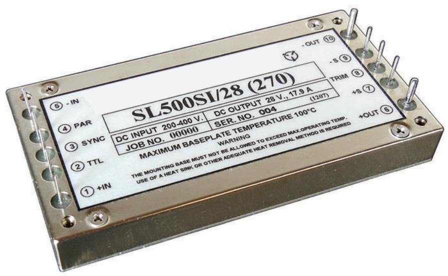
SL500 single-output DC/DC converters
200 – 400Vin, 3.3 – 28Vout, 500 watts



The SL500 converter is a standalone, 91% efficient COTS converter in a standard 2.4” x 4.6” x 0.52” full brick package.
Protection features include overvoltage, overcurrent, overtemperature, and short circuit protection.
The converter is parallelable for higher power requirements and synchronizable for noise sensitive systems.
A 300 KHz fixed switching frequency aids in filtering of EMI. The SL500 EMI filter is third party qualified and meets Mil-Std-461F for conducted emissions.

Features

- Input Range from 200Vdc to 400Vdc
- No Derating from -55°C to +100°C
- Efficiency: Up to 91%
- Parallelable
- Synchronizable
- Power Density: Up to 87W / in³
- Non-latching Overtemperature Protection
- Fixed Frequency Power Conversion
- Latching Output Overvoltage Protection

Agency Approvals

100% Environmental Screening for Military Versions
Meets MIL – Standards:
MIL – STD – 454
P4855 – 1A
MIL – STD – 704D
MIL – STD – 810E
MIL – S – 901C
MIL-STD- 461F with companion filter

Military Grade Environmental Screening

All “Mil” Grade units receive the following:

Stabilization Bake:
+125°C for 24 hours per Mil-Std-883, M1108, Condition B

Temperature Cycling:
10 cycles at -55°C to +125°C (transition period 36 minutes) per Mil-Std-883, M1010, Condition B

Burn-in:
160 hours at +85°C min.

Final Testing

Notes:
See “Guide to Operation” for full details

How to Order

SL 500 S I / 28 - C (270)

- Series (SL)
- Total Output Power (500)
- Single Output (S)
- Options (I)
  - I - Unscreened
  - M - Screened
- Output Voltage (28)
- Options (C)
  - C - Thru Hole Inserts (0.140 DIA)
  - I - Metric Inserts (M3)
- Input Voltage (270)

Model Number (Unscreened)	Nominal Output (Vdc)	Output Current (Amps)
SL500SI/28 (270)	28	17.9
SL500SI/24 (270)	24	20.9
SL500SI/15 (270)	15	25
SL500SI/12 (270)	12	25
SL500SI/5 (270)	5	40
SL500SI/3.3 (270)	3.3	40

Notes:
Standard unit has pins out the top with 6-32 THD inserts, written as SL500SI/28-270

EATON
Powering Business Worldwide

For additional information, call 310.542.8561
or e-mail: Orders-EP@eaton.com

Input Characteristics - 270Vdc Input

	MIN	TYP	MAX	UNITS
Input Voltage	200	270	400	Vdc
Brown Out (75%) Full Load	185			Vdc
No Load Power Dissipation		27		W
Inrush Current <20µS Duration		30		A
Reflected Ripple Current		2.8		A rms
Logic Disable Current (Sink)			0.5	mA
Logic Disable Power In			2	W
Input Ripple Rejection (120HZ)		60		dB
Efficiency Up To		91		%
Input Transient Per MIL-STD-704D (Operating 100ms)			**500**	**Vdc**
EMI	Use Companion Filter			

Output Characteristics

	MIN	TYP	MAX	UNITS
Set Point Accuracy			1	% Vout
Load Regulation			±0.3	% Vout
Line Regulation			±0.2	% Vout
Ripple P-P (20MHz)		1	3	% Vout
Trim Range	90		110	% Vout
Remote Sense 12V, 15V, 24V, 28V			0.50	Vdc
3.3V, 5V			0.25	Vdc
Overvoltage Protection		125	135	% Vout
Current Sharing			±8	% Iout / at Full Load
Transient Response 50-75% Load (0.2A/µS)			3/300	% Vout / µS Setting Time to Within 1% Vout
Temperature Drift		0.01	0.03	%Vout / ^{o}C
Long Term Drift		0.02	0.05	%Vout / 1KHrs
Current Limit	110		140	%Iout
Short Circuit Current	25		75	%Iout Hiccup Type
Turn-on Time (Power Input)		150		mS FL 270V
Logic Turn-on Time		90		mS FL 270V
Switching Frequency		300		KHz
Sync Input Voltage	4.5		5.5	Vp-p
Sync Input Frequency	330		360	KHz
Sync Input Duty Cycle	15		55	%
Turn-on Overshoot			0.1	% Vout

Note: Output Ripple is measured with 1µF ceramic and 22µF low ESR Tantalum Capacitor

Specifications

Temperature Characteristics

	MIN	TYP	MAX	UNITS
Operating (Baseplate)	-55		+100	^{0}C
Storage (Ambient)	-55		+125	^{0}C
Over Temperature Shutdown		+105	+110	^{0}C / Auto Recovery
Thermal Resistance (Case to Ambient)		5.71		^{0}C / W

