HUMMER Hold-Up Module for DC-DC Converters
28 VOLT INPUT - 40 WATT

FEATURES

- Powers 28 volt dc-dc converters during power dropout
- Input voltage 12 to 40 volts
- Operating temperature -55° to +125°C
- Reduces hold-up capacitance by 80%
- Inhibit function
- Synchronization function
- Low power flag
- Hold up time 15 μs/μf

DESCRIPTION

The Interpoint® HUMMER™ Hold-Up Module Series provides a single product solution to the problem of maintaining electronic system operation during input power drop-out, typically reducing bulk capacitance requirements by more than 80%. The HUMMER module is compatible with the Interpoint dc-dc converters that have a 28 volt nominal input and a high input line of 40 volts.

The traditional procedure for providing hold-up during power loss is to buffer the device with enough bulk capacitance to allow a controlled shutdown to occur or an alternative power source to be brought on line. The problem with this approach is that very large capacitor banks are required because the capacitors are charged at the relatively low voltage at which power fails.

The HUMMER hold-up module provides an alternative with two important advantages: 1) it effectively reduces the low line voltage for normal dc-dc converter operation to 12 volts thereby reducing power drop-out events, and 2) it charges hold-up capacitors to 40 volts, reducing the capacitance needed to produce a given hold-up time.

GENERAL OPERATION

The HUMMER module and two external components (a hold-up capacitor and a diode) are connected between the line source and the dc-dc converter as shown in Figure 1 on page 2. If an EMI filter is employed, the HUMMER module is connected between the filter and the converter). The module first charges the external capacitor to 40 volts, and then allows the converter to operate off the line voltage. When the line voltage drops to between 12 to 18 volts, a boost converter in the module supplies an output at the capacitor charging voltage (40 volts). If power fails (the input voltage drops below 12 volts), the converter is powered from the external hold-up capacitor.

DETAILED OPERATIONAL DESCRIPTION

The detailed operation of the HUMMER module is divided into 4 operations: Initialization and Charging, Normal Operation, Low Line Operation, and Power Fail Operation. For details, refer to the following text, Figure 2 on page 2 and Figure 3 on page 3.

1. INITIALIZATION AND CHARGING

As the input voltage ramps up to 8 to 10 volts, the internal HUMMER module circuits are biased to provide correct output states on all flags. As the input reaches 14 volts, the power fail flag (active low) is released, the voltage control switch (VCS) is closed, and the module begins operating in a boost mode to charge the external capacitor to 40 volts. At this point, if the recommended connection has been made between the capacitor charged pin and the inhibit pin of the converter as shown in Figure 1 on page 2, all of the module energy is dedicated to charging the capacitor and the converter will be inhibited until the capacitor charge reaches 36 volts. If this connection has not been made, the energy available to charge the capacitor will be the difference between the current required by the converter’s load and the current capacity of the HUMMER module.

The HUMMER module is rated at a total operating power more than its output rating in order to allow it to both deliver a full load and to continue charging the external capacitor, for example, is rated at a 40 watt output and 60 watt total operating power, allowing it to deliver 40 watts to a load and charge a capacitor at 10 to 20 μ/sec). However, if the input voltage ramps up slowly into a full converter load, the total power drawn at low voltage could send the module into current limit which would shut the unit down.

MODELS

<table>
<thead>
<tr>
<th>OUTPUT POWER (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HUM-40</td>
</tr>
<tr>
<td>40 watts</td>
</tr>
</tbody>
</table>

Crane Aerospace & Electronics
Power Solutions – Interpoint Products
10301 Willows Rd. NE, Redmond, WA 98052
+1 425-882-3100 • power@crane-eg.com
www.craneae.com/interpoint
When the input voltage reaches approximately 22 volts dc, the VCS is opened, isolating the stored charge on the external capacitor and allowing the converter to operate directly from the input power bus via the external system diode (unless the converter is still inhibited by the connection between the Capacitor Charged pin and converter’s inhibit pin) while the capacitor continues to charge.

When the charge on the external capacitor reaches approximately 35 volts (80% of a full charge), the capacitor charged flag will be asserted (removing the inhibit from the converter if applicable) and the HUMMER module will be in normal operation.

2. NORMAL OPERATION
Normal operation continues with the capacitor charged and the input line voltage between 18 and 40 volts. During this time, the converter will operate from the line voltage through the external diode. When the external capacitor reaches its final charge of 40 volts, the HUMMER module enters an idle state, consuming only enough power to keep the capacitor charged. Idle state power for the module is approximately 1 watt.

