment. You will need a torque-limiting Torx T15 screwdriver and a Phillips head screwdriver to remove the rear case.

Removal. To remove the rear case, refer to the figure below and perform the following steps:

1. Place the Arbitrary Function generator face down on a soft surface such as an antistatic mat.
2. Remove the four screws located on the rear case. Tilt the handle to gain better access to the top two screws.
3. Use a Phillips head screwdriver to remove the chassis ground screw.
4. Lift the rear case off of the Arbitrary Function generator.



Figure 10: Removing the rear case

Installation. To install the rear case, you will perform the removal procedure in reverse order. Be aware of the following:

- When you remove the rear case, the front rubber feet (attached to the front case) come off. Before you reinstall the rear case, reattach the front feet to the front case. Confirm that they are in place before reassembling the case.
- Remember to install the chassis ground screw.

AWG310xx and AFG325xx only. Urethane foam gaskets must be installed in the case. Perform the following steps to install the gaskets:

1. Remove the protective backing from the adhesive urethane foam gaskets (Tektronix part numbers 348-1848-00 (x2), 348-1849-00 (x2), and 348-1850-00 (x1)).
2. Attach the gaskets firmly to the inside of the case as shown below, making sure that the gaskets stick out 2.0 mm to 2.5 mm from the edge of the case to ensure good contact with chassis ground.

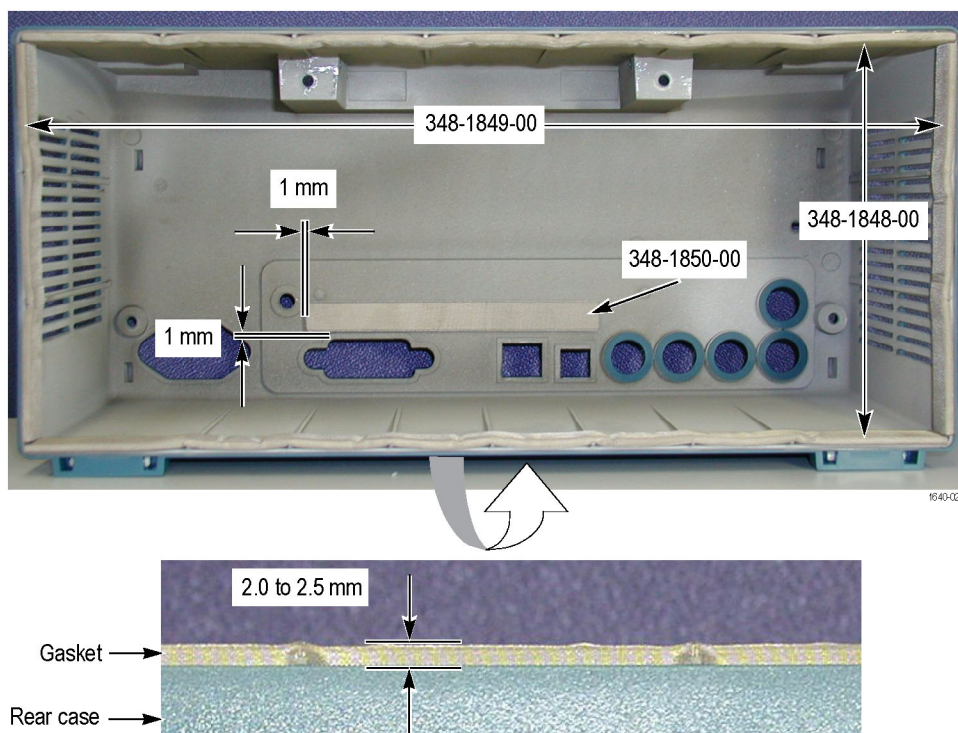


Figure 11: Pasting the urethane foam gaskets on the rear case

Top cover removal/installation

Required equipment. You will need a torque-limiting Torx T-15 screwdriver and a flat-blade screwdriver for this procedure.

Removal. To remove the top cover, refer to the figure below and perform the following steps:

1. Remove the nine screws attaching the top cover to the main chassis and the rear sub-panel. Four screws are on the upper part of the top cover. Five screws are on the rear panel side.
2. Using a flat-blade screwdriver, pull the top cover backward.

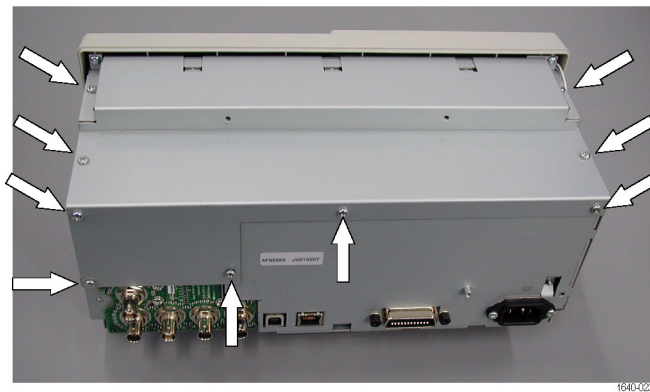


Figure 12: Removing the top cover

Installation. To install the top cover, perform the removal procedure in reverse order.

Front case removal/installation

Required equipment. You will need a torque-limiting Torx T15 screwdriver for this procedure.

Removal. To remove the front case, refer to the figure below and perform the following steps:

1. Remove the front-panel knob by firmly grasping the knob and pulling it away from the front panel.
2. Remove the four tapping screws attaching the front case to the main chassis.
3. The front case and the rubber switch can be removed together.

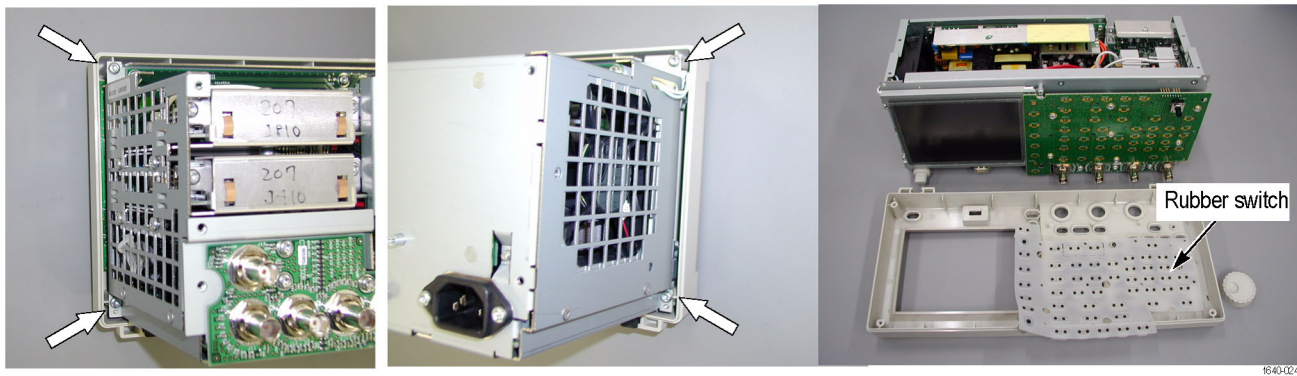


Figure 13: Removing the front case

Installation. To install the front case, perform the removal procedure in reverse order. Remember to attach the rubber front feet to the front case.

A75 Front Panel board removal/installation

Required equipment. You will need a torque-limiting Torx T15 screwdriver for this procedure.

Removal. To remove the A75 Front Panel board, refer to the figure below and perform the following steps:

1. Remove the front case. (See page 49, *Top cover removal/installation.*).
2. Remove the seven screws attaching the A75 Front Panel board to the main chassis.
3. Disconnect the A75 Front Panel board cable.

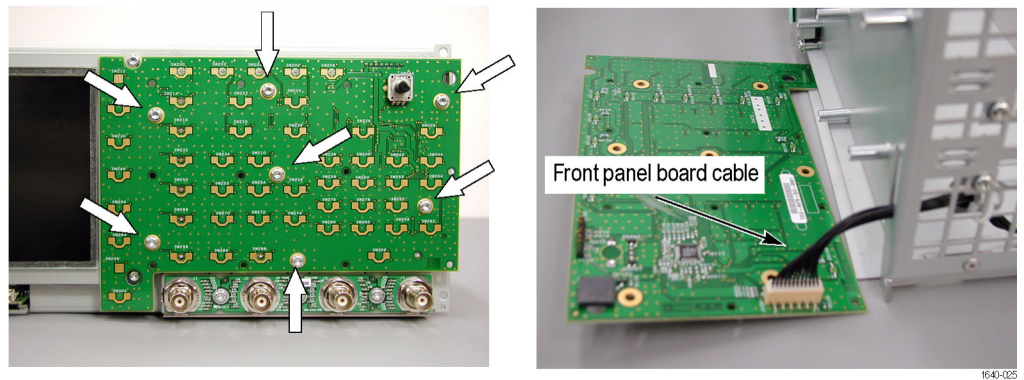


Figure 14: Removing the A75 front-panel board

Installation. To install the A75 Front Panel board, perform the removal procedure in reverse order.

Display module removal/installation

Required equipment. You will need a torque-limiting Torx T15 screwdriver and tweezers for this procedure.

Removal. To remove the Display module, refer to the figure below and perform the following steps:

1. Use tweezers or needle-nose pliers to disconnect the backlight cable at the Inverter unit located near the fan unit.
2. Remove the four screws attaching the display module to the main chassis.
3. Disconnect the display cable at on the back side of the display module.

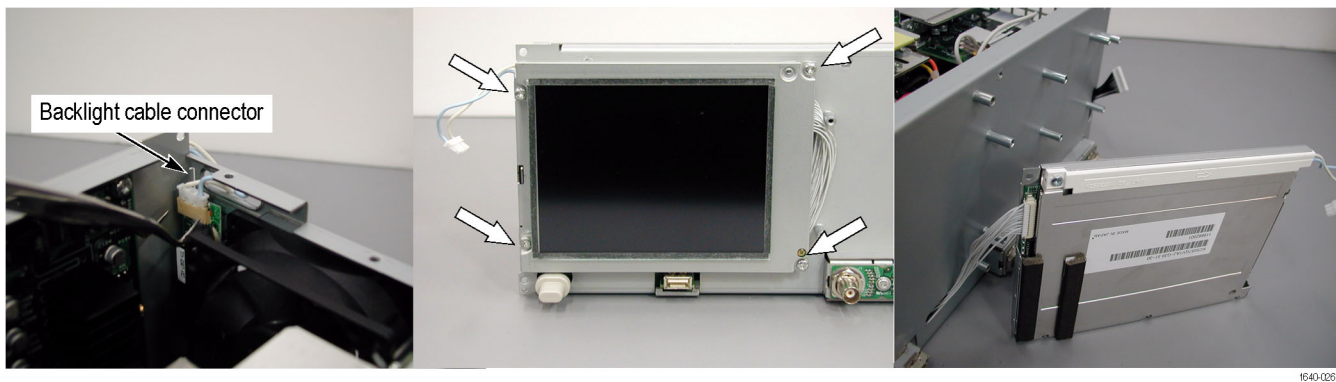


Figure 15: Removing the Display module

Installation. To install the Display module, perform the removal procedure in reverse order.

