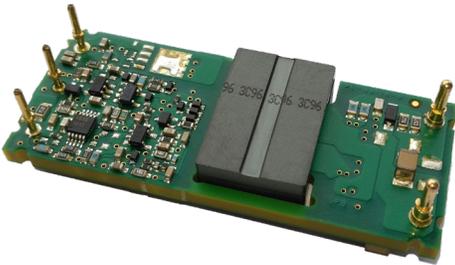


Typical unit



The ULE Series “Eighth-Brick” DC-DC Converters are isolated power converters designed to deliver power to PoE (Power-over-Ethernet) devices in High-density system boards.

## FEATURES

- RoHS compliant
- Eighth-brick package, industry standard pinout  
0.89 x 2.22 x 0.36 in. (22.6 x 56.4 x 9.9mm)
- 53 Vout / 1.13A Output for PoE+ (Power-over-Ethernet)
- Input voltage: 36-75V (48V nominal)
- Diode-Rectifier topology delivers:
  - Low noise
  - Stable no-load operation
  - No output reverse conduction
- Full Power @ 65°C, natural convection
- On/off control
- Basic Insulation System
- Fully I/O protected; Thermal shutdown
- Output OVP 59.5Vmax (single fault condition)
- Certified to UL/IEC/EN 60950-1 and CAN/CSA C22.2 No.60950-1, 2nd edition
- Lead-free construction

## PRODUCT OVERVIEW

Measuring just 0.89 × 2.22 × 0.36 inches (22.6 × 56.4 × 9.9mm), this open-frame, low-profile device fits the industry-standard eighth-brick footprint.

From a 36-75V input, the ULE-53/1.1-D48 delivers 53 Volt outputs with current up to 1.13 Amps. The ULE-53/1.1-D48 achieves high efficiency, low noise, tight line/load regulation, and quick step response.

An open-frame design and planar magnetics embedded in heavy-copper pc boards contribute to impressive thermal derating. The ULE-53/1.1-D48

includes high isolation (2250Vdc), input Pi filters, input undervoltage shutdown, output overvoltage protection, current limiting, short-circuit protection, and thermal shutdown. The standard footprint carries on/off control.

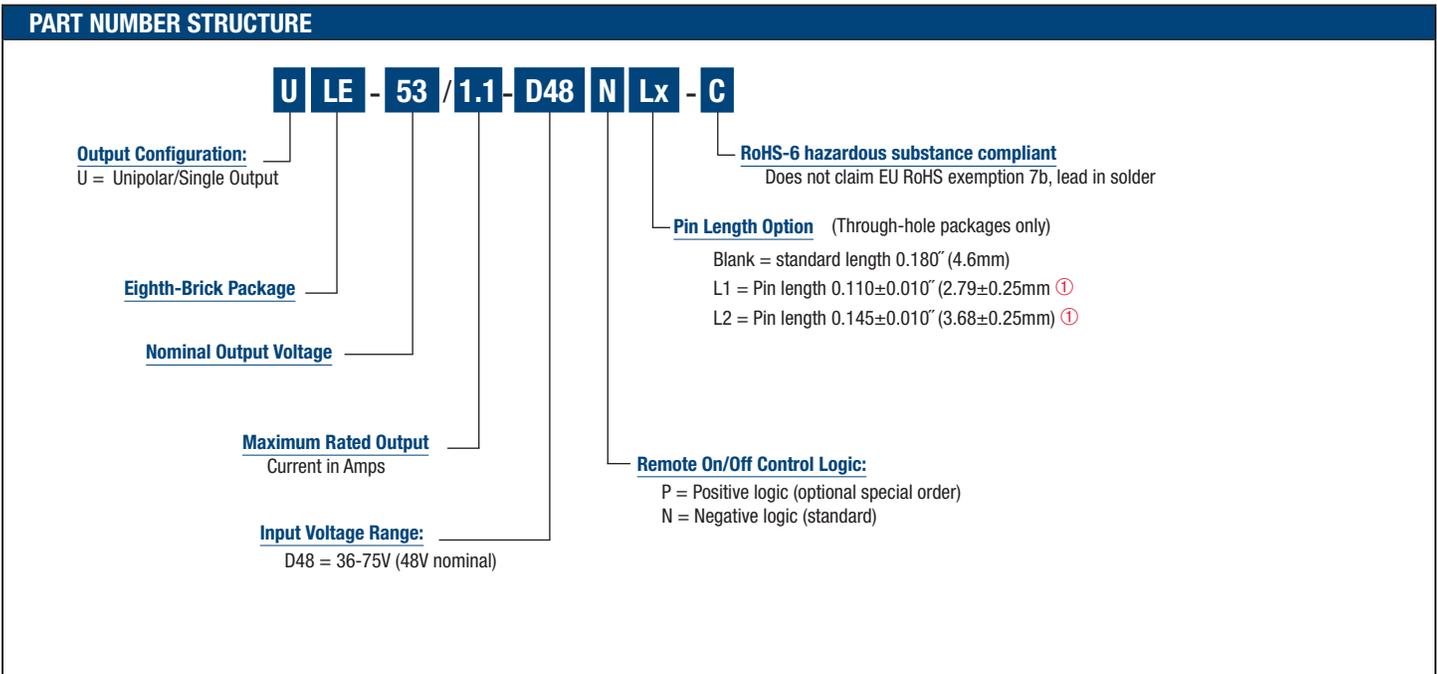
ULE eighth-bricks are certified to the BASIC-insulation requirements of UL/EN/IEC60950-1, 2nd edition, and carry the CE mark. Safety certifications, EMC compliance testing and qualification testing are available.



PERFORMANCE SPECIFICATIONS SUMMARY AND ORDERING GUIDE													
Model Family ①	Output						Input				Efficiency		
	Vout (V)	Iout (A)	Power (W)	R/N (mVp-p) ②		Regulation (Max.)		VIN Nom. (V)	Range (V)	Iin no load (mA)	Iin full load (A)	Min.	Typ.
				Typ.	Max.	Line	Load						
ULE-53/1.1-D48x-C	53	1.13	60	640	750	±0.5%	±3.6%	48	36-75	75	1.35	91%	92.5%

① Please refer to the full model number structure for additional ordering part numbers and options.

