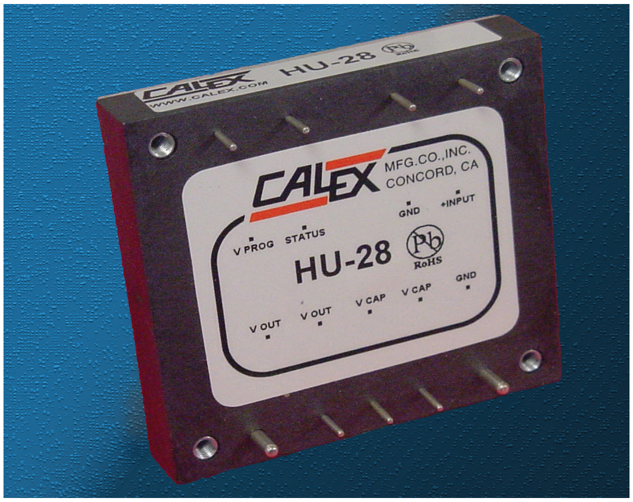
CBAM™ HU-28



Features

- All ceramic solution
- High energy density
- User programmable hold-up trip voltage
- Trip status indicator
- Designed for use with Calex DC/DC Converters
- Compact package design (2.40" x 2.28" x 0.50")
- Aluminum substrate technology
- All applicable materials used are a minimum of UL94V-0 rated. Designed to meet UL60950.
- Five year warranty
- Available with RoHS compliant construction, simply add "(RoHS)" after the part number: HU-28 (RoHS)

Description

The HU-28 is a hold-up module designed for use with Calex DC/DC converters to protect against brown-out and temporary power loss conditions and provide a clean, uninterrupted source of power for downstream circuitry. The HU-28 is built in a compact package with a user programmable hold-up trip voltage.

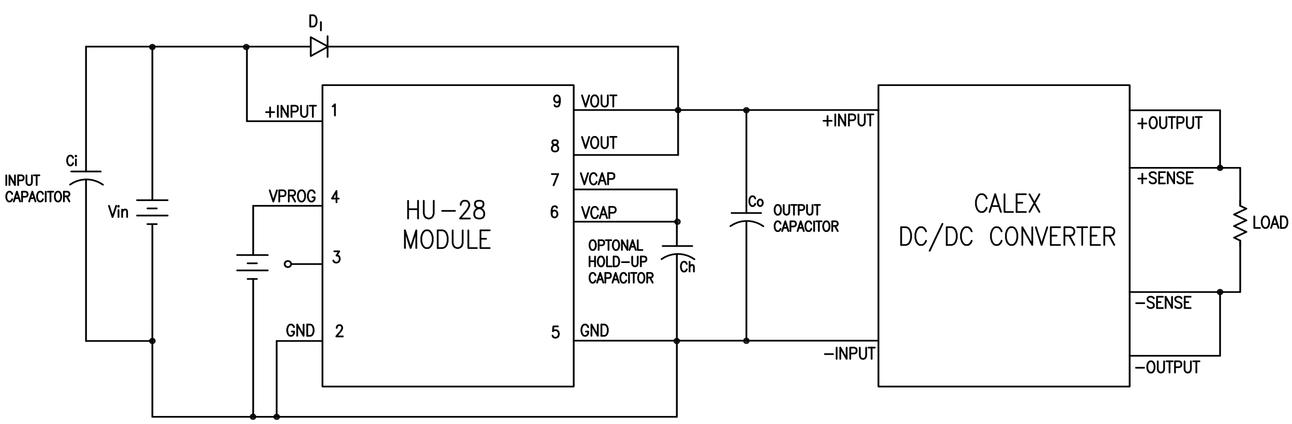


Figure 1. Recommended Application

Principles of Operation

The HU-28 has two modes of operation: “stand-by” and “tripped”. During stand-by, the HU-28 charges the internal hold-up capacitor to 45V and maintains that voltage. When tripped, the HU-28 stops charging the hold-up capacitor and connects it to the V_{OUT} pins.

The mode of operation is determined by the value of the input voltage (+INPUT) in relation to the “trip voltage”. Tripped mode is entered when the input voltage drops below a preset trip voltage. Stand-by mode is entered when the input voltage rises 2.1V above the trip voltage. The trip voltage is set by the user via the V_{PROG} pin.