Isolation Characteristics

	MIN	TYP	MAX	UNITS
Input to Output	1000			Vdc
Output to Base-plate	500			Vdc
Input to Base-plate	1000			Vdc
Insulation Resistance (Measured at 50 VDC)	50			Mohm
Input to Output Capacitance		0.003		µF

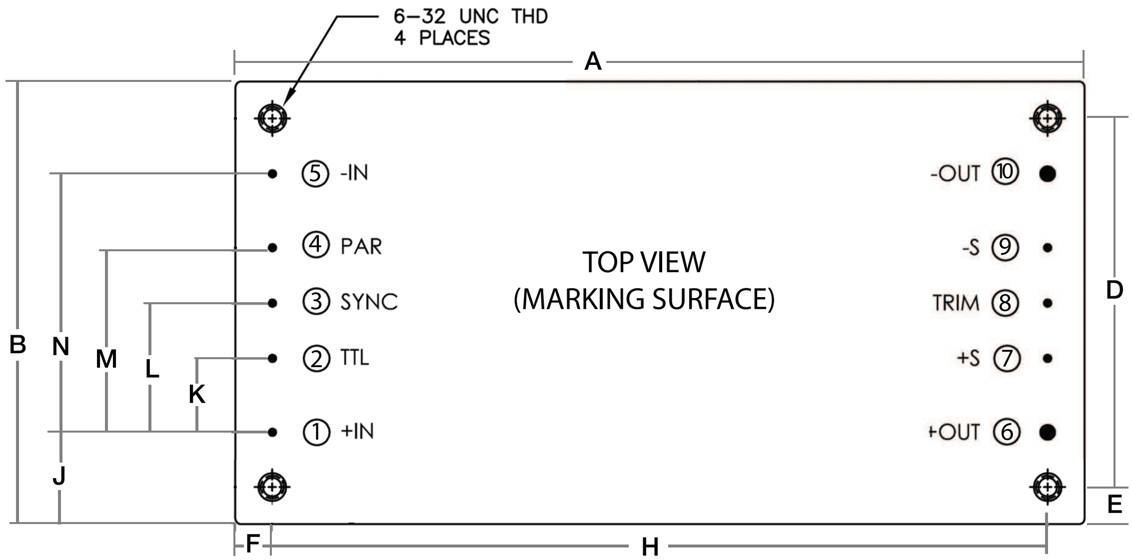
Mechanical Characteristics

	TYP	UNITS
Weight	7.6	oz
Size	2.4 x 4.6 x 0.52	in
	61 x 116.9 x 13.2	mm
Volume	5.74	in^3
	94	cm^3
Mounting (STD)	Threaded, #6-32	
Construction	5 sided metal can, nickel plated cover, aluminum baseplate	

Case drawings

Standard Model

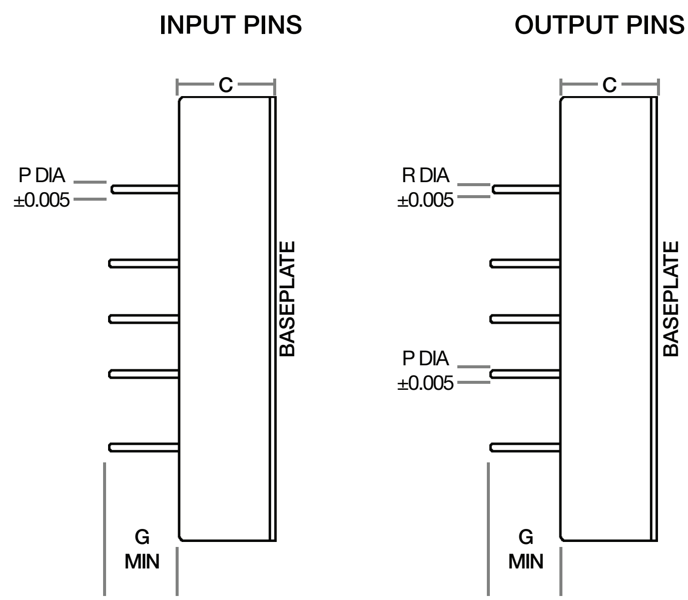
Pin placement on top of unit



C Option

Thru hole inserts (0.140 DIA)
Model number written as SL500SI/28-C (270)

Tolerances: Inches x.xx = ±0.03
x.xxx = ±0.015
mm x.xx = ±0.4
x.x = ±0.8



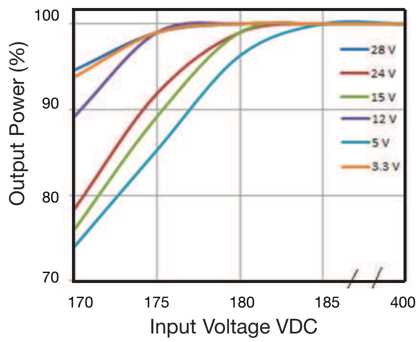
Material: Pin = Brass (Solder Plating)
Baseplate = Aluminum 5050-H32
Case = Steel
Finish = Nickel Plating

