Model 5427 AC/DC Source

Hardware Reference Manual

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1. SAFETY

1.1 WARNING: LIVE CIRCUITS

NO INTERNAL ADJUSTMENT OR COMPONENT REPLACEMENT IS ALLOWED BY NON-NH RESEARCH QUALIFIED PERSONNEL. COMPLETE THE FOLLOWING BEFORE ACCESSING THE INSTRUMENT INTERNALS:

- **REMOVE ALL EXTERNAL VOLTAGE SOURCES**
- **DISCONNECT POWER CORD**
- **WAIT A MINIMUM OF 1 MINUTE TO DISCHARGE CIRCUITS**
- **VERIFY CIRCUITS ARE DISCHARGED**

2. MODEL 5427 AC/DC SOURCE

2.1 Introduction

The NH Research Model 5427 AC/DC Source was designed to provide 2000 Watts of output from a single phase 240V input with the ability to provide peak currents up to 100 Amps. Its operation is unique from most PWM sources in that the output is DC coupled to the load (no output transformer), both in the AC and DC modes of operation.

2.2 Features

The AC/DC Source uses input power factor correction to pull maximum rated power from a single-phase line supply varying from 90 - 265 VAC RMS. In AC mode, the large peak current output capacity allows testing of switching supplies with input current crest factors of up to eight to one. In DC mode, the four quadrant output capability allows discharge of capacitive DC loads much faster than traditional sources. The source has multiple output voltage ranges and a constant power envelope to provide a wide variety of maximum current and voltage capabilities.

Another feature is remote sense capability (true RMS volts in AC, average volts in DC) to compensate for losses in fixture wiring and give an accurate match between the programmed set value and the voltage seen by the UUT. The source also has a programmable current limit for AC RMS current and DC average current, as well as staged hardware current limits to allow peak current delivery to the UUT while protecting the unit from damage.

The output waveform generation and RMS value calculations are performed by an onboard DSP device for fast measurement and command response times. All the micro code for the DSP and the communication microcontroller is stored in FLASH memory so that firmware upgrades can be performed in the field by downloading over the serial interface.

Separate safety interlock inputs are provided for AC and DC operation. If the interlock signal loop becomes open, the Source output power bridge will be tri-stated immediately and the source output will then perform the normal output off sequence.

The output of the source is completely isolated from the line supply and chassis ground. Control communication with the source is over the NHR Network Instrument Interface, which provides isolation between the host computer and any source or load outputs.

2.3 Software Commands

Several output commands are available to control the output of the source and perform measurements using the internal metering circuits. The operations available are:

Reset the source

Turn the output on or off

Set the operating mode to AC or DC output

Set output voltage and current limit

Set current measurement range

Set output voltage range

Set output voltage frequency

Set frequency and voltage sweep rates

Set turn on/turn off phase angle

Set cycle count

Set trigger control

Set current trip level and delay

Read output voltage, current, power and waveforms

Read status and configuration

See the Software Users Manual for more detail on the command set.

2.4 Safety Features

2.4.1 Hardware Interlocks

The source has separate safety interlock inputs for AC and DC mode of operation, as well as a Network Bus family system interlock input. The AC/DC interlock inputs are on the Output Power terminal block. Each interlock signal has a pair of pins which must remain connected by switch or relay contact for the Source output to be enabled. In AC mode, the AC interlock pins must remain connected to enable output and the DC interlock pin connection has no effect. In DC mode, the DC interlock pins must be connected and the AC interlock pins are ignored.

The Network Bus interlock pins are on the rear panel Interlock In and Out connectors. These pins must remain connected for output to be enabled, regardless of the operating mode of the source.

Because the Source will provide AC and DC voltage on the same output pins, it is important to use the appropriate AC or DC interlock connection in any UUT fixturing to avoid damage from applying the wrong type of voltage. Using the rear panel interlocks also provides a safety feature in preventing lethal voltage to be present on output pins which are operator accessible.

Note: For safety, always use Output Power terminal block interlock connections in fixture wiring.

Opening an interlock connection while the output is on will immediately disable the output of the source and set an error status. The output will not be re-enabled by re-connecting the interlock pins after opening. The Source must be sent an Output Off command before output can be re-enabled after an interlock open event.

3. SWITCHES AND INDICATORS

3.1 Network Interface Initialize Switch

The recessed switch on the front of the AC/DC Source unit is used to reset network settings to known values to enable re-establishing a lost network connection. A small object must press the push button through the hole in the panel for 6 seconds to reset. After the reset operation, the Instrument will first attempt for 30 seconds to obtain an IP address using the DHCP protocol, then self-assign an address in the range 169.254.x.x as required by the Dynamic Configuration IP Protocol. The reset operation will also turn off the Instrument and return it to a reset state.

3.2 SW1 Rear Panel Dipswitch

These switches are used for factory test and debug. The normal operating position is all switches to the left (towards circuit board) when facing the rear of the unit.

Position 1 - Force LAN to fixed IP address 192.168.0.2
Position 2 - Force DSP to run from PROM
Position 3 - Use default configuration parameters and ignore those in FLASH
Position 4 - Reserved
Position 5 - Reserved
Position 6 - Reserved

3.3 Indicators

The Output Power On indicator light on the front panel will light whenever the output relay is closed, enabling voltage to the output connector pins. An LED device is used for long life; however failure is always a possibility. When the light is on, output voltage is present, however voltage cannot be guaranteed to be absent if the light is off, since it may be due to failure of the LED.

The front panel on/off switch also includes an Input Power On indicator light.

There are two LEDs viewable from the front of the Source for diagnostic purposes;

Network Status indicator - green

Status Indicator - yellow/green/red

The Network Status indicator will be on when a good network connection is established. It will turn off if the network cable is unplugged, or a network IP conflict is detected. It can be set to blink in response to a control button available on the web page served by the instrument.

The Status indicator will blink yellow about once per second while the source is powered on to indicate normal operation of the command execution microcontroller. If this LED stops blinking, the microcontroller is not running correctly and a power on reset will be required.

The Status indicator will alternately blink yellow/red when the command execution microcontroller detects any of several errors, either in hardware, DSP communication, or

command execution. The red blink continues until a Reset or Mode Change command is executed by the Source.