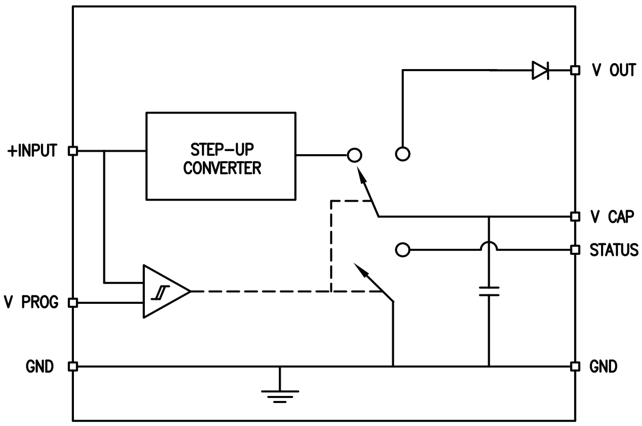


Figure 2. Internal Block Diagram

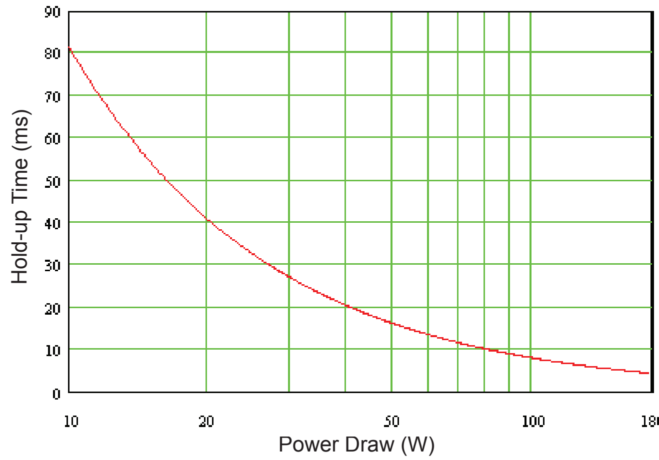


Figure 3. Hold-up Time as a function of Power Draw

Hold-up Time

Hold-up time is defined as the maximum time that the downstream circuitry can be powered solely from the hold-up capacitor. In this data sheet, hold-up time is defined as the time when the downstream circuitry is powered solely from the hold-up capacitor and the hold-up capacitor is charged to at least 10V. Figure 3 illustrates the maximum hold-up time (ms) that can be achieved at different levels of power draw. This time can be increased by adding external capacitance to the HU-28. Ceramic capacitors are used to store the hold-up energy. The capacitance of ceramic capacitors decreases logarithmically with time. Therefore the hold-up time will decrease slightly over the lifetime of the HU-28. The capacitors may be reset to their original value by heating them above the Curie temperature. Contact the factory for details.

Thermal Considerations

In stand-by mode, the HU-28 does not dissipate much heat and the baseplate temperature will typically be 5ºC higher than ambient temperature in a still air environment. When the HU-28 transitions from tripped to stand-by mode and vice versa, a large amount of power is dissipated in the HU-28. If frequent transitions are expected, care should be taken to ensure the baseplate temperature does not exceed 100ºC.

Caution

After shutting off power to the HU-28, do not handle the circuit until the hold-up capacitor is discharged. With no load on the output, voltages in excess of 45V may be present on the V_{CAP} and V_{OUT} pins for a prolonged period of time.

Parameter	Condition		Value	Units
Input Parameters				
Input Voltage Range		MIN (3) TYP MAX	15.5 28 36	VDC
Input Current, hold-up capacitor charged		TYP	25	mA$_{RMS}$
Input Current while charging hold-up capacitor		MIN MAX	20 350	mA
Input Overvoltage, 100ms		MAX	50	VDC
Switching Frequency		TYP	310	kHz
Reflected Ripple		TYP	40	mA $_{P-P}$
Recommended Input Fuse			Note (2)	
Output Parameters				
Hold-up Cap voltage (pins 6 and 7)		MIN TYP MAX	44 45 46	VDC
Hold-up Cap Charge Time		TYP	330	ms
Maximum User Capacitance		MAX	50,000	μF
Response Time (4)		TYP	5	μs
V_{CAP} to V_{OUT} Voltage Drop		MIN	0.6	VDC
Hold-up Output Power		MAX	200	W
Hold-up capacitor aging		Contact the Factory		
V_{OUT} Voltage		MIN MAX	9.0 45.5	VDC
Output Capacitance (5)	$T_C \leq 80°C$	MAX	350	μF
	$T_C \leq 100°C$	MAX	170	μF
Control Parameters				
Trip Voltage	V_{PROG} = 0V	MIN TYP MAX	21.4 22 22.5	VDC
	V_{PROG} Open	MIN TYP MAX	17.5 18 18.5	VDC
	V_{PROG} = 5V	MIN TYP MAX	13 13.5 14	VDC
Trip Voltage Hysteresis		TYP	2.1	VDC
V_{PROG} Voltage		MIN MAX	0 5	VDC
Input Impedance		TYP	24	kOhm
Status Pin Voltage		MAX	50	VDC
Status Pin Current		MAX	2	mA

Notes:

(1) All parameters measured at Tc=25ºC, Vin=28VDC, unless otherwise noted. Refer to the CALEX Application Notes for the definition of terms, measurement circuits, and other information.

(2) Refer to the CALEX Application Notes for information on fusing.

(3) The HU-28 does not charge the hold-up capacitor when the input voltage is below the trip voltage.

(4) The response time is defined as the time from when the input voltage drops to the trip voltage to the time when the output voltage "V_{OUT}" starts rising.

(5) This capacitance includes all input capacitance on the downstream circuitry: internal and Co.

(6) Isolation is measured by applying a DC voltage between pins and baseplate.