Output board removal/installation (AFG310xx and AFG325xx only)

Required equipment. You will need a torque-limiting Torx T15 screwdriver for this procedure.

Removal. To remove the Output board, refer to the figure below and perform the following steps:

1. Disconnect the two Peltola cables at J100 (CH1 from J380, CH2 from J780) and J170 (CH1 from J390, CH2 from J790) on the Output board.
2. Remove the two screws attaching the Output module to the rear sub-panel.
3. Gently pull out the Output board toward the rear according to the guide.



Figure 16: Removing the Output board

Installation. To install the Output board, perform the removal procedure in reverse order.

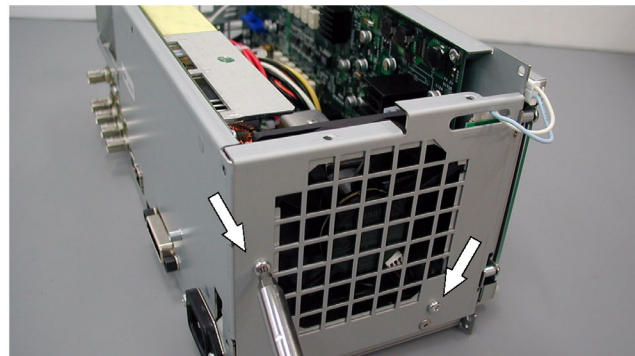
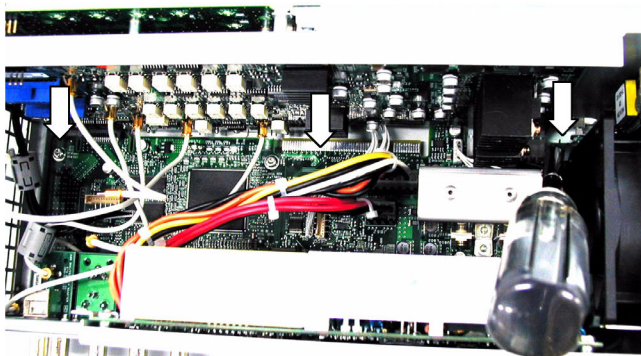
Rear module and main chassis separation

To remove and replace the internal modules (Generator board, CPU board, Power supply, fan, and backlight Inverter board), you must first separate the rear module and main chassis.

Required equipment. You will need a torque-limiting Torx T15 screwdriver and a flat-blade screwdriver for this procedure.

Removal. To separate the rear module and main chassis, refer to the two figures below and perform the following steps:

1. Disconnect the following cables:
 - The front-panel cable at J300
 - The display inverter cable from the LCD Display
 - The display data cable at J400 from the LCD Display
 - The add-in cable at J370 from the ADD Input connector
2. Remove the three screws attaching the CPU board to the main chassis.
3. Remove the two screws near the air outlet attaching the rear module and main chassis.



1640-028

Figure 17: Separating the rear module and main chassis

4. Use the flat-blade screwdriver to loosen the rear module and main chassis.
5. Pull out the rear module toward the rear.

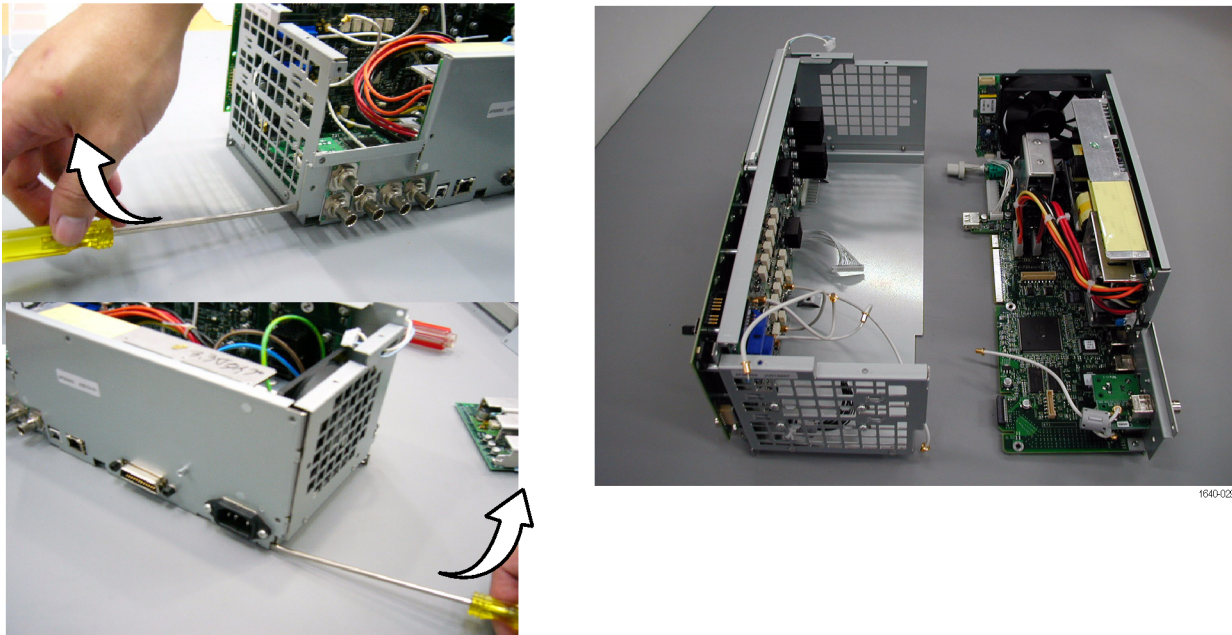


Figure 18: Pulling out the rear module

Installation. To reconnect the rear module and main chassis, perform the removal procedure in reverse order.

Backlight Inverter board removal/installation

Required equipment. You will need needle-nose pliers and tweezers for this procedure.

Removal. To remove the backlight Inverter board, refer to the figure below and perform the following steps:

1. Separate the rear module and main chassis. (See page 54, *Rear module and main chassis separation*.)
2. On the rear module, use needle-nose pliers to bend the two Inverter-bracket tabs out of the way.
3. Remove the Inverter board.
4. Disconnect the Inverter cable from the CPU board.

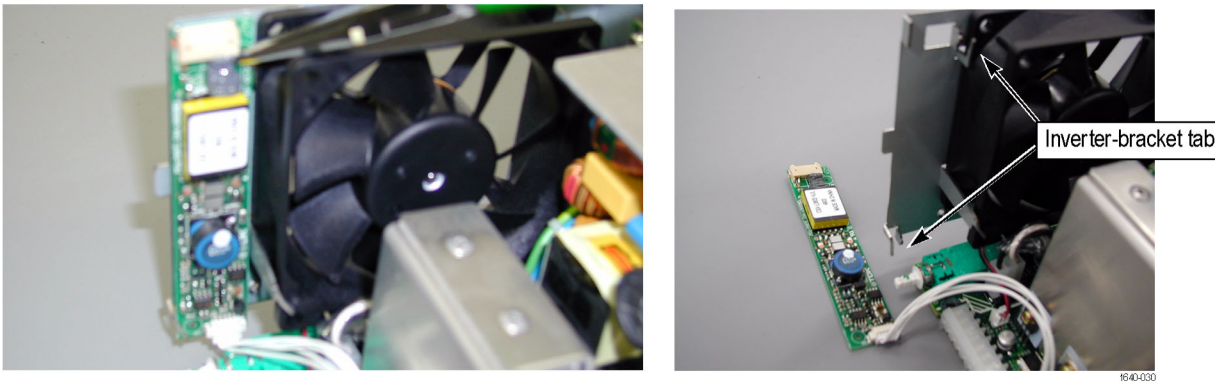


Figure 19: Removing the Inverter board from the rear module

Installation. To install the Inverter board in the rear module, refer to the figure below and perform the following steps:

1. Connect the Inverter cable from the CPU board at J404.
2. Align the Inverter board with the Inverter bracket. Make sure that the two hooks on the Inverter bracket align with the two holes on the Inverter board.
3. Use the pliers to bend the two Inverter bracket tabs into place and secure the Inverter board.
4. Install the rear module and main chassis. (See page 54, *Rear module and main chassis separation.*)

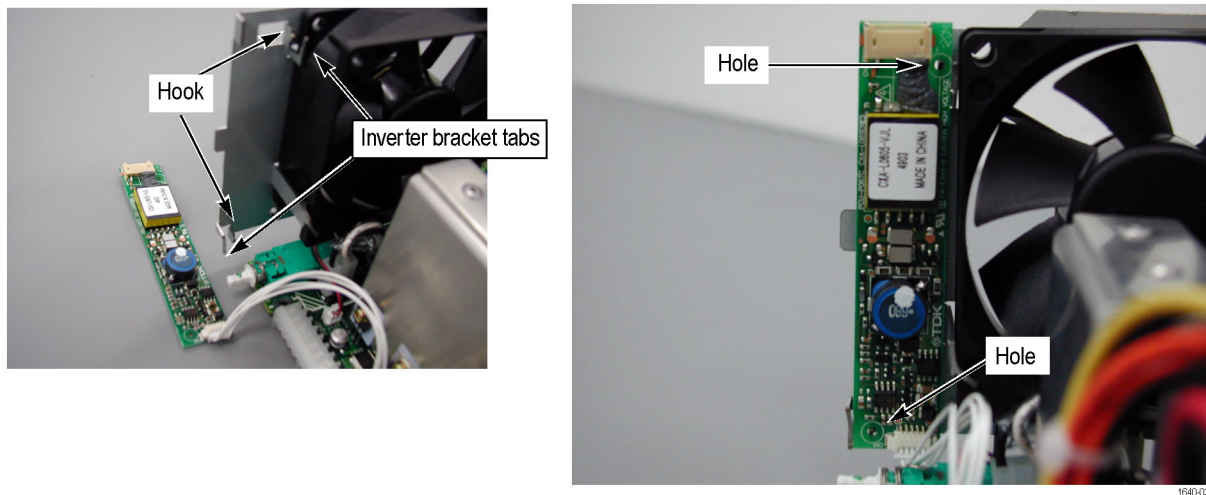


Figure 20: Installing the Inverter board in the rear module

Fan removal/installation

Required equipment. You will need needle-nose pliers and tweezers for this procedure.

Removal. To remove the fan from the rear module, refer to the figure below and perform the following steps:

1. Separate the rear module and main chassis. (See page 54, *Rear module and main chassis separation*.)
2. Use needle-nose pliers to bend the two fan-bracket tabs out of the way.
3. Remove the fan.
4. Disconnect the fan cable from the CPU board.

