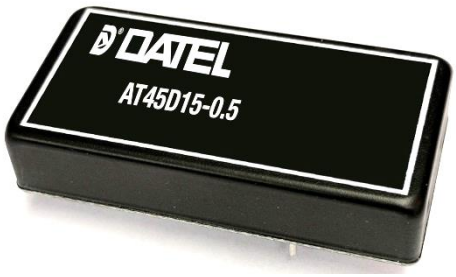
AT SERIES (2” x 1” Package)

Up to 15 Watt DC-DC Converter



PRODUCT OVERVIEW

The AT series offer up to 15 watts of output power in standard 2.00 x 1.00 x 0.4 inches packages. This series features high efficiency and 1500 Volts of DC isolation. The AT series provides a 4:1 wide input voltage range of 9 to 36 or 18 to 75VDC, and delivers accurate regulated output. These modules operate over the ambient operating temperature range of –40°C to +85°C. These converters are fully protected against input UVLO (Under Voltage Lock Out), over-current, over-voltage and continuous short circuit protection. In addition, the option control functions include Positive Remote On/Off and adjustable output voltage.

FEATURES

- Industry standard footprint (2 inch X 1 inch)
- Regulated Outputs, Fixed Switching Frequency
- Up to 88 % Efficiency
- 4:1 Input Range
- Up to 15 Watts of Power
- -40°C to +85°C temperature range
- Remote On/Off logic control (Option)
- No Tantalum Capacitors
- Continuous Short Circuit and Over Current Protection

APPLICATIONS:

- Distributed Power Architecture
- Mobile telecommunication
- Industrial applications
- Battery operated equipment

AVAILABLE OPTIONS

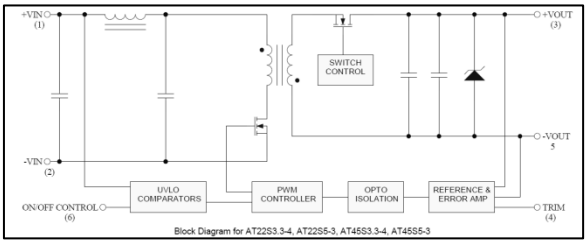
- Customizable output voltages
- CE Mark 2004/108/EC certification
- UL60950-1, EN60950-1, and IEC60950-1 safety

Contact DATEL for other series in 2.00" x 1.00" footprint

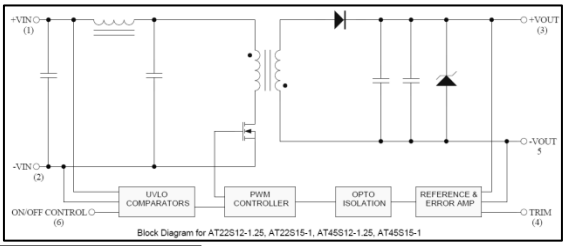
- Cost Savings, Lower Power, Other Voltage outputs, Higher Efficiency, etc.

MODEL NUMBER	INPUT VOLTAGE	OUTPUT VOLTAGE	OUTPUT CURRENT MAX	EFFICIENCY %	LOAD REGULATION	OPTION
AT22S3.3-4	9-36 VDC	3.3VDC	4 A	87	± 0.2 %	P, T
AT22S5-3	9-36 VDC	5.0 VDC	3 A	87	± 0.2 %	P, T
AT22S12-1.25	9-36 VDC	12 VDC	1.25 A	87	± 0.2 %	P, T
AT22S15-1	9-36 VDC	15 VDC	1 A	88	± 0.2 %	P, T
AT22D5-1.5	9-36 VDC	±5 VDC	±1.5 A	85	±1 %	P, T
AT22D12-0.62	9-36 VDC	±12 VDC	±0.62 A	87	±1 %	P, T
AT22D15-0.5	9-36 VDC	±15 VDC	±0.5 A	88	±1 %	P, T
AT45S3.3-4	18-75VDC	3.3 VDC	4 A	88	± 0.2 %	P, T
AT45S5-3	18-75VDC	5 VDC	3 A	88	± 0.2 %	P, T
AT45S12-1.25	18-75VDC	12 VDC	1.25 A	87	± 0.2 %	P, T
AT45S15-1	18-75VDC	15 VDC	1 A	87	± 0.2 %	P, T
AT45D5-1.5	18-75VDC	±5 VDC	±1.5 A	85	±1 %	P, T
AT45D12-0.62	18-75VDC	±12 VDC	±0.62 A	87	±1 %	P, T
AT45D15-0.5	18-75VDC	±15 VDC	±0.5 A	87	±1 %	P, T

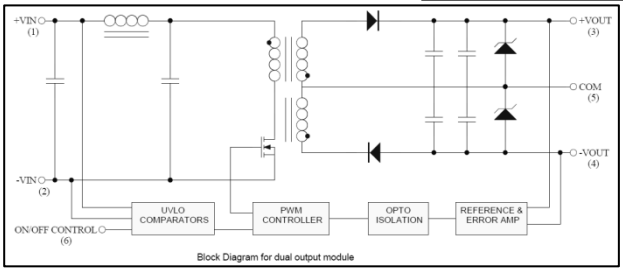
FUNCTIONAL BLOCK DIAGRAM



Block Diagram for AT22S3.3-4, AT22S5-3, AT45S3.3-4, AT45S5-3



Block Diagram for AT22S12-1.25, AT22S15-1, AT45S12-1.25, AT45S15-1



Block Diagram for dual output module

ABSOLUTE MAXIMUM RATINGS

Parameters	Conditions	Model	Min.	Typical	Max.	Units
Input Voltage						
Continuous	DC	$24V_{in}$ $48V_{in}$	0 0		36 75	Volts
Transient	100ms, DC	$24V_{in}$ $48V_{in}$			50 100	Volts
Operating Ambient Temperature	Derating, Above 78°C	All	-40		+85	°C
Case Temperature		All			+105	°C
Storage Temperature		All	-55		+125	°C
Input / Output Isolation Voltage	1 minute	All			1500	Volts

INPUT CHARACTERISTICS

Note: All specifications are typical at nominal input, full load at 25°C unless otherwise noted

Parameters	Conditions	Model	Min.	Typical	Max.	Units
Operating Input Voltage		$24V_{in}$ $48V_{in}$	9 18	24 48	36 75	Volts
Maximum Input Current	100% Load, V_{in} =9V	24Vin			2100	mA
	100% Load, V_{in} =18V	48Vin			1000	
No-Load Input Current	V_{in} =Nominal input	AT22S3.3-4 AT22S5-3 AT22S12-1.25 AT22S15-1 A22D5-1.5 AT22D12-0.62 AT22D15-0.5 AT45S3.3-4 AT45S5-3 AT45S12-1.25 AT45S15-1 AT22D5-1.5 AT45D12-0.62 AT45D15-0.5		60 70 30 30 30 30 30 40 40 20 20 20 20 20		mA
Off Converter Input Current	Shutdown input idle current	All		4	10	mA
Inrush Current (I^2t)	AT per ETS300 132-2	All			0.1	A^2s
Input Reflected-Ripple Current	P-P thru 12uH inductor, 5Hz to 20MHz	All			30	mA