(7) The case thermal impedance is defined as the case temperature rise over ambient per package watt dissipated.

(8) Thermal impedance is tested with the module mounted vertically and facing another printed circuit board 1/2 inch away.

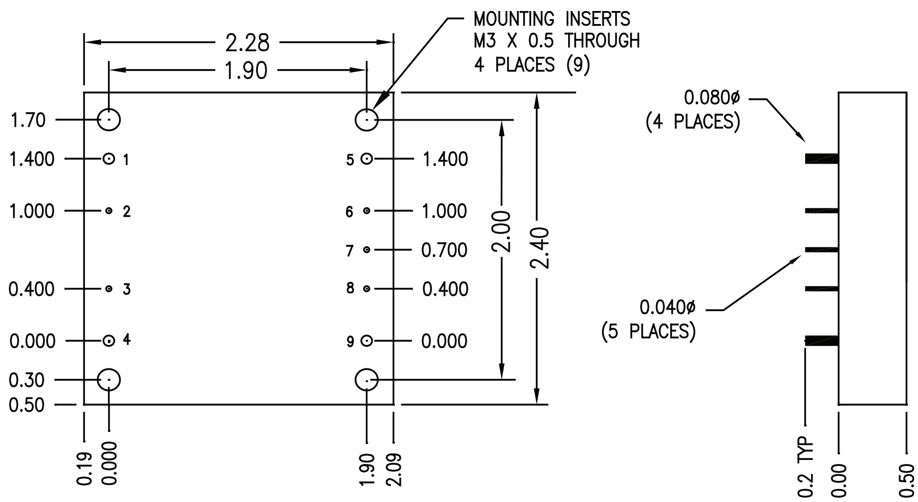
(9) Torque fasteners into threaded mounting inserts at 12 in. oz. or less. Greater torque may result in damage to unit and void the warranty.

(10) Calex CBAM™ modules are designed to withstand most solder/wash processes. Careful attention should be used when assessing the applicability in your specific manufacturing process. The CBAM™ modules are not hermetically sealed.

(11) MTBF is calculated based on MIL-HDBK-217F under the following conditions:
Reliability prediction method = Part Stress Analysis
Baseplate temperature = 40ºC
Environment = Ground, Benign

(12) Available with RoHS and Non-RoHS construction, contact factory for details.
RoHS Compliance means conformity to EU Directive 2002/95/EC of 27 January 2003, on the restriction of the use of certain hazardous substances in electrical and electronic equipment, lead, cadmium, mercury, hexavalent chromium, polybrominated biphenyls, and polybrominated diphenyl ethers are not present in quantities exceeding the following maximum concentrations in any homogeneous material, except for applicable exemptions.
0.1% (by weight of homogeneous material) lead, mercury, hexavalent chromium, polybrominated biphenyls, polybrominated diphenyl ethers, or 0.01% (by weight of homogeneous material) cadmium.
The RoHS marking is as follows.

Isolation			
Baseplate to Input (6)	MIN	700	VDC
Enviromental			
Baseplate Operating Temp Range	MIN MAX	-40 100	ºC
Storage Temperature Range	MIN MAX	-40 120	ºC
Case Thermal Impedance (7), (8)	TYP	7	ºC/Watt
MTBF MIL-STD-217F (11)	Contact the Factory		
General			
Unit Weight	TYP	125	g
Case Dimension		2.40" x 2.28" x 0.50"	
Torque on Mounting Inserts (9)	MAX	12 in. oz	



BOTTOM VIEW

SIDE VIEW

Pin	Diameter	Name
1	0.080"	+INPUT
2	0.040"	GND
3	0.040"	STATUS
4	0.080"	VPROG
5	0.080"	GND
6	0.040"	VCAP
7	0.040"	VCAP
8	0.040"	VOUT
9	0.080"	VOUT

Mechanical tolerances unless otherwise noted:
X.XX dimensions: ±0.020 inches
X.XXX dimensions: ± 0.005 inches

HU-28 Application Section

Hold-up Time

Hold-up time, as defined earlier, depends on downstream circuitry power draw, power loss in the HU-28, the amount of external hold-up capacitance, and the initial voltage of the hold-up capacitor.
Generally, for a C farad capacitor charged to V volts, the amount of energy available to provide hold-up is:

$$E = \frac{1}{2} \cdot C \cdot V^2 - \frac{1}{2} \cdot C \cdot 10^2$$

Therefore, a load drawing P watts will be supplied for t seconds:

$$t = \frac{E}{P} = \frac{1}{2} \cdot \frac{C}{P} \cdot (V^2 - 10^2)$$

Assuming full 45V charge in the hold-up capacitor, constant power draw, and *no loss in the HU-28*, the hold-up time can be estimated by:

$$t_h = \frac{1}{2} \cdot \frac{C}{P} \cdot (45^2 - 10^2)$$

where t_h is the hold-up time in seconds. The HU-28 has a 0.85mF internal hold-up capacitor. An external hold-up capacitor will increase hold-up time as shown in figure A1. In general, for a given power draw, the HU-28 can provide a hold-up time $t_{h,0}$ as shown in figure 3. If more hold-up time is desired, external capacitance Ch (mF) may be added. For a desired hold-up time, $t_{h,e}$, compute required capacitance as:

$$C_h = 0.85\left(\frac{t_{h,e}}{t_{h,0}} - 1\right)$$

For example, a 100W load requires 20ms hold-up time. According to figure 3, the HU-28 can only provide 8ms hold-up time. Therefore 0.85 • (20/8 -1) = 1.28mF of external capacitance is required.