The Status indicator will indicate it is communicating with the network controller PC with an alternating green/yellow or non-steady yellow blinking pattern.

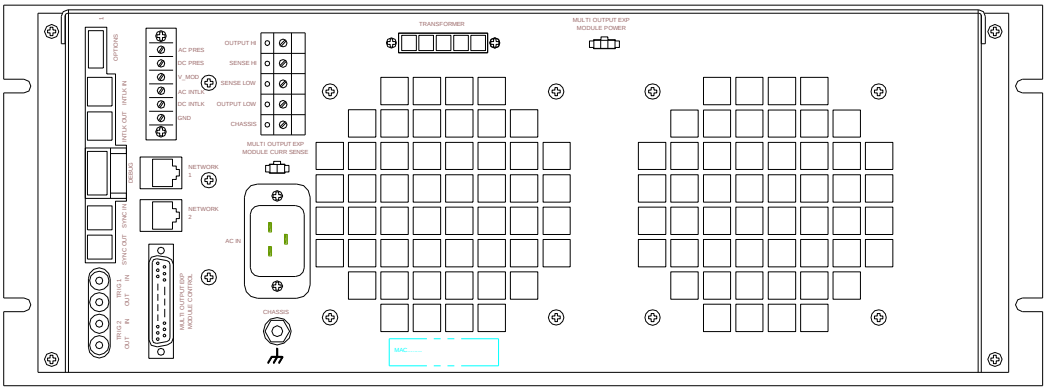


Figure 1.1 Rear View of Model 5427 AC/DC Source

Rack Mount Dimensions:

24.0 Inch depth requirement

7.0 inch rack height

19.0 inch wide rack requirement

Weight 60 lbs

Air cooled - 4 inch rear exhaust zone and unrestricted front intake zone

4. CONNECTOR PIN OUTS

4.1 AC IN

An IEC 60320 Inlet is used to supply input power to the AC/DC Source. Input power should be connected to a single phase source from 90-280 VAC RMS, 50-60 Hz. Input power has no polarity line and neutral can be connected to the inlet in any orientation. Chassis ground must be returned to earth ground for safety.

4.2 Output Power / Voltage Sense Terminal Block

Term	Signal	Description
1	OUTPUT HI	0 to 350 VAC RMS, 0 to ±424 VDC, 20 A maximum
2	SENSE HI	0 to ±500 V Peak input maximum
3	SENSE LOW	0 to ±500 V Peak input maximum
4	OUTPUT LOW	0 to 350 VAC RMS, 0 to ±424 VDC, 20 A maximum
5	CHASSIS	Chassis connection, tie to earth and Output Voltage -

The remote sense leads must be connected to the supply outputs. They should be connected to the supply outputs at the load connection terminals to compensate for voltage drop over fixture wiring. They can be connected at the source outputs if compensation is not required. The output is isolated but must be referenced to chassis earth locally or remotely.

4.3 Aux / Interlock Terminal Block

Term	Signal	Description
1	AC PRES AC Present	0V when set AC voltage is 0 and output relay is open. +5V when set AC voltage is greater than 0.
2	DC PRES DC Present	0V when set DC voltage is 0 and output relay is open. +5V when set DC voltage is not 0.
3	V_MOD Voltage Modulation	If enabled, voltage applied to this input will change the output set voltage.
4	AC INTLK AC Interlock	Connect to Gnd to enable AC output.
5	DC INTLK DC Interlock	Connect to Gnd to enable DC output.
6	GND	Chassis-referenced (not isolated) ground

For output to be enabled in AC mode, AC Interlock must be connected to ground.

For output to be enabled in DC mode, DC Interlock must be connected to ground.

4.4 Transformer

Term	Signal	Description
1	Transformer Out	0 to 350 VAC RMS Transformer output
2	Transformer In	0 to 300 VAC RMS Transformer input
3	Transformer Common	Transformer common
4	+5 Volts	Supply voltage, chassis-referenced (not isolated)
5	Transformer Detect	Enables Transformer operation when tied to +5 Volts, chassis-referenced (not isolated)

An optional external transformer may be connected to this terminal block for 350VAC output.

4.5 Interlock In / Out Modular Jack Connectors

Rear panel connector J1 and J2 are RJ45 type modular connectors that carry a system interlock signal as well as a serial data interface used for determining the physical location of instruments.

There are two connectors to facilitate a daisy-chain type connection between multiple instruments using inexpensive commercial cables.

Interlock Input Connector

Term	Signal	Description
1	+5VI	Fused low current voltage supply for isolated interlock
2	Interlock in	Interlock input from “upstream” device - high disables
3	Ground for +5VI	Isolated voltage return
4	MAC serial data In	Serial data input from upstream device - MAC value
5	Serial data in clock	Serial clock from “upstream” device for shifting MAC
6	Spare	Unused

Mating connector is RJ11 6P/6C type.

Interlock Output Connector

Term	Signal	Description
1	+5VI	Fused low current voltage supply for isolated interlock
2	Interlock out	Interlock passed from input unless disabled locally
3	Ground for +5VI	Isolated voltage return
4	MAC serial data Out	Serial data output to downstream device - MAC value
5	Serial data output clock	Serial clock to downstream device for shifting MAC
6	Spare	Unused

Mating connector is RJ11 6P/6C type.

4.6 Network 1 and Network 2 Connectors

Standard 100BaseT Ethernet connections. Auto MDIX is implemented so no cross-over cables are required. The Network1 connection can be used to control the Instrument, and Network2 can be used to connect directly to another NH Networked Instrument. All network instrument

connections should remain on a private network, behind a router or connected to a second NIC card in a computer.

NOTE: NH Instruments should NEVER be connected directly to a company network or Wide Area Network through a network switch.

Mating connector RJ45 8P/8C type.

4.7 Debug/Legacy Bus Header Connector

This connector provides an RS232 connection to the embedded microcontroller for factory use. It also provides connections to the trigger and interlock signals used on the S6000 legacy product bus. This should facilitate using the S5427 in systems with other NH instruments controlled by the S6000 protocol COM IN/COM OUT connectors.

If an S5427 is used with S6000 family instruments, it must be at the "end" of the COM IN/COM OUT chain. This means that the "last" S6000 instrument will have a special adapter cable from its COM OUT connection to the J3 debug/legacy connector on the S5427 rear panel.

