

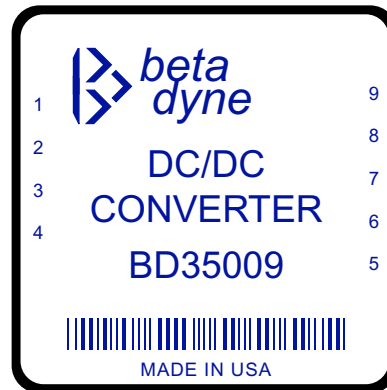


# BD35009

DC/DC CONVERTER  
 Single, Adjustable Output  
 18–36V<sub>IN</sub>, 24–32V<sub>OUT</sub>

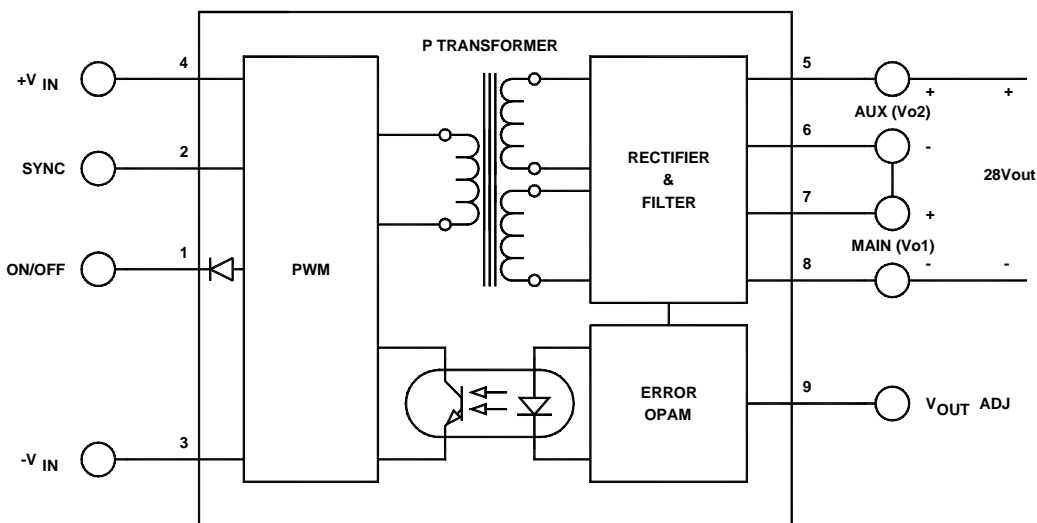
## Key Features

- Efficiency up to 84%
- 2:1 input voltage range
- Input under/overvoltage protection
- Input-to-output isolation
- Soft start
- Dual short circuit protection
- 500µA off state current
- Multiple converter synchronization
- Adjustable outputs
- 170kHz switching frequency
- Thermal protection
- Six-sided shielding



## Functional Description

The BD35009 is a single, adjustable output DC/DC converter that accepts 18–36V<sub>IN</sub> and generates a nominal 28V<sub>OUT</sub> between Pin 5 positive and Pin 8 negative. The output voltage can be adjusted from 24–32V<sub>OUT</sub>. The converter supplies 1A of output current for any output voltage from 24–32V<sub>OUT</sub>. Additional features include total input-to-output isolation, short circuit and thermal protection, soft start, under/overvoltage protection, and efficiency up to 84%.



Typical Block Diagram

## Electrical Specifications

### INPUT SPECIFICATIONS

Unless otherwise specified, all parameters are given under typical +25°C with nominal input voltage and under full output load conditions.