The HUMMER module itself can sustain continuous voltages of up to 50 volts and voltage spikes of 80 volts for up to 50 msec, and it will pass these voltages on to the converter through the external bypass diode. If these ratings exceed the rating of the converter, care should be taken to control the line voltage to prevent damage to the converter.

Normal operation will continue indefinitely until the input voltage drops below 18 volts.

3. LOW LINE OPERATION
Low line operation occurs when the input voltage drops to a range between 18 and 12 volts. When the voltage reaches 18 volts, the HUMMER module’s VCS closes and then operates in a boost mode. In this mode, the HUMMER module supplies 40 volts through VCS to the converter, and at the same time maintains the charge on the capacitor. The module will operate indefinitely in this low line region until the input line voltage drops below 12 volts.
4. **POWER FAIL OPERATION**

When the input line voltage drops to 12 volts, the power fail flag is asserted (pulled low) and the HUMMER module’s boost mode is disabled. At this point, the converter load is powered by the stored energy in the external capacitor. When the voltage on the external capacitor falls to 20 volts, the capacitor charged flag is released (pulled low), indicating that 90% of the usable stored energy has been depleted. If the connection has been made between the Capacitor Charged pin and the converter’s Inhibit pin, the converter will also be inhibited.

**EXTERNAL CAPACITOR SELECTION**

The external capacitor supplies the energy for the dc-dc converter’s operation during power failure. Interpoint recommends CLR-79 or CLR-81 wet slug tantalum capacitors because of their high CV properties and extended temperature operation. An alternative choice is a high quality grade aluminum electrolytic. To ensure maximum system stability, the capacitors should have a minimum ESR of 0.25 ohms, a minimum capacitance of 330 µF, and a maximum capacitance of 1 F.

The capacitance needed and derating required will depend on the system requirements, the load, and the efficiency of the converter being supplied power. The amount of capacitance for a given hold-up time is determined by the formula:

\[ C = \frac{2P\Delta t}{n(V12 - V22)} \]

where:

- \( C \) is required capacitance (in Farads).
- \( P \) is power to the load (output of converter) to be held up (in watts)
- \( n \) is the efficiency of the converter at rated load (in %)
- \( \Delta t \) is required hold-up time (in seconds)
- \( V1 \) is charged capacitor voltage (in volts)
- \( V2 \) is low-line voltage of dc-dc converter (in volts)

For a 50 msec hold-up of 30 watts output from a converter with an efficiency of 80%, a 16 volt low line and a 40 volt capacitor charge:

\[ C = \frac{(2) \cdot (30) \cdot (0.050)}{(0.80) \cdot (402 - 162)} = 3 \approx 2790 \mu F \]

\[ C = 1075.2 \]

**FIGURE 3: HUMMER MODULE BLOCK DIAGRAM**

The output power delivered by the HUMMER module to deliver 30 watts to the load with an 80% efficient converter is 37.5 watts. The HUM-40 is rated to deliver a maximum of 40 watts to the input of the converter. Interpoint data sheets for individual converters supply an efficiency curve vs. line and load for each converter model. In calculations, assume the efficiency rating for the nominal (usually 28 volt) line condition.

If the Capacitor Charged pin is connected to the converter’s inhibit pin as shown in Figure 1 on page 2, use 20 V as the low line figure in the formula.
DIODE SELECTION AND CONNECTION
An external diode is required for system operation as shown in
Figure 1 on page 2, with the diode cathode connected to
the HUMMER module’s VCS pin and the dc-dc converter’s +V
in pin. This diode supplies input voltage to the converter when
the internal voltage control switch (VCS) is open. The diode
should be selected with a minimum current rating of 5 A and a
voltage breakdown rating of 50 V or greater (similar to Motorola
MDR1060 or equivalent).

CAUTION: Do not connect the HUMMER module’s input return
pin to the Cext return. This connection will short the module’s
current limit sense resistor resulting in excessive currents that
can also damage the dc-dc converter.

INHIBIT FUNCTION
The HUMMER module’s inhibit pin disables the internal boost
converter when the Inhibit pin is pulled low. This is accomplished
by an external connection to the Vin Return pin or Vout Return
pin. The inhibit open circuit voltage is is 10 V and the short circuit
current is 15 mA. It is open-collector TTL or CMOS compatible.
The pin is diode-isolated and can be reverse biased to include
the input potential. Power Fail and Capacitor Charged flags are
operable when the unit is inhibited.