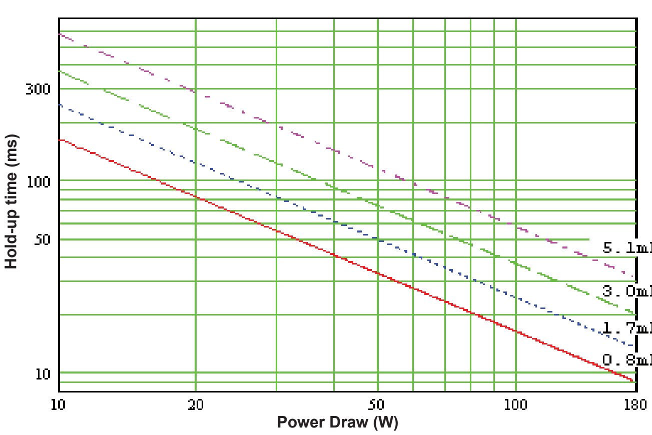


Figure A1. Hold-up time as a function of external capacitance (C_h) and power draw

Note that this hold-up time can only be achieved after the hold-up capacitor has been fully charged. Therefore the hold-up time is reduced or non-existent whenever the hold-up capacitor is not charged to 45V. *This condition is present immediately after start-up and immediately after recovering from a brown-out.* Power loss due to the voltage drop from V_{CAP} to V_{OUT} will slightly reduce this theoretical hold-up time.

Trip Voltage Set-point

There are three ways to set the trip voltage for the HU-28.

I. Connect a voltage source (0 to 5V) to V_{PROG} to obtain any trip voltage between 13.5V and 22V. The trip voltage may be computed as:

$V_{TRIP} = 21.9 - 1.69V_{PROG}$

Alternately it can be estimated from figure A2.

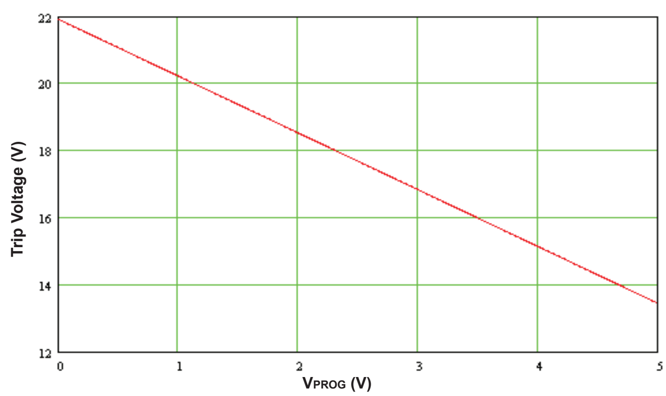


Figure A2. Trip voltage as a function of V_{PROG}

II. For 18V trip voltage, leave V_{PROG} open. Hysteresis is reduced to 1.6V.

III. External resistor method. This method allows the trip voltage to be set to any value between 13.5V and 22V, without using a separate voltage source. However, using this method, the hysteresis is reduced to as low as 1V, therefore stand-by mode may be entered whenever the line voltage rises as low as 1V above the trip voltage.

a. For a trip voltage smaller than 18V, connect a resistor between V_{PROG} and +INPUT as shown in figure A3. The trip voltage can be estimated from figure A4.

b. For a trip voltage greater than 18V, connect a resistor between V_{PROG} and GND as shown in figure A5. The trip voltage can be estimated from figure A6.

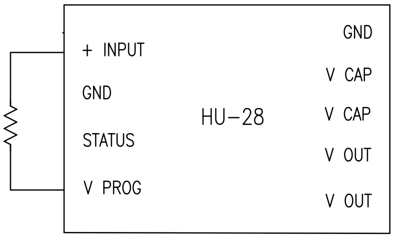


Figure A3. External resistor method for obtaining a trip voltage smaller than 18V

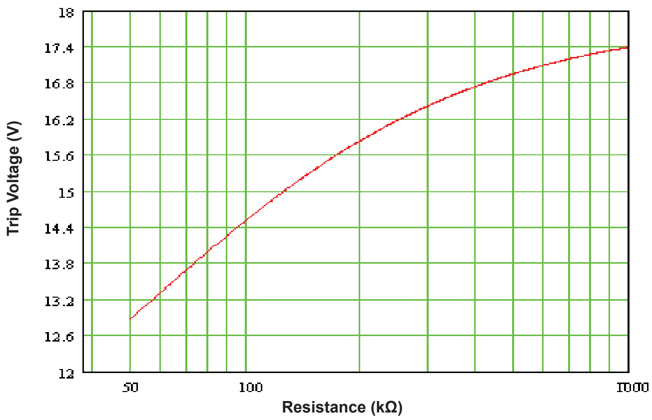


Figure A4. Trip voltage as a function or resistance connected between VPROG and +INPUT