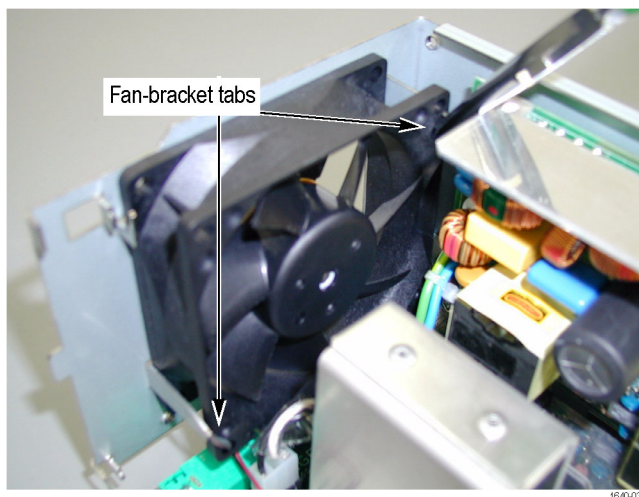


Figure 21: Removing the fan from the rear module

Installation. To install the fan, perform the following steps:

1. Connect the fan cable to the CPU board at J920 in the rear module.
2. Align the fan with the fan-bracket. Align the fan so that air blows out the side of the chassis, not into the chassis.
3. Use the pliers to bend the two fan-bracket tabs into place and secure the fan.
4. Reconnect the rear module and main chassis. (See page 54, *Rear module and main chassis separation*.)

Power Supply module removal/installation

Required equipment. You will need a torque-limiting Torx T15 screwdriver for this procedure.

Removal. To remove the Power supply module, refer to the figure below and perform the following steps:

1. Remove the fan from the rear module. (See page 58, *Fan removal/installation*.)
2. Disconnect the three cable connectors at J866, J862, and J900.
3. Remove the four screws attaching the Power Supply module and the insulator to the rear sub-panel.

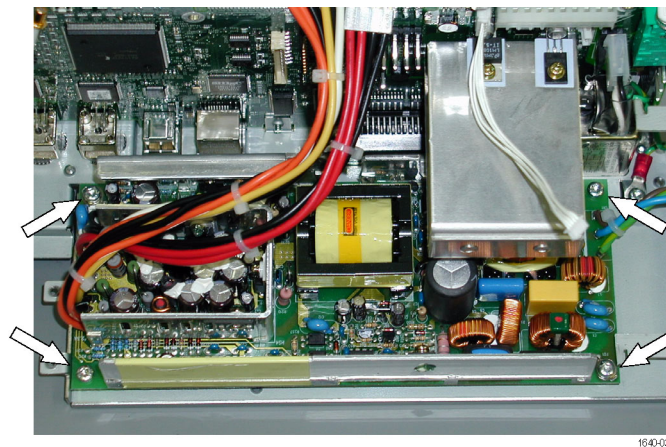


Figure 22: Removing the Power Supply module

Installation. To install the Power Supply module, perform the removal procedure in reverse order.

A72 CPU board removal/installation

Required equipment. You will need a torque-limiting Torx T15 screwdriver, a torque wrench, a 16 mm (5/8 inch) deep socket, 7 mm socket, and needle-nose pliers for this procedure.

Removal. To remove the A72 CPU board, follow these steps:

1. Remove the Power Supply module from the rear module. (See page 59, *Power Supply module removal/installation*.)
2. Use the 7 mm socket torque wrench to remove the two hex screws and the two washers attaching the GPIB connector to the rear sub-panel.
3. Remove the CH1 Add Input BNC connector:
 - a. Disconnect the Peltola cable at J370 on the Generator board.
 - b. Use the 16 mm (5/8 inch) deep socket to remove the nut and the wave washer from the BNC connector.
 - c. Push the CH1 Add Input BNC connector and the insulator bushing to remove them from the rear sub-panel.
4. **AFG3022B/C, AFG3102/C, and AFG3252/C only:** Remove the EXT Modulation CH2 Input BNC connector:
 - a. Disconnect the Peltola cable at J852 on the CPU board.
 - b. Use the 16 mm (5/8 inch) deep socket to remove the nut and the spring washer from the BNC connector.
 - c. Push the EXT Modulation CH2 Input BNC connector and the insulator bushing to remove them from the rear sub-panel.
5. Remove the nuts and wave washers from the EXT Modulation CH1 Input, the Ext Ref Input, and the Ext Ref Output connectors on the CPU board:
 - a. Use the 16 mm (5/8 inch) deep socket to remove the nuts and the spring washers from these BNC connectors.

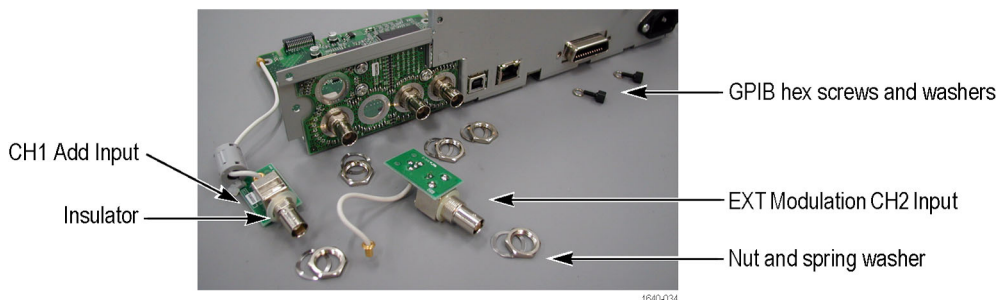


Figure 23: Removing the BNC connectors

6. Disconnect the AC input cable at J860 on the CPU board.
7. Disconnect the A75 Key Board cable at J300 on the CPU board.
8. Remove the three screws from the bottom side that attach the CPU board to the rear sub-panel.
9. Remove the CPU board from the rear sub-panel.

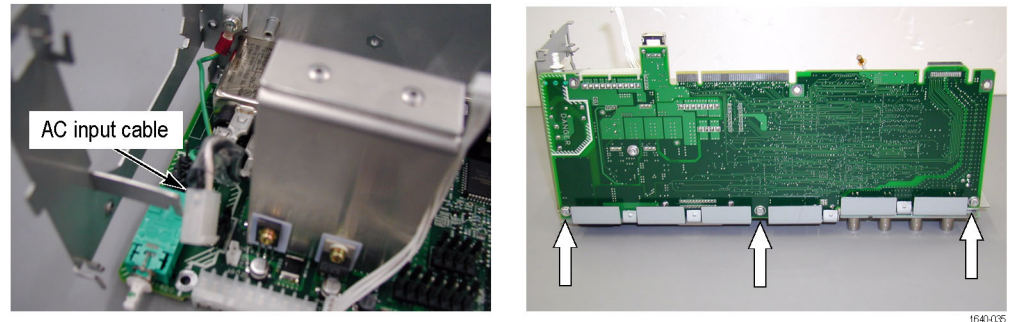


Figure 24: Removing the CPU board

Installation. To install the CPU board, perform the removal procedure in reverse order. Remember to attach the wave washers and the insulator bushings.

NOTE. After you replace the CPU board, you must reset the instrument serial number. (See page 36, *Resetting the serial number.*)

A82 BNC Insulator board removal/installation

Required equipment. You will need a torque-limiting Torx T15 screwdriver, a torque wrench, and a 16 mm (5/8 inch) deep socket for this procedure.

Removal. To remove the A82 BNC Insulator board, perform the following steps:

1. Separate the rear module and main chassis. (See page 54, *Rear module and main chassis separation.*)
2. On the rear module, remove the CH1 Add Input BNC connector and the EXT Modulation CH2 Input BNC connector.
3. Remove the nuts and wave washers of the EXT Modulation CH1 Input, the Ext Ref Input, and the Ext Ref Output connectors.
4. Remove the three screws that attach the A82 BNC Insulator board to the rear sub-panel.
5. Remove the A82 BNC Insulator board from the rear sub-panel.

Installation. To install the A82 BNC Insulator board, perform the removal procedure in reverse order.

Generator board removal/installation

Required equipment. You will need a torque-limiting Torx T15 screwdriver for this procedure.

Removal. To remove the Generator board, refer to the figure below and perform the following steps:

1. Separate the rear module and main chassis. (See page 54, *Rear module and main chassis separation*.)
2. Remove the six screws attaching the Generator board to the main chassis.
3. Remove the two screws attaching the Generator board to main chassis from the bottom side.
4. Remove the Generator board from the main chassis.

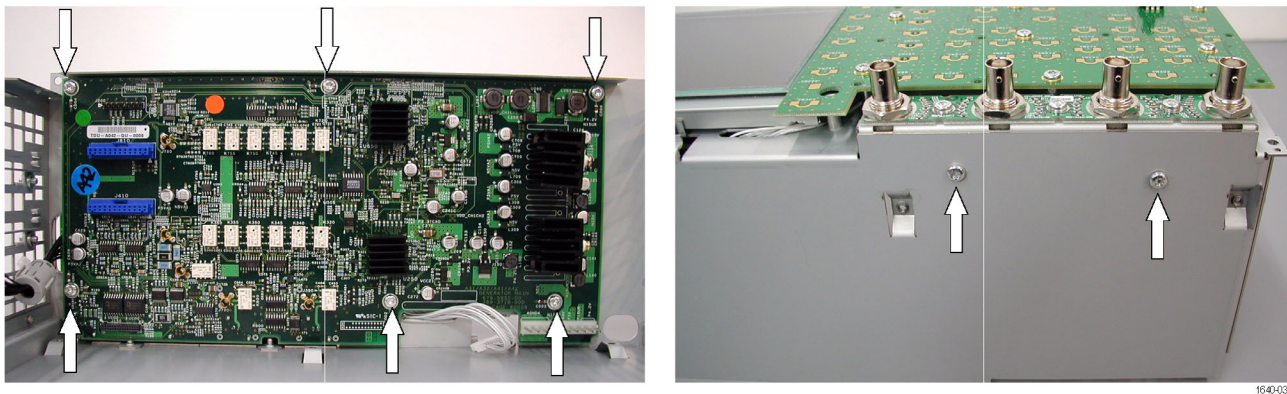


Figure 25: Removing the Generator board

Installation. To install the Generator board, perform the removal procedure in reverse order.

A81 BNC Insulator board and BNC bracket removal/installation

Required equipment. You will need a torque-limiting Torx T15 screwdriver, a torque wrench, and a 16 mm (5/8 inch) deep socket for this procedure.

Removal. To remove the A81 BNC Insulator and BNC bracket, refer to the figure below and perform the following steps:

1. Remove the Generator board. (See page 62, *Generator board removal/installation*.)
2. Use the 16 mm (5/8 inch) deep socket to remove the nuts and the wave washers from the BNC connectors (CHx Output, Trigger Input, and Trigger Output).
3. Remove the three screws that attach the A81 BNC Insulator board to the Generator board.
4. Remove the A81 BNC Insulator board and BNC bracket.