② All specifications are at nominal line voltage and full load, +25°C unless otherwise noted. See detailed specifications.



① Special quantity order is required; samples available with standard pin length only.

② Some model number combinations may not be available. See website or contact your local Murata sales representative.

## FUNCTIONAL SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS	Conditions ①	Minimum	Typical/Nominal	Maximum	Unit
Input Voltage, Continuous	Full temperature range			75	Vdc
Input Voltage, Transient	Operating or non-operating, 100 mS max. duration			100	Vdc
Isolation Voltage	Input to output tested	2250			Vdc
Input Reverse Polarity	None, install external fuse		N/A		Vdc
On/Off Remote Control	Power on or off, referred to -Vin	0		13.5	Vdc
Output Power		0.00		61.20	W
Output Current	Current-limited, no damage, short-circuit protected	0.00		1.13	A
Storage Temperature Range	Vin = Zero (no power)	-55		125	°C
Absolute maximums are stress ratings. Exposure of devices to greater than any of these conditions may adversely affect long-term reliability. Proper operation under conditions other than those listed in the Performance/Functional Specifications Table is not implied or recommended.					
INPUT	Conditions ① ②				
Operating voltage range		36	48	75	Vdc
Recommended External Fuse	Fast blow			15	A
Start-up threshold	Rising input voltage	32.00	34.00	36.00	Vdc
Undervoltage lockout (@ ½ load)	Falling input voltage	30.00	32.00	34.00	Vdc
Turn-On/Turn-Off Hysteresis					Vdc
Overvoltage shutdown	Rising input voltage		N/A		Vdc
Reverse Polarity Protection	None, install external fuse		N/A		Vdc
Internal Filter Type			LC		
Input current					
Full Load Current Conditions	Vin = nominal		1.35	1.40	A
Low Line Input Current	Vin = minimum		1.79	1.86	A
Inrush Transient	Vin = 48V		0.05		A2-Sec.
Short Circuit input current			0.05	0.10	mA
No Load input current	Iout = minimum, unit=ON		75	95	mA
Shut-Down Mode input current (Off, UV, OT)			1	2	mA
Reflected (back) ripple current ②	Measured at input with specified filter			45	mA, pk-pk
GENERAL and SAFETY					
Efficiency	Vin=48V	91.0	92.5		%
	Vin=36V	91.5	93.0		%
Isolation					
Isolation Voltage, Input to Output		2250			Vdc
Insulation Safety Rating			Basic		
Isolation Resistance			100		MΩ
Isolation Capacitance			1500		pF
Safety (certified to the following requirements)	UL-60950-1, CSA-C22.2 No.60950-1, IEC/60950-1, 2nd edition		Yes		
Calculated MTBF ④	Per Telcordia SR332, Issue 3, Method 1 Case 1, Tambient=+40°C		9.86		Hours x 10 <sup>6</sup>
DYNAMIC CHARACTERISTICS					
Fixed Switching Frequency		230	250	270	KHz
Startup Time	Power On, to Vout regulation band, 100%		80		mS
Startup Time	Remote ON to Vout Regulated		80		mS
Dynamic Load Response	50-75-50% load step to 1% of Vout		±200	±380	µSec
Dynamic Load Peak Deviation	same as above		850	1200	mV
FEATURES and OPTIONS					
Remote On/Off Control ⑤					
"N" suffix					
Negative Logic, ON state	ON = pin grounded or external voltage	0		1	Vdc
Negative Logic, OFF state	OFF = pin open or external voltage	1.3		13.5	Vdc
Control Current	open collector/drain		1	2	mA
"P" suffix					
Positive Logic, ON state	ON = pin open or external voltage	3.5		13.5	V
Positive Logic, OFF state	OFF = ground pin or external voltage	0		1	V
Control Current	open collector/drain		1	2	mA