| PARAMETER                                       | CONDITION / NOTE                            | MIN | TYP  | MAX | UNIT              |
|---|---|-----|------|-----|-------------------|
| Input Voltage Range                             |   | 18  | 24   | 36  | Vdc               |
| Input Startup Voltage, 24V <sub>IN</sub>        |   | 17  | 18   |     | Vdc               |
| Input Overvoltage Protection, 24V <sub>IN</sub> |   | 37  | 38   |     | Vdc               |
| Input Filter                                    | Pi (π)                                      |     |      |     |                   |
| Reverse Polarity <sup>1</sup>                   | External series-blocking diode              |     |      |     |                   |
| Reflected Ripple <sup>2</sup> $\Delta$          | I <sub>o</sub> = FL, C <sub>IN</sub> = 10μF |     |      |     |                   |
| No Load Input Current                           |   |     | 30   |     | mA                |
| Full Load Input Current                         |   |     | 1380 |     | mA                |
| Input Surge Current (20μS Spike)                |   |     |      | 10  | A                 |
| Short Circuit Current Limit                     | See Short Circuit Protection                |     | 150  |     | % I <sub>IN</sub> |
| Off State Current                               |   |     | 500  |     | μA                |
| Remote ON/OFF Control                           |   |     |      |     |                   |
| Supply ON                                       | Pin 1 Open (Open circuit voltage: 13V max.) |     |      |     |                   |
| Supply OFF                                      |   | 0   |      | 0.8 | Vdc               |
| Logic Input Reference                           | -Input for ON/OFF and SYNC                  |     |      |     |                   |
| Logic Compatibility for Reference               | TTL Open Collector or CMOS Open Drain       |     |      |     |                   |
| Sync, High                                      | See External Synchronization, Figure 4      | 2   |      | 6   | Vdc               |
| Sync, Low                                       | See External Synchronization, Figure 4      | 0   |      | 0.8 | Vdc               |

### OUTPUT SPECIFICATIONS

| PARAMETER                    | CONDITION / NOTE          | MIN | TYP  | MAX | UNIT                                 |
|------------------------------|---------------------------|-----|------|-----|--------------------------------------|
| Output Voltage               |                           | 24  | 28   | 32  | Vdc                                  |
| Output Voltage Accuracy      |                           |     | ±1   | ±2  | %                                    |
| Output Current               |                           |     | 1    |     | A                                    |
| Ripple & Noise               | (See App. Note DC-003)    |     | 1    | 2   | %V <sub>PP</sub> of V <sub>OUT</sub> |
| Line Regulation, Single      |                           |     | ±0.5 | ±1  | %                                    |
| Load Regulation, Single      |                           |     | ±1   | ±2  | %                                    |
| Temperature Coefficient @ FL |                           |     | 0.02 |     | %/°C                                 |
| Transient Response Time      | 50% FL to FL to 50% FL    |     | 200  | 250 | μS                                   |
| Short Circuit Protection     | By input current limiting |     |      |     |                                      |
| Output Adjust Range          | See Figure 3              | ±5  |      | ±10 | %                                    |

### GENERAL SPECIFICATIONS

| PARAMETER                                    | CONDITION / NOTE          | MIN | TYP             | MAX | UNIT |
|--|---------------------------|-----|-----------------|-----|------|
| Efficiency                                   | V <sub>o</sub> = 28V @ 1A |     | 84              |     | %    |
| Isolation Voltage (1 min.), Input to Output  |                           |     | 1500            |     | Vdc  |
| Isolation Voltage (1 min.), Output to Output |                           |     | 500             |     | Vdc  |
| Isolation Resistance                         |                           |     | 10 <sup>9</sup> |     | Ω    |
| Isolation Capacitance                        |                           |     | 2700            |     | pF   |
| Switching Frequency                          |                           |     | 170             |     | kHz  |
| Turn On Delay                                | See Figure 6              |     | 7               | 10  | mS   |
| Soft Start Time                              | See Figure 6              |     | 7               | 15  | mS   |

## ENVIRONMENTAL SPECIFICATIONS

| PARAMETER                              | CONDITION / NOTE                         | MIN | TYP                 | MAX  | UNIT                 |
|--|--|-----|---------------------|------|----------------------|
| Operating Temperature Range (Ambient)* | See Figure 2                             | -40 |                     | +71  | °C                   |
| Storage Temperature Range              |  | -55 |                     | +125 | °C                   |
| Thermal Resistance                     | °C per watt internally dissipated        |     | 7                   |      | °C/W <sub>DISS</sub> |
| Maximum Operating Case Temperature     |  |     |                     | 110  | °C                   |
| Derating                               | See Figure 2                             |     |                     |      |                      |
| Cooling                                | Free-air convection                      |     |                     |      |                      |
| EM/RFI                                 | Six-sided continuous shielded metal case |     |                     |      |                      |
| MTBF                                   | per MIL-HNBK-217F (Ground benign, +25°C) |     | 1.1×10 <sup>6</sup> |      | hours                |
| Humidity                               | Up to 95% non-condensing                 |     |                     |      |                      |
| Thermal Shutdown                       | Case Temperature                         |     | 110                 | 115  | °C                   |
| Thermal Hysteresis                     |  | 2   | 5                   |      | °C                   |

