



AMERICAN HIGH VOLTAGE
POWER SUPPLIES FOR THE WORLD

CT Series Center-tapped High Voltage Power Supply

General Description

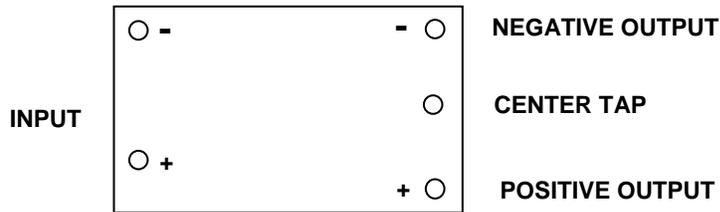
The CT Series high voltage power supplies are a derivative of the SC family - the workhorse of the high voltage industry. They provide isolated center tapped outputs of up +/- 2,500V and 5 Watts in power (depending on model). The output voltage of the CT power supply is directly proportional to the input voltage. The output ripple is typically less than 1% at full power. The two output leads are floating and fully isolated from the input power leads by over 1T Ohm (@ 25 deg C) with less than 50 pF of coupling capacitance. The high voltage output is provided with a center tap that allows for positive and negative outputs at the same time. All CT's are reverse input voltage and short circuit protected.

Features

- Center tapped
- positive and negative outputs
- +/- 50 VDC to +/- 2,500 VDC available
- 1.5, 3, and 5 Watt power
- Various input voltages available



Connection Diagram



Bottom View

Available Models: (other input voltages available):

1.5 Watt Models:

Name	Maximum Output Voltage	Maximum Output Current	1 st Year
CT-1 1.5W	+/- 50 VDC	15 mA	1990
CT-2 1.5W	+/- 100 VDC	7.5 mA	1987
CT-5 1.5W	+/- 250 VDC	3 mA	1993
CT-10 1.5W	+/- 500 VDC	1.5 mA	1993
CT-20 1.5W	+/- 1,000 VDC	0.75 mA	2003
CT-30 1.5W	+/- 1,500 VDC	0.5 mA	1999
CT-40 1.5W	+/- 2,000 VDC	0.38 mA	2001
CT-50 1.5W	+/- 2,500 VDC	0.30 mA	1996

3.0 Watt Models:

Name	Maximum Output Voltage	Maximum Output Current	1st Year
CT-1 3W	+/- 50 VDC	30 mA	1993
CT-2 3W	+/- 100 VDC	15 mA	2002
CT-5 3W	+/- 250 VDC	6 mA	1994
CT-10 3W	+/- 500 VDC	3 mA	2004
CT-20 3W	+/- 1,000 VDC	1.5 mA	1999
CT-30 3W	+/- 1,500 VDC	1.0 mA	2006
CT-40 3W	+/- 2,000 VDC	0.75 mA	2005
CT-50 3W	+/- 2,500 VDC	0.60 mA	1991

5.0 Watt Models:

Name	Maximum Output Voltage	Maximum Output Current	1st Year
CT-1 5 W	+/- 50 VDC	50 mA	2003
CT-2 5 W	+/- 100 VDC	25 mA	1995
CT-5 5 W	+/- 250 VDC	10 mA	1993
CT-10 5 W	+/- 500 VDC	5 mA	1997
CT-20 5 W	+/- 1,000 VDC	2.5 mA	2002
CT-30 5 W	+/- 1,500 VDC	1.67 mA	2000
CT-40 5 W	+/- 2,000 VDC	1.25 mA	2002
CT-50 5 W	+/- 2,500 VDC	1 mA	2000



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Electrical Characteristics

(at 25 degrees C unless otherwise specified)