Mounting: 6-32 THD inserts are provided in baseplate
Metric: M3 inserts

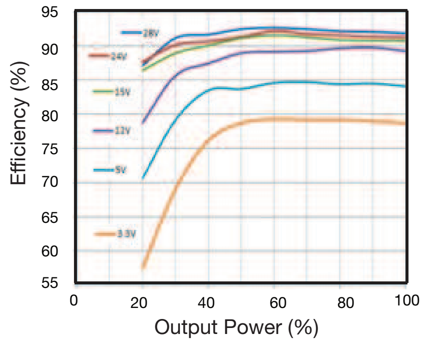
	A	B	C	D	E	F	G	H	J	K	L	M	N	P	R
inch	4.60	2.40	.52	2.000	.20	.20	.375	4.200	.50	.400	.700	1.000	1.400	.040	.080
mm	116.9	61.0	13.2	50.80	5.1	5.1	9.53	106.68	12.7	10.20	17.8	25.40	35.60	1.02	2.03

Characteristics

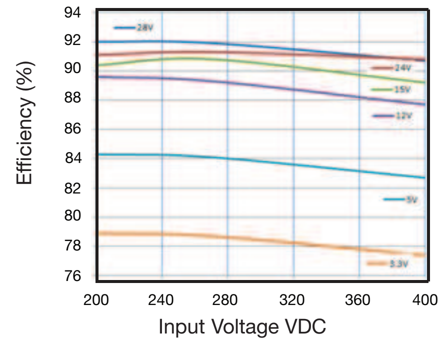
I. Input Voltage vs. Output Power



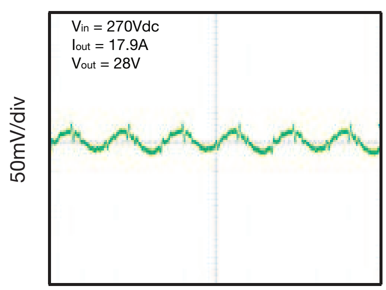
II. Efficiency vs. Output Power



III. Efficiency vs. Input Voltage

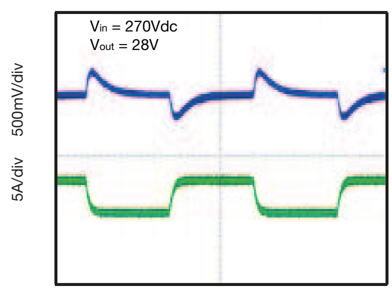


IV. Output Voltage Ripple



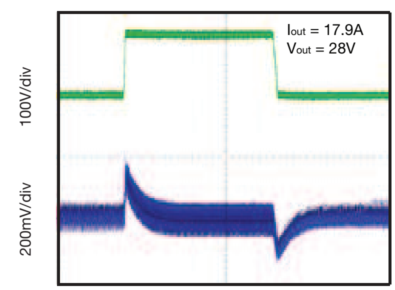
Time: 2µS/div
Bandwidth: 20MHz

V. Load Transient Response



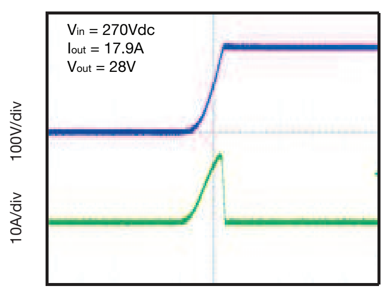
Time: 400µS/div

VI. Input Transient Response



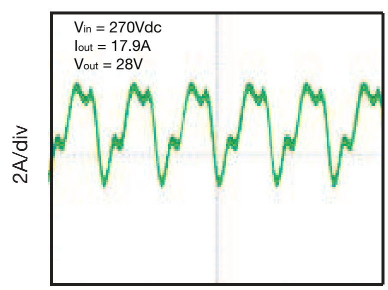
Time: 400µS/div

VII. Input Inrush Current



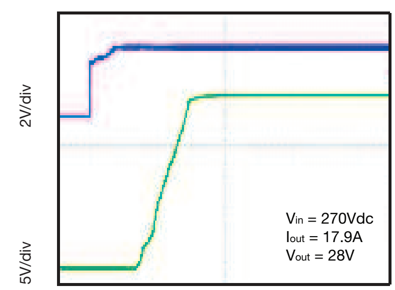
Time: 10µS/div

VIII. Input Current Ripple



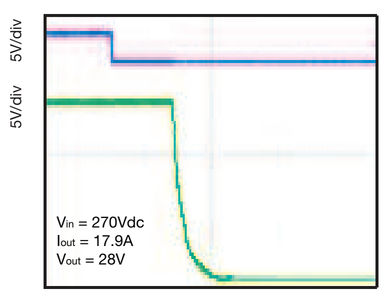
Time: 2µS/div

IX. TTL Turn On



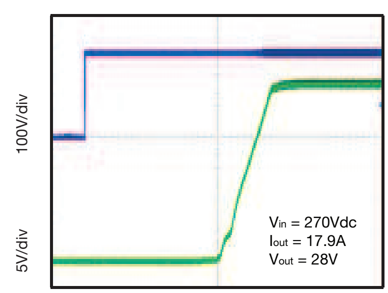
Time: 20mS/div

X. TTL Turn Off



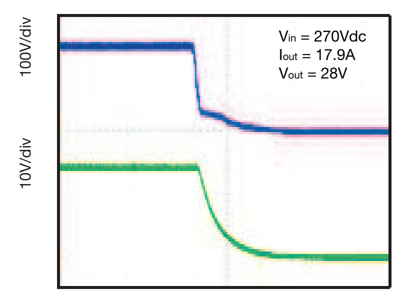
Time: 400µS/div

XI. Turn On



Time: 20mS/div

XII. Turn Off



Time: 200µS/div

General Application Notes

The SL family of power converters, designed as military grade standalone power converters, can also be used as components in complex power systems. The SL Series utilizes a high efficiency full bridge isolated DC to DC converter which operates at 300 KHz constant frequency. The SL units are supplied in five sided metal case to minimize radiated noise. A number of protection features, as well as electrical and thermal derating of internal components per NAVSO P3641A guidelines and the use of proven topology allow for high reliability throughout an operating range of -55°C to +100°C. In applications where even greater reliability is required, the converter can be screened to MIL-STD-883 upon request.

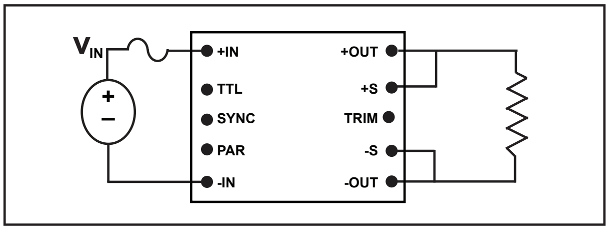


Figure 1

The most basic use of the power converter is shown in ***Figure 1***. An input fuse is always recommended to protect both the source and the power supply in the event of failures. Slow-blow fuse is recommended with a current rating approximately 200% of the full load input current to the converter. Having a slow-blow type fuse will allow for the converter's inrush charge at turn-on. The sense pins of the converters must be connected to their corresponding output bus. Inherently, power converters will have some internal energy loss, which is dissipated in the form of heat through an aluminum mounting surface. This surface must be cooled to maintain a temperature below the maximum operating temperature.