## FUNCTIONAL SPECIFICATIONS, CONTINUED

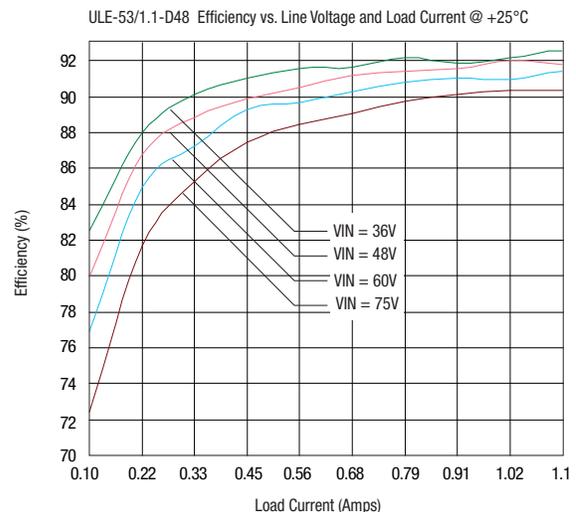
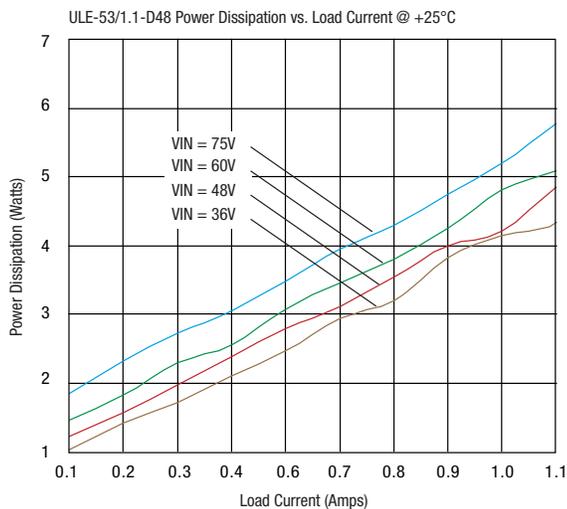
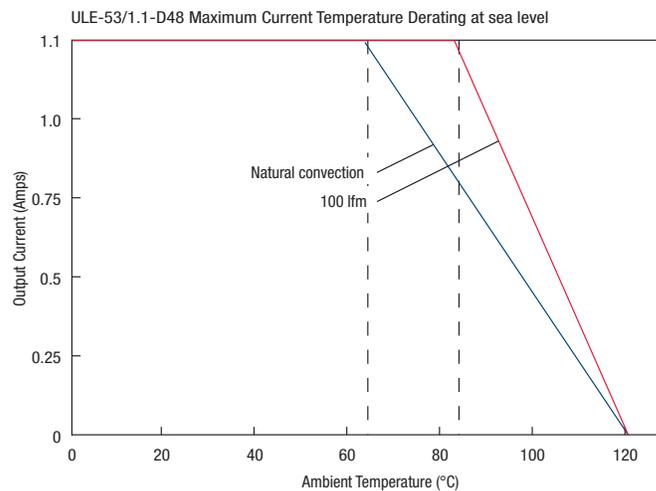
OUTPUT	Conditions ①	Minimum	Typical/Nominal	Maximum	Units
<b>Total Output Power</b>		0.00	60		W
<b>Voltage</b>					
<b>Nominal Output Voltage</b>		51.940	53.00	54.060	Vdc
<b>Setting Accuracy</b>	At 50% load		2		% of Vout.nom
<b>Overvoltage Protection</b>				59.5	Vdc
<b>Current</b>					
<b>Output Current Range</b>		0.00	1.13	1.13	A
<b>Minimum Load</b>	no minimal load required				
<b>Current Limit Inception</b>	98% of Vout.min., after warmup	1.60	2.10	2.80	A
<b>Short Circuit ⑥</b>					
<b>Short Circuit Current</b>	Hiccup technique, autorecovery within ±1.25% of Vout		0.5		A
<b>Short Circuit Duration (remove short for recovery)</b>	Output shorted to ground, no damage		CONTINUOUS		
<b>Short circuit protection method</b>	Hiccup current limiting				
<b>Regulation</b>					
<b>Line Regulation</b>	Vin=min. to max., Vout=nom., full load		±0.5		% of Vout
<b>Load Regulation</b>	Iout=min. to max., Vin=nom.		±3.6		% of Vout
<b>Ripple and Noise</b>	Tested with eight 47µF ceramic caps in parallel		640	750	mV pk-pk
<b>Temperature Coefficient</b>	At all outputs		0.02		% of Vout./°C
<b>Maximum Capacitive Loading</b>	Low ESR			470	µF
<b>Minimum Capacitive Loading</b>	Low ESR	100			µF
<b>MECHANICAL (Through Hole Models)</b>					
	<b>Conditions ① ③</b>	<b>Minimum</b>	<b>Typical/Nominal</b>	<b>Maximum</b>	<b>Units</b>
<b>Outline Dimensions</b>			0.89 x 2.22 x 0.39		Inches
<b>(Please refer to outline drawing)</b>			22.61 x 56.39 x 9.9		mm
<b>Weight</b>			0.7		Ounces
			20		Grams
<b>Through Hole Pin Diameter</b>			0.06 & 0.04		Inches
			1.524 & 1.016		mm
<b>Through Hole Pin Material</b>					
<b>TH Pin Plating Metal and Thickness</b>	Nickel subplate Gold overplate				µ-inches µ-inches
<b>ENVIRONMENTAL</b>					
<b>Operating Ambient Temperature Range</b>	See derating curves	-40		85	°C
<b>Storage Temperature</b>	Vin = Zero (no power)	-55		125	°C
<b>Thermal Protection/Shutdown</b>			125		°C
<b>Electromagnetic Interference</b>	External filter is required				
<b>Conducted, EN55022/CISPR22</b>			B		Class
<b>RoHS rating</b>	RoHS 6/6				

## FUNCTIONAL SPECIFICATION NOTES

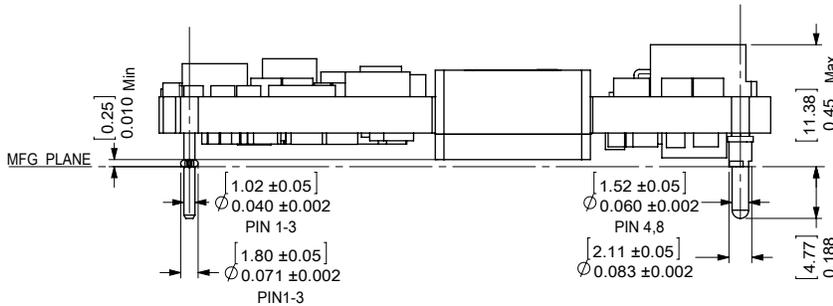
- The ULE-53/1.1-D48 is tested and specified with external 1110 µF ceramic/tantalum output capacitors and a 22 µF external input capacitor. All capacitors are low ESR types. These capacitors are necessary to accommodate our test equipment and may not be required to achieve specified performance in your applications. General conditions for Specifications are +25 deg.C, VIN=nominal, VOUT=nominal, full load. Adequate airflow must be supplied for extended testing under power.
- Input Ripple Current is tested and specified over a 5 Hz to 20 MHz bandwidth. Input filtering is CIN=33 µF tantalum, CBUS=220 µF electrolytic, LBUS=12 µH.
- Note that Maximum Power Derating curves indicate an average current at nominal input voltage. At higher temperatures and/or lower airflow, the DC-DC converter will tolerate brief full current outputs if the total RMS current over time does not exceed the Derating curve. All Derating curves are presented at sea level altitude. Be aware of reduced power dissipation with increasing density altitude.
- Mean Time Before Failure is calculated using the Telcordia (Belcore) SR-332 Issue 3, Method 1 Case 1, Tpcboard=+40°C, full output load, natural air convection.
- The On/Off Control is normally controlled by a switch. But it may also be driven with external logic or by applying appropriate external voltages which are referenced to Input Common. The On/Off Control Input should use either an open collector or open drain transistor.
- Short circuit shutdown begins when the output voltage degrades approximately 2% from the selected setting.

