



OPAL-RT



OP8665 Controller Interface User Guide

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SYMBOL DEFINITIONS

The following table lists the symbols used in this document to denote certain conditions:

Symbol	Definition
	ATTENTION: Identifies information that requires special consideration
	TIP: Identifies advice or hints for the user, often in terms of performing a task
	REFERENCE _ INTERNAL: Identifies an additional source of information within the bookset.
CAUTION	Indicates a situation which, if not avoided, may result in equipment or work (data) on the system being damaged or lost, or may result in the inability to properly operate the process.
	Indicates a situation where users must observe precautions for handling electrostatic sensitive devices.
	CAUTION: Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury. It may also be used to alert against unsafe practices.
	WARNING: Indicates a potentially hazardous situation which, if not avoided, could result in serious injury or death.

OP8665 CONTROLLER INTERFACE

INTRODUCTION

The OP8665 Controller Interface is a rapid control prototyping platform.

It allows the user to interface a commercial DSP quickly and easily with an OPAL-RT real-time simulator. The OP8665 comes with one TI TMDSCNCD28335 module, cabling, power supplies and the software suite from TI as well as code composer studio for the development of the controller code.

FEATURES

Main features of the OP8665 Controller Interface :

- Support for up to two development boards hosting one DSP card each,
- Easily accessible signal probing area,
- Can and Serial (RS232) communication ports
- Direct interface to OPAL-RT simulators via DB37 cable
- Switches and potentiometers for injection of stimuli
- User configurable status LED
- JTAG connector interface for programming and debugging
- Analog and digital input protection
- Scaled analog inputs
- Breakout signals via jumpers
- On board 5V and 3.3V regulator

CONTROLLER INTERFACE DESCRIPTION

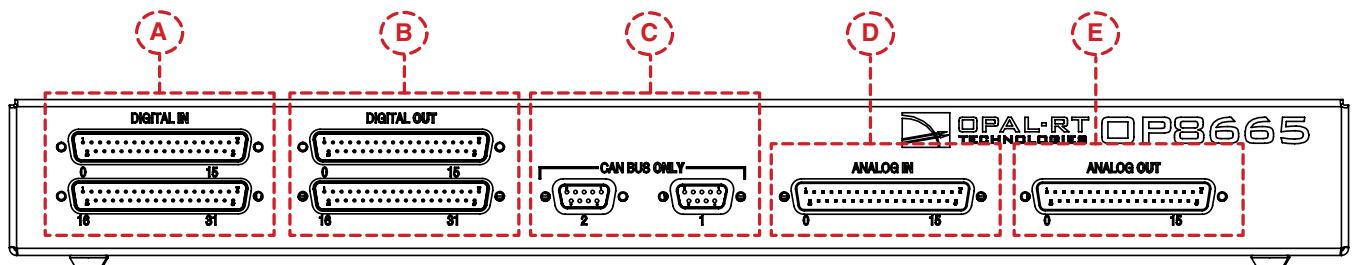


Figure 1: Front view

- DIGITAL IN: 32 channels split over two DB37 male connectors. Each connector can be connected to the digital output channels of the OPAL-RT real-time simulator via a pin to pin DB37 female to male cable
- DIGITAL OUT: 32 channels split over two DB37 male connectors. Each connector can be connected to the digital output channels of the OPAL-RT real-time simulator via a pin to pin DB37 female to male cable
- CAN BUS ONLY: 2 DB9 female connectors
- ANALOG IN: Each connector can be connected to the analog output channels of the OPAL-RT real-time simulator via a pin to pin DB37 female to male cable
- ANALOG OUT: Each connector can be connected to the analog input channels of the OPAL-RT real-time simulator via a pin to pin DB37 female to male cable.

CONTROLLER INTERFACE BOARD

The controller interface is divided into two identical sections: Section1 on the right and Section2 on the left. Each section can connect to one controller board. A single power source, located in Section 1, is used for both sections. The signals from the DB37 are equally distributed between both sections, according to the Pin Assignments table.