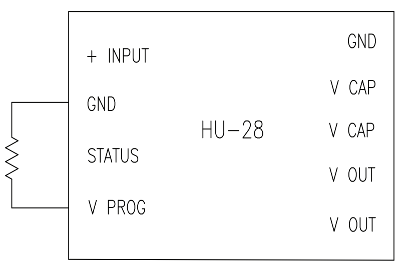


Figure A5. External resistor method for obtaining a trip voltage greater than 18V

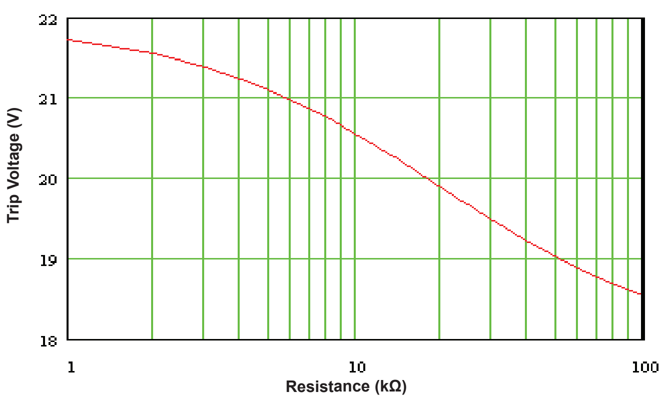


Figure A6. Trip voltage as a function of resistance connected between VPROG and GND

Follow these steps to pick a trip voltage:

1. Decide on the lowest acceptable voltage for the downstream circuitry.
2. Compute or measure the change in voltage on the positive input of the downstream circuitry during the 5µs HU-28 response time. This depends on downstream circuitry input capacitance (both internal and external), power draw, and trip voltage.
3. To obtain the trip voltage, add the two values above and the forward voltage drop of the input diode DI.

Status Pin

Pin 2, STATUS, allows external circuitry to monitor the state of the HU-28 as shown in the table below. This pin is connected to the open drain of a FET, therefore a pull-up resistor to the logic high voltage is required for normal operation.

Status Pin	HU-28 Status
logic low	Tripped
logic high	Stand-by

Figure A7 shows an arrangement where a TTL compatible signal is generated at the STATUS pin. VPROG is open, therefore the trip voltage is 18V. The voltage on +INPUT is ramped down then up. Figure A8 shows the behavior of the STATUS pin. Note that the HU-28 returns to stand-by mode only after +INPUT rises about 2V above the trip voltage.

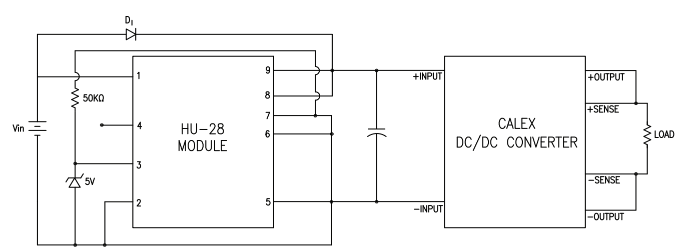


Figure A7. STATUS pin configured for TTL operation

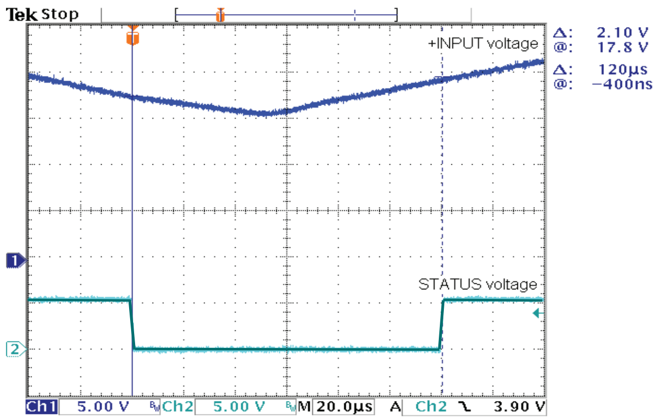


Figure A8. STATUS pin operation. ch1: +INPUT voltage, ch2: STATUS voltage

Ground Connection

There are two GND pins (2 and 5) on the HU-28. Avoid running current through the module from one pin to the other. The correct configuration is shown in figure A9. Some incorrect configurations are presented in figures A10a and A10b.