OUTPUT CHARACTERISTIC

Parameters	Conditions	Model	Min.	Typical	Max.	Units
Output Voltage Set Point	V_{in} =Nominal V_{in} , I_o = I_{o_max}, Tc=25°C	Vo=3.3 Vo=5.0 Vo=12 Vo=15 Vo=±5 Vo=±12 Vo=±15	3.2505 4.925 11.82 14.775 ±4.925 ±11.82 ±14.775	3.3 5 12 15 ±5 ±12 ±15	3.3495 5.075 12.18 15.225 ±5.075 ±12.18 ±15.225	Volts
Output Voltage Balance	V_{in} =nominal, Io= I_{o_max}, Tc=25°C	Dual			±2.0	%
Output Voltage Regulation						
Line Regulation	V_{in} =High line to Low line Full Load	Single Dual			±0.2 ±0.5	% %
Load Regulation	I_o = Full Load to min. Load	Single Dual			±0.2 ±1.0	% %
Temperature Coefficient	TC=-40°C to 80°C				±0.03	%/°C
Cross Regulation	Load cross variation 10%/100%	Dual			±5	%
Output Voltage Ripple and Noise	5Hz to 20MHz bandwidth					
Peak-to-Peak	Full Load, 20MHz bandwidth 0.1uF ceramic capacitor	Vo=3.3V Vo=5V Vo=±5V			75	mV
		Vo=15V Vo=12V Vo=±15V Vo=±12V			100	
Operating Output Current Range		Vo=3.3V Vo=5V Vo=12V Vo=15V Vo=±5V Vo=±12V Vo=±15V	0 0 0 0 0 0 0		4000 3000 1250 1000 ±1500 ±625 ±500	mA
Output DC Current-Limit Inception	Output Voltage=90% $V_{0,\ nominal}$	All	110	140	160	%
Maximum Output Capacitance	Full load, Resistance	Vo=3.3V Vo=5V Vo=12V Vo=15V Vo=±5V Vo=±12V Vo=±15V			4000 3000 1250 1000 1500 625 470	µF

DYNAMIC CHARACTERISTICS

Parameters	Conditions	Model	Min.	Typical	Max.	Units
Output Voltage Current Transient						
Step Change in Output Current	75% to 100% of I_{o_max} di/dt=0.1A/us	All			±5	%
Setting Time (within 1% Vo $_{nominal}$)		All			250	µs
Turn-On Delay and Rise Time						
Turn-On Delay Time, From Input	$V_{in\ \_min}$ to 10%V_{o_set}	Vin=24V Vin=48V		10 10		ms
Turn-On Delay Time, From On/Off Control	Von/off to 10%Vo,set	All		10		ms
Output Voltage Rise Time	10% V_{o_set} to 90% V_{o_set}	Vin=24V Vin=48V		10 10		ms

FEATURE CHARACTERISTICS

Parameters	Conditions	Model	Min.	Typical	Max.	Units
Efficiency 100% Load	V_{in} =24 Vdc, $I_o = I_{o\_max}$, Tc=25°C	AT22S3.3-4		87		%
		AT22S5-3		87		
		AT22S12-1.25		87		
		AT22S15-1		88		
		AT22D5-1.5		85		
		AT22D12-0.62		87		
		AT22D15-0.5		88		
	V_{in} =48 Vdc, $I_o = I_{o\_max}$, Tc=25°C	AT45S3.3-4		88		%
		AT45S5-3		88		
		AT45S12-1.25		87		
		AT45S15-1		87		
		AT45D5-1.5		85		
		AT45D12-0.62		87		
		AT45D15-0.5		87		
ISOLATION CHARACTERISTICS						
Input to Output	1 minutes	All			1500	Volts
Isolation Resistance		All	1000			MΩ
Isolation Capacitance		All		1000		pF
Switching Frequency		Vin=24V		400		KHz
		Vin=48		400		
On/Off Control (Option P) , Positive Remote On/Off logic						
Logic High (Module On)	$V_{on/off}$ at $I_{on/off}$=0.1uA	All	3.5 or Open Circuit		75	Volts
Logic Low (Module On)	$V_{on/off}$ at $I_{on/off}$=0.1uA	All			1.2	Volts
Output Voltage Trim range (Option T)	At rated Power	All	-10		+10	%
ON/OFF Current	Ion/off at Von/off=0.0V			0.3	1	mA
Leakage Current	Logic High, Von/off=15V				30	µA
Output Over Voltage Protection	Zener or TVS Clamp	Vo=3.3V		3.9		VDC
		Vo=5V		6.2		
		Vo=12V		15		
		Vo=15V		18		
		Vo=±5V		±6.2		
		Vo=±12V		±15		
		Vo=±15V		±18		
MTBF	I_o =100%of I_{o_max};Ta=25°C per MIL-HDBK-217F	All		TBD		M hours
Weight		All		35		grams

Operating Temperature Range

The AT series of converters operates over the wide temperature of -405°C to +85°C. This module starts to derate above +78°C. The module operate normally up to +105°C case temperature.

Output Voltage Adjustment

The output voltage on the T option models is adjustable within the range of -10% to +10%.

Remote ON/OFF (Option)

Module with option P has Remote On/Off function. This feature allows the user to switch the module on and off electronically. All models are available in "positive logic" versions. The converter turns on if the remote ON/OFF pin is high (>3.5Vdc or open circuit). Setting the pin low (<1.2Vdc) will turn the converter off. The signal level of the remote on/off input is defined with respect to ground. If not using the remote on/off pin, leave the pin open (converter will be on).

UVLO (Under Voltage Lock Out)

Input under voltage lockout is standard on the AT unit. The unit will shut down when the input voltage drops below a threshold, and the unit will operate when the input voltage goes above the upper threshold.

Over Current Protection

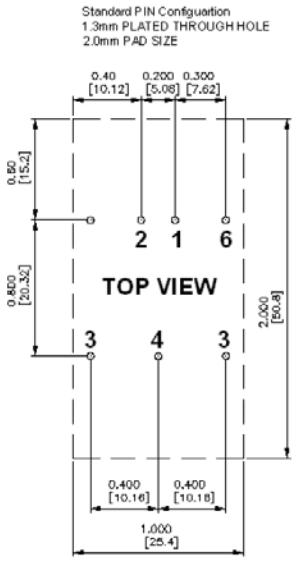
All models have internal over current and continuous short circuit protection. The unit operates normally once the fault condition is removed. At the point of current limit inception, the converter will go into hiccup mode protection.

Over Voltage Protection

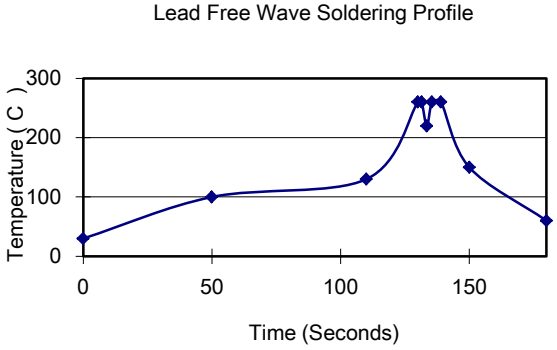
The over-voltage protection consists of a Zener diode to limit the output voltage.

