

## HIGH TEMPERATURE HYBRID DC-DC CONVERTER    **HTB28XXS** 185°C, 5W, 28V Input, Single Output

### Description

The HTB28XXS Series is a hybrid, hermetically sealed, single output 5W DC-DC converter designed to operate in high temperature up to 185°C and shock and vibration environments such as those encountered in oil exploration applications. Features include small size, 1" width and low weight. All internal components are specifically selected to meet the intended operating environment. Documentation, including electrical stress and thermal analysis, is available to customers.

The HTB28XXS Series of DC-DC converters use flyback topology, operating at a nominal frequency of 550 kHz. High input to output galvanic isolation is achieved through the use of transformers in the power and feedback paths. The advanced feedback design provides fast loop response for superior line and load transient characteristics and offers greater reliability than converters incorporating optical feedback circuits.

These converters are designed to meet full performance over a 17 to 34 volts input range and provide output power of up to 5 watts. An inhibit pin allows to shut the converter down or enable it.

Output current is limited under any load fault condition to approximately 180% of rated value. An overload condition causes the converter output to limit current. The converter will remain in current limit mode until the load current is reduced below the overcurrent limit, at which time it will resume normal operation. This protects the converter as well as load from both overload and short circuit conditions.

The converters are enclosed in a 1.0"W x 0.41"H x 2.82"L flanged package excluding mounting tabs and I/O pins and weigh less than 44 grams. The cold rolled steel (CRS) package utilizes rugged ceramic feed-thru copper core pins and is sealed with parallel seam welding.

Full environmental screening includes temperature cycling, constant acceleration, fine and gross leak testing and burn-in as per Device Screening table. Variations in electrical specifications and screening to meet custom requirements may be accommodated.



### Features

- Case Operating Temperatures: -35°C to +185°C
- Life > 1200 hours @ +185°C
- Up to 5W Output Power
- Wide Input Voltage Range: 17 to 34 Volts
- Single Outputs: 3.3V, 5V, 12V and 15V
- Minimum Efficiency 69%
- Low Inhibit Current (less than 3.5mA)
- External Inhibit / Enable
- Short Circuit and Overload Protection
- Under-Voltage Lockout Protection
- Industry Standard Pin-out
- Compact Flanged Package: 1.0"W x 0.41"H x 2.82"L
- Parallel Seam Welded Steel Package

### Applications

- Down Hole Exploration Tools

# HTB28XXS (185°C, 28V Input, Single Output)

Absolute Maximum Ratings		Maximum Operating Conditions	
Input voltage range	-0.5V <sub>DC</sub> to 40V <sub>DC</sub>	Input voltage range	17V <sub>DC</sub> to 34V <sub>DC</sub>
Output power	Internally limited	Output power	0 to Max. Rated
Lead temperature	+300°C for 10 sec	Case Operating temperature	-35°C to +185°C
Storage temperature	-45°C to +125°C		

Note: Storage at high temperature will effect life.