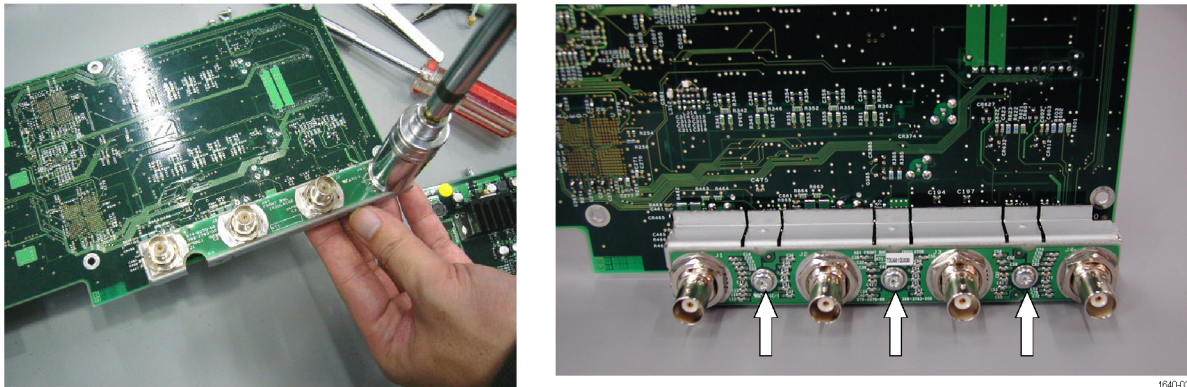


Figure 26: Removing the A81 BNC Insulator board and BNC bracket

Installation. To install the A81 BNC Insulator and BNC bracket, perform the removal procedure in reverse order.

Troubleshooting

This section contains the following information to help you isolate faulty modules in the AFG3000 Series Arbitrary Function generators.

- Troubleshooting trees – Show how to find and isolate faulty modules.
- Diagnostics – Describes the diagnostics supplied with the Arbitrary Function generator, its operation, and status messages.

After you troubleshoot and identify a faulty part, use the *Removal and installation procedures* section to exchange the modules. (See page 43.)

Troubleshooting tools and equipment

You may need the following tools and equipment to troubleshoot the Arbitrary Function generator.

Table 8: Troubleshooting equipment

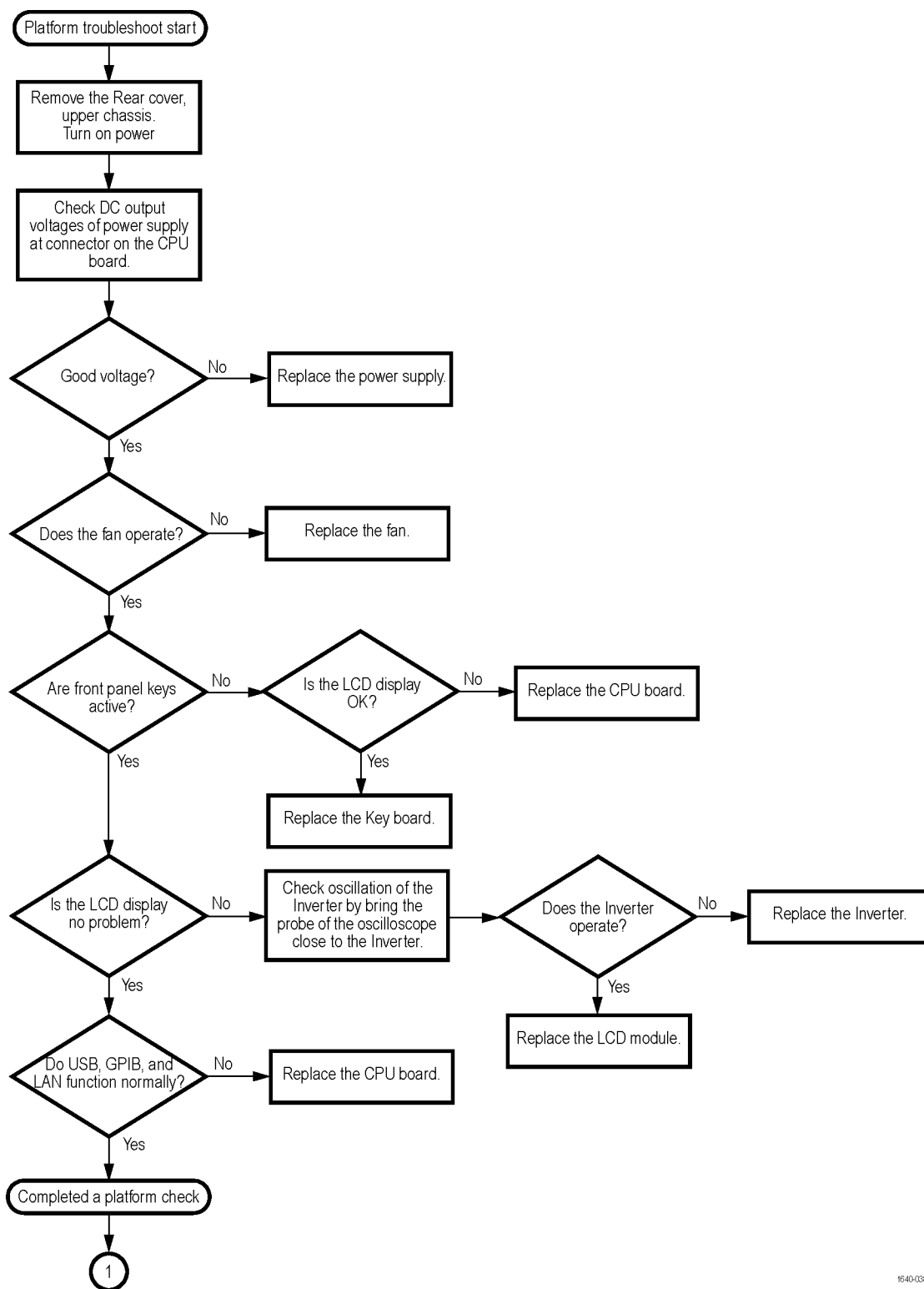
Tools and equipment	Example
Digital multimeter (DMM)	3.5 or greater digit DMM
Oscilloscope with probe	Tektronix TDS1000 or TDS2000 series oscilloscope

Troubleshooting trees

To isolate a problem to a specific troubleshooting procedure, use the following troubleshooting trees. The trees make use of internal diagnostic routines to speed fault isolation to a module.

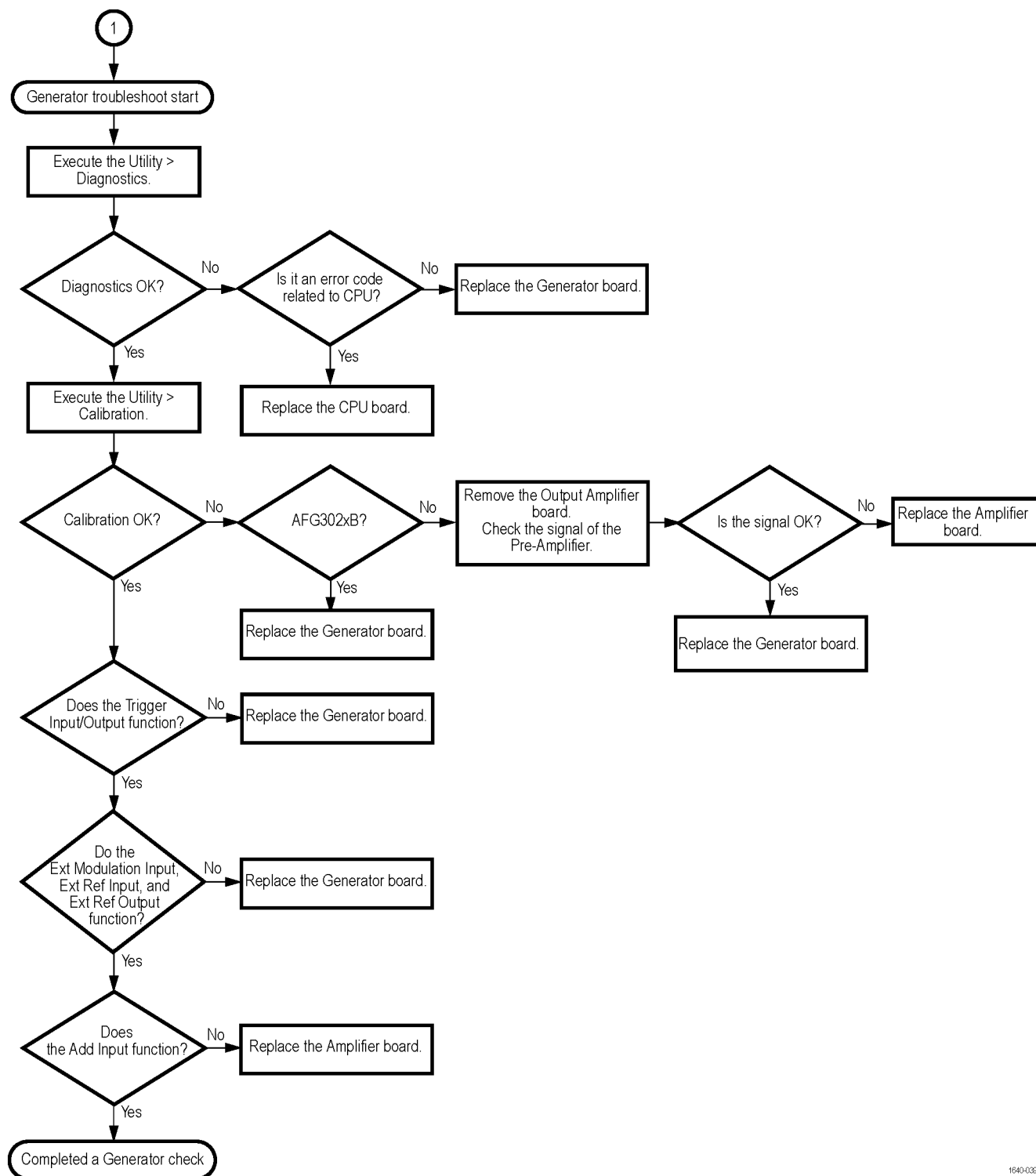


WARNING. *To prevent electrical shock, do not touch the heat sink of the Power Supply module. There are potentially dangerous voltages present on the heat sink of the Power Supply module.*



1640-038

Figure 27: Platform troubleshooting tree



1640-039

Figure 28: Generator troubleshooting tree

Diagnostics

Power-on diagnostic test

When you power on the AFG3000 Series, the instrument automatically executes a diagnostic test for all the diagnostics items before the Startup screen appears.

When an error is detected, the diagnostic test displays an error message. If you see such an error message, press the **OK** button to proceed with the next step. The AFG3000 Series software starts. When the AFG3000 Series contains an unresolved error, the test cannot be conducted normally.

Utility menu diagnostic test

This procedure uses internal routines to verify that the instrument is operating correctly.

Prerequisites. Before you run the Utility menu diagnostic test:

- Power on the instrument and allow a 20 minute warm-up before doing this procedure.
- The instrument must be operating at an ambient temperature between +0 °C and +50 °C.

Procedure. Perform the following steps to run the Utility menu diagnostic test:

1. Select Execute Diagnostics in the Utility menu (**Utility > -more- > Diagnostics/Calibration > Execute Diagnostics**).
2. Wait until the test is completed.
3. Verify that the diagnostic test passed.
 - If the diagnostic completes without finding any problems, the message “PASSED” is displayed.
 - When an error is detected during diagnostic execution, the instrument shows an error code. (See page 70, *Diagnostic error codes*.)
4. Press any front panel button to exit from the diagnostics test.