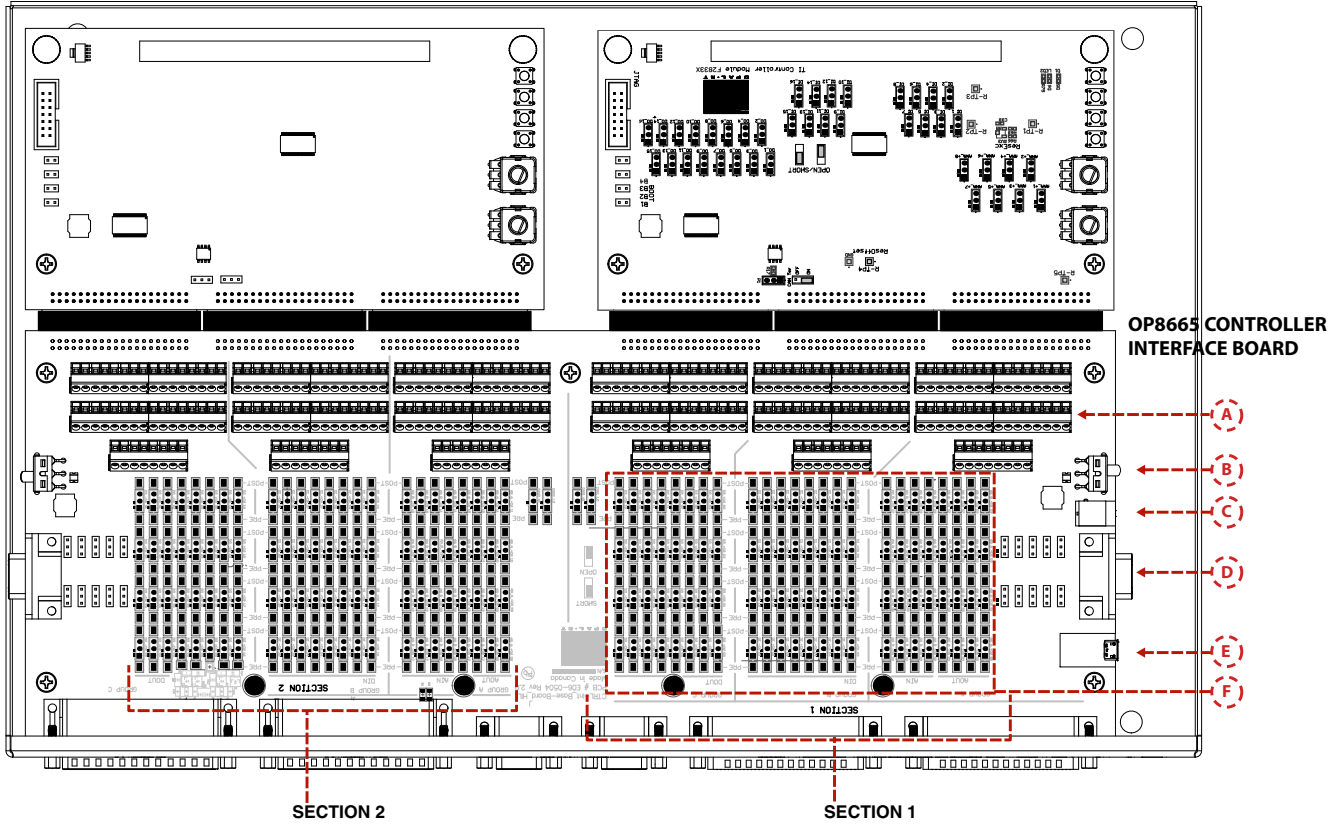


Figure 2: OP8665 with controller interface and two controller boards

- A. **Screw terminal area:** connect to probe signals
- B. **Power On/Off Switch:** 1 for each section, with green status LED
- C. **Power Input:** 12V connector in Section 1 powers both sections
- D. **RS232:** 1 DB9 female for each section
- E. **USB to UART Adaptor:** 1 USB connector for each section, with green status LED
- F. **TestPoint Area**

TEST POINT AREA

By default, the OP8665 board has a probing area provides test points that have an integrated 0 Ohm resistor: the user can probe the signals either before (PRE, HIL side) or after (POST, controller side) of the signal break.

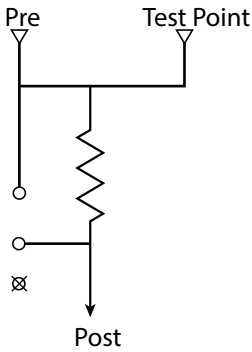


Figure 3: Typical circuit diagram

The OP8665 controller interface also has an available option to add a breakout area (with pins and jumpers) to open or short a signal. The user can move the jumper to an open/short position to simulate faults or to jump a signal.