PHYSICAL CHARACTERISTICS AND SAFETY	
Outline dimensions	See mechanical specs (below)
Pin material	Copper alloy
Pin diameter	0.04/0.062" (1.016/1.524mm)
Pin finish	Nickel underplate with gold overplate
Weight	1 ounce (28 grams)
Electromagnetic interference (external filter required)	Designed to meet EN55022/CISPR22 with external filter
Safety	Certified to UL/cUL 60950-1, CSA-C22.2 No. 60950-1, IEC/EN 60950-1, 2nd edition

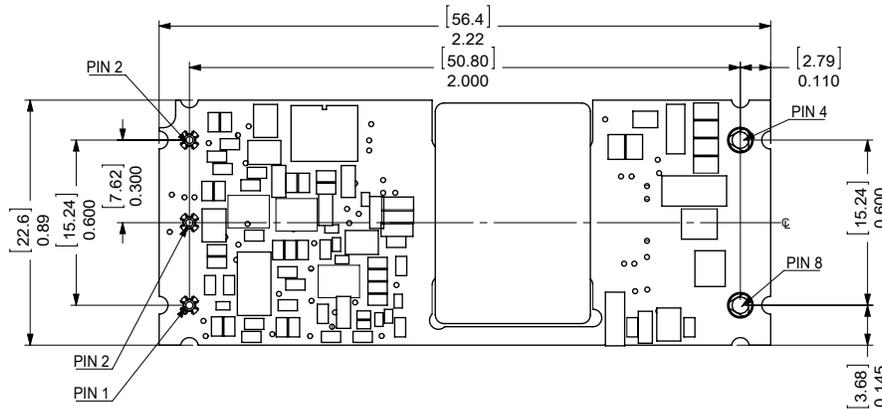
## TYPICAL PERFORMANCE CURVES



## MECHANICAL SPECIFICATIONS

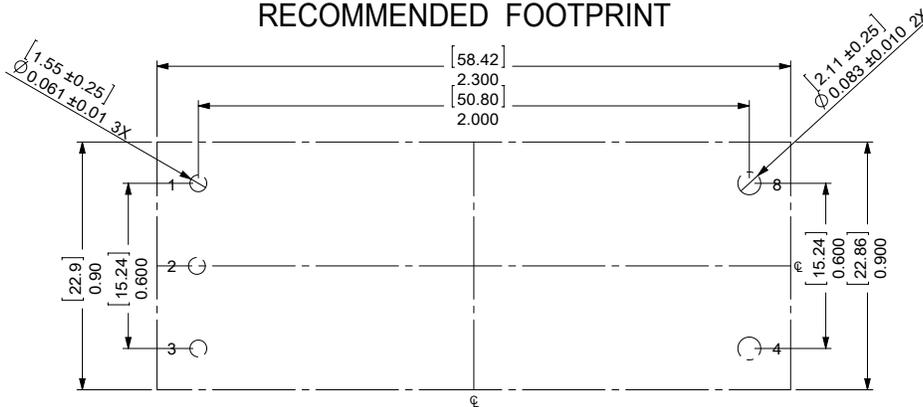


SIDE VIEW



BOTTOM VIEW

## RECOMMENDED FOOTPRINT



DOSA-Compliant Input/Output Connections	
Pin	Function
1	+Vin
2	On/Off Control*
3	-Vin
4	-Vout
5	Not Available
6	Not Available
7	Not Available
8	+Vout

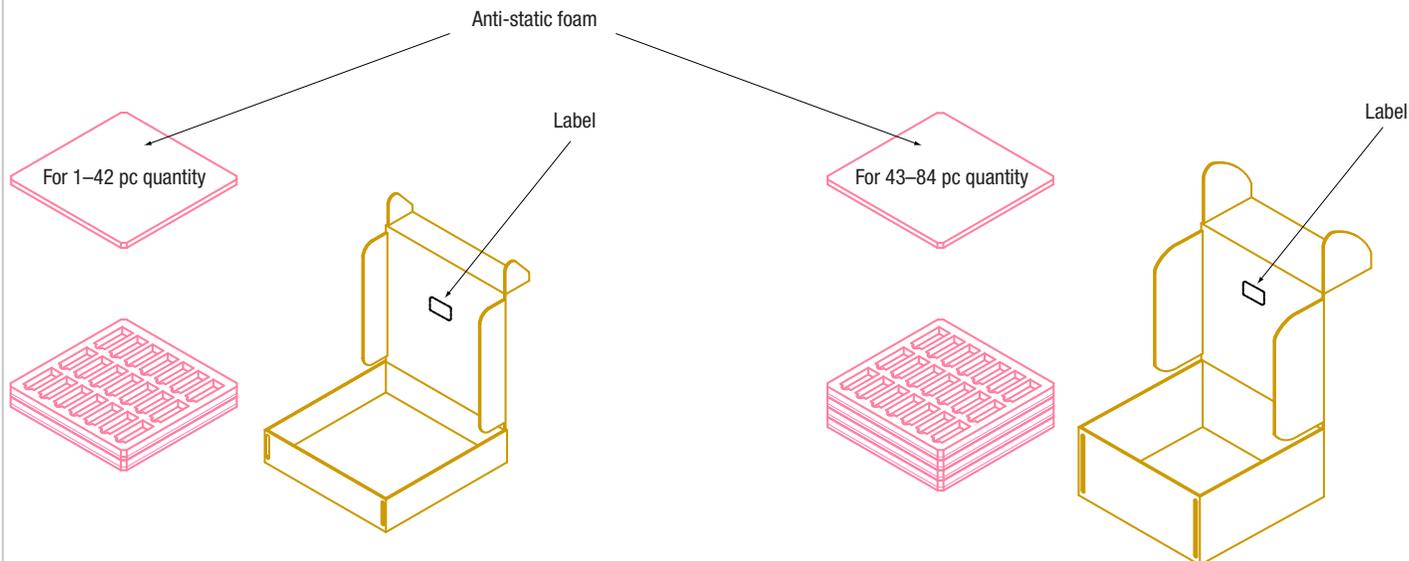
\* The Remote On/Off can be provided with either positive (P suffix) or negative (N suffix) logic.