Wire Gage & Distance to Load

If the resistance of the wire, printed circuit board runs or connectors used to connect a converter to system components is too high, excessive voltage drop will result between the converter and system components, degrading overall system performance.

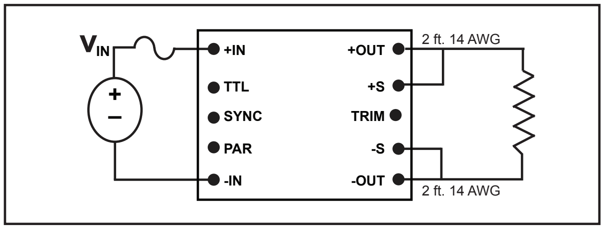


Figure 1a

For example, if the DC/DC converter in ***Figure 1a*** is a 50W unit (5VDC @ 10 Amps) with output load regulation specified at 0.2%; the connection as shown will degrade load regulation by a factor of 10. In this example, the 4 feet of #14 AWG wire used to connect the converter output to the load, has a total line resistance of 10mΩ (ignoring any contact resistance). For a 50W, 5 VDC output converter, the drop across the lead resistance will be 100 mV (10A x 0.010Ω) or 2% of the output. Thus, the converter is selected for 0.2% regulation, but the power system layout achieves only 2.2%.

This can be corrected by decreasing the distance between the converter output and load. If that is not possible, using larger diameter wire (see ***Table 1***), or PCB runs that have larger cross sectional area and shorter length will also reduce conductor resistance. The use of the converter's remote sense capability will also work (see *Remote Sense* for more information on this option).

# AWG	Current Resistance (mΩ/Foot)	# AWG	Current Resistance (mΩ/Foot)
9	0.792	21	12.77
10	0.998	22	16.20
11	1.261	23	20.30
12	1.588	24	25.67
13	2.001	25	32.37
14	2.524	26	41.02
15	3.181	27	51.44
16	4.020	28	65.37
17	5.054	29	81.21
18	6.386	30	103.7
19	8.046	31	130.9
20	10.13	32	162.0

Table 1

General Application Notes - con't

NOTE: High IR drops between the converter and load may cause converter parameters, such as output voltage accuracy, trim range, etc., to appear to be out of specification. High IR drops on input lines may cause start up problems (voltage at the input pins below the input range of the converter).

Obviously, any connections made to the power distribution bus present a similar problem. Poor connections (such as microcracking around solder joints) can cause serious problems such as arcing. Contact resistance must be minimized. Proper workmanship standards must be followed to insure reliable solder joints for board mount converters. Terminal strips, spade lugs and edge connectors must be free of any corrosion, dust or dirt. If parallel lines or connections are available for routing converter output currents, they should be utilized.