Calibration diagnostic test

This procedure uses internal routines to verify that the instrument is operating correctly.

Prerequisites. Before you run the Calibration diagnostic test:

- Power on the instrument and allow a 20 minute warm-up before doing this procedure.
- An ambient temperature is between +20 °C and +30 °C.

Procedure. Perform the following steps to run the internal routines that confirm basic functionality and proper adjustment:



WARNING. *To prevent the loss of data, do not turn off the power while executing calibration. If the power is turned off while the calibration is in progress, data stored in internal nonvolatile memory may be lost.*

1. Select the Execute Calibration in the Utility menu (**Utility > -more- > Diagnostics/Calibration > Execute Calibration**).
2. Wait until the test is completed.
3. Verify that the diagnostic test passed.
 - If the diagnostic completes without finding any problems, the message “PASSED” is displayed.
 - When an error is detected during diagnostic execution, the instrument shows an error code. (See page 70, *Diagnostic error codes*.)
4. Press any front panel button to exit from the calibration test.

Diagnostic error codes

If a diagnostic test detects a malfunction, the character string “Fail” and the associated error code is displayed. The following table describes the error codes and lists the related modules.

Table 9: Error codes

Error code	Description	Related module(s)
— Calibration —		
1101	CH1 Internal offset calibration failure	A1x/A3x/A4x/A51/A61
1102	CH2 Internal offset calibration failure	A12/A32/A42/A51/A61
1103	CH1 Output offset calibration failure	A1x/A3x/A4x/A51/A61
1104	CH2 Output offset calibration failure	A12/A32/A42/A51/A61
1105	CH1 Output gain Calibration failure	A1x/A3x/A4x/A51/A61
1106	CH2 Output gain Calibration failure	A12/A32/A42/A51/A61
1201	CH1 x3dB attenuator calibration failure	A1x/A3x/A4x/A51/A61
1202	CH2 x3dB attenuator calibration failure	A12/A32/A42/A51/A61
1203	CH1 x6dB attenuator calibration failure	A1x/A3x/A4x/A51/A61
1204	CH2 x6dB attenuator calibration failure	A12/A32/A42/A51/A61
1205	CH1 x10dB attenuator calibration failure	A1x/A3x/A4x/A51/A61
1206	CH2 x10dB attenuator calibration failure	A12/A32/A42/A51/A61
1207	CH1 x20dB 1 attenuator calibration failure	A1x/A3x/A4x/A51/A61
1208	CH2 x20dB 1 attenuator calibration failure	A12/A32/A42/A51/A61
1209	CH1 x20dB 2 attenuator calibration failure	A1x/A3x/A4x/A51/A61
1210	CH2 x20dB 2 attenuator calibration failure	A12/A32/A42/A51/A61
1211	CH1 Filter calibration failure	A1x/A3x/A4x/A51/A61
1212	CH2 Filter calibration failure	A12/A32/A42/A51/A61
1213	CH1 x20dB 3 attenuator calibration failure	A43
1301	CH1 Sine Flatness calibration failure	A1x/A3x/A4x/A51/A61
1302	CH2 Sine Flatness calibration failure	A12/A32/A42/A51/A61
1401	CH1 ASIC TINT calibration failure	A1x/A3x/A4x/A51/A61
1402	CH2 ASIC TINT calibration failure	A12/A32/A42/A51/A61
1403	CH1 ASIC SGEN calibration failure	A1x/A3x/A4x/A51/A61
1404	CH2 ASIC SGEN calibration failure	A12/A32/A42/A51/A61
1405	CH1 ASIC clock duty calibration failure	A1x/A3x/A4x/A51/A61
1406	CH2 ASIC clock duty calibration failure	A12/A32/A42/A51/A61

Table 9: Error codes (cont.)

Error code	Description	Related module(s)
— Diagnostics —		
2100	Calibration data not found	A72
2101	Calibration data checksum	A72
2102	Calibration data invalid	A72
2201	ASIC1 memory failure	A1x/A3x/A4x
2202	ASIC2 memory failure	A12/A32/A42
2203	ASIC1 Overheat	A1x/A3x/A4x
2204	ASIC2 Overheat	A12/A32/A42
— Output Diagnostics —		
2301	CH1 Internal offset failure	A1x/A3x/A4x
2302	CH2 Internal offset failure	A12/A32/A42
2303	CH1 Output offset failure	A1x/A3x/A4x/A51/A61
2304	CH2 Output offset failure	A12/A32/A42/A51/A61
2305	CH1 Output gain failure	A1x/A3x/A4x/A51/A61
2306	CH2 Output gain failure	A12/A32/A42/A51/A61
2401	CH1 x3dB attenuator failure	A1x/A3x/A4x
2402	CH2 x3dB attenuator failure	A12/A32/A42
2403	CH1 x6dB attenuator failure	A1x/A3x/A4x
2404	CH2 x6dB attenuator failure	A12/A32/A42
2405	CH1 x10dB attenuator failure	A1x/A3x/A4x
2406	CH2 x10dB attenuator failure	A12/A32/A42
2407	CH1 x20dB 1 attenuator failure	A1x/A3x/A4x
2408	CH2 x20dB 1 attenuator failure	A12/A32/A42
2409	CH1 x20dB 2 attenuator failure	A1x/A3x/A4x
2410	CH2 x20dB 2 attenuator failure	A12/A32/A42
2411	CH1 Filter failure	A51/A61
2412	CH2 Filter failure	A51/A61
2413	CH1 x20dB 3 attenuator failure	A43
2501	CH1 Sine Flatness failure	A1x/A3x/A4x/A51/A61
2502	CH2 Sine Flatness failure	A12/A32/A42/A51/A61

Diagrams

The diagrams in this section show how the modules in the different models of the Arbitrary Function generator connect together.