\* See footnotes 3, 4 and 5

## PHYSICAL CHARACTERISTICS

| PARAMETER                               | CONDITION / NOTE                         | MIN | TYP | MAX | UNIT |
|---|--|-----|-----|-----|------|
| Dimensions (L×W×H)                      | 2.00×2.00×0.50 in. (50.80×50.80×12.70mm) |     |     |     |      |
| Weight                                  | 2.43 oz. (69g)                           |     |     |     |      |
| Case Material                           | Coated metal                             |     |     |     |      |
| Shielding Connection, 24V <sub>IN</sub> | -V <sub>N</sub> (Pin 3)                  |     |     |     |      |

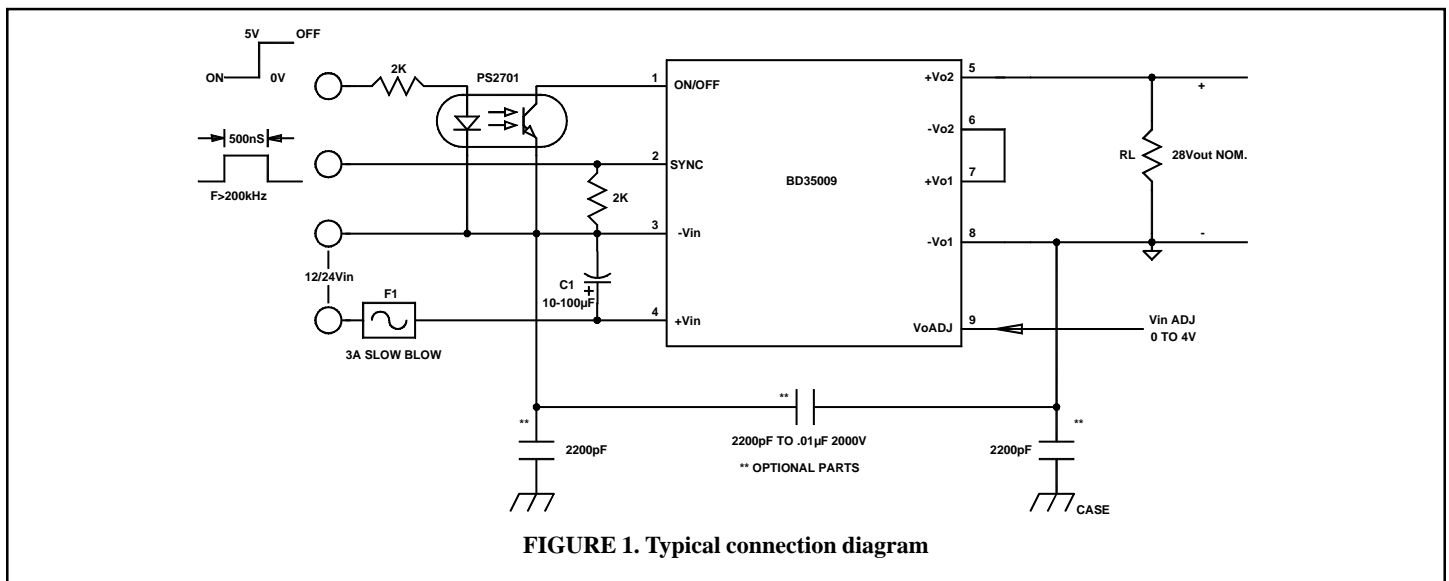
<sup>1</sup> ⚠ WARNING - Usage of input fuse with adequate ratings is essential to avoid possible hazard and damage of the unit. A suppressor diode with adequate ratings is intended to be connected in series to the supply for reverse polarity protection.

<sup>2</sup> Measured with 10μF capacitor at the input power pins.