Parameter	Conditions	Value			Units
		Min	Typical	Max	
Supply Voltage*:	(all power models)	2 VDC	12VDC	18 VDC	VDC
Input Current:	No Load (1.5W model):	40	50	75	mA
	No Load (3W model):	90	100	125	mA
	No Load (5W model):	160	190	190	mA
	No Load (10W model):	175	190	200	mA
	Full Load (1.5W model):	180	190	220	mA
	Full Load (3W model):	400	420	440	mA
	Full Load (5W model):	600	650	750	mA
	Full Load (10W model):	1100	1250	1400	mA
Output Ripple:	No Load (all models):	0.7%	0.7%	1%	V _{pp}
	Full Load (all models):	0.8%	0.8%	1%	V _{pp}
Load Regulation:	No Load to Full Load	25%	25%	30%	V _{NL} /V _L
	Half Load to Full Load	20%	20%	30%	V _{NL} /V _L
Output Linearity	No Load		1%		$\frac{\Delta V_{OUT}}{\Delta V_{OUT} (ideal)}$
Output Linearity	Full Load (all models):		1%		$\frac{\Delta V_{OUT}}{\Delta V_{OUT} (ideal)}$
Short Circuit Current:			200	300	mA
Power Efficiency:	Full Load	60%	70%	75%	$\frac{P_{OUT}}{P_{IN}}$
Reverse Input Polarity	Protected to 20 VDC				
Temperature Drift:	No Load			1,000	ppm/DegC
	Full Load			1,000	ppm/Deg C
Thermal Rise:	No Load (case)			15	degrees C
	Full Load (case)			25	degrees C
Slew Rate (10% - 90%)	No Load			100	mS
	Full Load			120	mS
Slew Rate (90% - 10%)	No Load			200	mS
	Full Load			100	mS
Drain Out Time	No Load (5 TC)			150	mS
Tracking	No Load			10%	
	Full Load			15%	

* Other input voltages available: 5VDC, 15VDC, 24VDC, 28VDC and 48VDC



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Physical Characteristics

(at 25 degrees C unless otherwise specified)

Parameter	Conditions	Value	Units
Dimensions	MKS	38.1 W x 63.5 L x 19 H	mm
	English	1.5 W x 2.5 L x 0.75 H	inches
Volume:	MKS	46	cm ³
	English	2.8	inch ³
Mass:	MKS	120	grams
	English	4.3	oz
Packaging:	Solid Epoxy Thermosetting		
Finish	Smooth Dial-Phthalate Case		
Terminations:	Gold Plated Brass pins (4)		

Environmental Characteristics

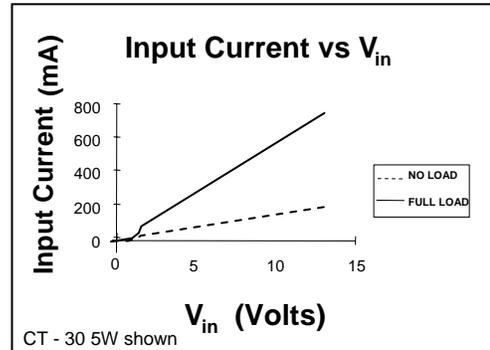
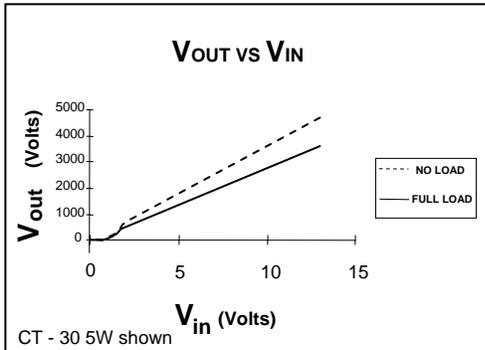
(at 25 degrees C unless otherwise specified)

Parameter	Conditions	Value	Units
Temperature Range	case temperature	-40 degrees to + 71 degrees	Celsius
	case temperature	-40 degrees to + 160 degrees	Fahrenheit
Shock:	MIL-STD-810 Method 516	40 g's	Proc IV
Altitude:	pins sealed against corona	-350 to + 16,700	meters
	pins sealed against corona	-1,000 to +55,000	feet
Vibrations:	MIL-STD-810 Method 514	20 g's	Curve E
Thermal Shock	MIL-STD-810 Method 504	-40 deg C to + 71 deg C	Class 2