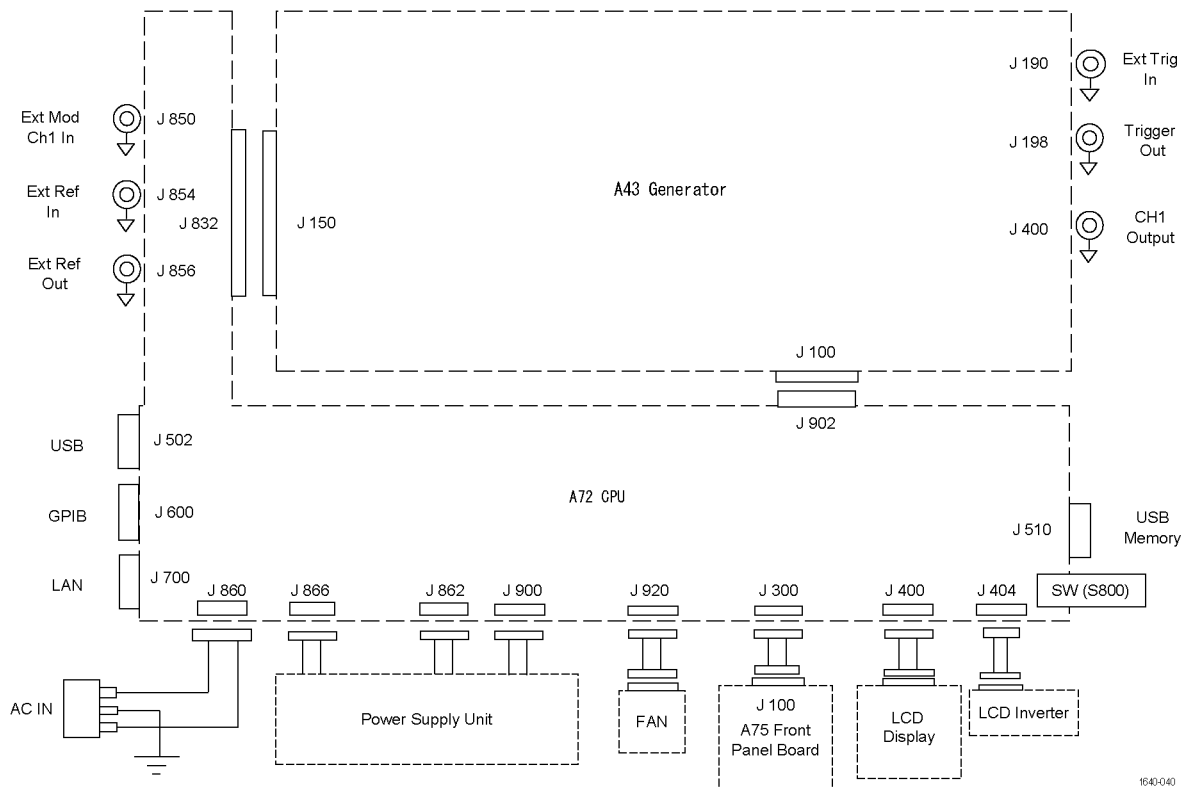


Figure 29: Interconnections for the AFG3011x



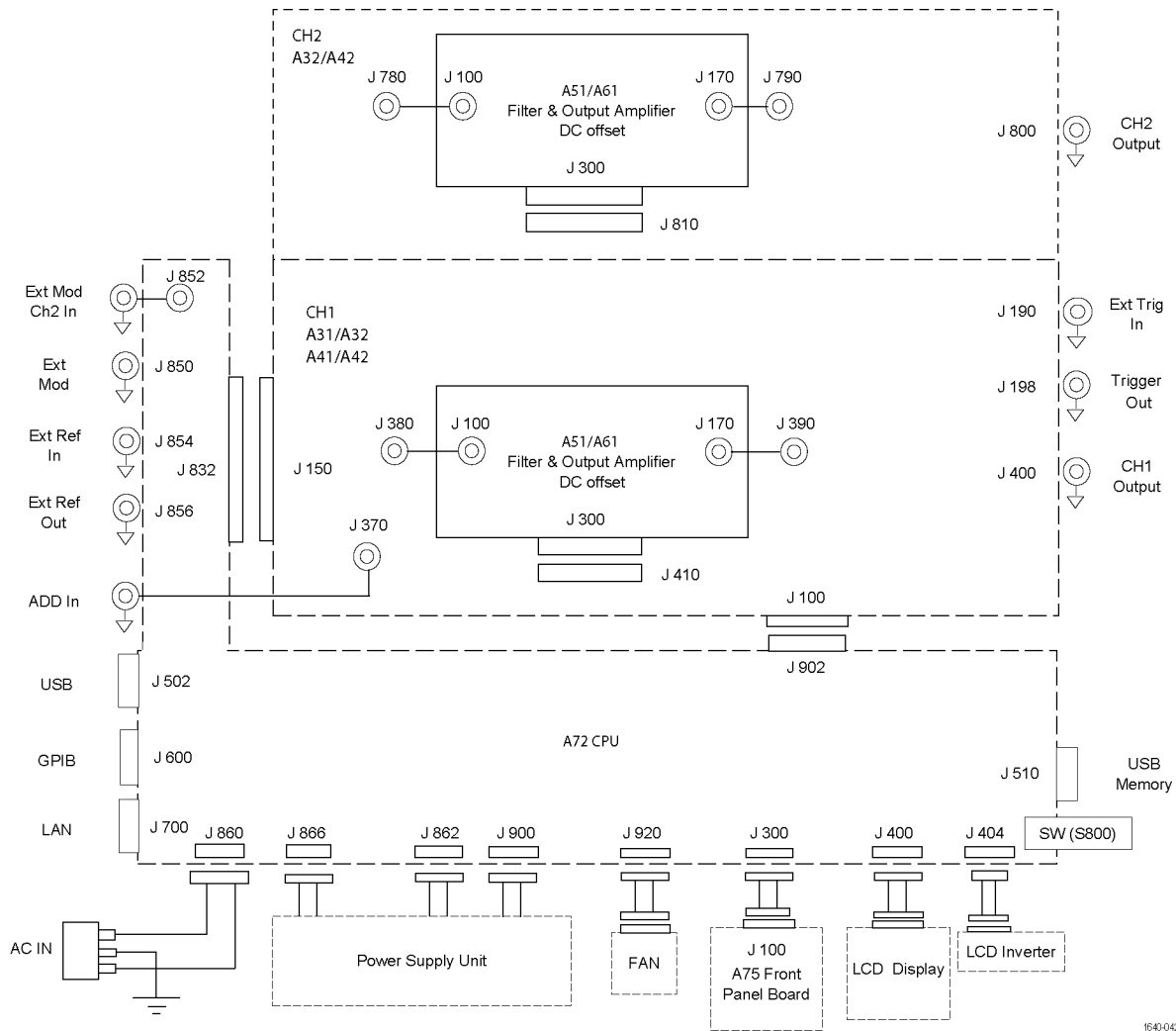


Figure 31: Interconnections for the AFG310xx and AFG325xx

Replaceable parts

This section contains a list of the replaceable modules for the AFG3000 Series Arbitrary Function Generators. Use this list to identify and order replacement parts.

Parts ordering information

Replacement parts are available through your local Tektronix field office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available and to give you the benefit of the latest circuit improvements. Therefore, when ordering parts, it is important to include the following information in your order.

- Part number
- Instrument type or model number
- Instrument serial number
- Instrument modification number, if applicable

If you order a part that has been replaced with a different or improved part, your local Tektronix field office or representative will contact you concerning any change in part number.

Using the replaceable parts list

This section contains a list of the mechanical and/or electrical components that are replaceable for the Arbitrary Function generator. Use this list to identify and order replacement parts. The following table describes each column in the parts list.

Table 10: Parts list column descriptions

Column	Column name	Description
1	Figure & index number	Items in this section are referenced by component number.
2	Tektronix part number	Use this part number when ordering replacement parts from Tektronix.
3	Instrument model	This indicates the model of instrument that uses this item.
4 and 5	Serial number	Column four indicates the serial number at which the part was first effective. Column five indicates the serial number at which the part was discontinued. No entries indicates the part is good for all serial numbers.
6	Qty	This indicates the quantity of parts used.
7	Name & description	An item name is separated from the description by a colon (:). Because of space limitations, an item name may sometimes appear as incomplete. Use the U.S. Federal Catalog handbook H6-1 for further item name identification.

Abbreviations Abbreviations conform to American National Standard ANSI Y1.1-1972.

Table 11: Exploded diagram replaceable parts (See Figure 32.)

Fig. & index no.	Tektronix part no.	Instrument model	Serial no. effective	Serial no. discontinued	Qty.	Name & description
32-						Exploded diagram
-1	650-4605-00	AFG3021B			1	FRAME ASSEMBLY; DISPLAY, MONO
	650-4349-01	AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			1	FRAME ASSEMBLY; DISPLAY, COLOR
-2	348-1845-00	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			2	GASKET, SHLD, ELEK; PU FORM, 60MM L W/3M 467MP BACKSIDE; TOURBILLON, LCD CABLE
-3	131-6363-00	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			1	EMI GASKET; GROUNDING, 0.320 L X 0.365 W (2 CONTACTS) X 0.110 DEEP, ELECTROLESS NICKEL PLATE
-4	441-2370-00	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			1	CHASSIS ASSY; MAIN, 0.039 EG STEEL
-5	211-1198-00	AFG3021B, AFG3022B			40	SCREW, MACHINE; 6-32 X 0.250, PNH, STL, ZNPL, T-15 TORX DR
	211-1198-00	AFG3101, AFG3251			42	SCREW, MACHINE; 6-32 X 0.250, PNH, STL, ZNPL, T-15 TORX DR
	211-1198-00	AFG3102, AFG3252			44	SCREW, MACHINE; 6-32 X 0.250, PNH, STL, ZNPL, T-15 TORX DR
-6	220-0265-00	AFG3021B, AFG3101, AFG3251, AFG3011			3	NUT, PLAIN, HEX; 0.5-28 X 0.625 HEX, BRS CD PL
	220-0265-00	AFG3022B, AFG3102, AFG3252			4	NUT, PLAIN, HEX; 0.5-28 X 0.625 HEX, BRS CD PL
-7	210-1544-00	AFG3021B, AFG3101, AFG3251, AFG3011			3	WASHER, SPRING; 0.610 OD X 0.490 ID X 0.007 THK, WAVE SHAPE, STAINLESS STEEL
	210-1544-00	AFG3022B, AFG3102, AFG3252			4	WASHER, SPRING; 0.610 OD X 0.490 ID X 0.007 THK, WAVE SHAPE, STAINLESS STEEL
-8	671-6070-XX	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			1	CIRCUIT BD ASSY; A81 FRONT BNC INSULATOR, 389378300 WIRED
-9	407-5043-00	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			1	BRACKET, CONN: GENERATOR BD, BNC SUPPORT, 0.039 EG STEEL

Table 11: Exploded diagram replaceable parts (See Figure 32.) (cont.)

Fig. & index no.	Tektronix part no.	Instrument model	Serial no. effective	Serial no. discontinued	Qty.	Name & description
-10	342-1135-00	AFG3021B, AFG3101, AFG3251, AFG3011			3	INSULATOR, BSHG: NYLON, 0.509 X 0.470 D HOLE X 0.687 OD X 0.035 T
	342-1135-00	AFG3022B, AFG3102, AFG3252			4	INSULATOR, BSHG: NYLON, 0.509 X 0.470 D HOLE X 0.687 OD X 0.035 T
-11	671-5973-XX	AFG3021B			1	CIRCUIT BD ASSY; A11 GENERATOR MAIN, 389361200 WIRED
	671-5842-XX	AFG3022B			1	CIRCUIT BD ASSY; A12 GENERATOR MAIN, 389361200 WIRED
	671-6052-XX	AFG3101			1	CIRCUIT BD ASSY; A31 GENERATOR MAIN 389371800 WIRED
	671-5955-XX	AFG3102			1	CIRCUIT BD ASSY; A32, GENERATOR MAIN 389371800 WIRED
	671-6083-XX	AFG3251			1	CIRCUIT BD ASSY; A41 GENERATOR MAIN 389371800 WIRED
	671-6084-XX	AFG3252			1	CIRCUIT BD ASSY; A42 GENERATOR MAIN 389371800 WIRED
	671-6374-XX	AFG3011			1	CIRCUIT BD ASSY; A43 GENERATOR MAIN 389371800 WIRED
-12	441-2371-00	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			1	CHASSIS, REAR; 0.039 EG STEEL
-13	202-0411-01	AFG3021B, AFG3022B, AFG3011			1	CASE, REAR; PC/ABS, PLASTIC BLEND, TEK BLUE, SAFETY CONTROLLED
	202-0435-01	AFG3101, AFG3102, AFG3251, AFG3252			1	CASE, REAR; 202041100 W/METALIZED, SAFETY CONTROLLED
-14	367-0538-00	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			1	HANDLE, CARRYING; OVERMOLDED
-15	650-4827-00	AFG3021B, AFG3022B, AFG3011			1	REAR CASE ASSY; 202041101 W/FEET & HANDLE
	650-4828-00	AFG3101, AFG3102, AFG3251, AFG3252			1	REAR CASE ASSY; 202043501 W/FEET & HANDLE
-16	335-1394-00	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			1	LABEL, MANUFACTURED; PRODUCT ID, 2- 5 IN X 1.5 IN, SAFETY CONTROLLED

Table 11: Exploded diagram replaceable parts (See Figure 32.) (cont.)

Fig. & index no.	Tektronix part no.	Instrument model	Serial no. effective	Serial no. discount'd	Qty.	Name & description
-17	335-1828-00	AFG3021B			1	MARKER, IDENT; LABEL, REAR PANEL, 2.05 X 9.51, 0.010 PC FILM, LEXAN, W/ADHESIVE BACK, SAFETY CONTROLLED, AFG3021B
	335-1829-00	AFG3022B			1	MARKER, IDENT; LABEL, REAR PANEL, 2.05 X 9.51, 0.010 PC FILM, LEXAN, W/ADHESIVE BACK, SAFETY CONTROLLED, AFG3022B
	335-1283-00	AFG3101, AFG3251			1	MARKER, IDENT; LABEL, REAR PANEL, 2.05 X 9.51, 0.010 PC FILM, LEXAN, W/ADHESIVE BACK, SAFETY CONTROLLED, AFG3101, AFG3251
	335-1175-00	AFG3102, AFG3252			1	MARKER, IDENT; LABEL, REAR PANEL, 2.05 X 9.51, 0.010 PC FILM, LEXAN, W/ADHESIVE BACK, SAFETY CONTROLLED, AFG3102, AFG3252
	335-1932-00	AFG3011			1	MARKER, IDENT; LABEL, REAR PANEL, 2.05 X 9.51, 0.010 PC FILM, LEXAN, W/ADHESIVE BACK, SAFETY CONTROLLED, AFG3011
-18	348-1791-00	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			2	FOOT; REAR, BLACK, 0.4 X 0.4 X 0.1 (HEIGHT)
-19	348-1703-00	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			2	FOOT; FRONT, FLIPMPC/ABS, SILVER GRAY
-20	348-1850-00	AFG3101, AFG3102, AFG3251, AFG3252			1	GASKET, ELEC; CONDUCTIVE URETHANE FOAM, 12.7 MM W X 3.2MM T X 125 MM L, W/ADHESIVE TAPE
-21	348-1849-00	AFG3101, AFG3102, AFG3251, AFG3252			2	GASKET, ELEC; CONDUCTIVE URETHANE FOAM, 12.7 MM W X 3.2MM T X 138 MM L, W/ADHESIVE TAPE
-22	348-1848-00	AFG3101, AFG3102, AFG3251, AFG3252			2	GASKET, ELEC; CONDUCTIVE URETHANE FOAM, 12.7 MM W X 3.2MM T X 325 MM L, W/ADHESIVE TAPE
-23	174-5154-00	AFG3101, AFG3251			1	CA ASSY, SP; PELTOLA, 4.35 L, SAFETY CONTROLLED
	174-5154-00	AFG3102, AFG3252			2	CA ASSY, SP; PELTOLA, 4.35 L, SAFETY CONTROLLED
-24	174-5153-00	AFG3101, AFG3251			1	CA ASSY, SP; PELTOLA, 6.7 L, SAFETY CONTROLLED
	174-5153-00	AFG3102, AFG3252			2	CA ASSY, SP; PELTOLA, 6.7 L, SAFETY CONTROLLED

Table 11: Exploded diagram replaceable parts (See Figure 32.) (cont.)