CONTROLLER BOARD DESCRIPTION

The controller board holds the Texas Instrument DSP module via a 100-pin DIMM interface. It also offers a number of features designed to make using the OP8665 more flexible and easy.

It allows users to scale 0-16V to 0-3.3V. Analog inputs are scaled using the scaling factor $V_o = V_i * (1 / 4.74)$, as in this example:

$V_i = 10V$ (From HIL)
 $10V * (1 / 4.74) = 2.1097V$ at the TI Controller

The controller board is powered by the controller interface (OP8665) via the 12V input power supply. It is connected to the interface board through three (3) 40-pin connectors.

Switches and potentiometers let users inject stimulus, a JTAG interface provides access for programming and debugging. The controller board also provides input protection.

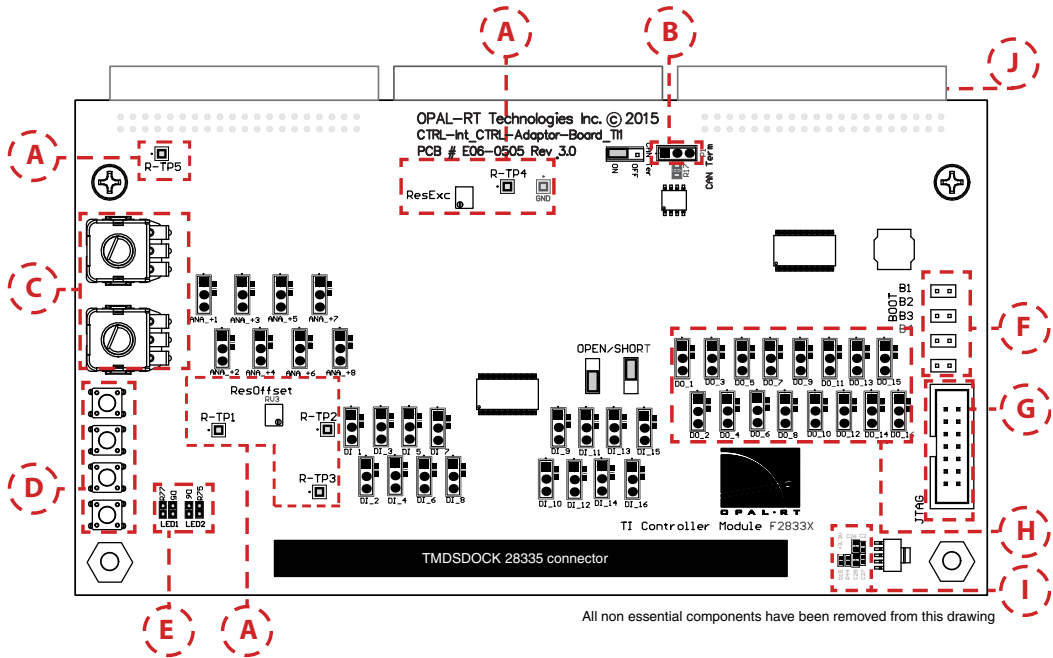


Figure 4: Controller board features

- A. Resolver signal calibration potentiometers (3)
- B. CAN Jumper, to connect or disconnect the CAN to DSP
- C. Potentiometers, to select controller supply of either a 0V to 3.3V input
- D. 4 push button switches to drive DSP input
- E. LEDs displaying DSP output
- F. BOOT selector jumpers. For OPAL-RT technicians' use or by engineers familiar with TI controller programming.
- G. JTAG connector for programming or debugging
- H. 36 Jumpers for input/output control resolver signal calibration
- I. Power LEDs

 ResOffset and ResExc labels are inverted in Version 2.x of 126-0505. Make sure to invert connections, as necessary. Failure to do so may result in incorrect results obtained when operating the system.