## Electrical Performance Characteristics

TEST	Conditions -35° ≤ T <sub>C</sub> ≤ +185°C V <sub>IN</sub> = 28V <sub>DC</sub> ±5% C <sub>L</sub> = 0 unless otherwise specified	Subgroup <sup>10</sup>	HTB2803R3S Preliminary		HTB2805S		HTB2812S Preliminary		HTB2815S Preliminary		Unit
			Min	Max	Min	Max	Min	Max	Min	Max	
Output voltage	I <sub>OUT</sub> = 100% I <sub>MAX</sub>	1	3.26	3.34	4.95	5.05	11.88	12.12	14.85	15.15	V
		2, 3	3.2	3.4	4.85	5.15	11.64	12.24	14.55	15.30	
Output current <sup>1</sup>	V <sub>IN</sub> = 17, 28, and 34 V <sub>DC</sub>	1, 2, 3		1.51 5.0		1.0		0.416		0.333	A
Output power	V <sub>IN</sub> = 17, 28, and 34 V <sub>DC</sub>	1, 2, 3		5.0		5.0		5.0		5.0	W
Output ripple voltage <sup>2</sup>	V <sub>IN</sub> = 17, 28 and 34 V <sub>DC</sub> I <sub>OUT</sub> = I <sub>MAX</sub>	1		50		50		50		50	mV <sub>PP</sub>
		2, 3		50		50		50		50	
Input Under Voltage	Turn-on (rising), I <sub>OUT</sub> = 0	1,2,3	12	15	12	15	12	15	12	15	V
	Turn off (decreasing), I <sub>OUT</sub> = 0	1,2,3	12	14	12	14	12	14	12	14	
	Hysteresis	1,2	0.7		0.7		0.7		0.7		V
		3	0.4		0.4		0.4		0.4		
Line regulation	V <sub>IN</sub> = 17, 28, and 34 V <sub>DC</sub> I <sub>OUT</sub> = 0, 50%, 100% I <sub>MAX</sub>	1, 2, 3	-0.5	+0.5	-0.5	+0.5	-0.5	+0.5	-0.5	+0.5	%
Load regulation	V <sub>IN</sub> = 17, 28, and 34 V <sub>DC</sub> I <sub>OUT</sub> = 0, 50%, 100% I <sub>MAX</sub>	1, 2, 3	-2.0	+2.0	-1.0	+1.0	-1.0	+1.0	-1.0	+1.0	%
Input current	I <sub>OUT</sub> = 0	1, 2, 3		15		15		20		20	mA
	I <sub>OUT</sub> = 0 (inhibited)			3.5		3.5		3.5		3.5	
Input ripple current <sup>2</sup>	I <sub>OUT</sub> = I <sub>MAX</sub>	1, 3		100		100		100		100	mA <sub>PP</sub>
		2		150		150		150		150	
Efficiency	I <sub>OUT</sub> = I <sub>MAX</sub>	1, 3	69		69		75		75		%
		2	69		70		71		71		
Current Limit Point Expressed as a percentage of full rated output power	V <sub>OUT</sub> = 90% of nominal	1, 2, 3		180		180		180		180	%
Isolation	V <sub>TEST</sub> 500 V <sub>DC</sub> , T <sub>C</sub> = 25°C Input to output or any pin to case	1	100		100		100		100		MΩ
Capacitive load <sup>3, 4, 10</sup>	No effect on DC performance, T <sub>C</sub> = 25°C I <sub>OUT</sub> = I <sub>MAX</sub>	4		1000		1000		300		300	μF
Power dissipation, load fault	Overload <sup>5</sup>	1, 2, 3		5.0		5.0		5.0		5.0	W
	Short circuit			2.5		3.0		2.5		2.5	
Switching frequency <sup>4</sup>	I <sub>OUT</sub> = I <sub>MAX</sub>	4, 5, 6	500	600	500	600	500	600	500	600	kHz

For Notes to Electrical Performance Characteristics, refer to page 4

**Electrical Performance Characteristics (continued)**

TEST	Conditions -35°C ≤ T <sub>C</sub> ≤ +185°C V <sub>IN</sub> = 28V <sub>DC</sub> ± 5% C <sub>L</sub> = 0 unless otherwise specified	Subgroup <sup>10</sup>	HTB2803R3S Preliminary		HTB2805S		HTB2812S Preliminary		HTB2815S Preliminary		Unit
			Min	Max	Min	Max	Min	Max	Min	Max	
Transient step load changes, overshoot <sup>6</sup>	50% I <sub>MAX</sub> ⇄ 100% I <sub>MAX</sub>	4, 5, 6	-4.0	+4.0	-3.0	+3.0	-1.0	+1.0	-1.0	+1.0	%
	10% I <sub>MAX</sub> ⇄ 50% I <sub>MAX</sub>										
Transient step load changes, delay	50% I <sub>MAX</sub> ⇄ 100% I <sub>MAX</sub>	4, 5, 6		200		200		100		100	μs
	10% I <sub>MAX</sub> ⇄ 50% I <sub>MAX</sub>			200		200		100		100	μs
Transient step line changes, overshoot	17 ⇄ 34 V <sub>DC</sub> I <sub>OUT</sub> = I <sub>MAX</sub>	4, 5, 6	-1.0	1.0	-1.0	+1.0	-2.0	2.0	-2.0	2.0	%
Transient step line changes, delay <sup>4, 7, 8</sup>	17 ⇄ 34 V <sub>DC</sub> I <sub>OUT</sub> = I <sub>MAX</sub>	4, 5, 6		200		200		200		200	μs
Turn-on response, overshoot <sup>9,10</sup>	I <sub>OUT</sub> = 0, I <sub>MAX</sub>	4, 5, 6		2.0		2.0		2.0		2.0	%
Turn-on response, delay <sup>9,10</sup>	I <sub>OUT</sub> = 0, I <sub>MAX</sub>	4, 5, 6	1.0	10	1.0	10	1.0	10	1.0	10	ms
Load fault recovery <sup>4,10,12</sup>	I <sub>OUT</sub> = I <sub>MAX</sub>	4, 5, 6		5.0		5.0		10		10	ms