### ULE Connections

The ULE-53/1.1-D48 does not include Sense or Trim connections. The remote On/Off control pin is installed. Please refer to the following table:

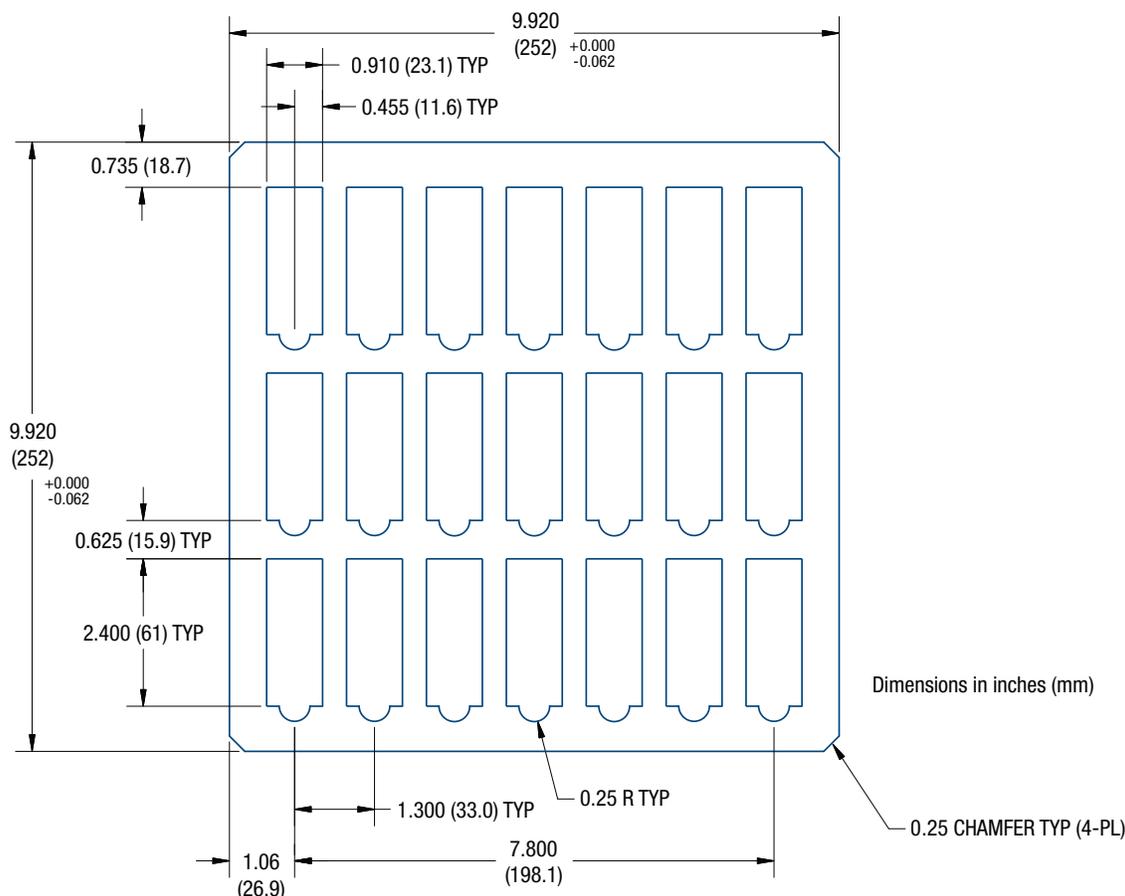
Model Number	Vout (Volts)	Iout (Amps, max.)	Number of Pins	On/Off pin?	Trim pin?	Sense pins?
ULE-53/1.1-D48	53	1.13	5	yes	no	no

## SHIPPING TRAYS AND BOXES



## SHIPPING TRAY

ULE modules are supplied in a 21-piece (3-by-7) shipping tray. The tray is an anti-static closed-cell polyethylene foam. Dimensions are shown below.



**TECHNICAL NOTES**

**Input Fusing**

Certain applications and/or safety agencies may require the installation of fuses at the inputs of power conversion components. Fuses should also be used if the possibility of sustained, non-current-limited, input-voltage polarity reversals exist. For Murata Power Solutions ULE 60 Watt DC-DC Converters, you should use fast-blow type fuses, installed in the ungrounded input supply line, with values no greater than the following.

Model	Fuse Values
48 Volt Input	4 Amps

All relevant national and international safety standards and regulations must be observed by the installer. For system safety agency approvals, the converters must be installed in compliance with the requirements of the end-use safety standard.

**Input Undervoltage Shutdown and Start-Up Threshold**

Under normal start-up conditions, devices will not begin to regulate until the ramping-up input voltage exceeds the Start-Up Threshold Voltage. Once operating, devices will not turn off until the input voltage drops below the Undervoltage Shutdown limit. Subsequent re-start will not occur until the input is brought back up to the Start-Up Threshold. This built in hysteresis prevents any unstable on/off situations from occurring at a single input voltage.

**Start-Up Time**

The VIN to VOUT Start-Up Time is the interval of time between the point at which the ramping input voltage crosses the Start-Up Threshold and the fully loaded output voltage enters and remains within its specified accuracy band. Actual measured times will vary with input source impedance, external input/output capacitance, and load. The ULE Series implements a soft start circuit that limits the duty cycle of its PWM controller at power up, thereby limiting the input inrush current.

The On/Off Control to VOUT start-up time assumes the converter has its nominal input voltage applied but is turned off via the On/Off Control pin. The specification defines the interval between the point at which the converter is turned on and the fully loaded output voltage enters and remains within its specified accuracy band. Similar to the VIN to VOUT start-up, the On/Off Control to VOUT start-up time is also governed by the internal soft start circuitry and

external load capacitance.

The difference in start up time from VIN to VOUT and from On/Off Control to VOUT is therefore insignificant.