CONTROLLER BOARD FEATURES

A: Resolver Offset potentiometer	The Controller Board provides a Resolver circuit. The Resolver circuit can be calibrated via two potentiometers and the signals can be probed via test points. RV3: used to adjust the Resolver SIN and COS signal offsets. The offset voltage can be measured by probing R-TP1 R-TP1: used to adjust 0.5-3.3V (adjustment in RV3 provides 1.5V on R-TP1) R-TP2: used to probe SIN offset value R-TP3: used to probe COS offset value																																	
A: Resolver Excitation calibration potentiometer	RV4: RV4: used to adjust the resolver excitation signal's voltage amplitude. R-TP4 is used to probe the excitation signal output of the Resolver Circuit																																	
B: CAN jumper settings	Users can add a 120 Ohm resistor simply by placing the CAN jumper in the ON position, as shown.																																	
C: Potentiometer settings	User potentiometers provide 0V to 3.3V output: POT1 is used for ADC_A5 POT2 is used for ADC_B5																																	
D: DSP switches	User switches SW1 to SW4. These switches are Normally Open and pulled-up to 3.3V. Press and hold to obtain 0 V (release to return to 3.3 V). SW1 – GPIO59 SW2 – GPIO58 SW3 – GPIO61 SW4 – GPIO60.																																	
E: DSP output display LEDs	Only ON when voltage is at 0. LED1 -> GPIO62 LED2 -> GPIO63																																	
F: BOOT selector jumpers	Selector Jumpers: these jumpers are reserved for OPAL-RT technicians or engineers who are experienced with Texas Instruments controllers. <table><tr><td>Jumper ID</td><td>Signal</td></tr><tr><td>B1</td><td>GPIO84</td></tr><tr><td>B2</td><td>GPIO85</td></tr><tr><td>B3</td><td>GPIO86</td></tr><tr><td>B4</td><td>GPIO87</td></tr></table>	Jumper ID	Signal	B1	GPIO84	B2	GPIO85	B3	GPIO86	B4	GPIO87																							
Jumper ID	Signal																																	
B1	GPIO84																																	
B2	GPIO85																																	
B3	GPIO86																																	
B4	GPIO87																																	
G: JTAG connector	allows the user to debug/flash the TI controller <table><tr><th>Signal</th><th>Pin</th><th>Signal</th><th>Pin</th></tr><tr><td>TMS</td><td>1</td><td>TRSTN</td><td>2</td></tr><tr><td>TDI</td><td>3</td><td>GND</td><td>4</td></tr><tr><td>NC</td><td>5</td><td>NC</td><td>6</td></tr><tr><td>TDO</td><td>7</td><td>GND</td><td>8</td></tr><tr><td>TCK</td><td>9</td><td>GND</td><td>10</td></tr><tr><td>TCK</td><td>11</td><td>GND</td><td>12</td></tr><tr><td>EMU0</td><td>13</td><td>EMU1</td><td>14</td></tr></table>	Signal	Pin	Signal	Pin	TMS	1	TRSTN	2	TDI	3	GND	4	NC	5	NC	6	TDO	7	GND	8	TCK	9	GND	10	TCK	11	GND	12	EMU0	13	EMU1	14	
Signal	Pin	Signal	Pin																															
TMS	1	TRSTN	2																															
TDI	3	GND	4																															
NC	5	NC	6																															
TDO	7	GND	8																															
TCK	9	GND	10																															
TCK	11	GND	12																															
EMU0	13	EMU1	14																															
H: Input/output jumpers	Jumpers allow users to insert a short or leave the circuit open, as needed. Each jumper controls a specific channel, identified at each jumper on the board (see image opposite).																																	
I: Power LEDs	Green when 3.3V power is functioning																																	