Other network instruments in the system can be used with the S5427 using the new style connections and cabling, and the S6000 trigger and interlock functions will be passed to them from the S5427.

Debug/Legacy Connector J3

Term	Signal	Description
1	Trigger In +	S6000 System trigger input - RS485 level positive
2	Trigger In -	S6000 System trigger input - RS485 level negative
3	Trigger Out +	S6000 System trigger output - RS485 level positive
4	Trigger Out -	S6000 System trigger output - RS485 level negative
5	Interlock In +	S6000 System interlock input - RS485 level positive
6	Interlock In -	S6000 System interlock input - RS485 level negative
7	Spare	
8	RS232 Rcv	Debug - factory use
9	RS232 Trans	Debug - factory use
10	Ground	Ground return common to all signals

Mating connector - TYCO 2-1761609-3 (10 pin ribbon cable used with top ejector)

Adapter cable for Legacy S6000 System COM OUT cable to S5427

J1 - S5427 Debug Pin	J2 - COM OUT Pin	Signal
1	2	Trigger In+
10	3	Ground
5	5	Interlock In +
6	6	Interlock In –
3	10	Trigger Out +
4	11	Trigger Out –
2	3	Trigger In -

4.8 Trigger1 and Trigger2 In/Out SMB Connectors

The Trigger 1 In/Out signal pair connectors are bussed together and either one can serve as an input or output. The output trigger pulse is negative (low-going) true with a minimum pulse width of about 10 us.

The Instrument can be programmed to output a Trigger1 on each command execution, or to wait for a trigger input to execute a command. The Trigger1 signal can be wired in a chain fashion to multiple instruments using the Out connector from one instrument to the In connector of the next.

The Trigger signals are TTL level, driven through a 50 Ohm resistor by a 74ACT244 device which remains tri-stated until an output is required. The signals are diode-clamped to +5V and ground through the 50 Ohm impedance, and have a 27.4KOhm pull-up resistor to +5V.

The Trigger 2 connector pair has the same characteristics as the Trigger1 pair.

Mating Connector type is:

NH Part	Description	Commercial Part #	Manufacturer
6200262	SMB co-ax 50 Ohm	131-1403-016	EF JOHNSON

This connector is used with RG178 type 50 ohm co-axial cable.

4.9 Sync In / Out Modular Jack Connectors

	SYNC OUT		SYNC IN
1	Waveform Sync	1	Waveform Sync
2	Gnd	2	Gnd
3	No Connect	3	No Connect
4	Command Sync	4	Command Sync

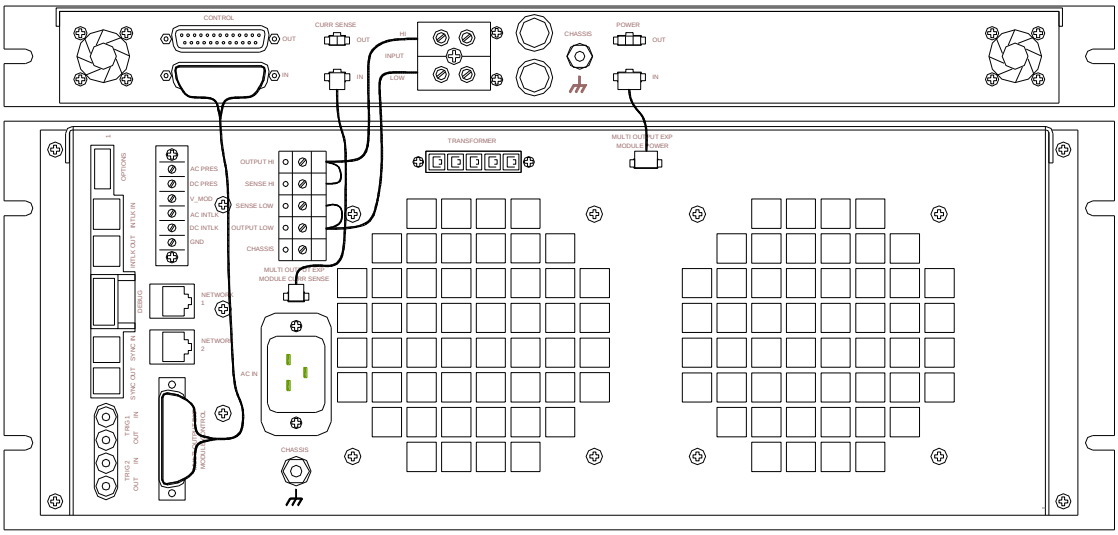
Mating connector is a modular RJ22 4P/4C type.

The Sync IN/OUT signals are used in a three phase configuration only. Instruments in a phase group will connect the SYNC Out of one instrument to the SYNC In of the next instrument to form a signal bus.

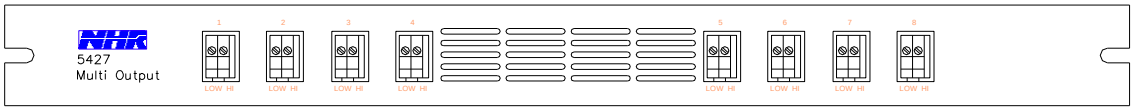
4.10 Multi Output Exp Module

These connectors are used to control an optional Multiple Output Expansion Module.

1. Connect a cable from the 5427 (Multi Output Exp Module Control) to the Multiple Output Expansion Module (Control In).
2. Connect a cable from the 5427 (Multi Output Exp Module Current Sense) to the Multiple Output Expansion Module (Current Sense In).
3. Connect a cable from the 5427 (Multi Output Exp Module Power) to the Multiple Output Expansion Module (Power In).
4. Connect a wire from the 5427 (Output Hi) to (Sense Hi) and the Multiple Output Expansion Module (Input Hi).
5. Connect a wire from the 5427 (Output Low) to (Sense Low) and the Multiple Output Expansion Module (Input Low).
6. Connect a wire from the 5427 (Chassis) and the Multiple Output Expansion Module (Chassis) to earth ground.



Many UUT's may be connected to the outputs of the Multiple Output Expansion Module.