Parameter	Conditions -35°C ≤ T <sub>C</sub> ≤ +185°C V <sub>IN</sub> = 28V DC ± 5%, C <sub>L</sub> = 0 unless otherwise specified	Subgroups <sup>10</sup>	Limits			Unit
			Min	Nom	Max	
Line rejection	MIL-STD-461, CS101 30Hz to 50kHz <sup>1</sup>	1	45	55		dB
Isolation	Input to output or any pin to case except case pin, test at 500V <sub>DC</sub>	1	100			MΩ
Device weight				41	44	g

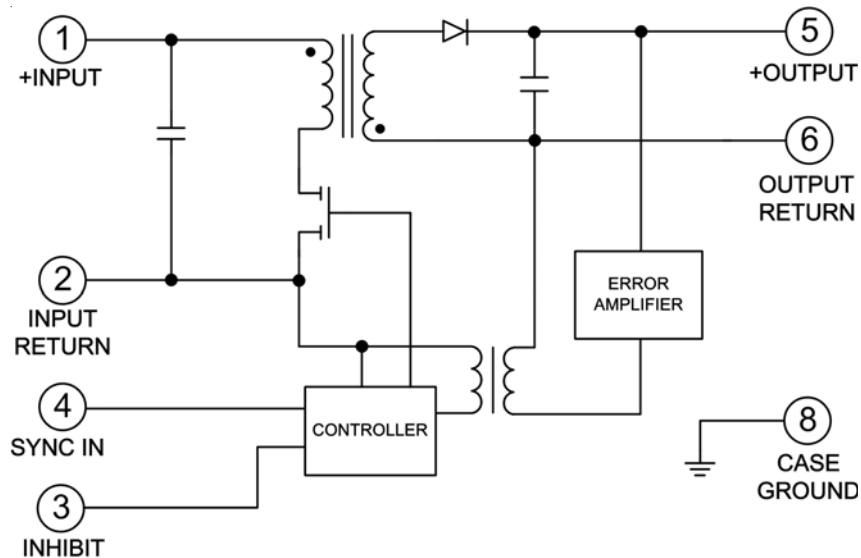
For Notes to Electrical Performance Characteristics, refer to page 4

# HTB28XXS (185°C, 28V Input, Single Output)

## Notes for Electrical Performance Characteristics Table

1. Parameter guaranteed and measured should be during line and load regulation tests.
2. Parameter tested with 10MHz bandwidth.
3. Capacitive load may be any value from 0 to the maximum limit without compromising DC performance. A capacitive load in excess of the maximum limit will not disturb loop stability but may interfere with the operation of the load fault detection circuitry, appearing as a short circuit during turn-on.
4. Parameter shall be tested as part of design characterization and after design or process changes.
5. An overload is that condition of load in excess of rated load but less than that necessary to trigger the short circuit protection and is the condition of maximum power dissipation.
6. Load step transition time between 2 and 10 microseconds.
7. Recovery time is measured from initiation of the transient to where  $V_{OUT}$  has returned to within  $\pm 1\%$  of  $V_{OUT}$  at 50% load.
8. Input step transition time between 2 and 10 microseconds.
9. Turn-on delay time measurement is for either a step application of power at the input or the removal of a ground signal from the Inhibit pin (pin 3) while power is applied to the input.
10. Subgroup 1, 4 electrical characteristics are measured at +25°C, subgroup 2, 5 at +185°C and subgroup 3, 6 at -35°C. Subgroups 1, 2 and 3 are static tests. Subgroups 4, 5 and 6 are dynamic tests.
11. Parameter tested with resistive load.
12. Recovery time is measured from the short removal to where  $V_{OUT}$  has returned to within  $\pm 10\%$  of  $V_{OUT}$  at full load.