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CT Series Performance Charts



CT Series Application Notes

The CT Series high voltage power supplies are driven by an input voltage of 2 to 12 VDC. The input current and output voltage as a function of input is shown in the above graphs. There are NO internal connections between the input and output pins. As can be seen from the above, the output voltage is approximately linear with respect to input except near the lower input voltage region. Here, the output drops off rapidly as the input voltage approaches zero with the absolute minimum input voltage needed for reliable starting being 0.9 VDC. As shown in Figure 1 below, the simple connection of a CT unit to a DC source of voltage will provide a high voltage stepped-up output. The input AC bypass capacitor C1 is optional and is utilized to prevent switching spikes from riding back on the input power lines. Values of 0.1 μ F to 10 μ F are commonly used.

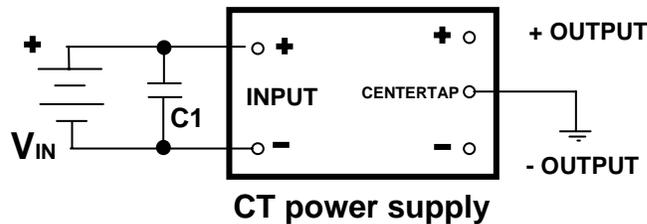


Figure 1: Basic CT hookup schematic (top view of CT shown)

The output voltage of the CT unit may be regulated by incorporating a simple op-amp circuit and linear control device such as an NPN transistor. Here, the output voltage is sensed and compared against an external reference control voltage. For single supply operation, the circuit of Figure 2 may be used for output voltage regulation. Here, the positive output is used as the regulating node. The negative side of the output tracks the positive output within 10%. A high voltage divider is made up of R5 and R6 to divide down the positive output to a value comparable with the control voltage. The resistor R5 is value is determined by power considerations. A good rule of thumb is to be 10% of the full output load. Too high a value may lead to output drift problems due to operational amplifier input bias current drift. The resistor R5 must be rated for the voltage that it is to step down. Simple high value carbon film resistors are usually avoided because their maximum voltage is limited to 300 VDC. Precision metal film resistors are more stable but also have limiting maximum voltages. It is possible to series several metal film resistors to build up the voltage rating of R5. Capacitor C4 likewise must be rated for the proper voltage. It serves to lower output ripple provide a feed-forward pole in the feedback loop for stability. Capacitor C5, the ground mirror capacitor serves as a lower end of the AC divider formed with C4 and prevents excessive voltage from being fed to the operational amplifier in the case of a shorted output. R6 is selected by calculating the resistance divider ration with R5, providing a 5 volt feedback at full output voltage. The input reference bypass capacitor C1 is used to remove any noise feeding to the non-inverting signal pin of the operational amplifier. For maximum temperature stability, R1 should be identical in value to R6.



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CT Series Application Notes (continued)