5. SPECIFICATIONS

5.1 Configuration

One, isolated (1∅AC)/DC Source with extended measurements. Three chassis may be configured for 3∅ operation.

5.2 Input

Single Phase.

5.2.1 Voltage Current

Volts	95AC	115AC	208AC	230AC
Amps	19AC	16AC	18AC	17AC

5.2.2 Frequency

47 - 63HZ

5.2.3 Power Factor

Greater than 0.95.

5.3 Output

Single Phase AC, DC or AC+DC.

5.3.1 Voltage Current

Volts	150AC	300AC	350AC	±212DC	±424DC
Amps	18AC	9AC	8AC	±18DC	±9DC
Amps peak	90A	45A	40A	90A	45A

5.3.2 Power

2kW maximum with input greater than 200VAC.

1kW maximum with input less than 200VAC.

5.3.3 Power Factor

0 to 1, lead or lag

5.3.4 Total harmonic distortion

1% typical @ 50/60Hz & unity power factor

3% worst case from 40 to 500Hz & unity power factor

5.3.5 Noise

<500mVrms typ., <800mVrms max. from 20khz to 1Mhz.

<100mVrms typ., <200mVrms max. from 20khz to 1Mhz with low noise filter.

5.4 Size 5427

19 inch rack mount, 7 inch high 22 inch deep.

5.5 Size Multi Output Exp Module

19 inch rack mount, 1.75 inch high 22 inch deep.

5.6 Weight

75 pounds.

5.7 Communication

NHR Network Instrument Bus.

5.8 Control

An *em**Power***® driver is used to control this load in a system.

5.9 Protection

Over Temperature protection is provided by thermal sensors.

Over Current protection is provided in firmware and hardware.

Over Power protection is provided in firmware.

5.10 Isolation

1000VDC between input, output and chassis ground.

5.11 Remote Sense

2VDC max drop between sense and output.

5.12 Calibration

All adjustments are done in software and stored in FLASH.

Equipment Required:

Multimeter, Hewlett Packard Model 3458A or equivalent

NHR Calibrator

5.13 Self-test

Power-up self-test is implemented in firmware and reports comprehensive error messages about the status of the input, output, control and protection mechanism.

5.14 Performance Monitoring

The Load's controller performs performance monitoring continuously. In case of measurement ambiguities, over / under range conditions, heat sink temperature limits reached, etc an appropriate error or warning is sent to the controlling device.

5.15 Temperature

Operational from 0 to 35°C at full power, 35°C to 50°C at reduced power.

Specifications apply at 25°C ±5°C after 10-minute warm-up.

Noncondensing humidity < 75% R.H.

5.16 Processor

Texas Instruments TMS320VC33 DSP is used for all control.

5.17 Efficiency

70% minimum at full load.

5.18 Interlock

The NHR Network Instrument Bus interlock is incorporated.

5.19 Three Phase

Phase and Frequency Synchronization signals allow 3∅ operation with three chassis.

5.20 Trigger Input

May start a measurement.

May change the output voltage, or start a macro.

Accuracy 100microseconds.

5.21 Trigger Output

May be programmed with an output voltage change or phase angle.

5.22 AC Present

True when programmed AC voltage is not zero, and output relay is on.

Accuracy 100microseconds.

5.23 DC Present

True when programmed DC voltage is not zero, and output relay is on.

Accuracy 100microseconds.

5.24 Programming

Frequency	Range Accuracy Resolution	40 - 500Hz 0.02% of setting 0.001Hz
Voltage	Range Accuracy Resolution	0 to 150VAC, ±212VDC, 0 to 300VAC, ±424VDC, 0 to 350VAC 0.2% of set +0.2% range 0.01% of range
Current Limit and Trip Limited to measurement range	Range Accuracy Resolution	0 to 18A, 0 to 9A 0.3% of set +0.3% of range 0.01% of range
Power Limit Limited to measurement range	Range Accuracy Resolution	0 - 2kW 0.5% of set + 0.5% of range 0.01% of range
Phase Angle Turn-on & Turn-off	Range Accuracy Resolution	0^o to 359^o 1^o @ 50/60Hz 0.5^o @ 50/60Hz
Trigger Cycle Count	Range	1 to 4Million cycles
Waveforms	Steps	720 at 35 - 70Hz, 360 at 70 - 140Hz, 180 at 140 - 280Hz, 90 at 280 - 560Hz

Accuracies apply when the setting is greater than 10% of the range.

350VAC range requires optional external transformer.