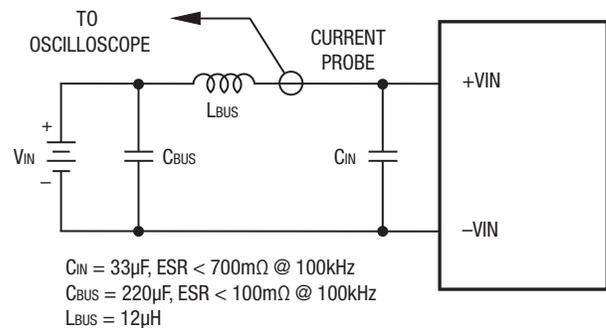
**Input Source Impedance**

ULE converters must be driven from a low ac-impedance input source. The DC-DC's performance and stability can be compromised by the use of highly inductive source impedances. The input circuit shown in Figure 2 is a practical solution that can be used to minimize the effects of inductance in the input traces. For optimum performance, components should be mounted close to the DC-DC converter. If the application has a high source impedance, low VIN models can benefit of increased external input capacitance.

**I/O Filtering, Input Ripple Current, and Output Noise**

The ULE-53/1.1-D48 is tested/specified for input reflected ripple current and output noise using the specified external input/output components/circuits and layout as shown in the following two figures.

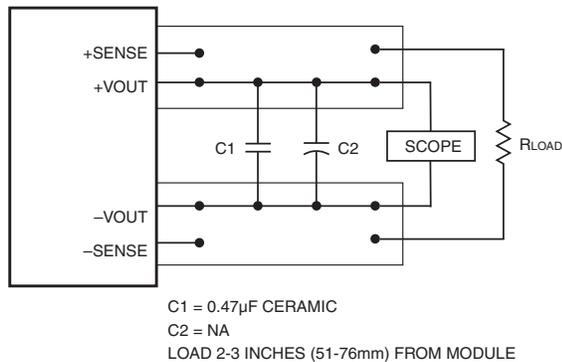
External input capacitors (CIN in Figure 2) serve primarily as energy-storage elements, minimizing line voltage variations caused by transient IR drops in conductors from backplane to the DC-DC. Input caps should be selected for bulk capacitance (at appropriate frequencies), low ESR, and high rms-ripple-current ratings. The switching nature of DC-DC converters requires that dc voltage sources have low ac impedance as highly inductive source impedance can affect system stability. In Figure 2, CBUS and LBUS simulate a typical dc voltage bus. Your specific system configuration may necessitate additional considerations.



**Figure 2. Measuring Input Ripple Current**

In critical applications, output ripple/noise (also referred to as periodic and random deviations or PARD) may be reduced below specified limits using filtering techniques, the simplest of which is the installation of additional external output capacitors. These output caps function as true filter elements and should be selected for bulk capacitance, low ESR and appropriate frequency response. All external capacitors should have appropriate voltage ratings and be located as close to the converter as possible. Temperature variations for all relevant parameters should also be taken carefully into consideration. The most effective combination of external I/O capacitors will be a function of line voltage and source impedance, as well as particular load and layout conditions.

In Figure 3, the two copper strips simulate real-world pcb impedances between the power supply and its load. In order to minimize measurement errors, scope measurements should be made using BNC connectors, or the



probe ground should be less than 1/2 inch and soldered directly to the fixture.  
**Figure 3. Measuring Output Ripple/Noise (PARD)**

### Floating Outputs

Since these are isolated DC-DC converters, their outputs are "floating" with respect to their input. Designers will normally use the -Output (pin 4) as the ground/return of the load circuit. You can, however, use the +Output (pin 8) as ground/return to effectively reverse the output polarity.

### Thermal Shutdown

These ULE converters are equipped with thermal-shutdown circuitry. If environmental conditions cause the internal temperature of the DC-DC converter to rise above the designed operating temperature, a precision temperature sensor will power down the unit. When the internal temperature decreases below the threshold of the temperature sensor, the unit will self start. See Performance/Functional Specifications.

### Output Overvoltage Protection

ULE output voltages are monitored for an overvoltage condition via magnetic feedback. The signal is coupled to the primary side and if the output voltage rises to a level which could be damaging to the load, the sensing circuitry will power down the PWM controller causing the output voltages to decrease. Following a time-out period the PWM will restart, causing the output voltages to ramp to their appropriate values. If the fault condition persists, and the output voltages again climb to excessive levels, the overvoltage circuitry will initiate another shutdown cycle. This on/off cycling is referred to as "hiccup" mode.

Contact Murata Power Solutions for an optional output overvoltage monitor circuit using a comparator which is optically coupled to the primary side thus allowing tighter and more precise control.

### Current Limiting

As soon as the output current increases to 10% to 50% above its rated value, the DC-DC converter will go into a current-limiting mode. In this condition, the output voltage will decrease proportionately with increases in output current, thereby maintaining somewhat constant power dissipation. This is commonly referred to as power limiting. Current limit inception is defined as the point at which the full-power output voltage falls below the specified tolerance. See Performance/Functional Specifications. If the load current, being drawn from the converter, is significant enough, the unit will go into a short circuit condition as specified under "Performance."

### Short Circuit Condition

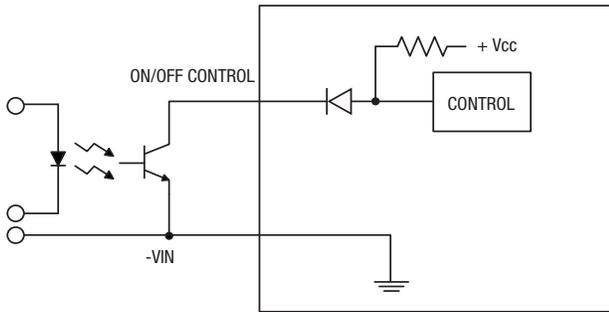
When a converter is in current-limit mode, the output voltage will drop as the output current demand increases. If the output voltage drops too low, the magnetically coupled voltage used to develop primary side voltages will also drop, thereby shutting down the PWM controller. Following a time-out period, the PWM will restart causing the output voltages to begin ramping to their appropriate values. If the short-circuit condition persists, another shutdown cycle will be initiated. This on/off cycling is referred to as "hiccup" mode. The hiccup cycling reduces the average output current, thereby preventing internal temperatures from rising to excessive levels. The ULE is capable of enduring an indefinite short circuit output condition.