Recommended Layout PCB Footprints and Soldering Information

The end user of the converter must ensure that other components and metal in the vicinity of the converter meet the spacing requirements to which the system is approved. Low resistance and low inductance PCB layout traces should be used where possible. Careful consideration must also be given to proper low impedance tracks between power module, input and output grounds. The recommended footprints and soldering profiles are shown in the next two figures



Recommended PCB Layout Footprints, Dimensions are in inches (mm)



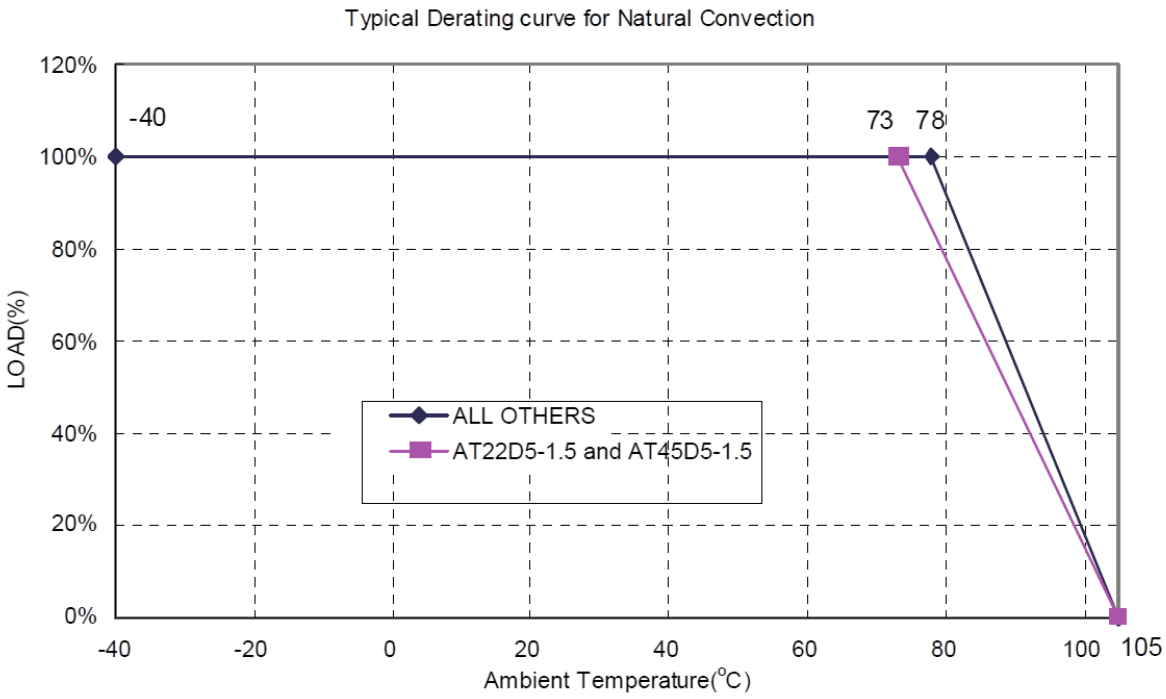
Wave Soldering Profiles

Note :

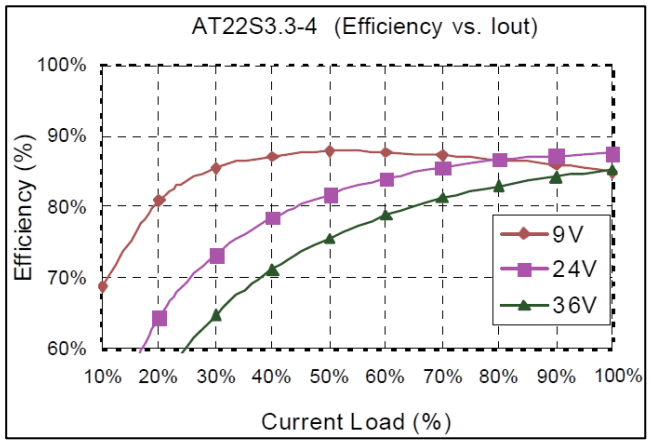
1. Soldering Materials: Sn/Cu/Ni
2. Ramp up rate during preheat: 1.4 °C/Sec (From 50°C to 100°C)
3. Soaking temperature: 0.5 °C/Sec (From 100°C to 130°C), 60±20 seconds
4. Peak temperature: 260°C, above 250°C 3~6 Seconds
5. Ramp up rate during cooling: -10.0 °C/Sec (From 260°C to 150°C)

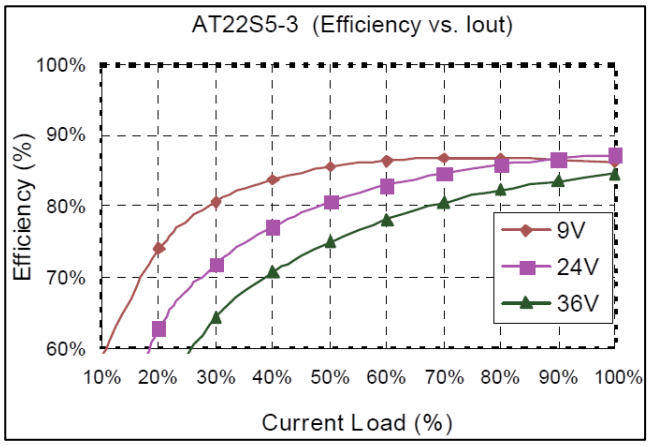
AT Series power de-rating Curves

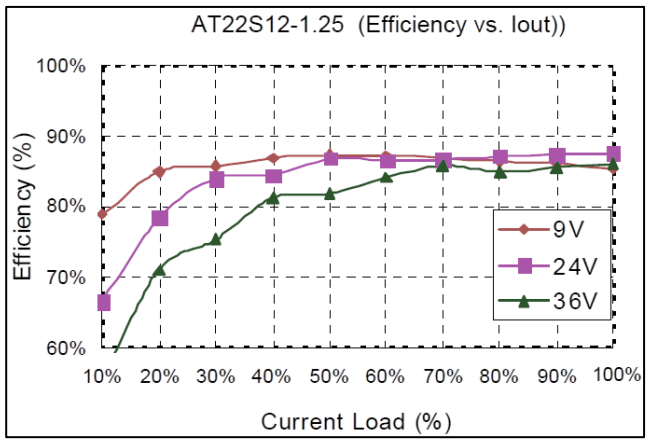
Note that the converter operating ambient temperature range is -40°C to + 85°C with derating above +78°C. Also, maximum case temperature under any operating condition should not exceed +105°C.