Figure 1. Block Diagram



**Technical Notes:**

**1. Inhibiting Converter Output:**

As an alternative to application and removal of the DC voltage to the input, the user can control the converter output by providing TTL compatible, positive logic signal to Inhibit pin (pin 3) and to Input Return (pin 2). Inhibit signal is internally pulled “high” so that when not used, an open connection on the Enable pin permits normal converter operation. A logical “low” on Inhibit pin will shut down the converter.

**2. Synchronization of Multiple Converters:**

Sometimes there is a need to synchronize the HTB converters to an external frequency. For example if several HTB converters have to be paralleled and operate off an external clock then this feature becomes useful. This helps get rid of the “beat” frequency, thus relieving the problem of having to filter out a very low frequency ripple. To accommodate this requirement, the HTB series of converters have a synchronization input. The Sync Input port (pin 4) permits synchronization of a HTB converter to any compatible external frequency source operating between 500 KHz and 600 KHz. This input signal should be referenced to the Input Return and should have 10% to 90% duty cycle. Compatibility requires transition times to be less than 100ns, maximum low level of +0.8V and a minimum high level of +2.0V. When external synchronization is not required, the Sync In pin should be left unconnected, thereby, permitting the converter to operate at its own internally set frequency. Five HTB converters can be operated in parallel with good current/load sharing.

**3. Mounting the HTB:**

It is important to mount the HTB converter on an aluminum plate or a heat sink before powering it up. For this following procedure is recommended:

1. Check all surfaces for foreign material, burrs, or anything that may interfere with the different parts..
2. Apply a very thin layer of thermal grease to the mounting surface, aluminum or copper, which has good thermal conductivity and surface flatness of 0.002" per inch. The thicker and wider the mounting plate, the better the operating thermal equilibrium will be, thus improving overall reliability.
3. Alternatively a Sil-Pad 2000 (made by <http://www.bergquistcompany.com>) may be used as an interface material between the converter and mounting surface.
4. Place the converter on the mounting surface and line it up with mounting holes.
5. Install screws using appropriate washers and tighten by hand (~6 in.oz) in the sequence shown below in Figure 2. Please use 8-32 size screws and #8 flat washers.
6. Tighten the screws with appropriate torque driver using a controlled torque of 6 in.lb in the sequence as shown in the diagram.
7. The case of the HTB converter is isolated from input or output return. It is optional for customer to decide to either ground it or leave it floating. However, it is important to note that common mode capacitors are internally tied to the case. Hence, connecting it to Ground (Earth) will enhance common mode noise rejection/reduction.