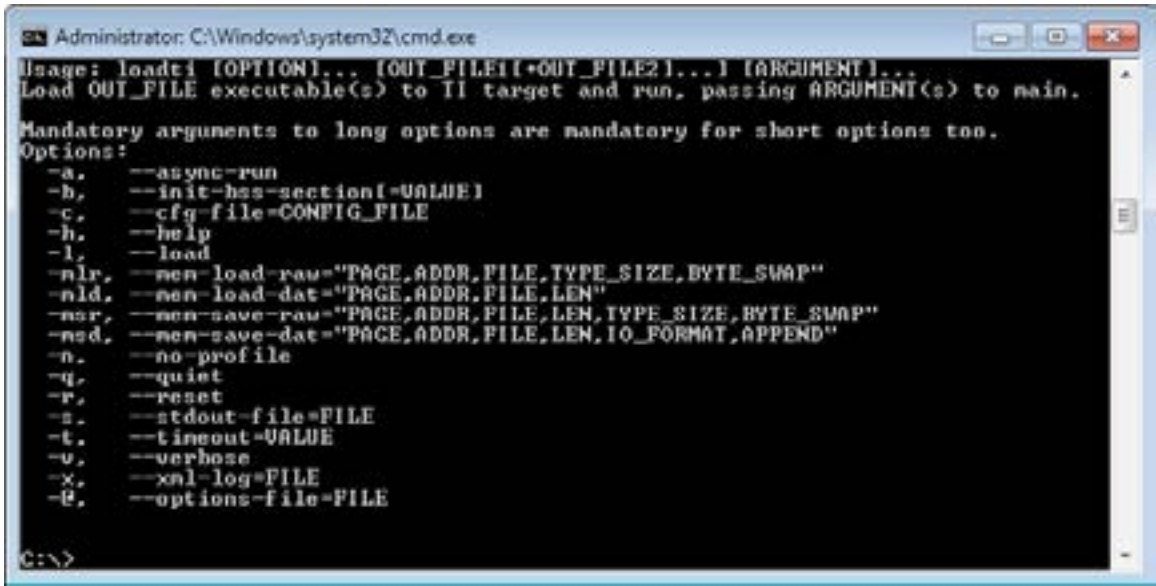
BOARD SETUP

The following section explains how to use the loadti application in order to flash the TI module. Before proceeding, make sure you have:

1. Installed Version of Code Composer Studio from TI (ccsv4, ccsv5 or ccsv6)
2. JTAG XDS100v2 hardware and cables
3. OP8665 setup with power supply
4. Target configuration file (.ccxml) and binary file to be flashed (.out)
 - Target configuration file: TMS320F28335_v2.ccxml
 - Binary file: openloop_can.out

STEPS

1. Open the Command Prompt window by clicking the Start button, clicking All Programs, clicking Accessories, and then clicking Command Prompt.
2. Type one of the following lines, depending on the version of CodeComposer Studio installed on your PC, to run loadti from any location:
 - CCSv4: set PATH=%PATH%;"<INSTALL PATH>\ccsv4\scripting\examples\loadti"
 - CCSv5: set PATH=%PATH%;"<INSTALL PATH>\ccsv5\ccs_base\scripting\examples\loadti";
 - CCSv6: set PATH=%PATH%;"<INSTALL PATH>\ccsv6\ccs_base\scripting\examples\loadti";
3. Once the location of loadti is added to the system PATH, it can be called anywhere. To validate that the path is properly set, type loadti in the command prompt window. The following options will appear:



```
Administrator: C:\Windows\system32\cmd.exe
Usage: loadti [OPTION]... [OUT_FILE1[+OUT_FILE2]...] [ARGUMENT]...
Load OUT_FILE executable(s) to TI target and run, passing ARGUMENT(s) to main.

Mandatory arguments to long options are mandatory for short options too.
Options:
-a, --async-run
-b, --init-has-section[=VALUE]
-c, --cfg-file=CONFIG_FILE
-h, --help
-l, --load
-nlr, --non-load-raw="PAGE,ADDR,FILE,TYPE_SIZE,BYTE_SWAP"
-nld, --non-load-dat="PAGE,ADDR,FILE,LEN"
-nsr, --non-save-raw="PAGE,ADDR,FILE,LEN,TYPE_SIZE,BYTE_SWAP"
-nsd, --non-save-dat="PAGE,ADDR,FILE,LEN,IO_FORMAT,APPEND"
-n, --no-profile
-q, --quiet
-r, --reset
-s, --stdout-file=FILE
-t, --timeout=VALUE
-u, --verbose
-x, --xml-log=FILE
-e, --options-file=FILE

C:\>
```

Figure 6: Windows command prompt window

You are now ready to flash the program to the TI module.

4. Connect the XDS100v2 TI 14 pin JTAG Emulator to JTAG connector on the controller board (OPAL-RT part number 126-0505), as shown in Figure 7.
5. Connect one end of the USB cable provided (Type A) to a free USB port on the PC being used. Connect the other end (mini-A) to J1 connector on the JTAG Emulator. DS1 indicator will turn on. See Figure 2