Remote Sense

Remote sense pins, +S and -S have been provided on the SL Series converters for applications where precise load regulation is required at a distance from where the converter is physically located. If remote sensing is NOT required, these pins **MUST** be tied to their repective output pins (+S to +OUT, -S to -OUT, see ***Figure 2***). If one or more of these sense pins are not connected to their respective output pins, the output of the unit will not regulate to within specification and may cause high output voltage condition.

Remote Sense - Single Output

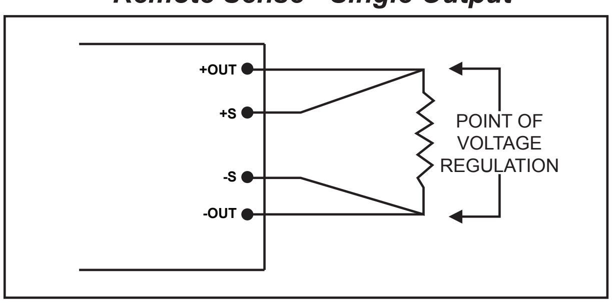


Figure 2

DO NOT connect sense pins to any pin other than their respective output pins or permanent damage will occur.

DO NOT connect sense pins to any load other than the same load the output pins are connected to or permanent damage may occur.

Remote On / Off

Remote turn ON / OFF (TTL Pin) is an additional feature to the SL Series. This feature is especially useful in portable/mobile applications where battery power conservation is critical. The voltage level at the TTL pin is referenced with respect to the converter's –VIN Input. When the TTL pin is pulled to less than 1.0V with respect to the –VIN pin. Via either an open collector (see ***Figure 3***) or a mechanical switch with a 0.5mA capability, the converter shuts down. An optocoupler can also be used IF the TTL Signals need to be referenced from the output side. If the TTL pin is left floating the unit remains on. When multiple units are tied to a central switch command, a series resistor of 200 Ohms to each TTL pin is recommended to increase noise immunity.

Remote Turn On / Off

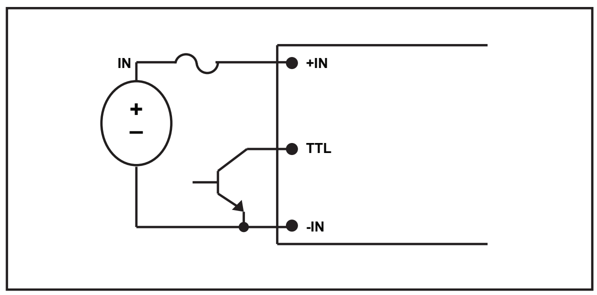


Figure 3

Output Trim

The output trim pin has been supplied on the SL family to provide output voltages other than the nominal fixed voltage. Output voltage can be increased or decreased (+10% Max, -10% Min) by simply connecting a resistor between the trim pin and the –Output return pin or the +Output pin respectively (see ***Figure 4***).

Basic Trim - Single Output

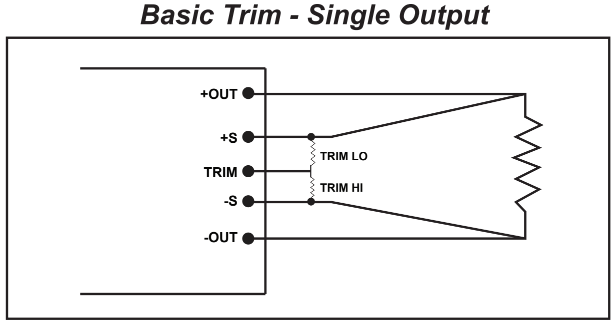


Figure 4

Output Trim - con't

The value of the resistors required to Trim Hi is shown in the ***Table 2***. The external resistor is connected between the Trim Pin and the Output Return Pin at the power supply (use standard value 1% resistor closest to the table value). Trimming the output voltage too high may activate the over voltage protection circuitry. The value of resistor required to Trim Lo is shown in ***Table 2***.

The external resistor is connected between the Trim Pin and the +Output Pin at the power supply (use standard value 1% resistor closest to the table value). A potentiometer can be substituted for the resistor to achieve a more precise output voltage setting. When trimming up or down, the maximum output current and/or maximum output power cannot be exceeded.

	3.3Vout		***5Vout***		***12Vout***	
	Volts	KΩ	Volts	KΩ	Volts	KΩ
110% Vout	3.63	8.30	5.50	18.3	13.20	92.6
108% Vout	3.56	10.4	5.40	24.8	12.96	117.1
106% Vout	3.50	14.0	5.30	36.1	12.72	158.1
104% Vout	3.43	21.4	5.20	58.1	12.48	241.7
102% Vout	3.37	43.3	5.10	134.0	12.24	504.6
100% Vout	3.30	OPEN	5.00	OPEN	12.00	OPEN
98% Vout	3.23	115.3	4.90	106.9	11.76	100.7
96% Vout	3.17	57.1	4.80	48.9	11.52	44.4
94% Vout	3.10	37.5	4.70	28.4	11.28	24.9
92% Vout	3.04	27.4	4.60	18.3	11.04	14.9
90% Vout	2.97	21.4	4.50	12.2	10.80	8.80