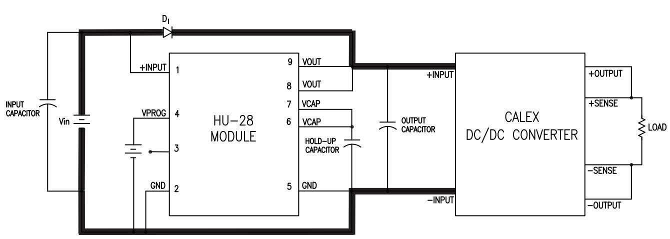


Figure A9. HU-28 properly configured to avoid high currents through the module

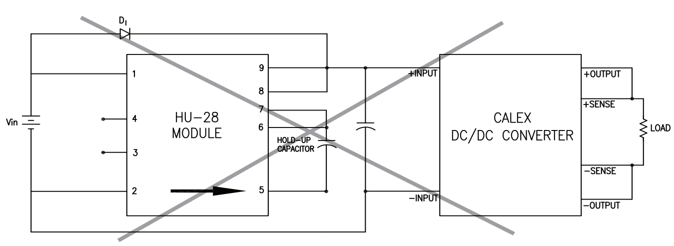


Figure A10a. Incorrect configuration: Hold-up current through HU-28

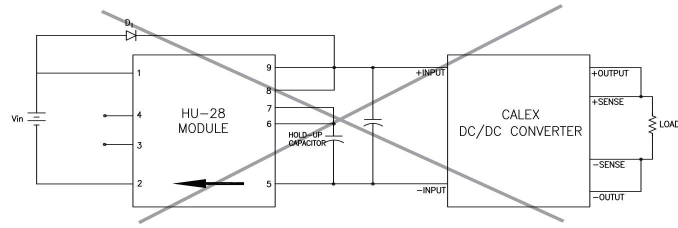


Figure A10b. Incorrect configuration: Converter current through HU-28

Hysteresis and Lack of Brown-out Protection

Once the HU-28 trips, the hold-up capacitor will not be recharged until the input voltage rises 2.1V above the trip voltage. If, after the HU-28 is tripped, the input voltage recovers but does not rise at least 2.1V over the trip voltage, the HU-28 will not provide any protection from any subsequent brown-out.

Consider the following scenario: The trip voltage is 18V. The line voltage (28V) drops out for 500ms. Uninterrupted power is provided by the HU-28. The line recovers, but only to 19V. The HU-28 remains in tripped mode, as the line voltage does not rise above 20V. Another 400ms brown-out occurs after which the line voltage fully recovers to 28V. Since the hold-up capacitor is only partially charged the HU-28 can not keep the load running. This is illustrated in figure A11. The same experiment is repeated after setting V_{PROG} to 3.5V for a trip voltage of 16V. The results are shown in figure A12.

To avoid this problem, set the trip voltage 2.1V lower than the lowest permissible value for the line voltage.

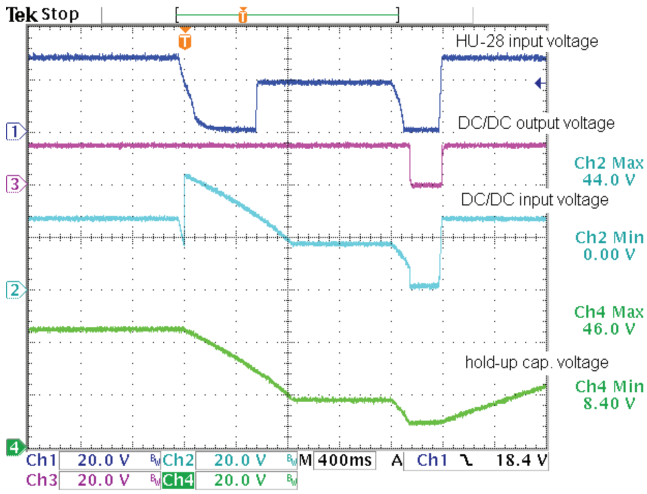


Figure A11. HU-28 does not provide protection due to high trip voltage.

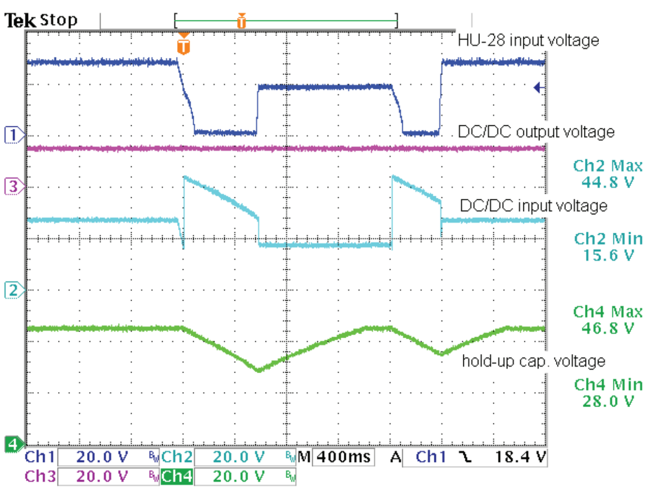


Figure A12. Lower trip voltage allows the HU-28 to provide protection.

Layout Issues

+INPUT connection.

Connect +INPUT directly to the anode of the input diode, DI. This will provide the best measurement of the input voltage.

Stray Inductance on Output.

Care must be taken to reduce stray inductance that may be present between any external hold-up capacitors, the HU-28, and the downstream circuitry. When HU-28 trips, the voltage on VOUT will suffer a step rise as large as 35V. This will be accompanied by a 35A inrush current into the output capacitance. Inductance present in the path of this current will cause a large voltage spike and/or ringing on VOUT.