<sup>3</sup> The maximum input current at any given input range measured at minimum input voltage is given as 1.6\*I<sub>NOMINAL</sub>. Nominal input current is the typical value measured at the input of the converter under full-load room temperature and nominal input voltage (24Vdc).

<sup>4</sup> Adequate insulation is to be provided to the converters at the end usage as per applicable requirements.

<sup>5</sup> Temperature rise on the case of the converters is to be considered during the end usage as per applicable requirements.



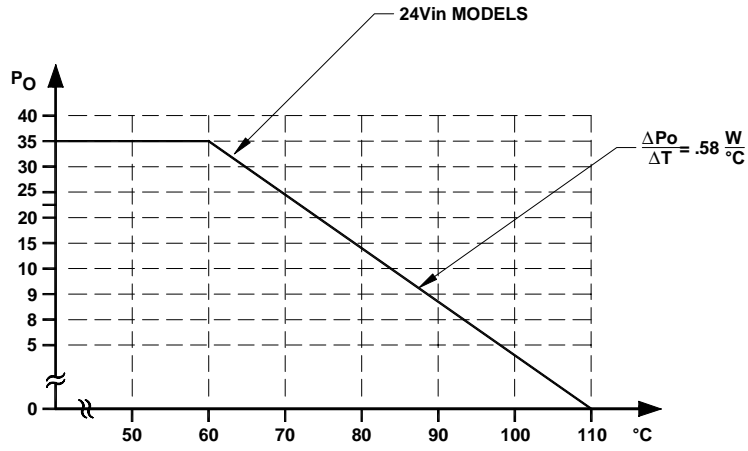


FIGURE 2. Typical derating curve for BD35009 with free air convection

**EXTERNAL TRIMMING OF OUTPUT VOLTAGES**

To trim the output voltage DOWN, connect a 5% 1/4W 1.5MΩ resistor (DO NOT GO BELOW 1MΩ) between the +V<sub>O1</sub> (Pin 7) output and trim pin of the converter. To trim the output voltage UP, connect a 5% 1/4W resistor between the -V<sub>O1</sub> (Pin 8) output and trim pins of the converter. For UP/DOWN trimming capability, connect a 2MΩ potentiometer between the + and - output pins, with the wiper arm connected to the trim pin.

The trim resistors/potentiometer can be connected at the con-

verter output pins or the load. However, if connected at the load, the resistance of the runs becomes part of the feedback network which improves load regulation. If the load is some distance from the converter, the use of #20 gauge wire is recommended to avoid excessive voltage drop due to the resistance of the circuit paths. See our application notes:

- DC-001: Testing Transient Response in DC/DC Converters
- DC-004: Thermal Consideration for DC/DC Converters

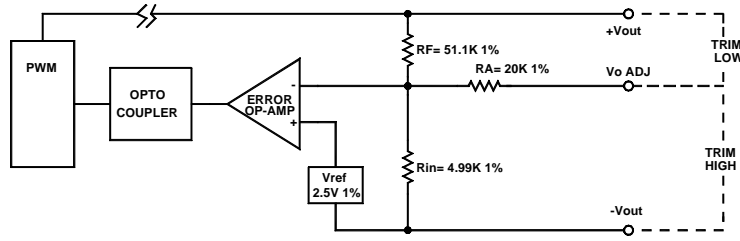


FIGURE 3. Output control circuit

$$V_o \cong 34.5 - 2.55V_{IN}$$

| V <sub>IN</sub> (V) | V <sub>O</sub> (V) |
|---------------------|--------------------|
| 0                   | 34.5               |
| 1                   | 31.9               |
| 2                   | 29.4               |
| 2.5                 | 28.1               |
| 3                   | 26.8               |
| 4                   | 24.3               |

### EXTERNAL SYNCHRONIZATION

A TTL signal applied at the SYNC pin of the converter will synchronize the switching frequency of the converter to that of the TTL input signal. The external (TTL) frequency must be equal or higher than the converter's frequency. At the positive-going edge of the applied pulse, the internal power-switching transistor turns off and the PWM discharges its timing capacitor. At the negative-going edge, the PWM resumes normal operation. The minimum positive pulse width of the TTL signal must be 300nS minimum

and its frequency between 150kHz and 180kHz. NOTE: Higher frequencies will reduce the efficiency of the converter and wide TTL pulses will force the PWM to follow the external TTL width modulation, which may effect regulation. A high TTL signal at the SYNC pin of the converter will turn the converter off. An internal pull-down resistor will keep this pin low when it is not used. A pulse differentiator (see Figure 5) can be used to shape a square wave sync signal as shown in Figure 4.