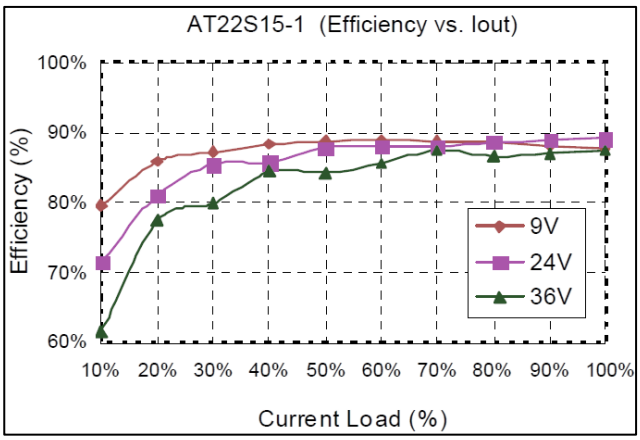


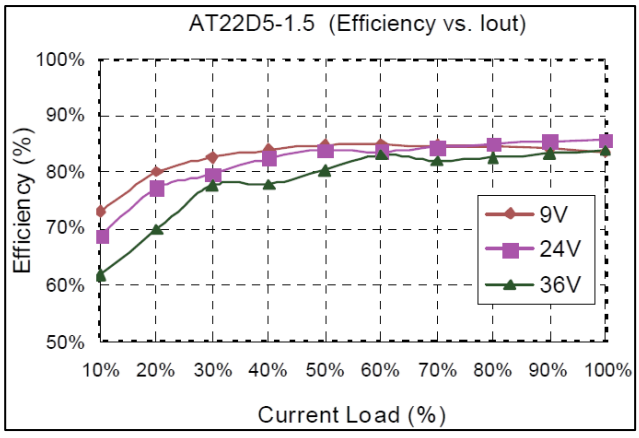
Efficiency vs. Load Curves

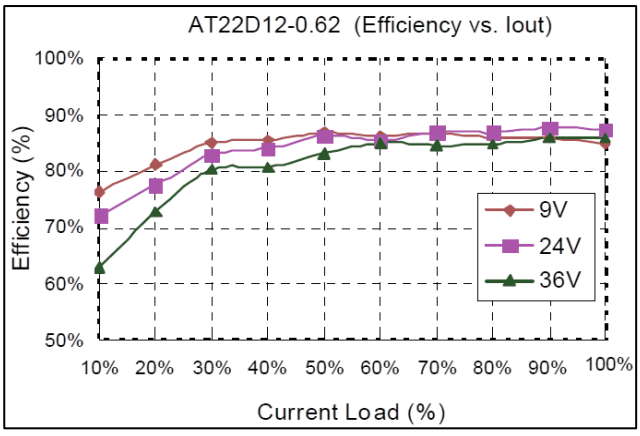


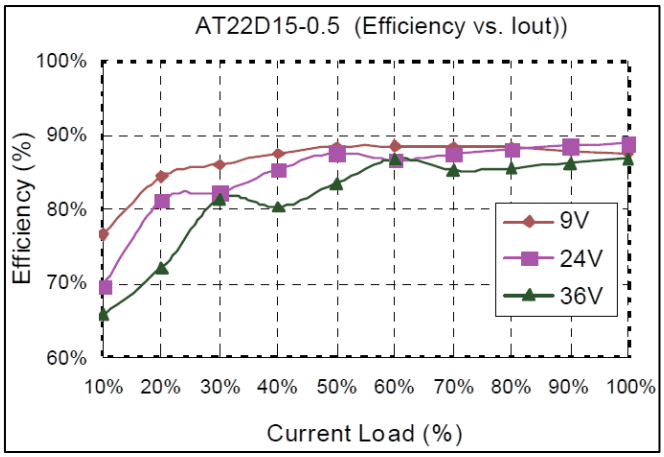


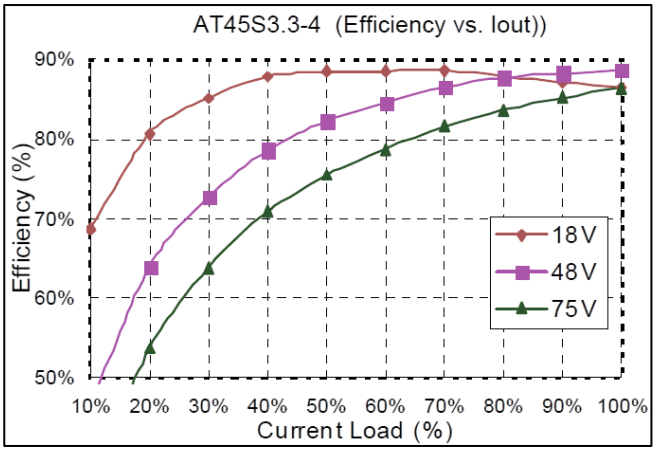


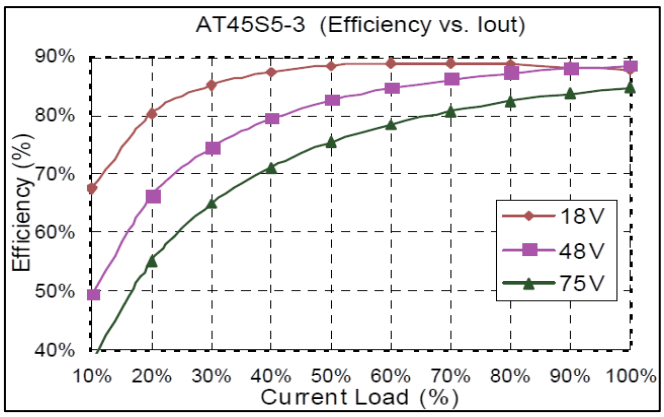


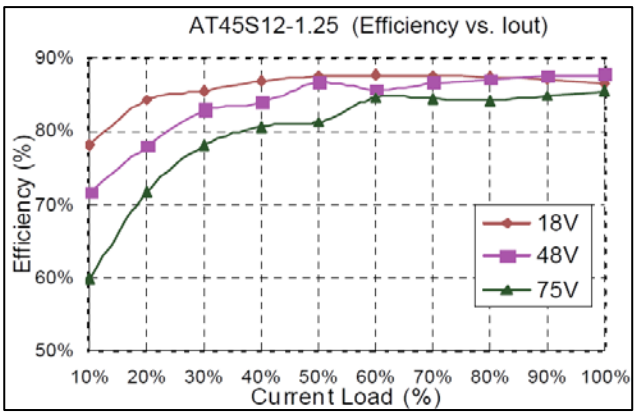


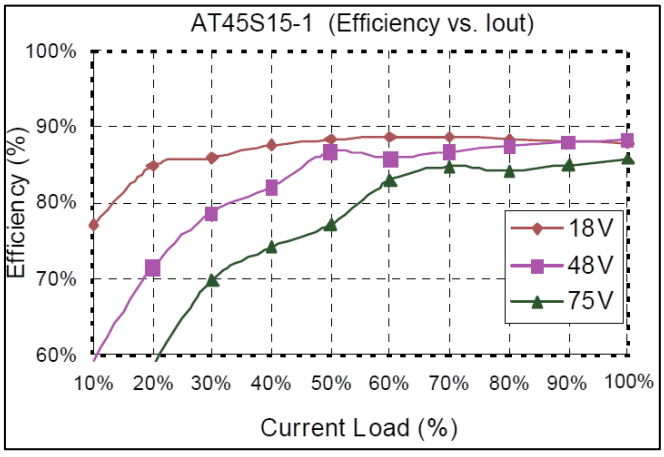


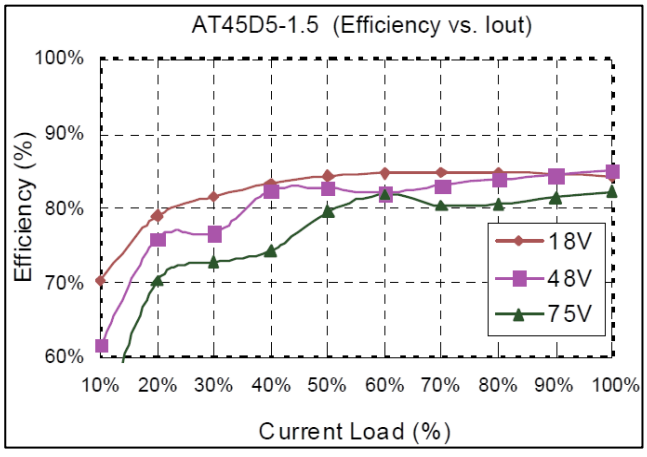

AT22D15-0.5 (Efficiency vs. Iout))
Efficiency (%)
100%
90%
80%
70%
60%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Current Load (%)
9V
24V
36V