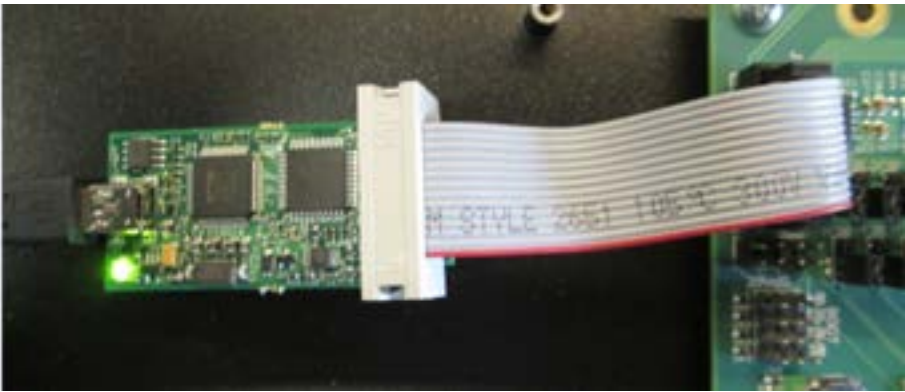
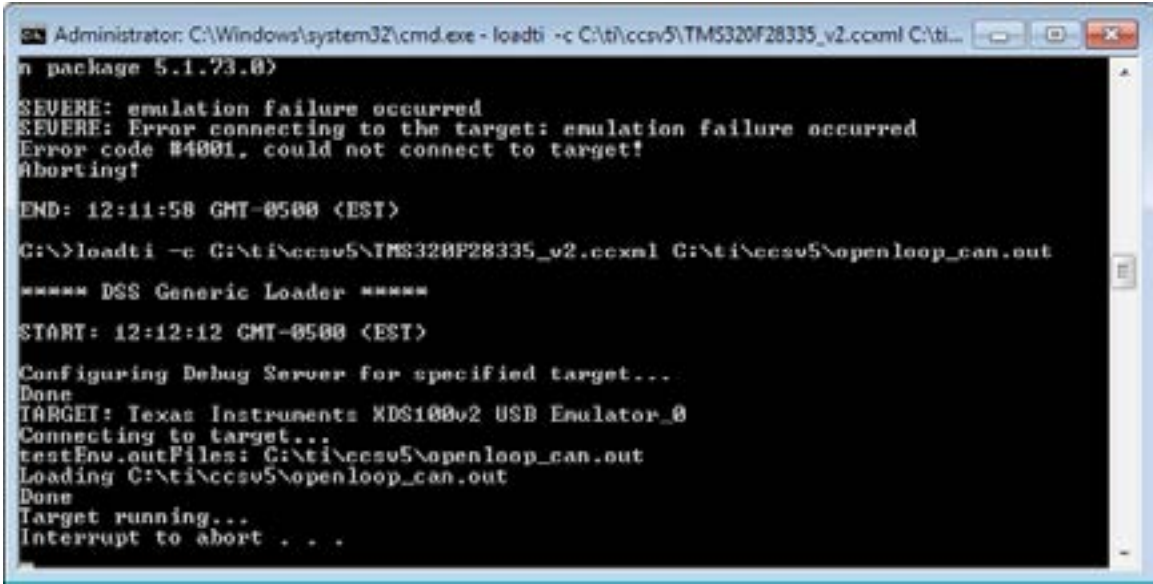


Figure 7: Connect JTAG emulator to controller board JTAG

6. Make sure the TI module is powered ON (TI module LD1 LED is on)
7. Flash the program to the TI Module by typing the following command:
loadti -c C:\<location of saved files>\TMS320F28335_v2.ccxml C:\<location of saved files>\openloop_can.out

The output on the command prompt window should look like this:



```
Administrator: C:\Windows\system32\cmd.exe - loadti -c C:\ti\ccsv5\TMS320F28335_v2.ccxml C:\ti...
n package 5.1.73.0)

SEVERE: emulation failure occurred
SEVERE: Error connecting to the target: emulation failure occurred
Error code #4001, could not connect to target!
Aborting!

END: 12:11:58 GMT-0500 (EST)

C:\>loadti -c C:\ti\ccsv5\TMS320F28335_v2.ccxml C:\ti\ccsv5\openloop_can.out

***** DSS Generic Loader *****

START: 12:12:12 GMT-0500 (EST)

Configuring Debug Server for specified target...
Done
TARGET: Texas Instruments XDS100v2 USB Emulator_0
Connecting to target...
testEnv.outFiles: C:\ti\ccsv5\openloop_can.out
Loading C:\ti\ccsv5\openloop_can.out
Done
Target running...
Interrupt to abort . . .
```