5.25 Measurements

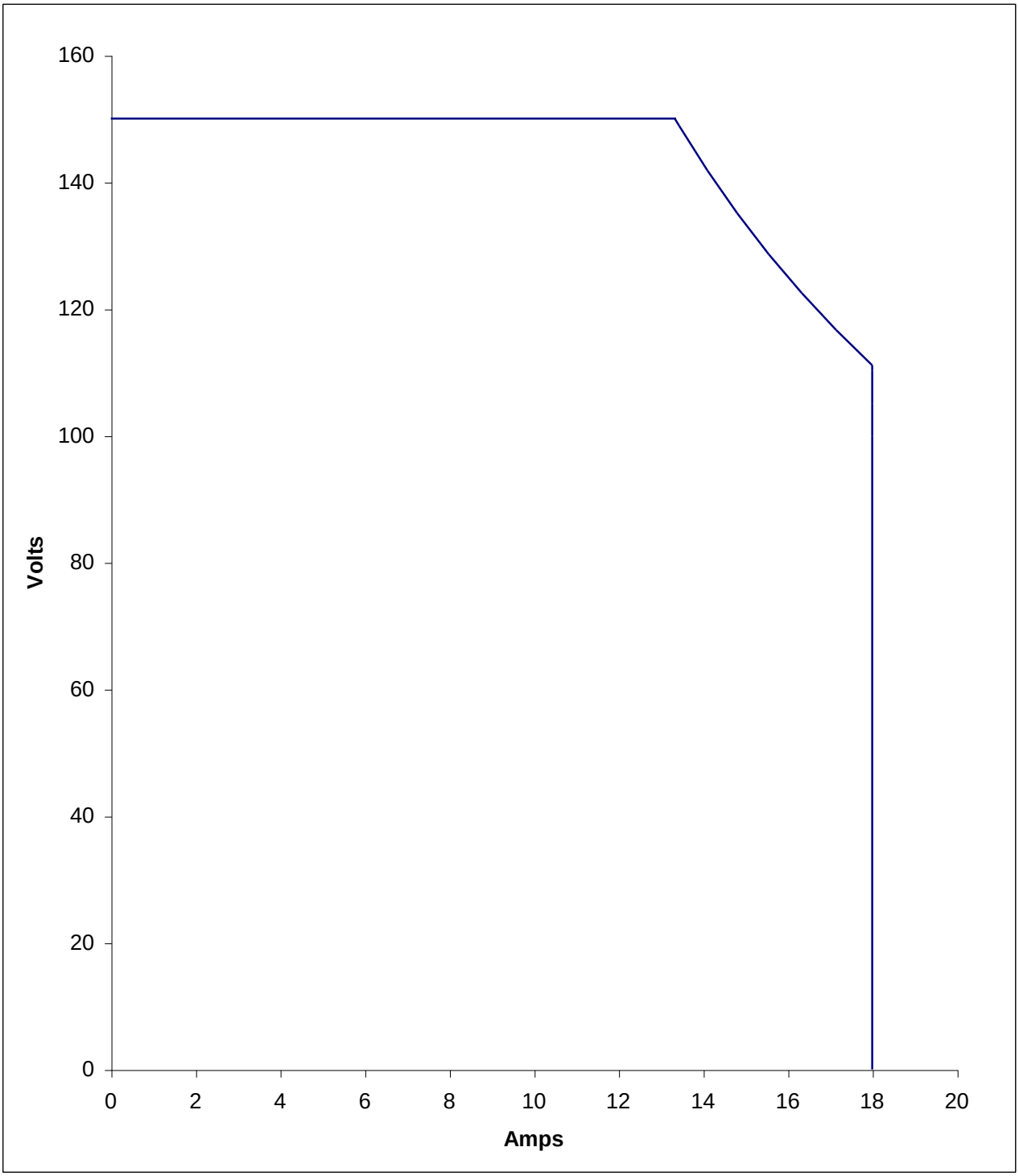
Voltage AC true rms or AC + DC true rms or DC average	Range Accuracy Resolution	0 to 150VAC, ±212VDC, 0 to 350VAC, ±500VDC 0.1% of reading, + 0.1% range 0.005% of range
Current AC true rms or AC + DC true rms or DC average *	Range Accuracy Resolution	0 to 20A, 0 to 2A, 0 to 0.1A, 0 to 0.01A, 0.2% of reading, + 0.2% range 0.005% of range
Current Peak	Range Accuracy Resolution	0 to ±100A, 0 to ±10A, 0 to ±0.5A, 0 to ±0.05A, 0.5% of reading, + 0.5% of range 0.005% of range
Multi Output Exp Module Current Inrush	Range Accuracy Resolution	0 to ±100A, 0 to ±10A, 1.5% of reading, + 1.5% of range, typical 0.005% of range
Power True, Apparent, Reactive, Watt-hour	Range Accuracy Resolution	Voltage Range times Current Range 0.3% of reading, + 0.3% of range 0.005% of range
Power Factor	Range Accuracy Resolution	0 to 1 0.5% of reading, + 0.5% of range 0.05%
Crest Factor	Range Accuracy Resolution	1 to 5 0.5% of reading, + 0.5% of range 0.005% of range
Waveforms	Voltage Bandwidth Current Bandwidth Accuracy Sample Rate Aperture Memory Resolution	DC to 100kHz DC to 20kHz 0.5% of range up to 1.2Million Samples/Second 0.2 to 10 Seconds 256k Samples 0.005% of range

DSO Range is the same as Current or Voltage being measured.

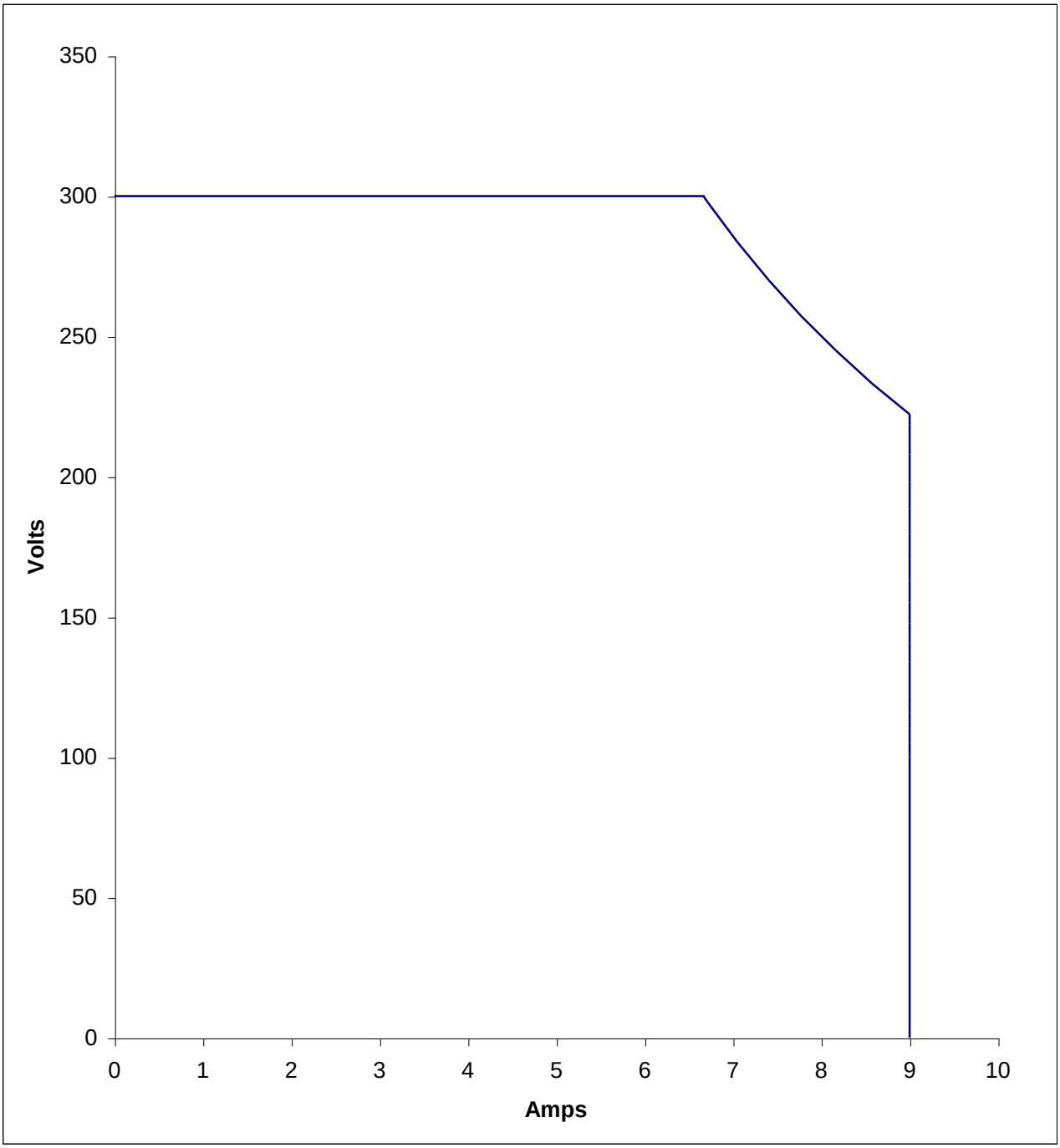
Accuracies apply when the measurement is greater than 10% of the range.