	15Vout		***24Vout***		***28Vout***	
	Volts	KΩ	Volts	KΩ	Volts	KΩ
110% Vout	16.50	122.9	26.40	224.0	30.80	268.6
108% Vout	16.20	153.9	25.92	278.6	30.24	331.8
106% Vout	15.90	205.1	25.44	369.8	29.68	435.9
104% Vout	15.60	309.9	24.96	554.9	29.12	650.6
102% Vout	15.30	616.8	24.48	1165	25.56	1282
100% Vout	15.00	OPEN	24.00	OPEN	28.00	OPEN
98% Vout	14.70	107.8	23.52	103.7	27.44	110.6
96% Vout	14.40	46.2	23.04	44.7	26.88	49.5
94% Vout	14.10	25.7	22.56	24.6	26.32	28.9
92% Vout	13.80	15.4	22.08	14.4	25.76	18.6
90% Vout	13.50	9.1	21.60	8.3	25.20	12.4

Table 2

Military Specifications

Specification	Condition	Method	Procedure	Test Condition
MIL-STD-704D	Input Transient			Transients up to 500V for 0.1 sec (270Vdc input)
MIL-STD-810E	Vibration	514.4	1	Up to 30 gs, each axis for 1 hour
	Humidity	507.3	1	95% humidity, non condensing for 10 days
	Temperature/Altitude	520.1	3	40 hours from -55°C to +71°C
	Acceleration	513.4	3	14 gs each axis
	Temperature Shock	503.3		-55°C to + 100°C (non-operating, one hour each cycle)
MIL-S-901C	High Impact Shock			5 foot hammer drop

Series Operation

The SL500 family of power converters may be arranged in a series operating mode to supply higher output voltages when required (see ***Figure 5***). In this configuration, D1 and D2 are added to protect against the application of a negative across the outputs of the power converters during power up and power down. The two (or more) units do not need to have the same output voltage, but the output current supplied in this configuration will be limited to the lowest maximum output current of the modules used.

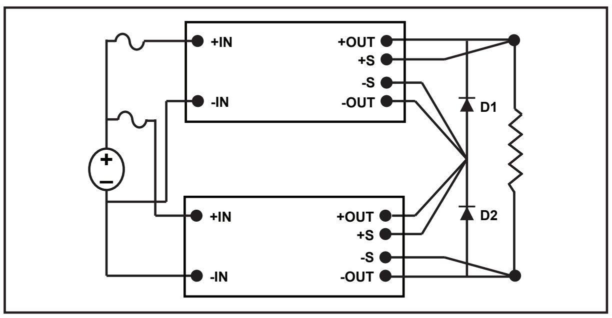


Figure 5

Parallel Operation

The SL500 converter family has the capability of being paralleled to drive loads of higher power than a single SL500 unit can handle. The PAR pin is supplied on the unit for this function (see ***Figure 6***). If parallel operation of two or more units is removed, the following precautions must be followed:

- Corresponding input and output leads or traces on each unit should be as equal in length and size as practical. The more equivalent the leads are, the closer the unit sharing.

- The PAR pins of all units should be tied together.

The units do not have to be synchronized for parallel operation but may be if required (see *Synchronization*). Or'ing diodes may be included in the positive output leads for true N + 1 redundant systems, but are not necessary. Local sensing should be used whenever possible to minimize noise on the +S and -S pins in parallel applications.

Parallel Operation

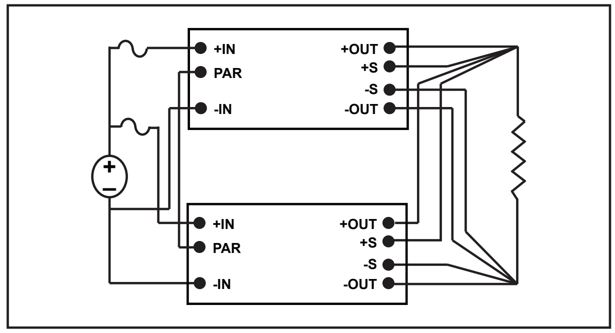


Figure 6

Synchronization

Synchronization of switch-mode converters to a central system clock frequency is often essential in noise sensitive systems. The SL Series can be tied to the central clock that is referenced to -OUT (see ***Figure 7***) by inputting a square wave clock signal which has a frequency amplitude and duty cycle within specified limits. The SL Series converter's internal synchonization circuit is triggered by rising edge of this clock waveform. **DO NOT** add any capacitance from the SYNC pin line to Ground.