**Figure 2. Top view of the HTB Converter with tightening sequence**

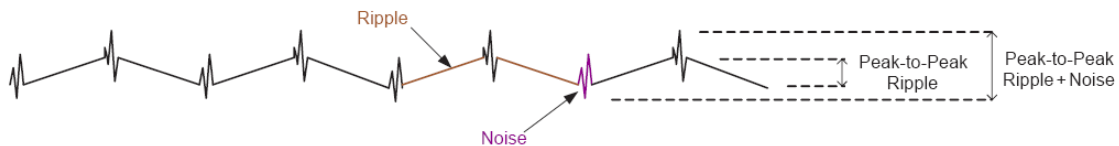


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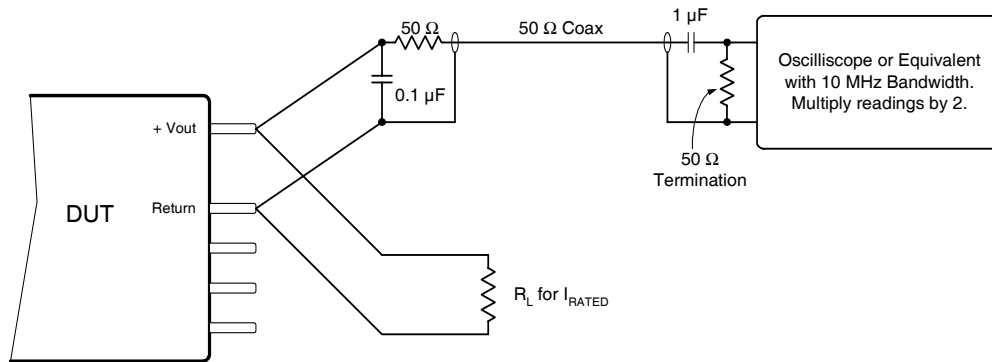
**4. Measuring Output ripple of HTB:**

The HTB converter's output ripple should be measured per prescribed procedure to get reliable values. Figure 4 shows how an oscilloscope and associated external R-C components should be connected to get true value of output ripple at full load.

**Figure 3. Pictorial Definition of O/P noise+ripple of any Converter**



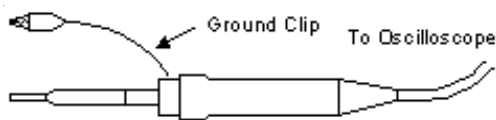
**Figure 4. Measuring O/P noise+ripple of HTB Converter**



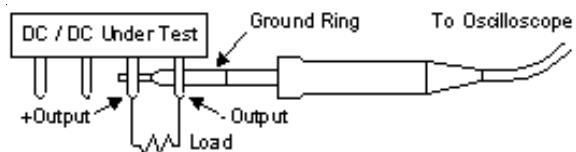
Because of the high frequency content of this ripple, special measurement techniques must be employed so that correct measurements are obtained. First, a 10 MHz bandwidth oscilloscope is normally used for the measurement so that all significant harmonics of the ripple spikes are included. Otherwise on a 200 MHz or 500 MHz oscilloscope, one can limit the bandwidth of measurement to 10 MHz.

The actual ripple voltage measurement must be carefully made in order not to induce error voltages in the test equipment. Therefore, the conventional ground clip on an oscilloscope probe (see Figure 5) should never be used in this type of measurement. This clip, when placed in a field of radiated high frequency energy, acts as an antenna or inductive pickup loop, creating an extraneous voltage that is not a part of the output noise of the converter.

**Figure 5. Oscilloscope probe**



**Figure 6. Correct method to use Oscilloscope Probe**



#### **5. Under Voltage Lock Out Protection:**

A minimum voltage is required at the input of the converter to initiate operation. This voltage is set to  $14.5V \pm 0.5V$ . To preclude the possibility of noise or other variations at the input falsely initiating and halting converter operation, a hysteresis of approximately 1.0V is incorporated in this circuit. Thus if the input voltage droops to  $12.5V \pm 0.5V$ , the converter will shut down and remain inoperative until the input voltage returns to  $\approx 14.5V$ .

#### **6. Lay-out and Connection of the HTB Converter:**

It is recommended to connect the HTB converter to the input power and to the load with as short wires as possible for best results. It is recommended that TEFLON coated stranded copper wires of correct AWG gauge be employed to meet current capacity and insulation requirements at high temperatures. Input Positive and Return wires can be twisted and likewise output Positive and Return wires can be twisted. If shielded wires are employed, shields can be connected to input return for input wires. Likewise, shield can be connected to output return for connections to load. As explained above, the case of the HTB converter can be grounded/earthed.