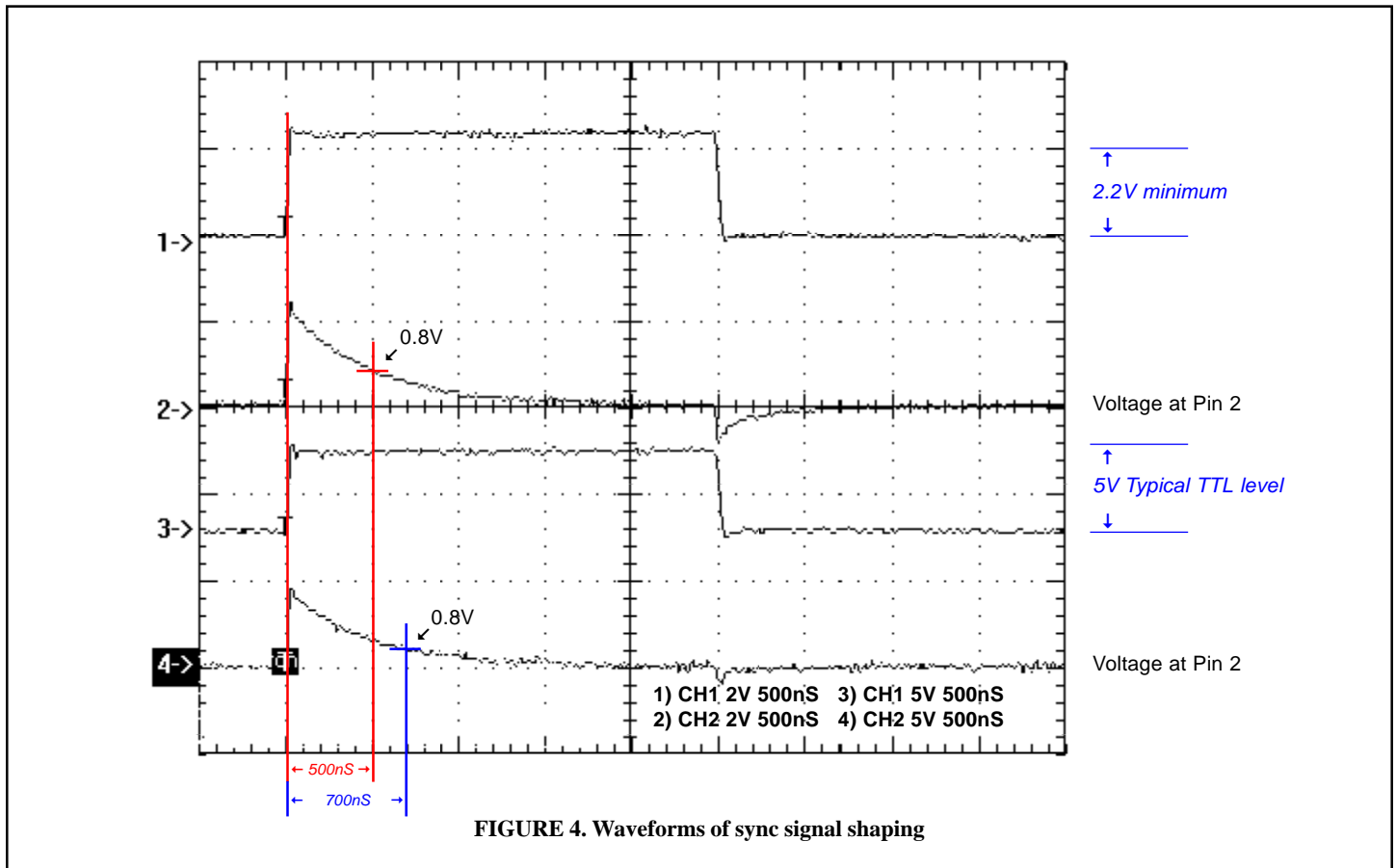


FIGURE 4. Waveforms of sync signal shaping

### SYNC SIGNAL SHAPING

As described in External Synchronization, the PWM of the converter requires a TTL signal of 0.8 to 2Vdc minimum amplitude and minimum duration of 300nS. When such a signal is not available (through one shot multivibrator or other pulse-shaping circuits) a C-R differentiator, such as the one in Figure 4, can be used to shape a square wave TTL signal. As is shown by the oscil-