Synchronization to External Clock

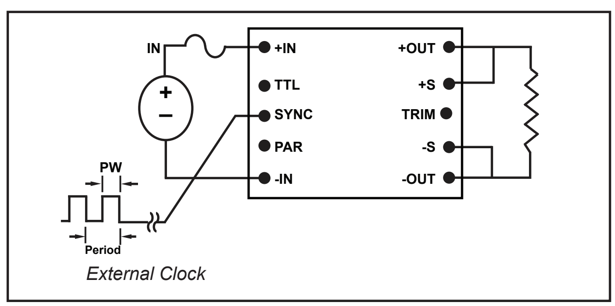


Figure 7

Ripple & Noise

Output ripple and noise (sometimes referred to as PARD or "Periodic and Random Deviations") can be defined as unwanted variations in the output voltage of a power supply. In switching power supplies, this output noise is seen as a series of pulses with a high frequency content and is therefore measured as a peak value (i.e., specified as "peak-to-peak").

Ripple & Noise - con't

The SL Series of power supplies are specified and tested in our factory with a 20 MHz bandwidth oscilloscope / probe. Measurements taken by a scope set at higher frequencies (i.e. 300 MHz) may produce significantly different results due to noise coupling on to the probe from sources other than the power supply.

Noise that is common to all output leads of a power converter with repect to the chassis is refered to as common mode noise. Noise that is apparent on one output lead with respect to the other output lead is referred to as differential mode noise. Common mode noise is produced in switching action. Martek Power, a brand of Cooper Bussmann, typically minimizes the level of output common mode noise by incorporating line to chassis ground capacitors (on input and output leads) into the power converters. In most cases, this is sufficient to minimize the level of common mode noise. However, if further attenuation is required, additional line to chassis ground capacitance may be added by the customer at the system level. Martek Power noise specifications (output ripple specifications) all reference the level of differential mode noise at a given bandwidth, not the level of common mode noise. The measurement of differential mode noise is detailed in the following paragraphs.

Measurement Techniques

The length of all measurement leads (especially the ground lead) should be minimized and the sense pins should be tied to their respective outputs (+SENSE to +OUTPUT, - SENSE to - OUTPUT). One inch or less from the output terminals, place a ceramic capacitor of 1µF and a 22µF low ESR Tantalum capacitor. Using an X1 scope probe with a 20 MHz bandwidth, we recommend measurement close to the capacitors. We do not recommend using the probe ground clip. Instead, replace it with connecting a short bus wire (generally 0.5 inches or less, making a loop at the end to place the probe in) to the negative and positive outputs on the backside of the connector. Place the tip of the probe on the +OUTPUT, and the ground ring (or ground band) on the -OUTPUT for a true ripple measurement (see ***Figure 8***). Utilizing the probe ground ring (as opposed to a ground clip) will minimize the chance of noise coupling from sources other than the power supply.

Ripple Reduction Techniques

In applications where the output ripple of the converter is higher than desired, various techniques can be employed to reduce output ripple and noise (PARD). One method is to add additional capacitance in parallel with the output leads of the converter (low ESR type tantalums or ceramic are recommended). This should substantially reduce PARD. See ***Table 3*** for maximum allowable capacitance that may be added to the output leads.

Maximum Allowable Capacitance

Output Voltage	Max Capacitance
3.3V	15,000µF
5V	15,000µF
12V	5,000µF
15V	5,000µF
24V	3,000µF
28V	3,000µF

Table 3

Ripple and Noise Test Set-Up

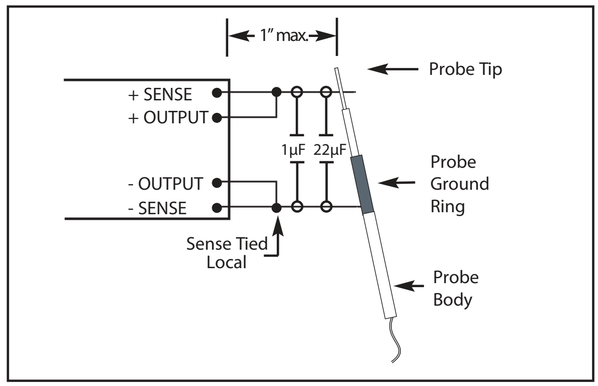


Figure 8

Electro Magnetic Filter (EMI) - SLF500

For applications where electromagnetic interference is a concern, the SLF500, a passive input line filter may be installed at the input of the SL Series converters (see Figure 9). If output power greater than 500 watts are required, multiple SLF500 units will be necessary. For more details, consult the factory.