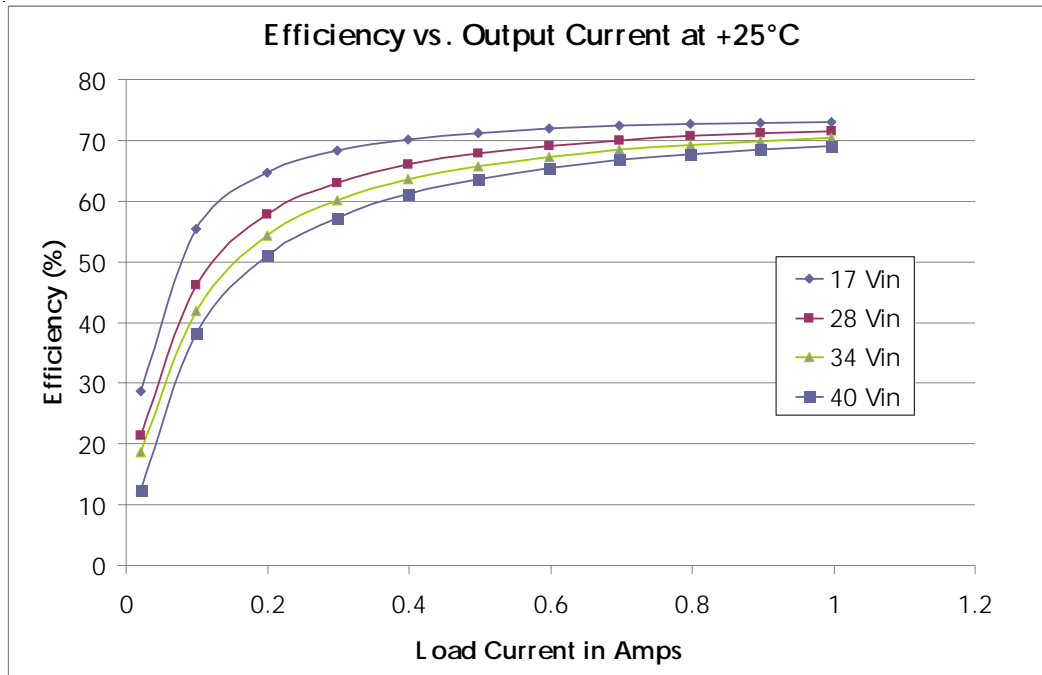
For noisy input power, it is recommended that an input EMI filter, comprising common mode and differential mode inductors be placed ahead of the HTB converter. These external inductors combined with the internal  $2\mu F$  capacitors would further attenuate noise.

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**7. Efficiency:**

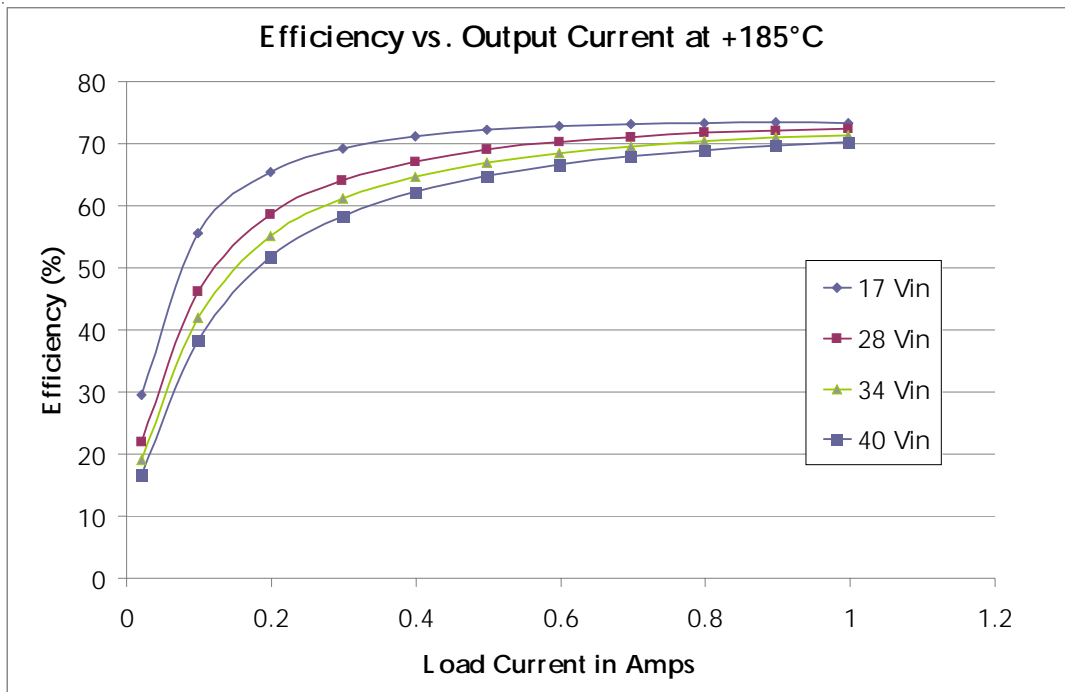
Efficiency measurements were done at three temperatures at different output load currents as shown below in Figures 7, 8 and 9 are for Model HTB2805S