HU-28 Input Capacitance

Ci and Co shown in figure 1 are optional and are not required for proper operation of the HU-28. Co may be used if downstream circuitry requires external capacitance. If the required input capacitance is greater than the limit set by the HU-28 output capacitance, Ci may be used in parallel with Co to attain the desired capacitance. When the HU-28 is used with Calex HEW series converters, 220µF for Ci and 40µF for Co are recommended. Depending on operating conditions and converter model, other values may be required.

Measurements

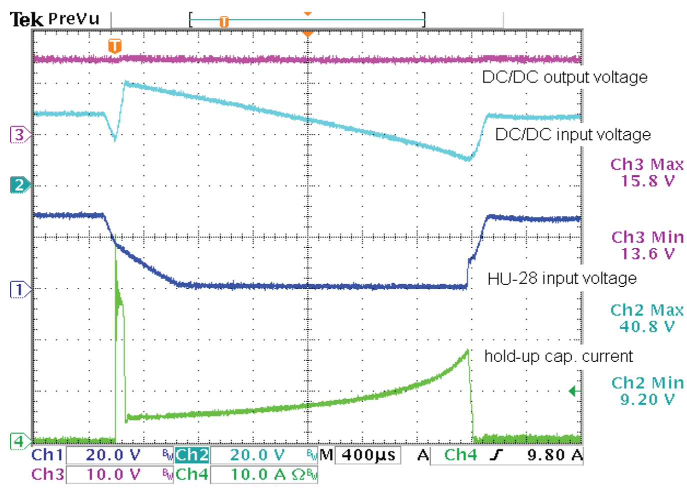


Figure A13. Brown-out event

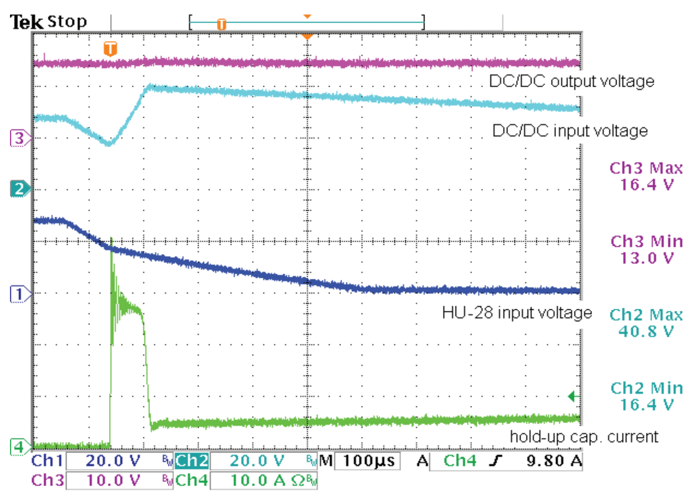


Figure A14. Start of brown-out event in figure A15

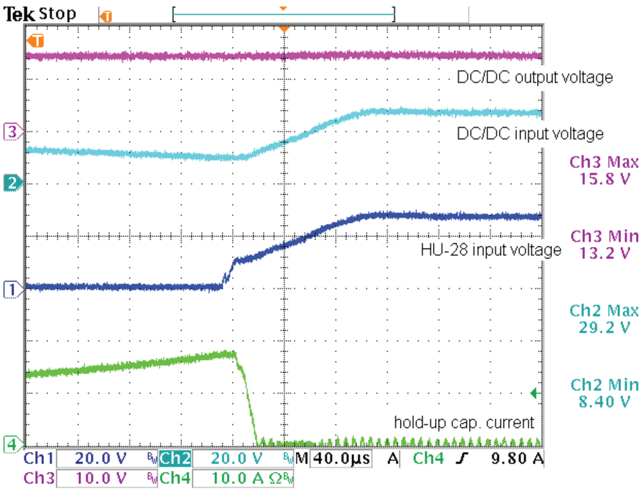


Figure A15. End of brown-out event in figure A13

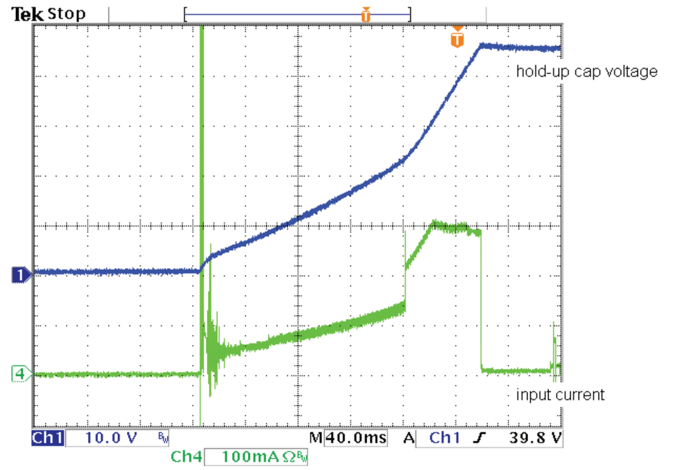


Figure A18. HU-28 input current (ch4) with respect to hold-up capacitor voltage (ch1) at +INPUT = 36V