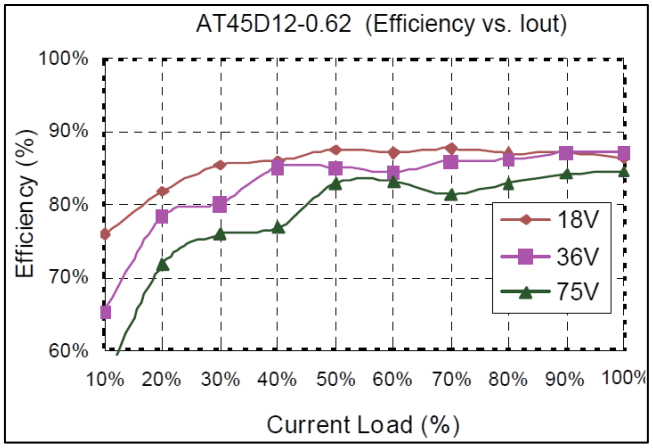

AT45S3.3-4 (Efficiency vs. Iout))
Efficiency (%)
90%
80%
70%
60%
50%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Current Load (%)
18V
48V
75V

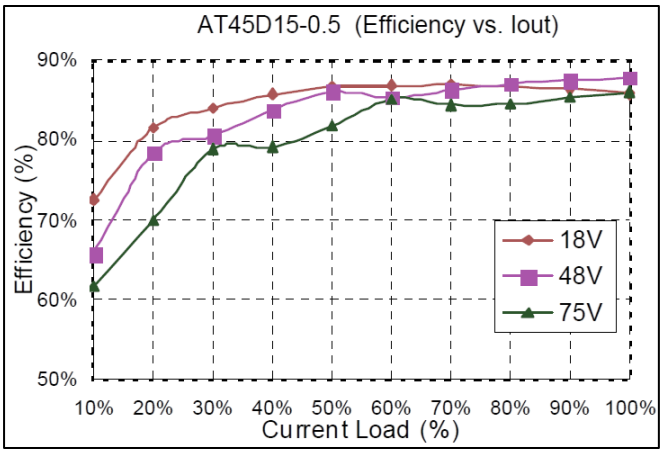

AT45S5-3 (Efficiency vs. Iout)
Efficiency (%)
90%
80%
70%
60%
50%
40%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Current Load (%)
18V
48V
75V


AT45S12-1.25 (Efficiency vs. Iout)
Efficiency (%)
90%
80%
70%
60%
50%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Current Load (%)
18V
48V
75V


AT45S15-1 (Efficiency vs. Iout)
Efficiency (%)
100%
90%
80%
70%
60%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Current Load (%)
18V
48V
75V

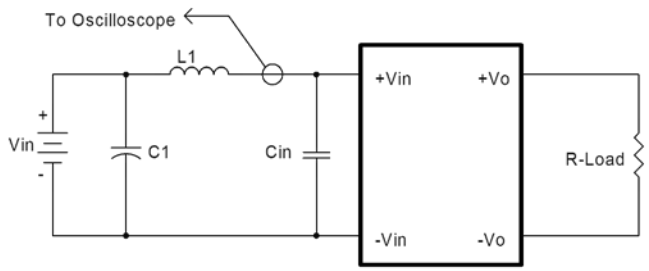

AT45D5-1.5 (Efficiency vs. Iout)
Efficiency (%)
100%
90%
80%
70%
60%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Current Load (%)
18V
48V
75V


AT45D12-0.62 (Efficiency vs. Iout)
Efficiency (%)
100%
90%
80%
70%
60%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Current Load (%)
18V
36V
75V


AT45D15-0.5 (Efficiency vs. Iout)
Efficiency (%)
90%
80%
70%
60%
50%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Current Load (%)
18V
48V
75V

Input Capacitance at the Converter

In order to avoid problems with loop stability, the converter must be connected to a low impedance AC source and a low inductance source. The input capacitors (Cin) should be placed close to the converter input pins to de-couple distribution inductance. The external input capacitors should have low ESR in order to quiet any ripple. Circuit AT shown in the figure below represents typical meATurement methods for reflected ripple current. The capacitor C1 and inductor L1 simulate the typical DC source impedance. The input reflected-ripple current is measured by a current probe oscilloscope with a simulated source Inductance (L1).



L1: 12uH
C1: None
Cin: 33µF ESR < 0.7ohm @100KHz

Input Reflected-Ripple Test Setup

Test Set-Up

The basic test set-up to measure efficiency, load regulation, line regulation and other parameters is shown in the next figure. When testing the converter under any transient conditions, the user should ensure that the transient response of the source is sufficient to power the equipment under test. Below is the calculation of :

1- Efficiency
2- Load regulation
3- Line regulation

The value of efficiency is defined AT:

$$\eta = \frac{V_O \times I_O}{V_{IN} \times I_{IN}} \times 100\%$$

Where

V_O is output voltage,
I_O is output current,
V_{IN} is input voltage,
I_{IN} is input current.

The value of load regulation is defined AT:

$$Load.reg = \frac{V_{FL} - V_{NL}}{V_{NL}} \times 100\%$$

Where

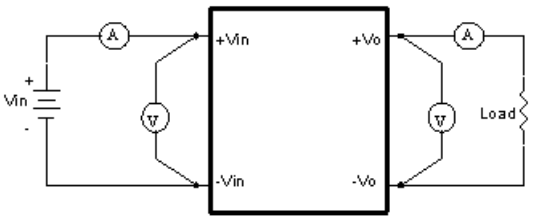
V_{FL} is the output voltage at full load
V_{NL} is the output voltage at 10% load

The value of line regulation is defined AT:

$$Line.reg = \frac{V_{HL} - V_{LL}}{V_{LL}} \times 100\%$$

Where

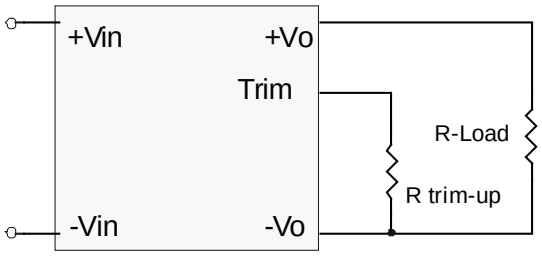
V_{HL} is the output voltage of the maximum input voltage at full load.
V_{LL} is the output voltage of the minimum input voltage at full load.