* Multi Output Exp Module 2ADC and 0.01ADC Accuracy is 0.6% of range.

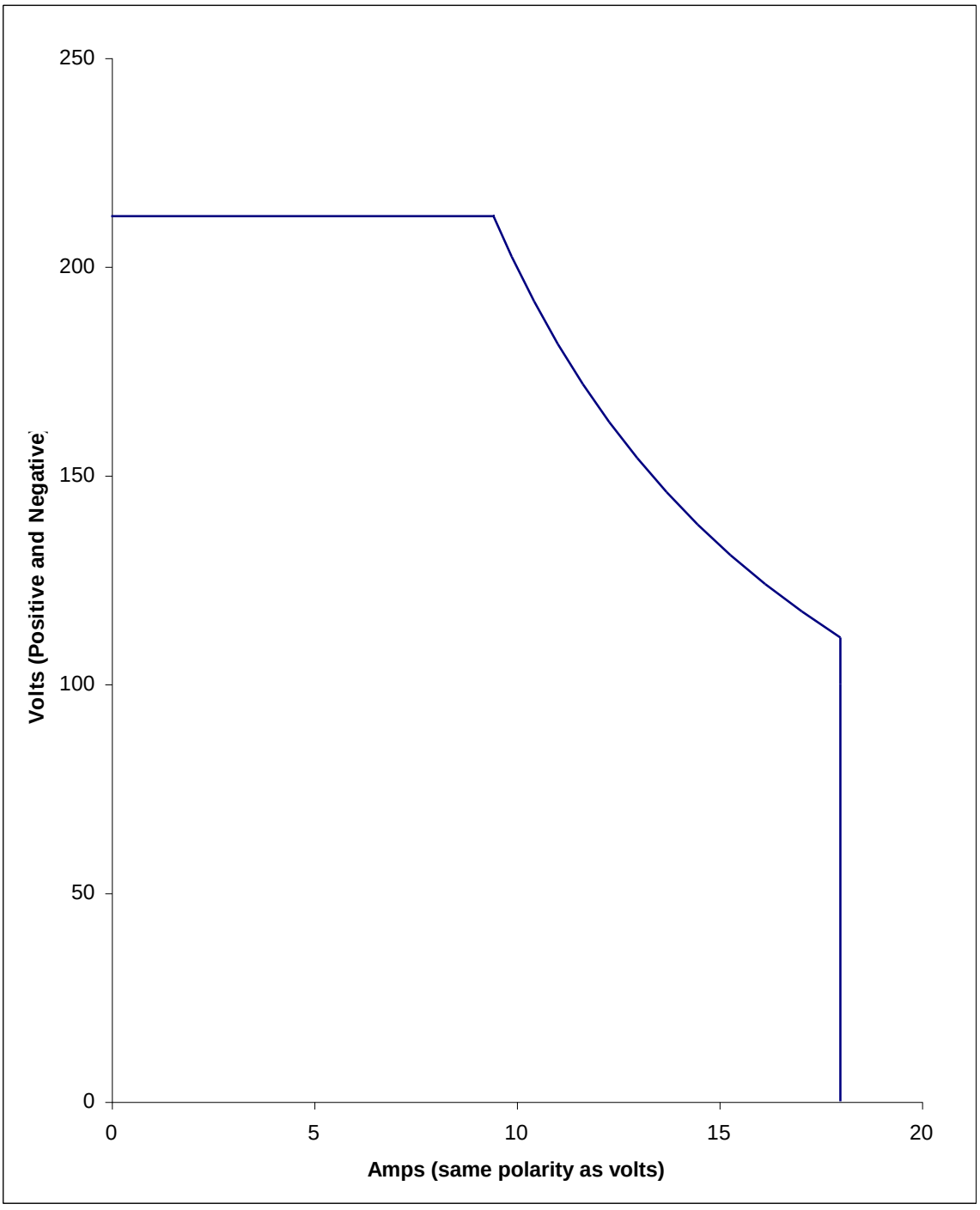
5.26 Low Voltage AC Operating Envelope



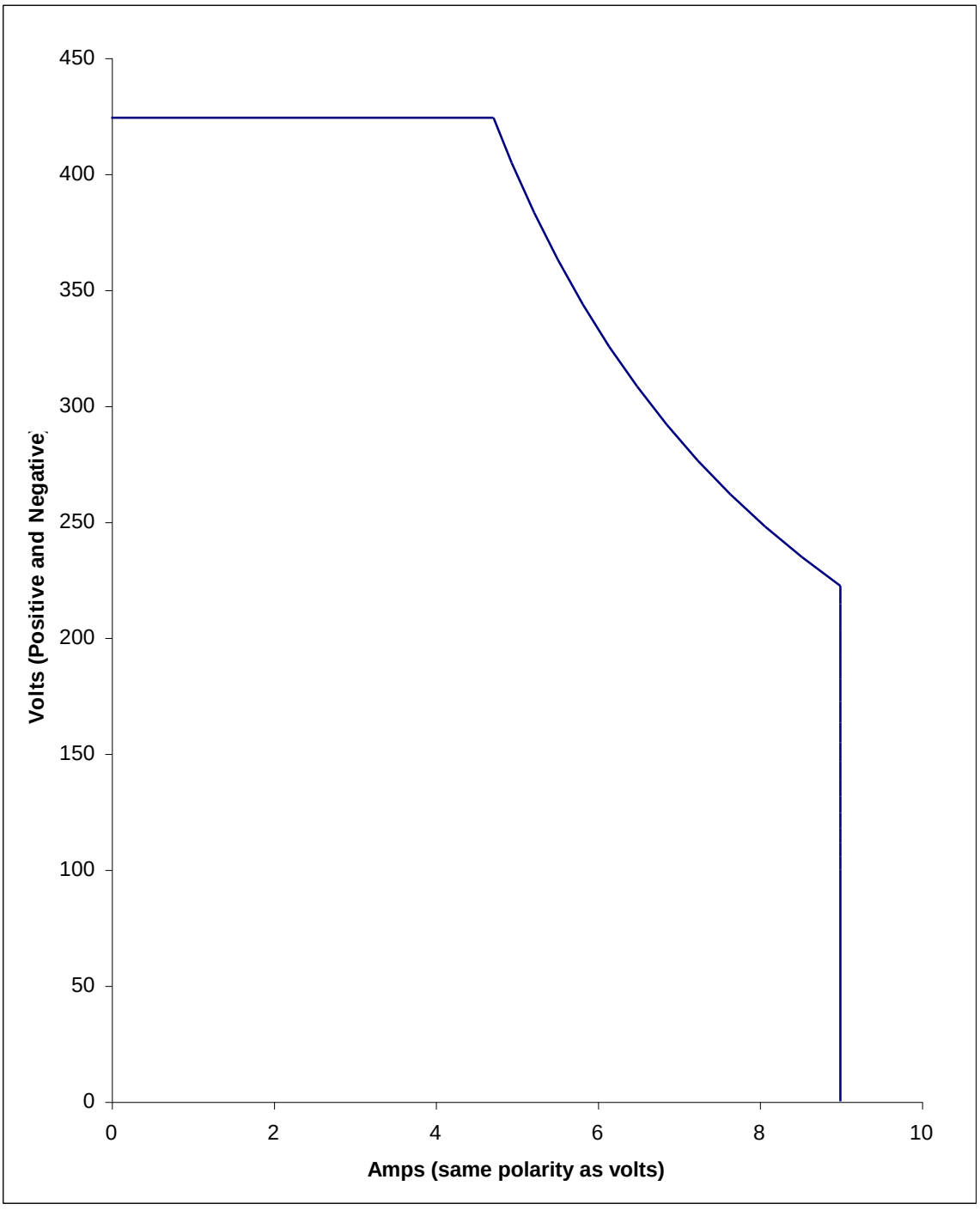
5.27 Hi Voltage AC Operating Envelope