FLAG FUNCTIONS
POWER FAIL FLAG
The Power Fail Flag output is implemented by a comparator
monitoring the input voltage. (The comparator is also used to
inhibit HUMMER module’s operation; note however, that the
flag is functional when the unit is inhibited.) The input voltage
threshold is nominally 14.5 volts to indicate that sufficient voltage
is present for operation. The comparator output drives an internal
MOSFET buffer which connects to the external Power Fail pin.
The buffer is of an open drain configuration and requires an
external pull-up resistor and voltage for indication. The maximum
recommended pull-up voltage is 36 volts. The maximum short circuit
should not exceed 10 mA. The buffer is protected by a shunt zener diode connected between the drain and the Cext
Return. In normal operation, the input voltage exceeds the 14
volt threshold and the output is high (open drain). When the input
voltage is below 12 volts the output is low, and the MOSFET
conducts to the Return.

CAPACITOR CHARGED FLAG
A capacitor charged flag is implemented by a comparator
monitoring the HUMMER module’s +Cext terminal. The capacitor
voltage threshold is 36 volts, at which point the external
capacitor is charged to 80% of its maximum value. When the
capacitor discharges, the flag resets at 20 volts indicating that
approximately 10% of the charge remains. The comparator
output drives a MOSFET buffer amplifier, and the buffer output
connects to the Cap Charged pin. The buffer is of an open drain
configuration and requires a pull-up resistor and voltage for
indication. The maximum recommended pull-up voltage is 36
volts. The maximum short circuit current should not exceed 10
mA. During normal operation, the input is 40 volts, exceeding
the threshold, and the output is high (open circuit). When the
capacitor voltage is below 20 volts, the output is low, and the
MOSFET conducts to the Return. The HUMMER module must be
supplied with a minimum of 8 volts dc for biasing internal circuits
to obtain correct output states.

\[
C = \frac{2P\Delta t}{n(V1^2 - V2^2)}
\]

where:

- \( C \) is required capacitance (in Farads).
- \( P \) is power to the load (output of converter) to be held up
  (in watts)
- \( n \) is the efficiency of the converter at rated load (in %)
- \( \Delta t \) is required hold-up time (in seconds)
- \( V1 \) is charged capacitor voltage (in volts)
- \( V2 \) is low-line voltage of dc-dc converter (in volts)

For a 50 msec hold-up of a 30 watt output from a converter with
a efficiency of 80%, a 16 volt low line and a 40 volt capacitor
charge:

\[
C = \frac{(2) \cdot (30) \cdot (0.050) \cdot (0.80) \cdot (40^2 - 16^2)}{1075.2} = 2790 \mu F
\]

The output power delivered by the HUMMER module to deliver
30 watts to the load with an 80% efficient converter is 37.5
watts. The HUM-40 is rated to deliver a maximum of 40 watts
to the input of the converter. Interpoint data sheets for individual
converters supply an efficiency curve vs. line and load for each
converter model. In calculations, assume the efficiency rating for
the nominal (usually 28 volts) line condition.

If the Capacitor Charged pin is connected to the converter’s
inhibit pin as shown in Figure 1 on page 2, use 20 volts as
the low line figure in the formula.
HUMMER Hold-Up Module for DC-DC Converters

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**PIN OUT**

<table>
<thead>
<tr>
<th>Pin</th>
<th>HUM-40</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No connection</td>
</tr>
<tr>
<td>2</td>
<td>Voltage Control Switch (VCS)</td>
</tr>
<tr>
<td>3</td>
<td>Ext. Capacitor, Positive (+ CEXT)</td>
</tr>
<tr>
<td>4</td>
<td>Ext. Capacitor, Return (CEXT Return)</td>
</tr>
<tr>
<td>5</td>
<td>Input Common</td>
</tr>
<tr>
<td>6</td>
<td>Positive Input</td>
</tr>
<tr>
<td>7</td>
<td>Case Ground</td>
</tr>
<tr>
<td>8</td>
<td>Cap Charged Flag</td>
</tr>
<tr>
<td>9</td>
<td>Inhibit</td>
</tr>
<tr>
<td>10</td>
<td>Power Fail Flag</td>
</tr>
</tbody>
</table>

**TABLE 1: PIN OUT**

**MODEL NUMBERING KEY**

- **Base Model**: HUM - 40
- **Output Power**: F
- **Case Option**: (Non-flanged case has no designator in this position)
- **Screening**: (Standard screening has no designator in this position)

**FIGURE 5: MODEL NUMBERING KEY**

**MODEL NUMBER OPTIONS**

To determine the model number enter one option from each category in the form below.