**Figure 7. Typical Efficiency vs Output Current at +25°C Case Temperature**

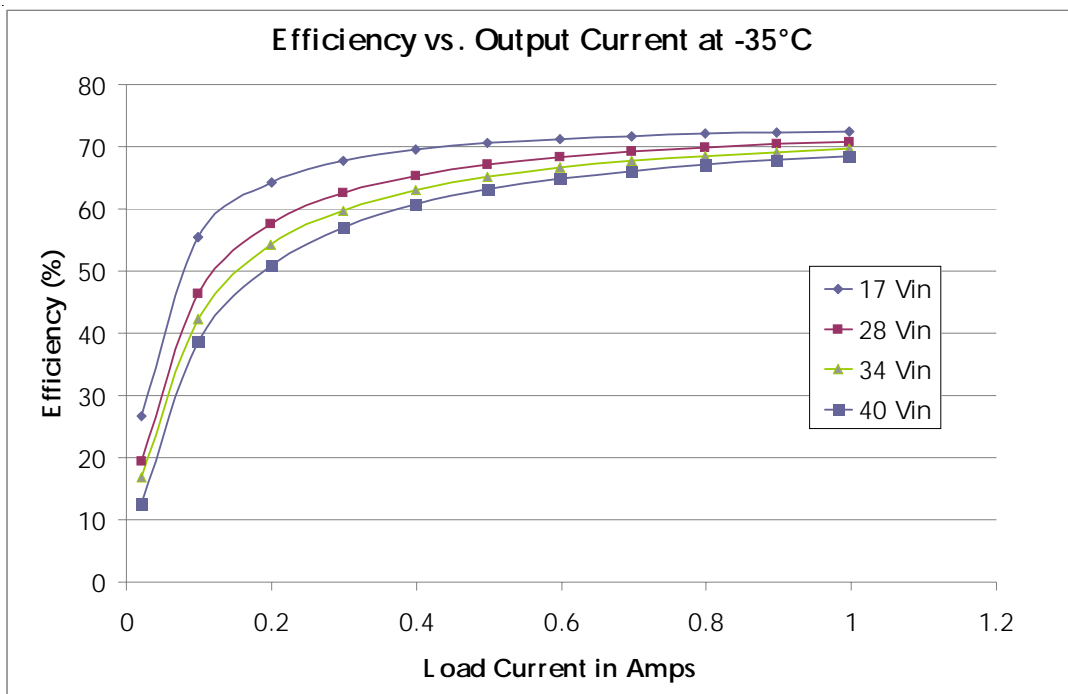




**Figure 8. Typical Efficiency vs Output Current at +185°C Case Temperature**

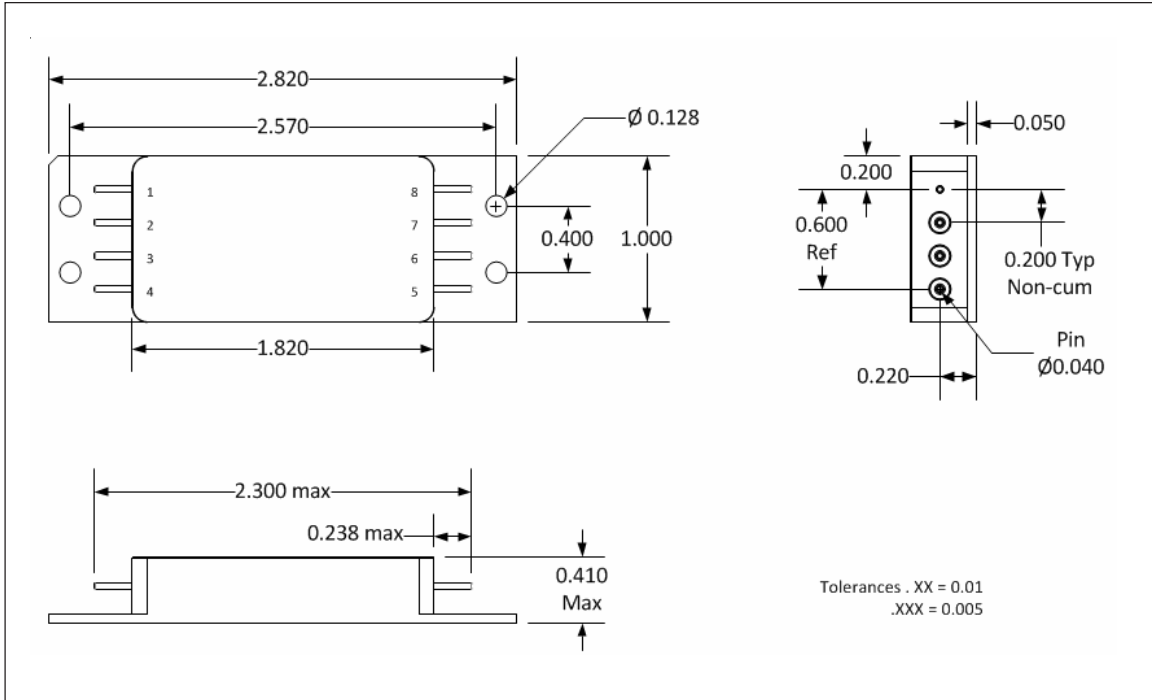


**Figure 9. Typical Efficiency vs Output Current at -35°C Case Temperature**



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**Case Outline**



**Pin Designation**

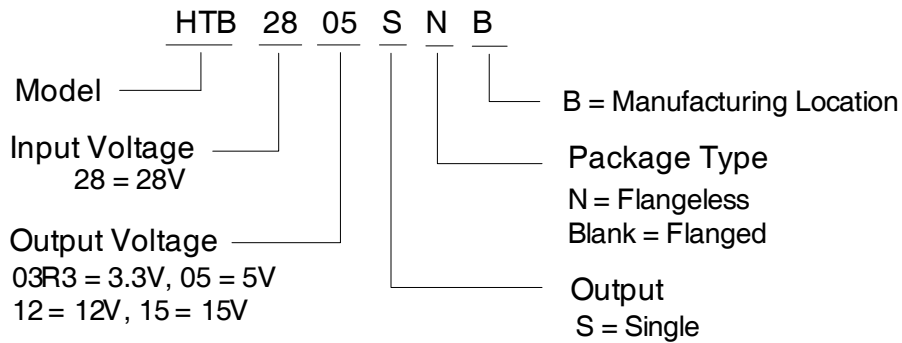
Pin No.	Designation	Pin No.	Designation
1	Positive Input	5	Positive Output
2	Input Return	6	Output Return
3	Inhibit	7	N/C
4	Sync.In	8	Case

**Device Screening**

Requirement	MIL-STD-883 Method	Coniditions
Internal Visual	2017	Pre-seal Inspection
Seal (Parallel Seam) including Fine and Gross Leak Test	1014	
Temperature Cycling	1010	185°C to -35°C, 10 cycles
Constant Acceleration	2001	500g, 1 minute
PIND	2020	Test condition "A" , 20G Peak @ 40Hz
Burn-in	1015	185°C for 48 hours
External Visual	2009	

Note: Custom screening available upon request.

**Part Numbering**



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