### Features and Options

#### On/Off Control

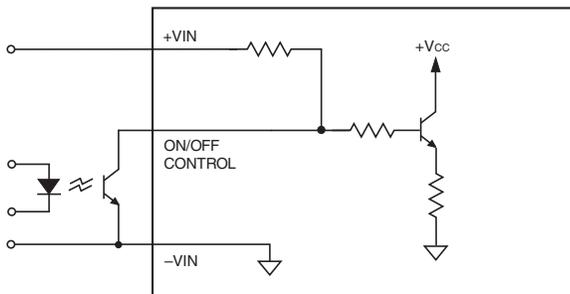
The input-side, remote On/Off Control function can be ordered to operate with either logic:

Optional Positive-Logic models ("P" part-number suffix) are enabled when the On/Off Control is left open or is pulled high, as per Figure 4. Positive-logic devices are disabled when the On/Off Control is pulled low.



**Figure 4. Driving the Positive Logic On/Off Control Pin**

Standard Negative-logic devices (“N” suffix) are off when the On/Off Control is open (or pulled high), and on when the On/Off Control is pulled low with respect to  $-V_{IN}$  as shown in Figure 5.



**Figure 5. Driving the Negative Logic On/Off Control Pin**

Dynamic control of the remote on/off function is facilitated with a mechanical relay or an open-collector/open-drain drive circuit (optically isolated if appropriate). The drive circuit should be able to sink appropriate current (see Performance Specs) when activated and withstand appropriate voltage when deactivated. Applying an external voltage to the On/Off Control when no input power is applied to the converter can cause permanent damage to the converter.

### Soldering Guidelines

Murata Power Solutions recommends the specifications below when installing these converters. These specifications vary depending on the solder type. Exceeding these specifications may cause damage to the product. Be cautious when there is high atmospheric humidity. We strongly recommend a mild pre-bake (100 °C. for 30 minutes). Your production environment may differ therefore please thoroughly review these guidelines with your process engineers.

Wave Solder Operations for through-hole mounted products (THMT)			
For Sn/Ag/Cu based solders:		For Sn/Pb based solders:	
Maximum Preheat Temperature	115° C.	Maximum Preheat Temperature	105° C.
Maximum Pot Temperature	270° C.	Maximum Pot Temperature	250° C.
Maximum Solder Dwell Time	7 seconds	Maximum Solder Dwell Time	6 seconds

### Power over Ethernet (PoE) Applications

Power-over-Ethernet (PoE) is a popular way to deliver power to all types of end-point networking and peripheral equipment. Powered devices, such as voice-over-IP telephones, wireless access points, video cameras, and point-of-sale devices that support PoE can receive power safely from the access ports that are used to connect personal computers to the network. Power over Ethernet (PoE) supports the implementation of the IEEE 802.3af and IEEE 802.3at standards. This implementation allows devices to draw/supply power using the same generic cabling as is used for data transmission. PoE implementations provide a 10BASE-T, 100BASE-TX, or 1000BASE-T device with a single interface to both the data it requires and the power to process this data.

Devices powered by POE have an input range between 44Vdc and 57Vdc for Type 1 devices and 50Vdc to 57Vdc for higher powered Type 2 devices. But there are further requirements to adequately and safely deliver this energy. The PoE standard IEEE 802.at requires a high degree of electrical isolation between anything attached to the Ethernet cable and any circuitry sending and receiving transmissions over that cable. This electrical isolation shall be in accordance with the isolation requirements between SELV circuits and telecommunication network connections as follows:

- 1500 Vrms steady-state at 50-60 Hz for 60 seconds, applied as specified in subclause 6.2 of IEC60950.
- 2250VDC for 60s, applied as specified in subclause 5.2.2 of IEC60950.

The original IEEE 802.3af-2003 PoE standard provides up to 15.4 W of DC power (minimum 44 V DC and 350 mA) on each port. Only 12.95 W is assured to be available at the powered device as some power dissipates along the length of the cable. The updated IEEE 802.3at-2009 PoE standard also known as PoE+ or PoE plus, provides up to 30W to each port for "Type 2" devices. Only 25.5 W of power is assured to be available at the powered device, as some power dissipates in the cable. The 2009 standard prohibits a powered device from using all four pairs for power, although this may change with the upcoming IEEE 802.3bt, also known as 4PPoE (4 Pair Power over Ethernet). This standard is slated for early 2018 is anticipated to introduce two new levels of power: 55 W (Type 3) and 90-100 W (Type 4).

The PoE standard provides support for legacy PoE devices. An IEEE 802.af powered device can operate normally when connected to IEEE 802.at power sourcing equipment.

Standard	Class	Maximum Power delivered by PoE port	Power range of powered device
IEEE 802.3af (PoE) and IEEE 802.3at (PoE+) Type 1	0	15.4 W	0.44 through 12.95 W
	1	4 W	0.44 through 3.84 W
	2	7.0 W	3.84 through 6.49 W
	3	15.4 W	6.49 through 12.95 W
IEEE 802.3at (PoE+) Type 2	4	30.0 W	12.95 through 25.5 W

### Typical PSE(Power Sourcing Equipment) Application

ULE-53/1.1-D48 series products can be used together with PSE controllers from various vendors, to provide reliable power in Endpoint or Midspan PSE. A typical application for PSE is shown below.

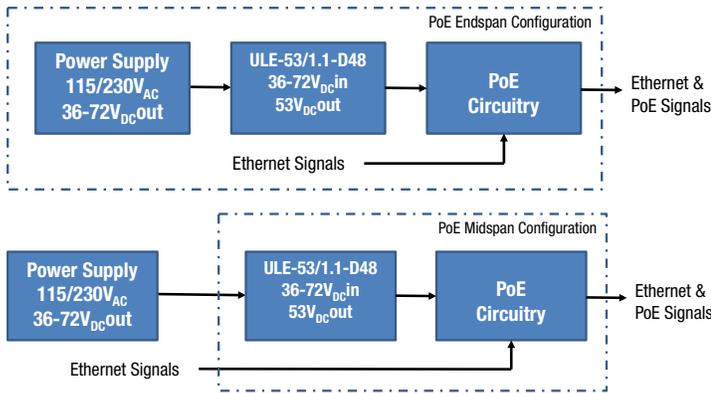


Figure 6. Typical Application for PSE

### Basic PSE

The PSE is kind of a power switch, controlling the PoE process described hereafter. As such, it holds the PoE "intelligence", therefore a CPU is required to control the PoE process while other analog components are doing the switching, sensing and power filtering activities.