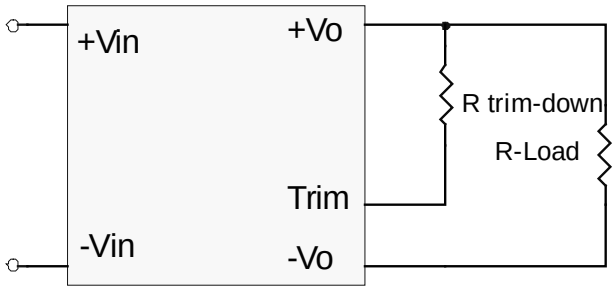
AT Series Test Setup

Output Voltage Adjustment (T-Option)

In order to trim the voltage up or down, the user needs to connect the trim resistor either between the trim pin and -Vo for trim-up and between trim pin and +Vo for trim-down. The output voltage trim range is ±10%. This is shown in the next two figures:



Trim-up Voltage Setup



Trim-down Voltage Setup

1. The value of Rtrim-up is defined as:

$$R_{trim-up} = \left(\frac{V_r \times R1 \times (R2+R3)}{(Vo - V_{o,nom}) \times R2}\right) - Rt \ \ (\mathrm{K\Omega})$$

Where

$R_{trim-up}$ is the external resistor in Kohm.

$V_{0,nom}$ is the nominal output voltage.

V_0 is the desired output voltage.

R1, R2, R3, Rt and Vr are internal to the unit and are defined in the table below

Trim up and Trim down Resistor Values

Model Number	Output Voltage(V)	R1 (KΩ)	R2 (KΩ)	R3 (KΩ)	Rt (KΩ)	Vr (KΩ)
AT22S3.3-4 AT45S3.3-4	3.3	2.74	1.8	0.27	9.1	1.24
AT22S5-3 AT45S5-3	5.0	2.32	2.32	0	8.2	2.5
AT22S12-1.25 AT45S12-1.25	12.0	6.8	2.4	2.32	22	2.5
AT22S15-1 AT45S15-1	15.0	8.06	2.4	3.9	2.7	25
AT22D5-1.5 AT45D5-1.5	±5V	2.32	2.32	0	8.2	2.5
AT22D12-0.62 AT45D12-0.62	±12V	6.8	2.4	2.32	22	2.5
AT22D15-0.5 AT45D15-0.5	±15V	8.06	2.4	3.9	2.7	25

For example, to trim-up the output voltage of the 5.0 Volts module (AT22S5-3) by 10% to 5.5V, R trim-up is calculated as follows:

Vo – Vo, nom = 5.5 – 5.0 = 0.5V
R1 = 2.32 KΩ
R2 = 2.32 KΩ
R3 = 0 KΩ
Rt = 8.2 KΩ,
Vr= 2.5 V

$$R_{trim-up} = \left(\frac{2.5 \times 2.32 \times (2.32+0)}{0.5 \times 2.32}\right) - 8.2 = 3.4(\mathrm{K\Omega})$$

2. The value of R trim-down defined as:

Where

Rtrim-down is the external resistor in Kohm.

VO, nom is the nominal output voltage.

VO is the desired output voltage.

R1, R2, are internal to the unit and are defined in the table below.

$$R_{trim-down} = R1 \times \left(\frac{Vr \times R1}{(V_{o,nom} - Vo) \times R2} - 1\right) - Rt \ \ (\mathrm{K\Omega})$$

Where

$R_{trim-up}$ is the external resistor in Kohm.

$V_{0,nom}$ is the nominal output voltage.

V_0 is the desired output voltage.

R1, R2, R3, Rt and Vr are internal to the unit and are defined in the table above Trim down Resistor Values

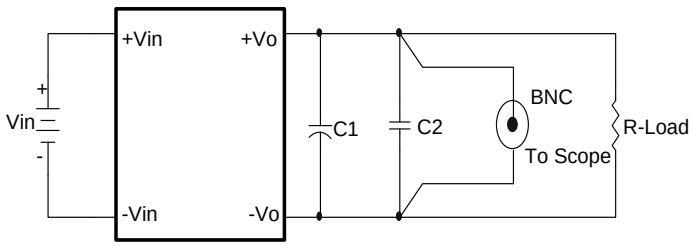
For example, to trim-down the output voltage of 5.0V module (AT22S5-3) by 10% to 4.5V, $R_{trim-down}$ is calculated as follows:

VO,nom – Vo = 5.0 – 4.5 = 0.5V
R1 = 2.32 KΩ
R2 = 2.32 KΩ
R3 = 0 KΩ
Rt = 8.2 KΩ
Vr= 2.5 V

$$R_{trim-down} = 2.32 \times \left(\frac{(2.5 \times 2.32)}{0.5 \times 2.32} - 1\right) - 8.2 = 1.08 \ \ (\mathrm{K\Omega})$$

Noise Measurement and Output Ripple

The test set-up for noise and ripple measurements is shown in the figure below. A coaxial cable was used to prevent impedance mismatch reflections disturbing the noise readings at higher frequencies. Measurements are taken with the output appropriately loaded and all ripple/noise specifications are from 0Hz to 20MHz Bandwidth.



Output Voltage Ripple and Noise Measurement Set-Up

Note: C1: None
C2: 0.1µF ceramic capacitor

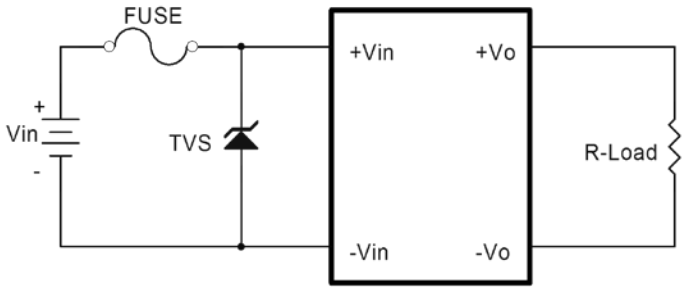
Output Capacitance

This series of converters provides unconditional stability with or without external capacitors. For good transient response, low ESR output capacitors should be located close to the point of load.

SAFETY and EMC

Input Fusing and Safety Considerations

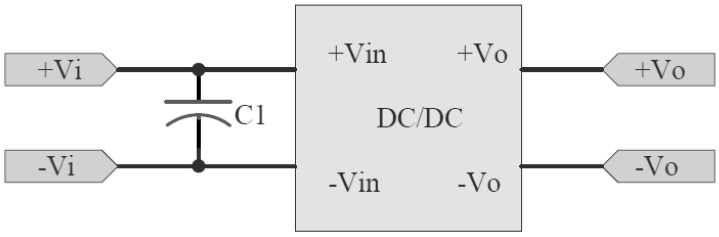
The AT series of converters do not have an internal fuse. However, to achieve maximum safety and system protection, always use an input line fuse. DATEL recommended a time delay fuse of 4A for 24Vin models and 2A for 48Vin modules. The circuit in the figure below is recommended by a Transient Voltage Suppressor diode across the input terminal to protect the unit against surge or spike voltage and input reverse voltage.