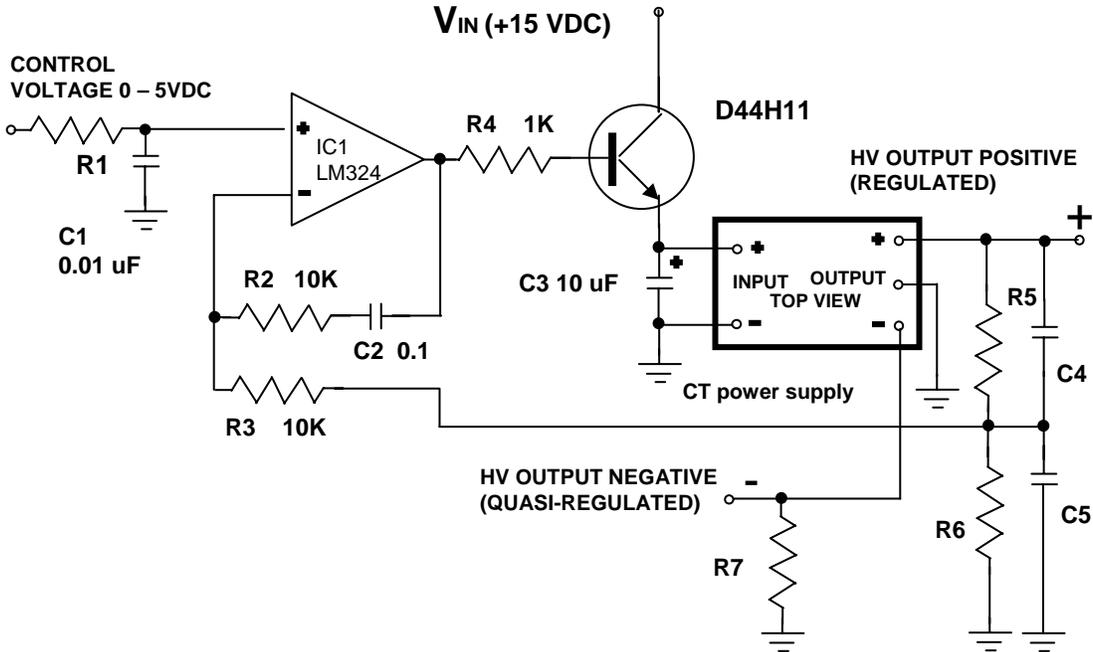


Figure 2: +/- 500 Volt Regulator

Resistor R2 and capacitor C2 provide frequency compensation for the amplifier IC1 a common bipolar amplifier is used since its outputs and signal inputs can reach almost to ground. R3 provides protection to the signal inverting input of the opamp in case of a short circuit or arcing condition exists on the HV output. R4 protects the output of the opamp in case of a shorted NPN transistor. R7 provides a preload on the negative output leg of the converter. Typical values for an +/- 500 volt piezoelectric driver power supply are as follows:

CT:	CT-10
R1:	62.9K Ohm
R5:	10 Megohms (Slimox 102 – Ohmite)
R6:	62.9K Ohm
R7:	10 Megohms (Slimox-102)
C4:	2200 pF 3KV disc
C5:	0.1 uF 50 V ceramic
IC1:	LM324
Q1:	Power NPN such as D44H11 or equivalent

Typical voltages seen during operation are as follows:

Voltage at junction of R5 and R6:	5V
Voltage at opamp output:	11.3V
Voltage into + supply TC:	10V (depends somewhat on output load)
Voltage of base of Q1:	10.7 V

The power supply feeding the opamp is not shown however it may be connected to the +15V supply and ground. It is a good idea to bypass the input power pins of the opamp with a 0.1 uF capacitor to reduce the EMI that may damage the opamp if an output arcing condition is suddenly encountered. By varying the control voltage from 1 to 5V, the high voltage output of the SC power supply may be regulated. Line and load regulation as good as 0.01% are achievable depending upon physical layout and quality of feedback resistor. To lower the output ripple further, an resistor (carbon composition type) of a high value may be inserted in series with the HV output of the CT unit before it continues on in the circuit. A value of 100K Ohm will drop the output ripple to less than 0.2 Vpp. Here the 100 K Ohm resistor works as a filter in conjunction with C4. Higher ripple reduction is achievable with a capacitor added directly to the output pin and ground.



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CT Series Application Notes (continued)