Fig. & index no.	Tektronix part no.	Instrument model	Serial no. effective	Serial no. discont'd	Qty.	Name & description
-25	650-4806-01	AFG3101			1	SHIELD SUBASSEMBLY; A51
	650-4806-01	AFG3102			2	SHIELD SUBASSEMBLY; A51
	650-4807-02	AFG3251			1	SHIELD SUBASSEMBLY; A61
	650-4807-02	AFG3252			2	SHIELD SUBASSEMBLY; A61
-26	366-0840-00	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			1	PUSH BUTTON; POWER, PC/ABS, SILVER GRAY
-27	348-1839-00	AFG3101, AFG3102, AFG3251, AFG3252			1	GASKET, EMI; 1.8 L, CLIP ON, BE CU, NICKEL PLATED
-28	211-1143-00	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			4	SCREW, PT; K35-1.57, PAN HEAD, T-15
-29	260-2791-00	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			1	ENCODER, DIGITAL; 24 CPR, 24 DETENTS, INCREMENTAL, QUADRATURE OUTPUT
-30	346-0299-00	AFG3251, AFG3252			1	BAND; BAND, PA
-31	276-0324-00	AFG3101, AFG3102			1	CORE; EM FERRITE, EMI; AFG310
-32	174-4658-00	AFG3021B, AFG3022B, AFG3101, AFG3102			1	CA ASSY, SP; DISCRETE, 26 AWG, 5.5 L, FEMALE, 1 X 12,0.059 (1.5 MM) CTR, DUAL ENDED, FRONT PANEL, 2 CHANNEL
	174-5231-00	AFG3251, AFG3252			1	174-4658 -00 W/COPPER TAPE
-33	671-5817-XX	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			1	CIRCUIT BD ASSY; A75 KEY BOARD, 389-3586-00 WIRED
-34	260-2797-00	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			1	SWITCH, KEYPAD; ELASTOMERIC, FRONT PANEL, PUSHBUTTON
-35	348-1525-00	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			2	FOOT; FRONT, SANTOPRENE, BLACK, 64 DEROMETER, TEXTURED
-36	202-0410-01	AFG3021B, AFG3022B, AFG3011			1	CASE, FRONT; PC/ABS, PLASTIC BLEND, SILVER GRAY, SAFETY CONTROLLED
	202-0434-01	AFG3101, AFG3102, AFG3251, AFG3252			1	CASE, FRONT; 202041000 WITH METALIZED, SAFETY CONTROLLED

Table 11: Exploded diagram replaceable parts (See Figure 32.) (cont.)

Fig. & index no.	Tektronix part no.	Instrument model	Serial no. effective	Serial no. discount'd	Qty.	Name & description
-37	335-1171-00	AFG3021B, AFG3101, AFG3251, AFG3011			1	MARKER, IDENT; LABEL, FRONT PANEL, 1 CH, 5.33 X 6.24, 0.010 PC FILM, LEXAN, W/ADHESIVE BACK, SAFETY CONTROLLED
	335-1172-00	AFG3022B, AFG3102, AFG3252			1	MARKER, IDENT; LABEL, FRONT PANEL, 2 CH, 5.33 X 6.24, 0.010 PC FILM, LEXAN, W/ADHESIVE BACK, SAFETY CONTROLLED
-38	366-0841-00	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			1	KNOB, CAP; 1.380 DIA, PC/ABS, SILVER GRAY
-39	335-1289-01				1	MARKER, IDENT; LABEL, FRONT PANEL, 6.100 X 3.800, 0.015 POLYCARBONATE, FRENCH
	335-1290-01				1	MARKER, IDENT; LABEL, FRONT PANEL, 6.100 X 3.800, 0.015 POLYCARBONATE, GERMAN
	335-1291-01				1	MARKER, IDENT; LABEL, FRONT PANEL, 6.100 X 3.800, 0.015 POLYCARBONATE, JAPANESE
	335-1292-01				1	MARKER, IDENT; LABEL, FRONT PANEL, 6.100 X 3.800, 0.015 POLYCARBONATE, SIMPLE CHINESE
	335-1293-01				1	MARKER, IDENT; LABEL, FRONT PANEL, 6.100 X 3.800, 0.015 POLYCARBONATE, TRADITIONAL CHINESE
	335-1294-01				1	MARKER, IDENT; LABEL, FRONT PANEL, 6.100 X 3.800, 0.015 POLYCARBONATE, KOREAN
	335-1539-00				1	MARKER, IDENT; LABEL, FRONT PANEL, 6.100 X 3.800, 0.015 POLYCARBONATE, RUSSIAN

Table 11: Exploded diagram replaceable parts (See Figure 32.) (cont.)

Fig. & index no.	Tektronix part no.	Instrument model	Serial no. effective	Serial no. discontinued	Qty.	Name & description
-40	335-1811-00	AFG3021B			1	MARKER, IDENT; LABEL, MKD AFG3021B, 0.010 PC FILM, LEXAN, W/ADHESIVE BACK, SAFETY CONTROLLED
	335-1812-00	AFG3022B			1	MARKER, IDENT; LABEL, MKD AFG3022B, 0.010 PC FILM, LEXAN, W/ADHESIVE BACK, SAFETY CONTROLLED
	335-1280-00	AFG3101			1	MARKER, IDENT; LABEL, MKD AFG3101, 0.010 PC FILM, LEXAN, W/ADHESIVE BACK, SAFETY CONTROLLED
	335-1168-00	AFG3102			1	MARKER, IDENT; LABEL, MKD AFG3102, 0.010 PC FILM, LEXAN, W/ADHESIVE BACK, SAFETY CONTROLLED
	335-1281-00	AFG3251			1	MARKER, IDENT; LABEL, MKD AFG3251, 0.010 PC FILM, LEXAN, W/ADHESIVE BACK, SAFETY CONTROLLED
	335-1167-00	AFG3252			1	MARKER, IDENT; LABEL, MKD AFG3252, 0.010 PC FILM, LEXAN, W/ADHESIVE BACK, SAFETY CONTROLLED
	335-1849-00	AFG3011			1	MARKER, IDENT; LABEL, MKD AFG3011, 0.010 PC FILM, LEXAN, W/ADHESIVE BACK, SAFETY CONTROLLED
-41	174-5150-00	AFG3021B			1	CA ASSY, SP; DATA, MONO, 7.0 L
	174-4673-00	AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			1	CA ASSY, SP; DATA, COLOR, 7.0 L

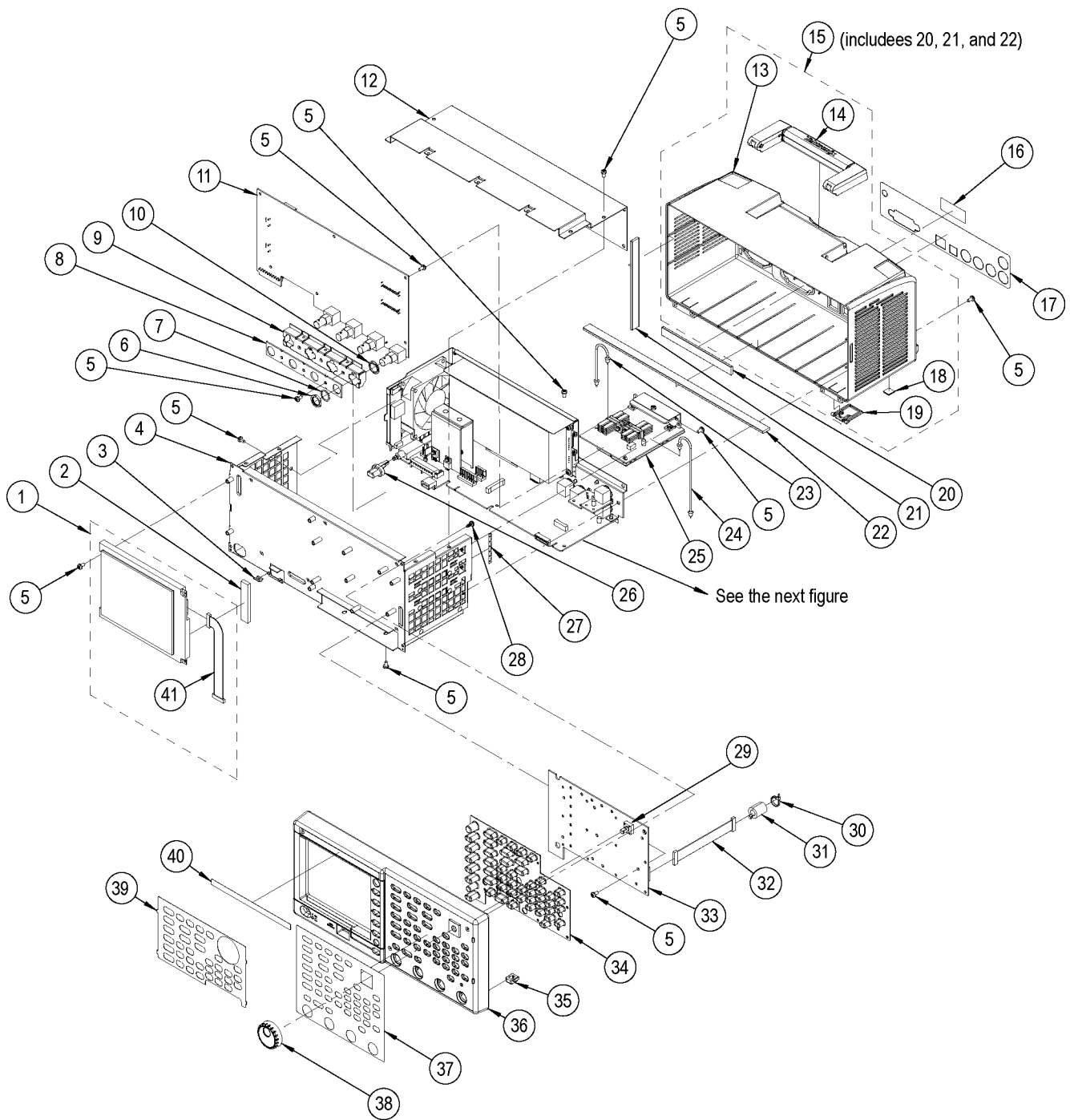


Figure 32: Exploded diagram

Table 12: Rear modules replaceable parts (See Figure 33.)