5.28 Low Voltage DC Operating Envelope



5.29 Hi Voltage DC Operating Envelope



5.30 Power Factor Correction Input Block Diagram

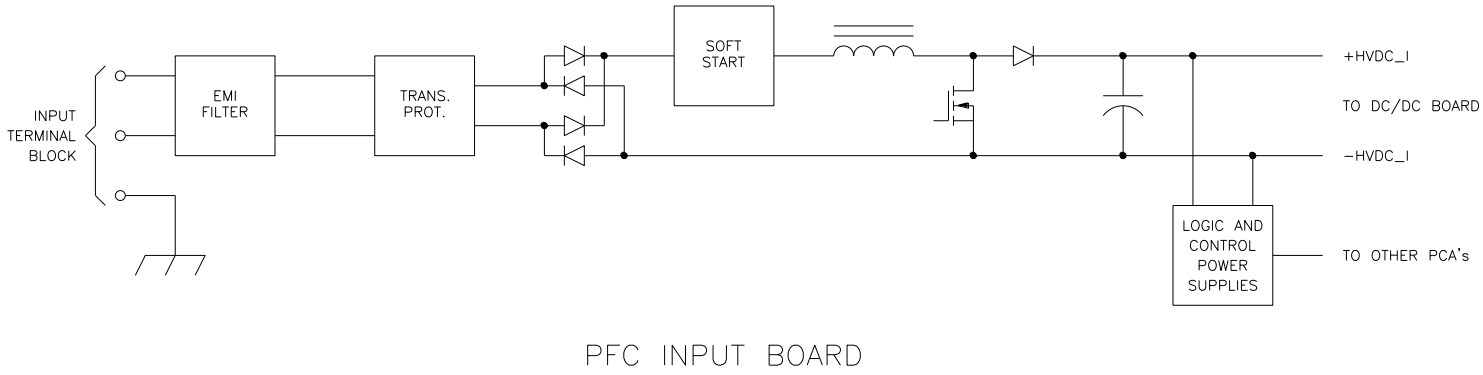


Figure 1.2

5.31 DC/DC Converter Block Diagram