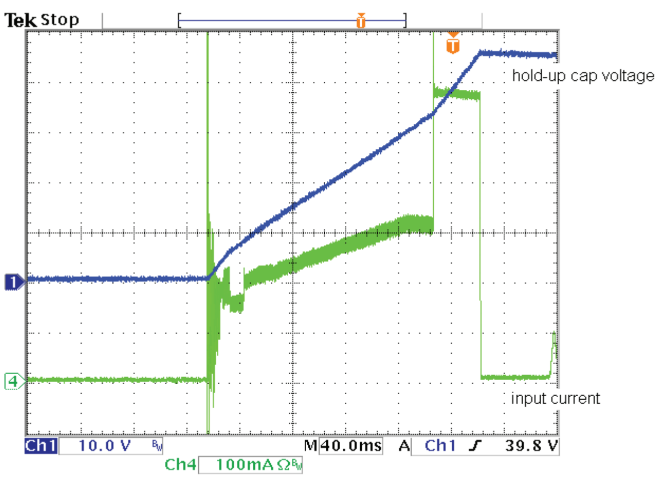


Figure A16. HU-28 input current (ch4) with respect to hold-up capacitor voltage (ch1) at +INPUT = 15.5V

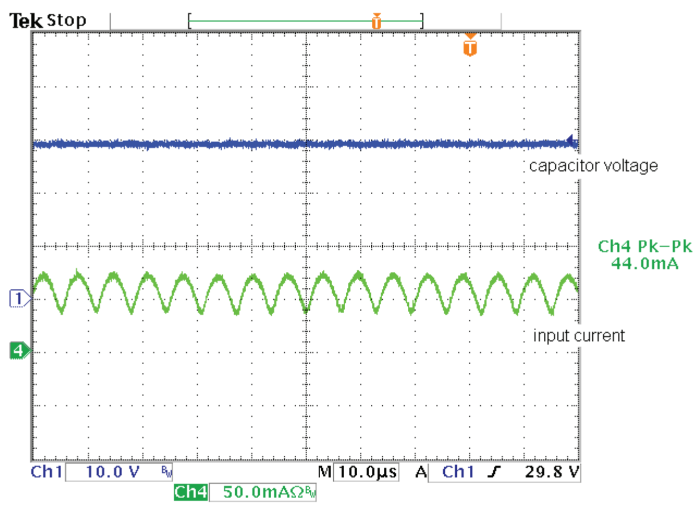


Figure A19. Typical input current ripple (ch4) while hold-up capacitor is charging (ch1)

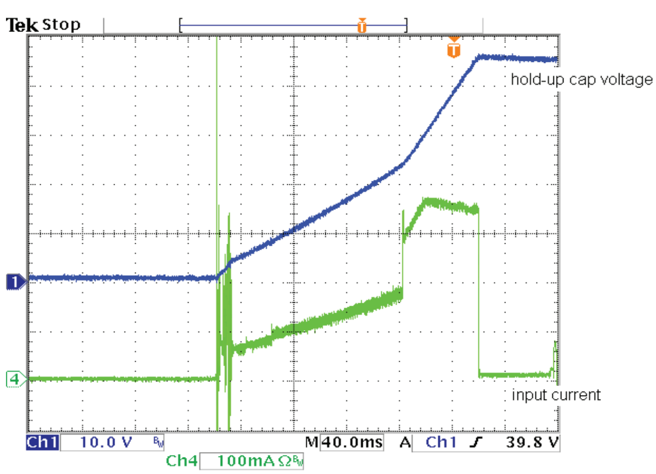


Figure A17. HU-28 input current (ch4) with respect to hold-up capacitor voltage (ch1) at +INPUT = 28V

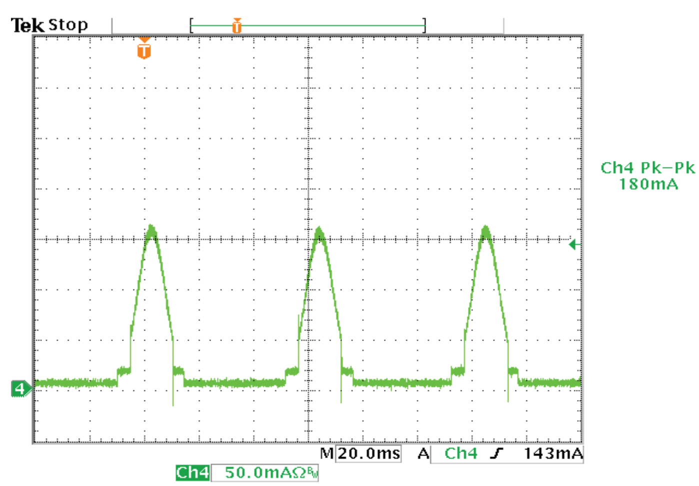


Figure A20. Typical input ripple when HU-28 is in stand-by mode