#### Endspan and Midspan

There are two basic types of PSE: Endspan and Midspan. Endspan PSE integrates PoE into Ethernet switches, while Midspan PSE is an element resides between the switch and the terminal, providing power only.

Endspans are mainly for green-field installations. Midspan devices, on the other hand, are for organizations looking to upgrade a network without replacing existing switches.

The Endspan is a switch that integrates the PoE source, to simplify the infrastructure, using "Phantom Feeding" on the center tap of the Ethernet pulse transformer. 802.3af allows the Endspan to use the spare pairs for power delivery instead of the data pairs, though the latter configuration is more commonly used.

The Midspan is a patch panel like device that receives data lines from the switch and inserts power over the spare pairs, providing data and power out to the PD (Powered Devices)

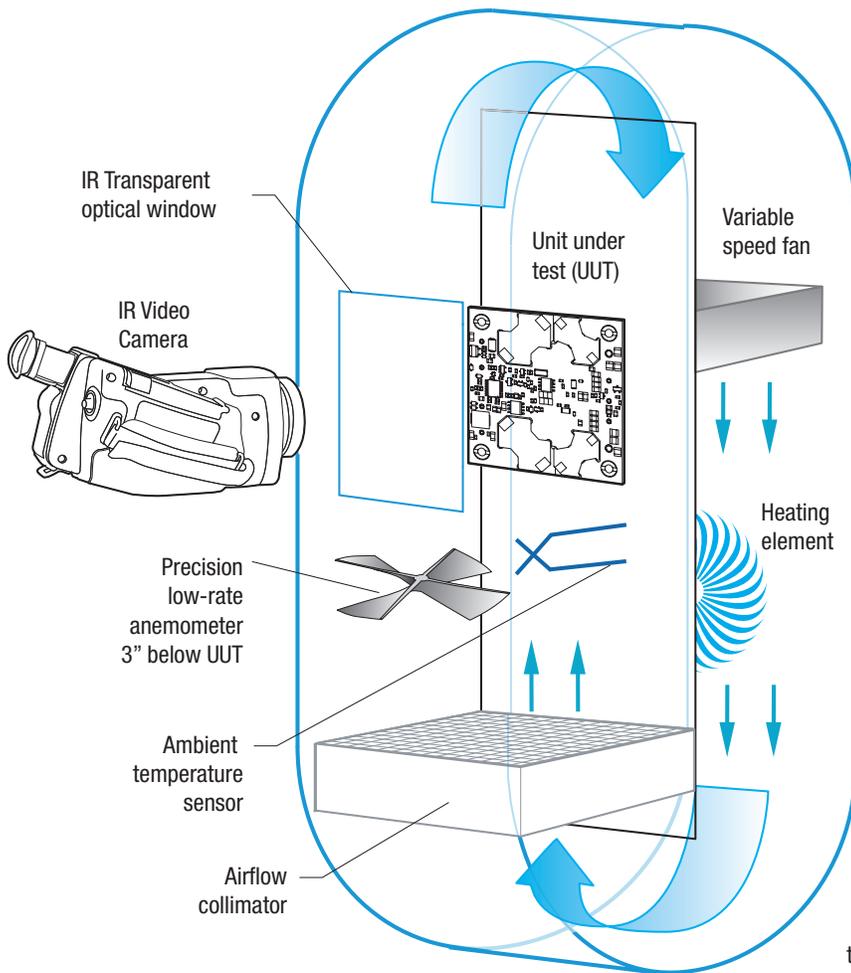
### Basic PD(Powered Devices)

802.3af defines a PD as a device that is either drawing power or requesting power from a PSE. The PD can be one of many different devices, including IP phone, wireless LAN access point, security network camera and other Ethernet terminals. Power can enter the PD with either polarity on data pairs (1/2 and 3/6) or on spare pairs (4/5 and 7/8). The data interface is a standard line transformer, with center tap on the primary that faces the RJ-45 jack. Data flows through the transformers to Ethernet PHY. The 48 Vdc power is extracted from the center taps and passes through a PoE interface block that acts as an intelligent switch.

### External Filtering

The specification for power feeding ripple and noise show below is required for common-mode and/or pair-to-pair static noise values for power outputs at the external port. The limits are meant to preserve data integrity. To meet EMI standards, lower values may be needed.

Power Feeding Ripple and Noise	Type	Max	Unit
f < 500 Hz	1,2	0.500	Vpp
500 Hz to 150 kHz 0.200	1,2	0.200	Vpp
150 kHz to 500 kHz 0.150	1,2	0.150	Vpp
500 kHz to 1 MHz	1,2	0.100	Vpp



**Figure 6. Vertical Wind Tunnel**

### Vertical Wind Tunnel

Murata Power Solutions employs a computer controlled custom-designed closed loop vertical wind tunnel, infrared video camera system, and test instrumentation for accurate airflow and heat dissipation analysis of power products. The system includes a precision low flow-rate anemometer, variable speed fan, power supply input and load controls, temperature gauges, and adjustable heating element.

The IR camera monitors the thermal performance of the Unit Under Test (UUT) under static steady-state conditions. A special optical port is used which is transparent to infrared wavelengths.

Both through-hole and surface mount converters are soldered down to a 10" x 10" host carrier board for realistic heat absorption and spreading. Both longitudinal and transverse airflow studies are possible by rotation of this carrier board since there are often significant differences in the heat dissipation in the two airflow directions. The combination of adjustable airflow, adjustable ambient heat, and adjustable Input/Output currents and voltages mean that a very wide range of measurement conditions can be studied.

The collimator reduces the amount of turbulence adjacent to the UUT by minimizing airflow turbulence. Such turbulence influences the effective heat transfer characteristics and gives false readings. Excess turbulence removes more heat from some surfaces and less heat from others, possibly causing uneven overheating.

Both sides of the UUT are studied since there are different thermal gradients on each side. The adjustable heating element and fan, built-in temperature gauges, and no-contact IR camera mean that power supplies are tested in real-world conditions.