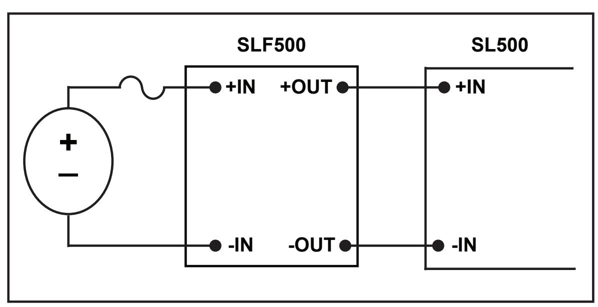
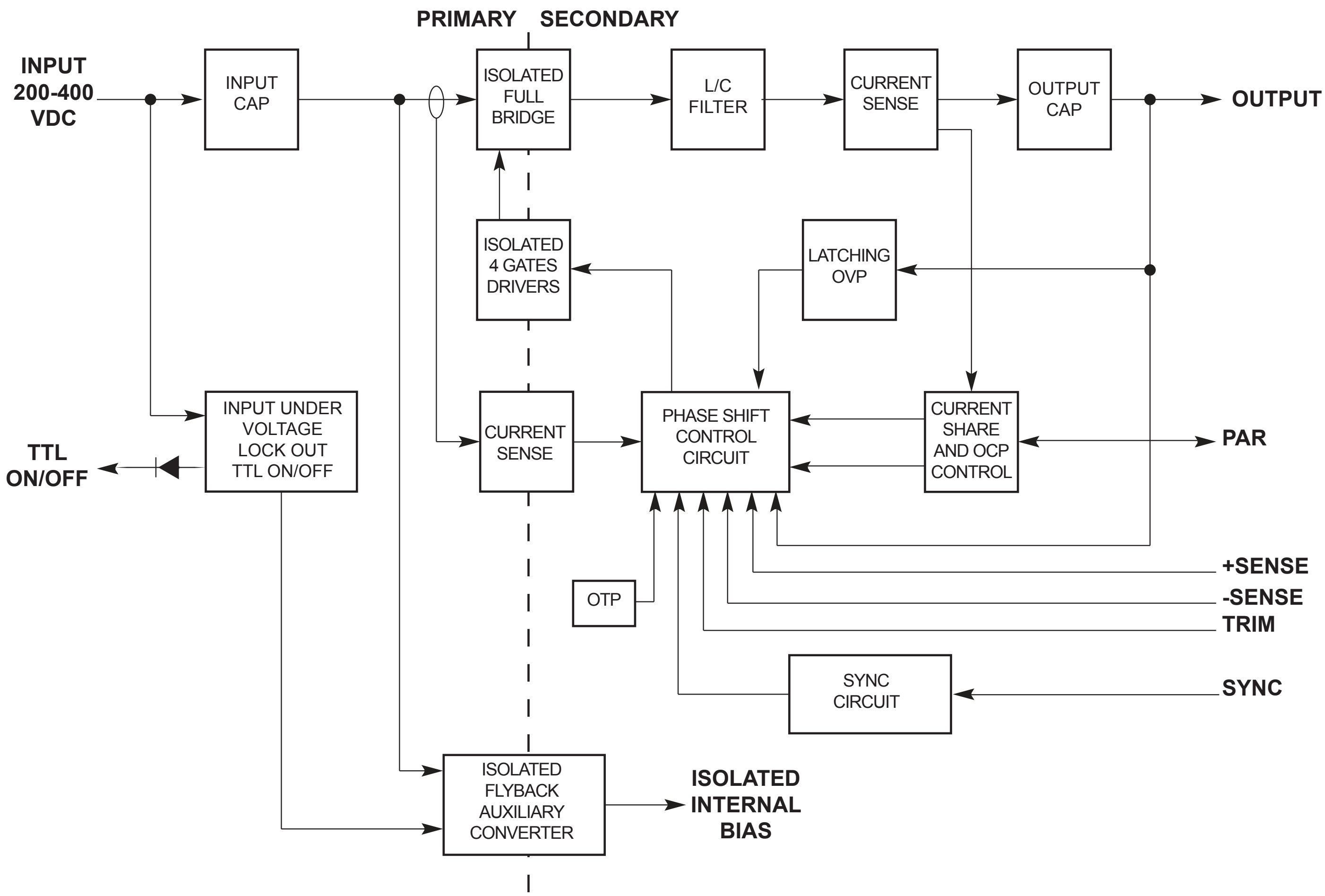
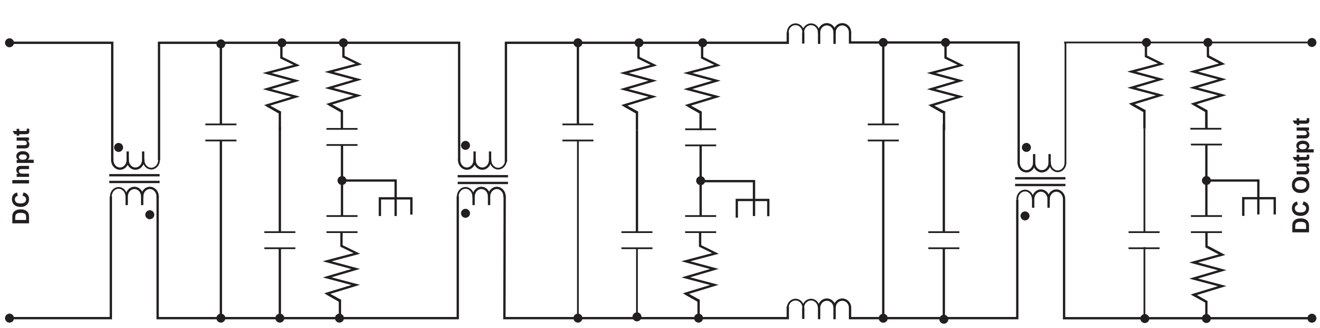


Figure 9

SL500 Block Diagram



SLF500 Schematic



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