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>Base Model</th>
<th>Case Options ¹</th>
<th>Screening ²</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPTIONS</td>
<td>HUM-40</td>
<td>(non-flanged, leave blank)</td>
<td>(standard, leave blank)</td>
</tr>
</tbody>
</table>

**FILL IN FOR MODEL #**

<table>
<thead>
<tr>
<th>Model #</th>
</tr>
</thead>
<tbody>
<tr>
<td>HUM-40</td>
</tr>
</tbody>
</table>

**Notes**

1. Case Options: For the standard case, Figure 6 on page 7, leave the case option blank. For the flanged case option, Figure 7 on page 8, insert the letter F in the Case Option position.

2. Screening: For standard screening leave the screening option blank. For the /ES screening option, insert /ES level. For more information see Table 5 on page 9.

**TABLE 2: MODEL NUMBER OPTIONS**
HUMMER Hold-Up Module for DC-DC Converters

28 VOLT INPUT - 40 WATT

**TABLE 3: OPERATING CONDITIONS: 25°C TC, 28 V_{IN}, 100% LOAD, UNLESS OTHERWISE SPECIFIED.**

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEAD SOLDERING TEMPERATURE ¹</td>
<td>10 SECONDS MAX.</td>
<td></td>
<td></td>
<td>300</td>
<td>°C</td>
</tr>
<tr>
<td>STORAGE TEMPERATURE ¹</td>
<td>-65</td>
<td></td>
<td>+135</td>
<td></td>
<td>°C</td>
</tr>
<tr>
<td>CASE OPERATING TEMPERATURE</td>
<td>FULL POWER</td>
<td>-55</td>
<td></td>
<td>+125</td>
<td>°C</td>
</tr>
<tr>
<td>INHIBIT ACTIVE LOW (OUTPUT DISABLED)</td>
<td>INHIBIT PIN PULLED LOW</td>
<td></td>
<td></td>
<td>0.8</td>
<td>V</td>
</tr>
<tr>
<td>Do not apply a voltage to the inhibit pin. ³</td>
<td>INHIBIT PIN SOURCE CURRENT ¹</td>
<td></td>
<td></td>
<td>15</td>
<td>mA</td>
</tr>
<tr>
<td>INHIBIT ACTIVE HIGH (OUTPUT ENABLED)</td>
<td>REFERENCED TO INPUT COMMON</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do not apply a voltage to the inhibit pin. ³</td>
<td>INHIBIT PIN CONDITION</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>OPEN COLLECTOR OR UNCONNECTED</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OPEN INHIBIT PIN VOLTAGE ¹</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td>V</td>
</tr>
</tbody>
</table>

**Notes**
1. Guaranteed by test and/or analysis. Not an in-line test.
2. Full load for specifications is 40 W for HUM-40.