Figure 8: output command prompt window

8. Once the module is programmed, LED indicator D6 will blink every two seconds.
- When the loading is complete, the batch file can be interrupted by typing CTRL-C. You are now ready to use the TI module

SPECIFICATIONS

Product name	OP8665 Controller Interface
Input power	12V, 3A, 36W 12V, 3A, 36W Max 15V
I/O connectors	DB9, DB37, RS232, screw terminals
Number of channels	Up to 32 DI and 32 DO (each side of the controller interface connects to 16 DI and 16 DO of the real-time simulator) Up to 16 ADC : 8 ADC on each controller board
Compatibility (TI boards)	F2808, F28044, F28335, F2803x, F2860x, F28M35x modules The basic OP8665 board uses the same standard pinout as the TI C2000. We are therefore compatible, pin-to-pin, with the boards listed, regardless if the F28335 comes with the module by default.
Dimensions (HxWxD)	5.41 x 43.18 x 27.28 cm (2.13" x 17" x 10.74")
Maximum rated ambient temperature	0C to 70C (32°F to 158°F)
Relative humidity	10 to 90% non-condensing
Maximum altitude	2000 m (6562 ft.)

OP8665 PIN ASSIGNMENTS

The DB37 connector pins are assigned to specific channels, as shown in the image.

Screw Terminals		40 pin connector		Signal Description			TI TMDSDOCK28335 Board signals			
ID	Pin	ID	Pin	From Connector	Signal Name	Pin	Signal Name	Connector	Pin	Description
"ST1A-1 ST2A-1"	1	"CN1-A CN2-A"	1	DB37 - IO	"AOut +00 AOut +08"	9	Resolver Excitation +	J1	26	GPIO6/EPWM4A/EPWMSYNCI/ EPWMSYNCO
"ST1A-2 ST2A-2"	1	"CN1-A CN2-A"	2	DB37 - IO	"AOut -00 AOut -08"	28	Resolver Excitation -			GND
"ST1A-1 ST2A-1"	2	"CN1-A CN2-A"	3	DB37 - IO	"AOut +01 AOut +09"	10				
"ST1A-2 ST2A-2"	2	"CN1-A CN2-A"	4	DB37 - IO	"AOut -01 AOut -09"	29				
"ST1A-1 ST2A-1"	3	"CN1-A CN2-A"	5	DB37 - IO	"AOut +02 AOut +10"	11				
"ST1A-2 ST2A-2"	3	"CN1-A CN2-A"	6	DB37 - IO	"AOut -02 AOut -10"	30				
"ST1A-1 ST2A-1"	4	"CN1-A CN2-A"	7	DB37 - IO	"AOut +03 AOut +11"	12				
"ST1A-2 ST2A-2"	4	"CN1-A CN2-A"	8	DB37 - IO	"AOut -03 AOut -11"	31				
"ST1A-1 ST2A-1"	5	"CN1-A CN2-A"	9	DB37 - IO	"AOut +04 AOut +12"	13				
"ST1A-2 ST2A-2"	5	"CN1-A CN2-A"	10	DB37 - IO	"AOut -04 AOut -12"	32				
"ST1A-1 ST2A-1"	6	"CN1-A CN2-A"	11	DB37 - IO	"AOut +05 AOut +13"	14				
"ST1A-2 ST2A-2"	6	"CN1-A CN2-A"	12	DB37 - IO	"AOut -05 AOut -13"	33				
"ST1A-1 ST2A-1"	7	"CN1-A CN2-A"	13	DB37 - IO	"AOut +06 AOut +14"	15				
"ST1A-2 ST2A-2"	7	"CN1-A CN2-A"	14	DB37 - IO	"AOut -06 AOut -14"	34				
"ST1A-1 ST2A-1"	8	"CN1-A CN2-A"	15	DB37 - IO	"AOut +07 AOut +15"	16				
"ST1A-2 ST2A-2"	8	"CN1-A CN2-A"	16	DB37 - IO	"AOut -07 AOut -15"	35				