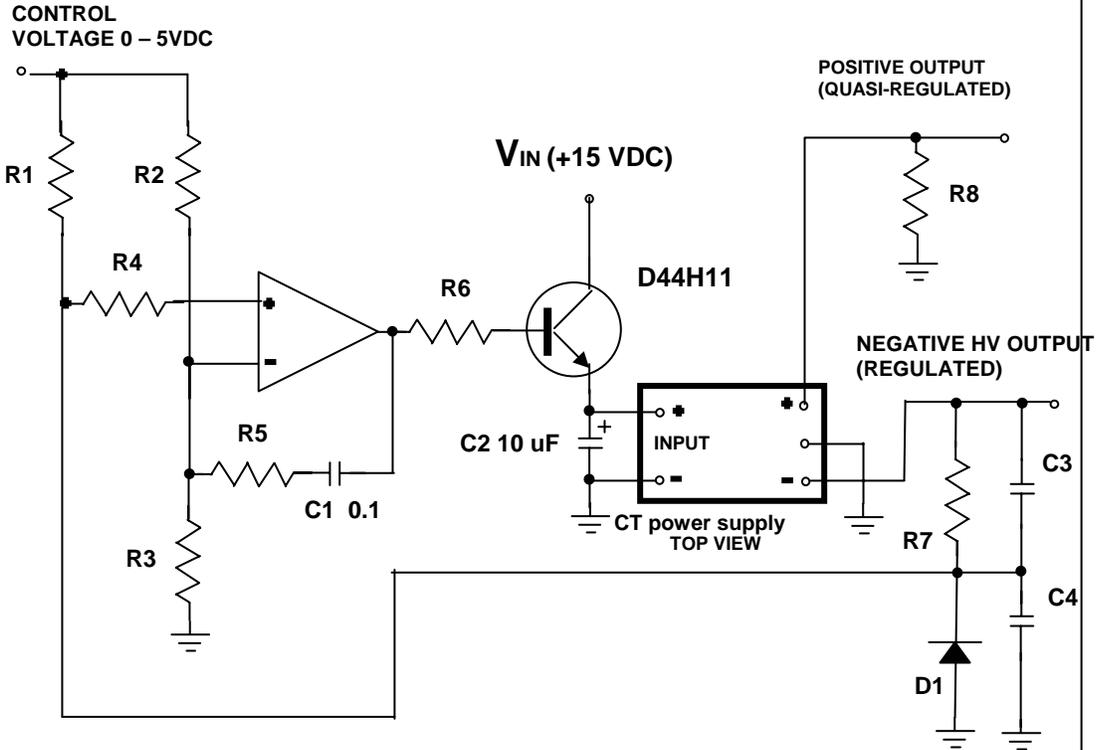


Figure 3: +/- 500 Volt Regulator (Negative output regulation)

A regulated 500 volt split supply in which the negative output is regulated by a feedback loop is easily obtained using the floating output feature of the CT unit. Figure 3 utilizes much of the same topology as the positive leg regulator (Figure 2) except that a summing junction is made for operational amplifier IC1. Again, the values of R7 and C3 are selected with respect to the proper HV output parameters. Dissipation in R7 should be limited to less than 10% full load. C3 must be a high voltage capacitor, capable of working at the full output voltage. Diode D1 provides a return path in case the output is suddenly shorted, protecting IC1 from huge positive spikes on the signal input. Resistors R2 and R3 form a simple divider, their values should be equal. The voltage drop in R1 should be such that at full output voltage the signal at the non-inverting input of IC1 should be exactly half the control voltage. R4 is a simple 10K Ohm limiter. The values of R2 and R3 should be twice that of R1 for good thermal stability. R8 is an external preload on positive output of the CT power supply. This serves to improve positive and negative output voltage tracking. Typical values for a +/- 500 volts power source are:

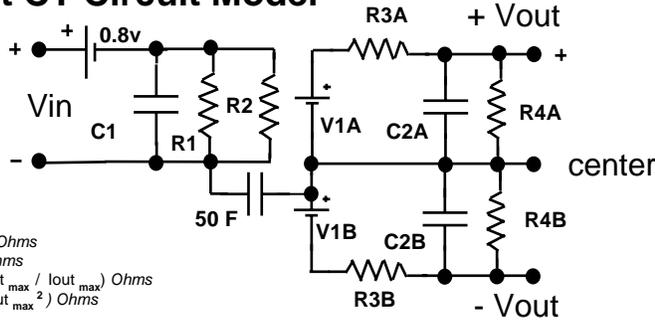
CT:	CT-10
R1:	100K Ohm
R2:	200K Ohm
R3:	200K Ohm
R5:	10K Ohm
R6:	10K Ohm
R7:	10 Megohms (Slimox 102 – Ohmite)
R8:	10 Megohms (Slimox 102 – Ohmite)
C3:	2200 pF 3kV disc
C4:	0.1 uF 50 V ceramic
IC1:	LM358 or LM324
Q1:	Power NPN such as D44H11 or equivalent
D1:	1N4148