Input Protection Circuit

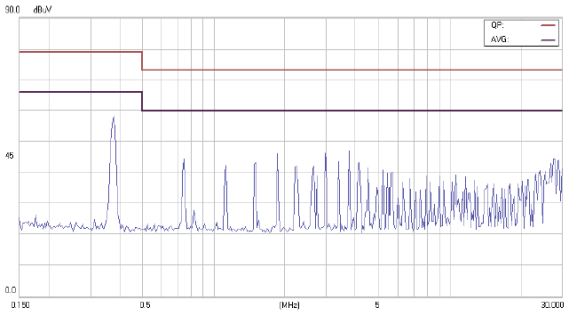
EMC Considerations

EMI Test standard: EN55022 Class A and B Conducted Emission
Test Condition: Input Voltage: Nominal, Output Load: Full Load
(1) EMI and conducted noise meet EN55022 Class A:

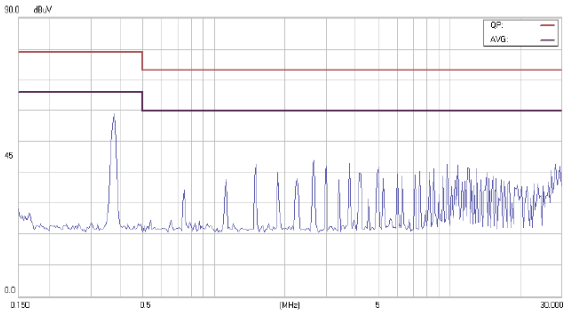


Connection circuit for conducted EMI testing

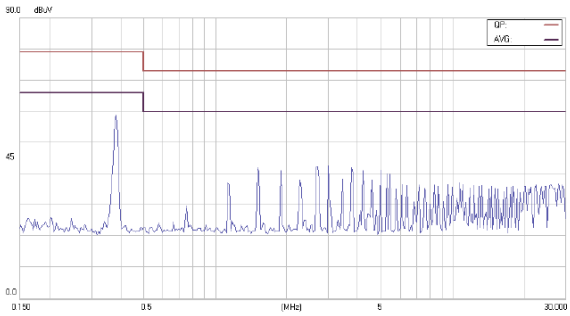
Note: To meet EN55022 Class A without capacitor to the input pin.