logram in Figure 4, the positive edge of the sync pulse must be 2V minimum and the decaying exponential must reach the low 0.8Vdc in 300nS minimum from the positive edge. The parallel diode with the resistor is a small signal switching diode or a Schottky signal diode with 0.3 to 0.5V forward drop, it is used to clamp the voltage at pin 2 @ -0.5Vdc.

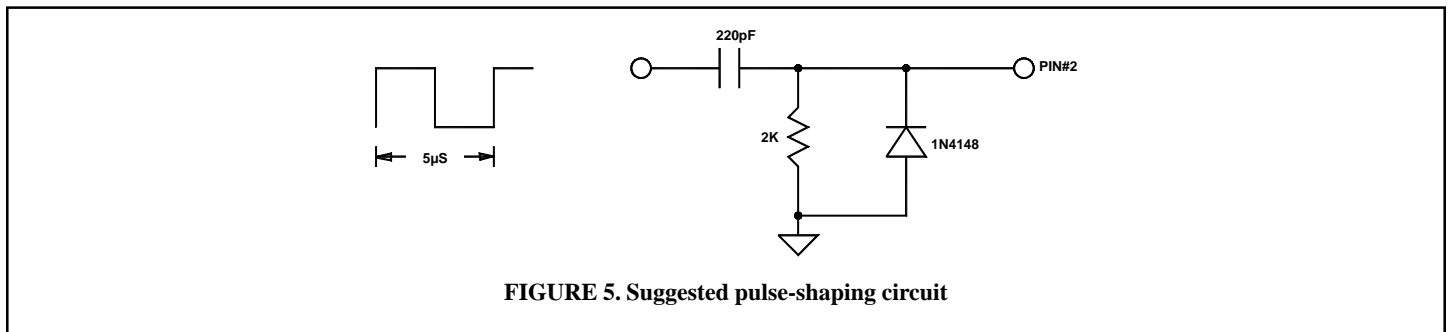


FIGURE 5. Suggested pulse-shaping circuit

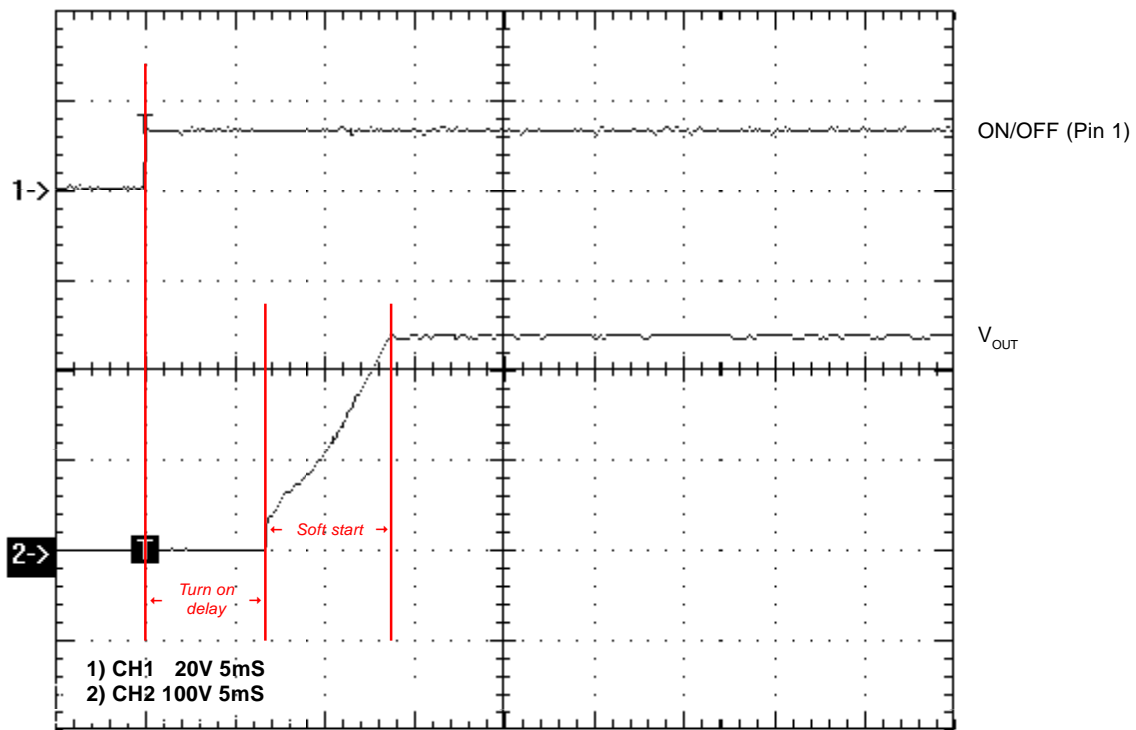


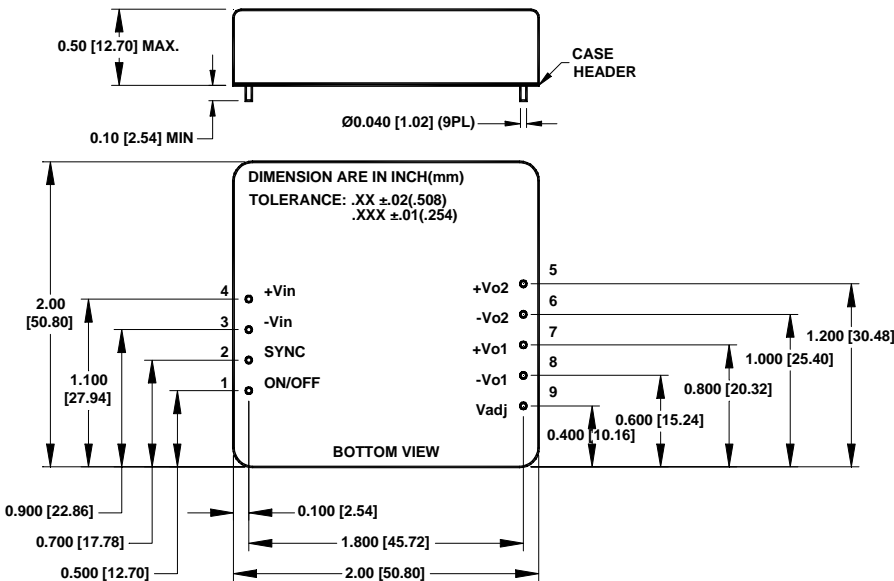
FIGURE 6. Turn on delay with soft start

### SHORT CIRCUIT PROTECTION

The converter has a dual short circuit protection feature. At the input side of the converter, two short circuit current comparators are used to monitor the input current of the converter. They are biased at different voltage levels; the lower threshold (LTH) comparator provides the power limiting function of the converter. Under normal operating conditions, the LTH comparator limits the output power of the converter when the maximum output power is exceeded.

When a hard short is applied across the output of the converter and the input current exceeds the set threshold of the second comparator, the converter goes into shutdown mode, the overcurrent latch is set and the converter is turned off. The converter will turn on again when its input voltage is recycled (OFF-ON) or if the ON/OFF pin is used to turn the converter on and off. The time required for the ON/OFF pin to be held low is between 100mS and 800mS.

### MECHANICAL SPECIFICATIONS



| Pin           | Function             |
|---------------|----------------------|
| <b>SINGLE</b> |                      |
| 1             | ON/OFF               |
| 2             | SYNC                 |
| 3             | -V <sub>IN</sub>     |
| 4             | +V <sub>IN</sub>     |
| 5             | +V <sub>O2</sub>     |
| 6             | -V <sub>O2</sub> *   |
| 7             | +V <sub>O1</sub> *   |
| 8             | -V <sub>O1</sub>     |
| 9             | V <sub>OUT</sub> ADJ |

\* Pins 6 and 7 are internally connected