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Equivalent CT Circuit Model

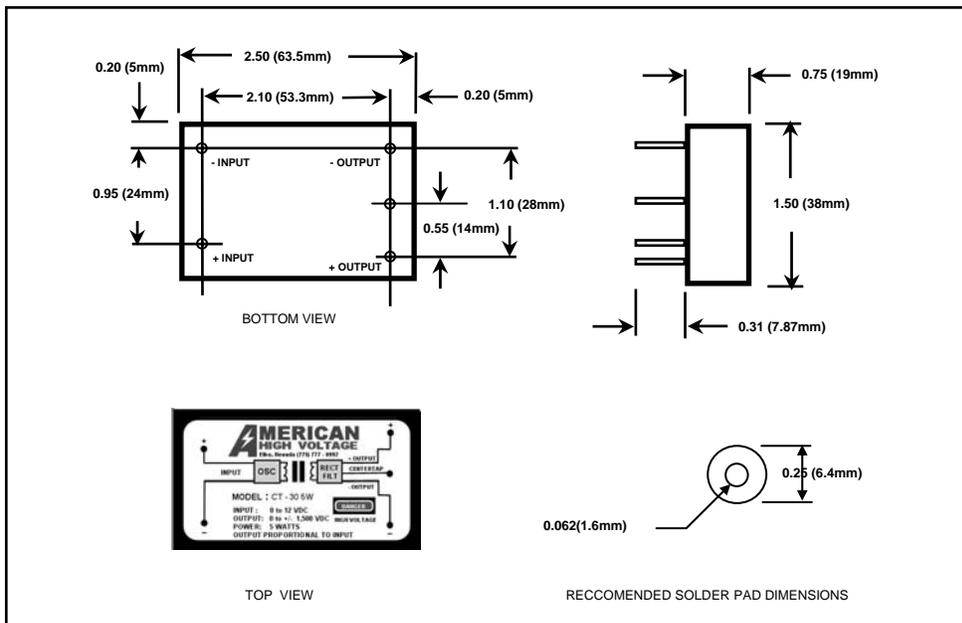


$R1 = (13 \times P_{out_max}) \text{ Ohms}$
 $R2 = (100 / P_{out_max}) \text{ Ohms}$
 $R3A \ \& \ B = (0.1 \times V_{out_max} / I_{out_max}) \text{ Ohms}$
 $R4A \ \& \ B = (2.5 \times V_{out_max}^2) \text{ Ohms}$
 $C1 = (10 \times 10^{-6}) \text{ Farads}$
 $C2A \ \& \ B = (0.005 \times I_{out_max} / V_{out_max}) \text{ Farads}$
 $V1 = (V_{r2} \times V_{out_max} / 24) \text{ Volts}$

Equivalent CT Circuit Model

For example, for a: CT - 10 5W
 $V_{out_max} = 1,000 \text{ V (total)}$
 $I_{out_max} = 0.005 \text{ A}$
 $P_{out_max} = 5 \text{ W}$
 From this information: $R1 = 65, R2 = 20, R3 = 20K, R4 = 2.5 \text{ M}, C2 = 0.025 \text{ uF}$

Outline Drawing: (inches (millimeters))



Ordering Information:

CT – XX Y Watt / Z

XX = Output voltage
 Y = Maximum power
 Z = Input voltage (blank if 12VDC)

Example:

CT – 30 5W: Maximum output = 3,000 V 5 Watts 12 VDC input (provides +/- 1,500 volts)
 CT – 5 3W/5V: Maximum output = 500 V 3 Watts 5VDC input (provides +/- 250 volts)