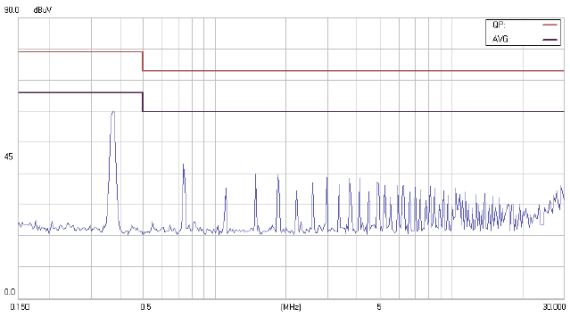
Conducted Class A test for AT22S3.3-4



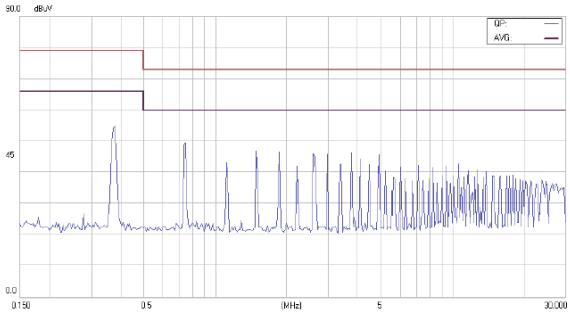
Conducted Class A test for AT22S5-3



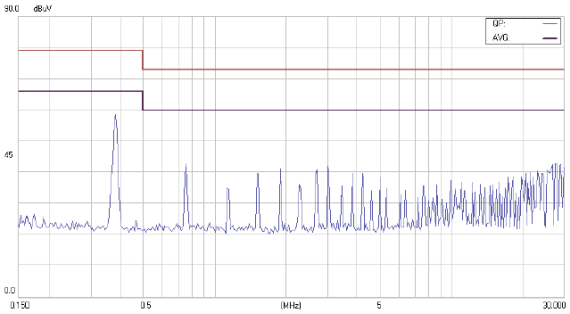
Conducted Class A test for AT22S12-1.25



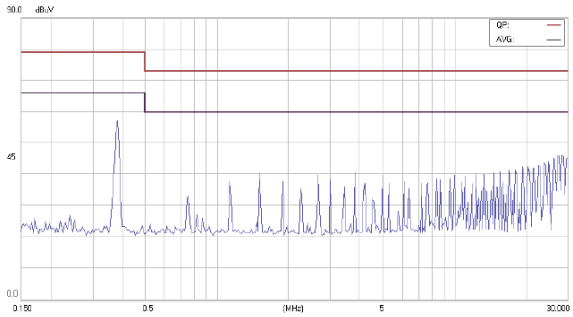
Conducted Class A test for AT22S15-1



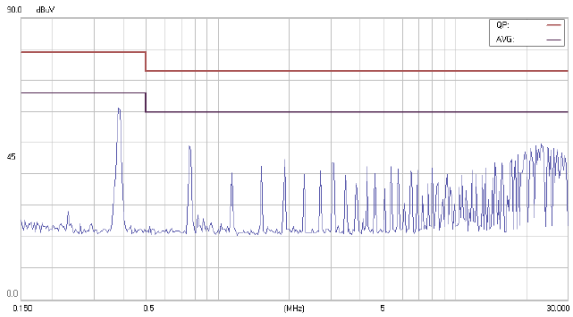
Conducted Class A test for AT22D5-1.5



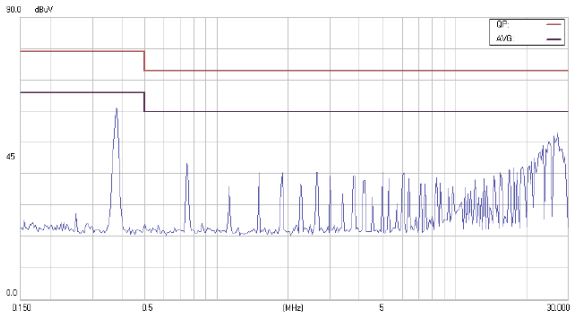
Conducted Class A test for AT22S12-0.62



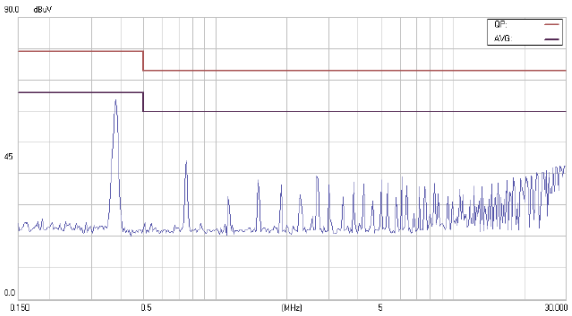
Conducted Class A test for AT22S15-1



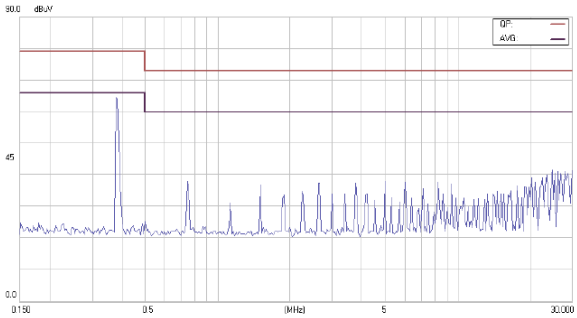
Conducted Class A test for AT45S3.3-4



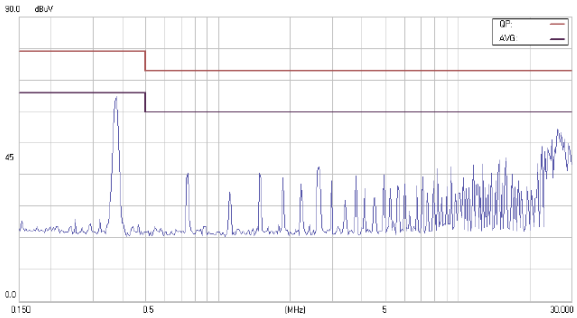
Conducted Class A test for AT45S5-3



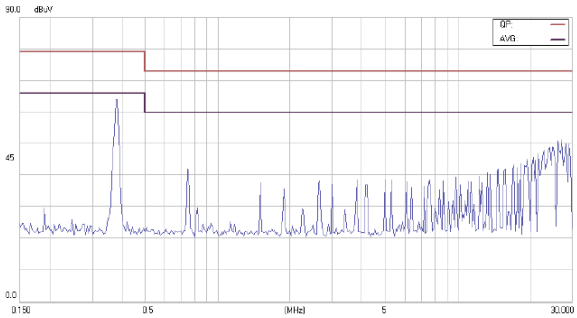
Conducted Class A test for AT45S12-1.25



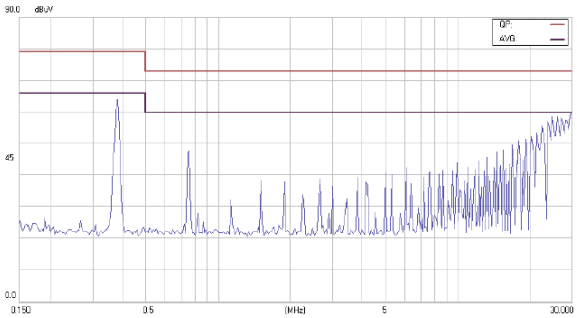
Conducted Class A test for AT45S15-1



Conducted Class A test for AT45D5-1.5

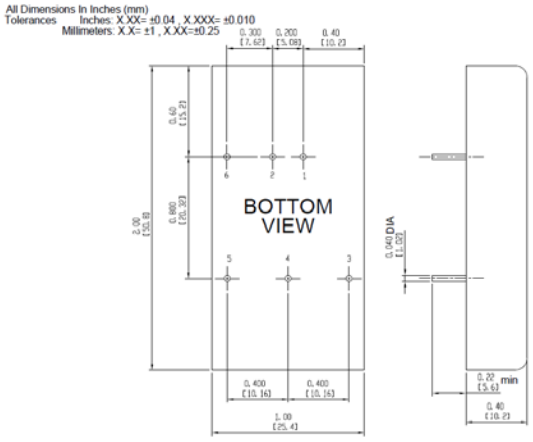


Conducted Class A test for AT45D12-0.62



Conducted Class A test for AT45D15-0.5

MECHANICAL DIMENSIONS Inches (mm)

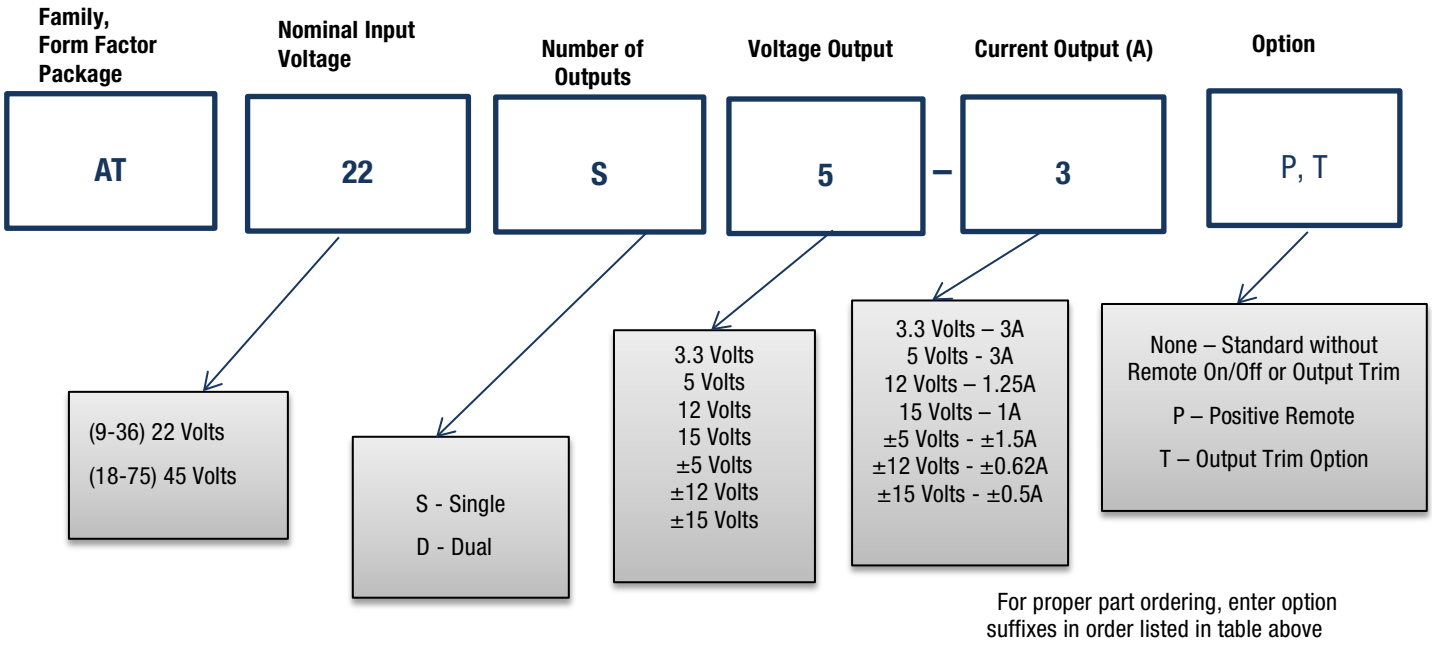


Note: All dimensions are in inches (millimeters). Tolerance: x.xx ±0.04 in. (0.5mm), x.xxx ±0.010 in. (0.25 mm) unless otherwise noted

PIN CONNECTIONS

Pin Connections		
PIN	**SINGLE OUTPUT**	**DUAL OUTPUT**
1	- V Input	- V Input
2	+ V Input	+ V Input
2	+ V Output	+ V Output
4	No Pin or Trim (option T)	Common
5	- V Output	- V Output
6	No Pin or Remote (option)	No Pin or Remote (option)

PART NUMBER AND ORDERING INFORMATION



For proper part ordering, enter option suffixes in order listed in table above