Fig. & index no.	Tektronix part number	Instrument model	Serial no. effective	Serial no. discont'd	Qty.	Name & description
33-						Rear modules
-01	211-1198-00	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			13	SCREW, MACHINE; 6-32 X 0.250, PNH, STL, ZNPL, T-15 TORX DR
-02	196-3496-00	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			1	LEAD, ELECTRICAL; 18 AWG, 4.0 L, 5-4 SAFETY CONTROLLED
-03	210-1539-00	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			1	WASHER, LOCK; #8 INTL, 0.02 THK, STL, ZN PL;
-04	386-7416-01	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			1	SUBPANEL, REAR; 0.039 EG STEEL
-05	174-5152-00	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			1	CA ASSY, SP, ELEC; 2, 28 AWG, 10 CM L, W/HOLDER, 173977-3 & 173977-2
-06	119-7116-00	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			1	FAN, DC: TUBEAXIAL, 12V, 2.08W, 2950RPM, 39.6CFM, 32.0DBA, 80MM X 80MM X 25.5MM, W/O LEAD, SAFETY CONTROLLED
-07	119-7406-00	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			1	CA ASSY, FAN; FAN, DC: TUBEAXIAL, 12V, 2.08W, 2950RPM, 39.6CFM, 32.0DBA, 80MM X 80MM X 25.5MM, W/O LEAD, FBA08A12H, SAFETY CONTROLLED, WITH ATTACHED CABLE, SP, ELEC; 2, 28 AWG, 10 CM L, W/HOLDER; 119-7116-00 WITH 174-5152-00
-08	119-7271-XX	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			1	POWER SUPPLY; AC-DC; 150 W MAX IN; 87-264 VAC 47-63 HZ, 100-127 VAC 360-440 HZ IN; +4.3V @ 2.3A, +7.5V @ 3.2A, +18V @ 2A, -18V @ 2A OUT; SAFETY CONTROLLED
-09	342-1146-00	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			1	INSULATOR; PROTECTION COVER, POWER SUPPLY, 0.5 MM THK CLEAR POLYCARBONATE, UL94-V1, SAFETY CONTROLLED
-10	119-6009-00	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			1	FILTER, RFI; 3A, 250VAC, 0.5, MA, 0.15OHM; SAFETY CONTROLLED

Table 12: Rear modules replaceable parts (See Figure 33.) (cont.)

Fig. & index no.	Tektronix part number	Instrument model	Serial no. effective	Serial no. discount'd	Qty.	Name & description
-11	174-5151-00	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			1	CA ASSY, SP, ELEC; 2, 18 AWG, 7 CM L, W/HOLDER, 09050-3031 & AMP; FASTON
-12	213-1061-00	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			2	JACKSCREW; 6-32 X 0.320 EXT THD, M3.5 X 0.6-6 INT THD X 0.215L, GPIB, BLACK OXIDE, BULK PACK
-13	210-0056-00	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			2	WASHER, LOCK; #10 SPLIT, 0.047 THK, SI BRZ NP
-14	131-6363-00	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			1	EMI GASKET; GROUNDING, 0.320 L X 0.365 W (2 CONTACTS) X 0.110 DEEP, ELECTROLESS NICKEL PLATE
-15	220-0265-00	AFG3021B, AFG3011			3	NUT, PLAIN, HEX; 0.5-28 X 0.625 HEX, BRS CD PL
	220-0265-00	AFG3022B, AFG3101, AFG3251			4	NUT, PLAIN, HEX; 0.5-28 X 0.625 HEX, BRS CD PL
	220-0265-00	AFG3102, AFG3252			5	NUT, PLAIN, HEX; 0.5-28 X 0.625 HEX, BRS CD PL
-16	210-1544-00	AFG3021B, AFG3011			3	WASHER, SPRING; 0.610 OD X 0.490 ID X 0.007 THK, WAVE SHAPE, STAINLESS STEEL
	210-1544-00	AFG3022B, AFG3101, AFG3251			4	WASHER, SPRING; 0.610 OD X 0.490 ID X 0.007 THK, WAVE SHAPE, STAINLESS STEEL
	210-1544-00	AFG3102, AFG3252			5	WASHER, SPRING; 0.610 OD X 0.490 ID X 0.007 THK, WAVE SHAPE, STAINLESS STEEL
-17	671-6071-XX	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			1	CIRCUIT BD ASSY; A82 REAR BNC INSULATOR, 389378400 WIRED
-18	348-1840-00	AFG3251, AFG3252			1	GASKET, ELEC; CONDUCTIVE URETHANE FOAM STRIP, 5MM W X 0.5 MM T X 95 MM L, W/ADHESIVE TAPE
-19	348-1841-00	AFG3251, AFG3252			1	GASKET, ELEC; CONDUCTIVE URETHANE FOAM STRIP, 5MM W X 0.5 MM T X 10 MM L, W/ADHESIVE TAPE

Table 12: Rear modules replaceable parts (See Figure 33.) (cont.)

Fig. & index no.	Tektronix part number	Instrument model	Serial no. effective	Serial no. discontinued	Qty.	Name & description
-20	348-1842-00	AFG3251, AFG3252			1	GASKET, ELEC; CONDUCTIVE URETHANE FOAM STRIP, 5MM W X 0.5 MM T X 20 MM L, W/ADHESIVE TAPE
-21	342-1135-00	AFG3021B, AFG3011			3	INSULATOR, BSHG: NYLON, 0.509 X 0.470 D HOLE X 0.687 OD X 0.035 T
	342-1135-00	AFG3022B, AFG3101, AFG3251			4	INSULATOR, BSHG: NYLON, 0.509 X 0.470 D HOLE X 0.687 OD X 0.035 T
	342-1135-00	AFG3102, AFG3252			5	INSULATOR, BSHG: NYLON, 0.509 X 0.470 D HOLE X 0.687 OD X 0.035 T
-22	671-6069-XX	AFG3022B, AFG3101, AFG3251			1	CIRCUIT BD ASSY; A80 BNC/PELTOLA ADAPTER, 389378200 WIRED
	671-6069-XX	AFG3102, AFG3252			2	CIRCUIT BD ASSY; A80 BNC/PELTOLA ADAPTER, 389378200 WIRED
-23	174-5155-00	AFG3101, AFG3102, AFG3251, AFG3252			1	CA ASSY, SP; PELTOLA, 5.5 L, SAFETY CONTROLLED
-24	276-0324-00	AFG3101, AFG3102, AFG3251, AFG3252			1	CORE; EM FERRITE, EMI; AFG310
-25	174-5156-00	AFG3022B, AFG3102, AFG3252			1	CA ASSY, SP; PELTOLA, 3.55 L, SAFETY CONTROLLED
-26	671-5815-XX	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			1	CIRCUIT BD ASSY; A72 CPU MAIN, 389358400 WIRED; ADDING HEATSINK ASSY
-27	211-1234-00	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			1	SCREW, MACHINE; 6-32 X 0.188, PNH, STL ZINC PL, PHILLIPS
-28	344-0629-00	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			2	MOUNT, CLIP; WIRE ROUTING CLIP, NYLON 6/6, ADHESIVE BACKING, NATURAL COLOR
-29	119-5489-00	AFG3021B, AFG3022B, AFG3101, AFG3102, AFG3251, AFG3252, AFG3011			1	EMI SUPPRESSION; FERRITE, ROUND CABLE; 50 OHM AT 10-100MHZ, 100 OHM AT 100-500MHZ; SNAP ON, 0.39 ID X 1.3 LEN X 0.83 OD

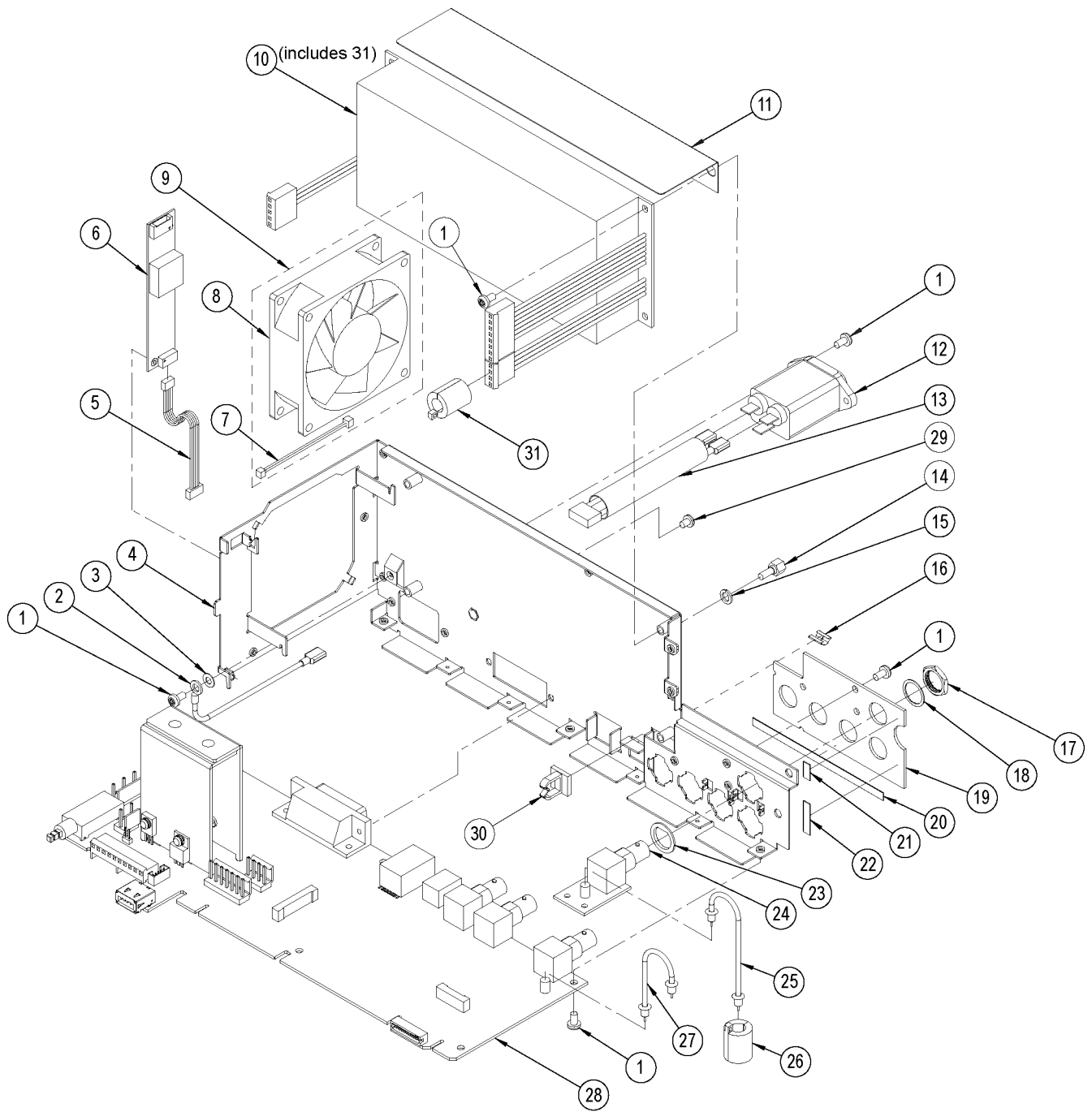


Figure 33: Rear modules