**TABLE 4: ELECTRICAL CHARACTERISTICS: 25°C TC, 28 V_{IN}, 100% LOAD, FREE RUN, UNLESS OTHERWISE SPECIFIED.**

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>OUTPUT VOLTAGE</td>
<td>CEXT TERMINAL</td>
<td>39</td>
<td>40</td>
<td>V</td>
</tr>
<tr>
<td>OUTPUT POWER</td>
<td>CONTINUOUS PEAK</td>
<td></td>
<td>40</td>
<td>W</td>
</tr>
<tr>
<td></td>
<td>2 SEC</td>
<td></td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>INPUT VOLTAGE</td>
<td>CONTINUOUS</td>
<td>12</td>
<td>50</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>TRANSIENT 50 ms</td>
<td></td>
<td>80</td>
<td>V</td>
</tr>
<tr>
<td>INPUT CURRENT</td>
<td>$V_{IN} = 28$ V, VCS OPEN</td>
<td></td>
<td>90</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td>$V_{IN} = 28$ V, INHIBITED</td>
<td></td>
<td>10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$V_{IN} = 12$ V, FULL LOAD</td>
<td></td>
<td>4.6</td>
<td>A</td>
</tr>
<tr>
<td>INPUT RIPPLE CURRENT</td>
<td>2 MHz BANDWIDTH</td>
<td></td>
<td>100</td>
<td>mA p-p</td>
</tr>
<tr>
<td>EFFICIENCY</td>
<td>$V_{IN} = 40$ V, FULL LOAD</td>
<td>92</td>
<td></td>
<td>%</td>
</tr>
<tr>
<td></td>
<td>$V_{IN} = 22$ V, FULL LOAD</td>
<td>87</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$V_{IN} = 12$ V, FULL LOAD</td>
<td>80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HOLD-UP TIME</td>
<td>FULL LOAD</td>
<td>15</td>
<td></td>
<td>µs/µF</td>
</tr>
<tr>
<td>POWER FAIL FLAG THRESHOLD</td>
<td>HIGH, OPEN CIRCUIT</td>
<td>14.0</td>
<td>14.5</td>
<td>V</td>
</tr>
<tr>
<td>THRESHOLD</td>
<td>LOW, SHORT RETURN</td>
<td>11.5</td>
<td>12.0</td>
<td></td>
</tr>
<tr>
<td>CAPACITOR VOLTAGE</td>
<td>OPEN</td>
<td>22</td>
<td>24</td>
<td>V</td>
</tr>
<tr>
<td>CONTROLLED SWITCH</td>
<td>CLOSED</td>
<td>18</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>CAP CHARGED FLAG</td>
<td>HIGH, OPEN CIRCUIT</td>
<td>34</td>
<td>36</td>
<td>V</td>
</tr>
<tr>
<td>THRESHOLD</td>
<td>LOW, SHORT RETURN</td>
<td>19.5</td>
<td>20.5</td>
<td></td>
</tr>
</tbody>
</table>

**Notes**
1. Full load for specifications is 40 W for HUM-40.
HUMMER Hold-Up Module for DC-DC Converters

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BOTTOM VIEW CASE F2
HUM-40

Solder Seal

Solder Tip-off

Squared corner and dot on top of case indicate pin one.

Seal hole: 0.083 ±0.003 (2.11 ±0.08)

Case dimensions in inches (mm)
Tolerance
±0.005 (0.13) for three decimal places
±0.01 (0.3) for two decimal places
unless otherwise specified

CAUTION
Heat from reflow or wave soldering may damage the device.
Solder pins individually with heat application not exceeding 300°C for 10 seconds per pin.

Materials
Header Cold Rolled Steel/Nickel/Tin
Cover Cold Rolled Steel/Nickel/Tin
Pins #52 alloy; compression glass seal or ceramic seal
Tin plating of 150 to 250 microinches
Seal hole 0.120 ± 0.005 (2.34 ± 0.05)

Case F2 HUM, Rev E, 2015.11.11
Please refer to the numerical dimensions for accuracy

FIGURE 6: CASE F2
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BOTTOM VIEW CASE J2
Flanged case: Designator required in Case Option position of model number.

Case dimensions in inches (mm)
Tolerance ±0.005 (0.13) for three decimal places
±0.01 (0.3) for two decimal places
unless otherwise specified

CAUTION
Heat from reflow or wave soldering may damage the device. Solder pins individually with heat application not exceeding 300°C for 10 seconds per pin.

Materials
Header Cold Rolled Steel/Nickel/Gold
Cover Kovar/Nickel
Pins #52 alloy/Gold compression glass seal
Tin plating of 150 to 250 microinches
Seal Hole: 0.091 ±0.001 (2.31 ±0.03)

FIGURE 7: CASE J2
**TABLE 1: ENVIRONMENTAL SCREENING DC-DC CONVERTERS AND EMI FILTERS STANDARD AND /ES, NON-QML^1**

<table>
<thead>
<tr>
<th>TEST PERFORMED</th>
<th>STANDARD</th>
<th>/ES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-cap Inspection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Method 2017, 2032</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature Cycle (10 times)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Method 1010, Cond. B, -55°C to +125°C, ambient</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant Acceleration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Method 2001, 500 g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burn-in Method 1015^2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>96 hours</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final Electrical Test MIL-PRF-38534, Group A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subgroups 1 and 4: +25°C case</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hermeticity Test</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gross Leak, Cond. C_1, fluorocarbon</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fine Leak, Cond. A_2, helium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gross Leak, Dip</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final visual inspection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Method 2009</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Test methods are referenced to MIL-STD-883 as determined by MIL-PRF-38534.

Notes
1. Standard and /ES, non-QML products, may not meet all of the requirements of MIL-PRF-38534.
2. Burn-in temperature designed to bring the case temperature to the maximum case temperature of the product. Refer to the specific product information for the maximum case temperature. Burn-in is a powered test.

**TABLE 5: ENVIRONMENTAL SCREENING**