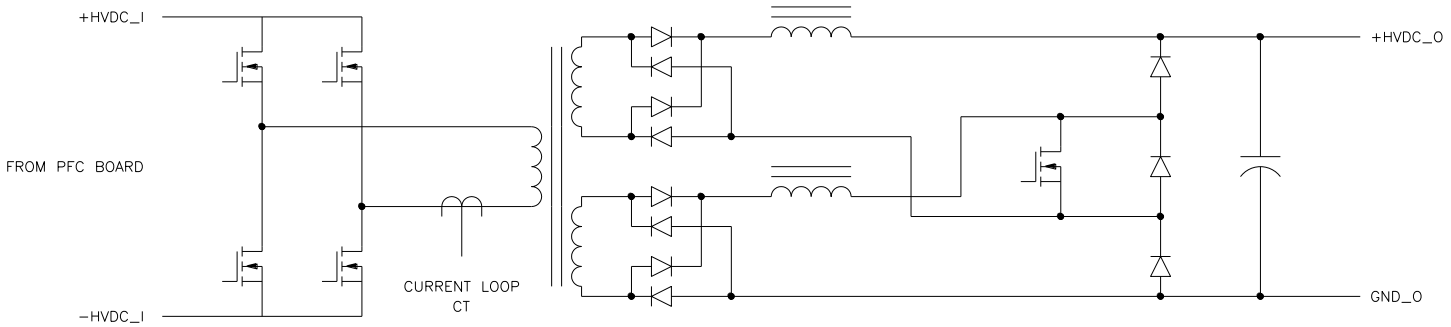


Figure 1.3

5.32 Output Block Diagram

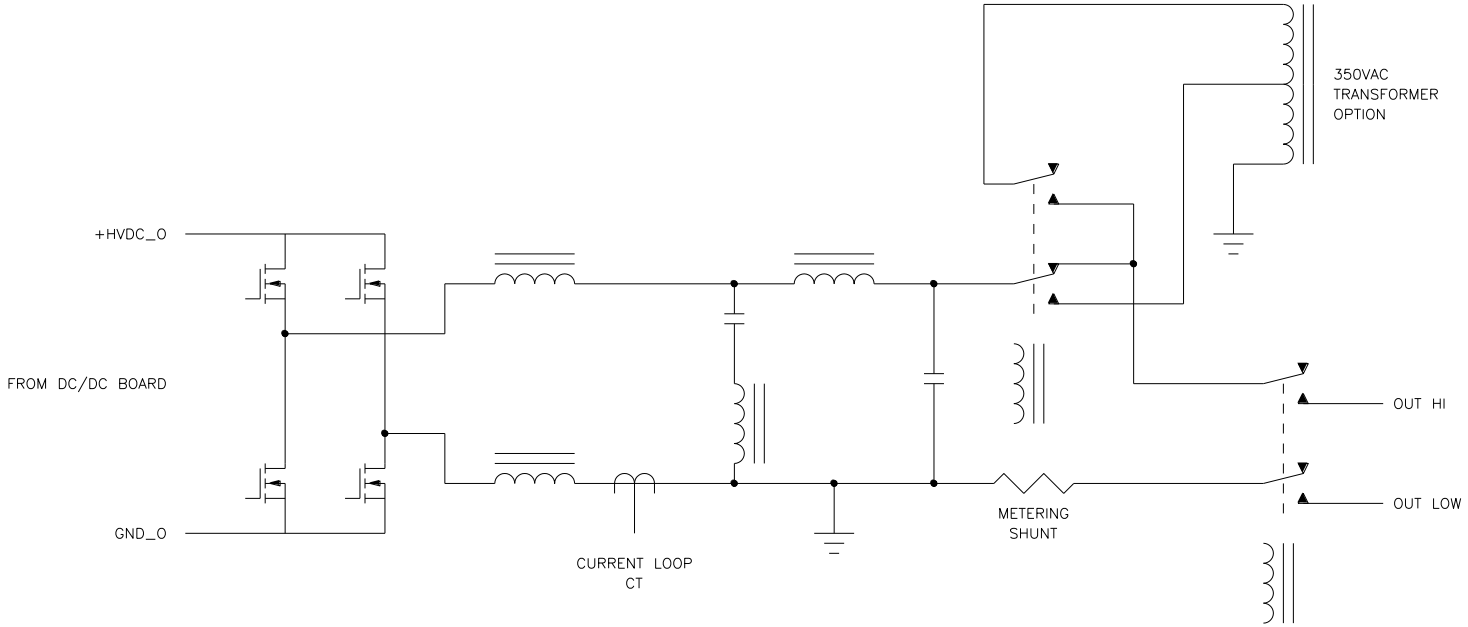


Figure 1.4

5.33 Control Block Diagram

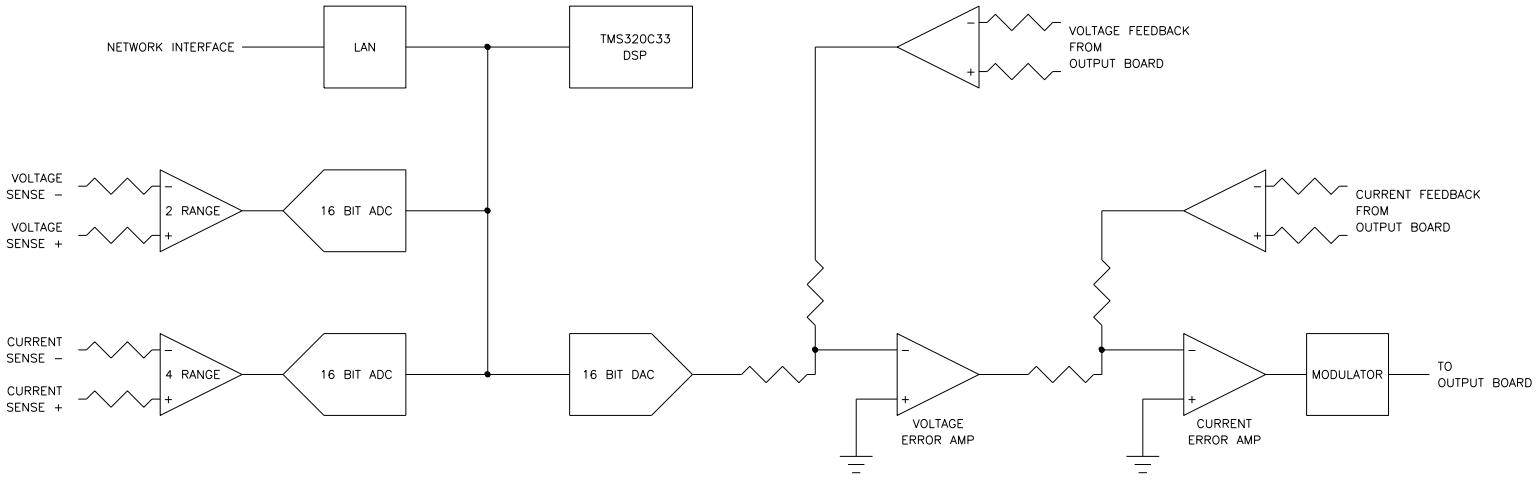


Figure 1.5