Screw Terminals		40 pin connector		Signal Description			TI TMDSDOCK28335 Board signals			
ID	Pin	ID	Pin	From Connector	Signal Name	Pin	Signal Name	Connector	Pin	Description
"ST1A-3 ST2A-3"	1	"CN1-A CN2-A"	17	DB37 - IO	"Aln +00 Aln +08"	1	ADCINA0	J1	57	
"ST1A-4 ST2A-4"	1	"CN1-A CN2-A"	18	DB37 - IO	"Aln -00 Aln -08"	20	AGND			
"ST1A-3 ST2A-3"	2	"CN1-A CN2-A"	19	DB37 - IO	"Aln +01 Aln +09"	2	ADCINA1	J1	59	
"ST1A-4 ST2A-4"	2	"CN1-A CN2-A"	20	DB37 - IO	"Aln -01 Aln -09"	21	AGND			
"ST1A-3 ST2A-3"	3	"CN1-A CN2-A"	21	DB37 - IO	"Aln +02 Aln +10"	3	ADCINA2	J1	61	
"ST1A-4 ST2A-4"	3	"CN1-A CN2-A"	22	DB37 - IO	"Aln -02 Aln -10"	22	AGND			
"ST1A-3 ST2A-3"	4	"CN1-A CN2-A"	23	DB37 - IO	"Aln +03 Aln +11"	4	ADCINA3	J1	63	
"ST1A-4 ST2A-4"	4	"CN1-A CN2-A"	24	DB37 - IO	"Aln -03 Aln -11"	23	AGND			
"ST1A-3 ST2A-3"	5	"CN1-A CN2-A"	25	DB37 - IO	"Aln +04 Aln +12"	5	ADCINB0	J1	7	
"ST1A-4 ST2A-4"	5	"CN1-A CN2-A"	26	DB37 - IO	"Aln -04 Aln -12"	24	AGND			
"ST1A-3 ST2A-3"	6	"CN1-A CN2-A"	27	DB37 - IO	"Aln +05 Aln +13"	6	ADCINB1	J1	9	
"ST1A-4 ST2A-4"	6	"CN1-A CN2-A"	28	DB37 - IO	"Aln -05 Aln -13"	25	AGND			
"ST1A-3 ST2A-3"	7	"CN1-A CN2-A"	29	DB37 - IO	"Aln +06 Aln +14"	7	ADCINB2, ADCINA4 (Revolver Sin)	J1	11, 65	
"ST1A-4 ST2A-4"	7	"CN1-A CN2-A"	30	DB37 - IO Connector	"Aln -06 Aln -14"	26	AGND			
"ST1A-3 ST2A-3"	8	"CN1-A CN2-A"	31	DB37 - IO Connector	"Aln +07 Aln +15"	8	ADCINB3, ADCINB4 (Resolver Cos)	J1	13, 15	
"ST1A-4 ST2A-4"	8	"CN1-A CN2-A"	32	DB37 - IO Connector	"Aln -07 Aln -15"	27	AGND			
"ST1A-5 ST2A-5"	1	"CN1-A CN2-A"	33	DB37 - IO Connector	"USB1-5V USB2-5V"	"- -"				
"ST1A-5 ST2A-5"	2	"CN1-A CN2-A"	34	DB37 - IO Connector	"USB1-3.3V USB2-3.3V"	"- -"				

Screw Terminals		40 pin connector		Signal Description			TI TMDSDOCK28335 Board signals			
ID	Pin	ID	Pin	From Connector	Signal Name	Pin	Signal Name	Connector	Pin	Description
"ST1A-5 ST2A-5"	3	"CN1-A CN2-A"	35	DB37 - IO Connector	"USB1-GND USB2-GND"	"- -"				
"ST1A-5 ST2A-5"	4	"CN1-A CN2-A"	36	DB37 - IO Connector	"USB1-VIO USB2-VIO"	"- -"				
"ST1A-5 ST2A-5"	5	"CN1-A CN2-A"	37	DB37 - IO Connector	"USB1-TXD USB2-TXD"	"- -"	GPIO15/TZ4/XHOLDA/SCIRXDB/ MFSXB	J1	34	
"ST1A-5 ST2A-5"	6	"CN1-A CN2-A"	38	DB37 - IO Connector	"USB1-RXD USB2-RXD"	"- -"	GPIO14/TZ3/XHOLD/SCITXDB/ MCLKXB	J1	84	
"ST1A-5 ST2A-5"	7	"CN1-A CN2-A"	39	DB37 - IO Connector	"USB1-CTS USB2-CTS"	"- -"				
"ST1A-5 ST2A-5"	8	"CN1-A CN2-A"	40	DB37 - IO Connector	"USB1-RTS USB2-RTS"	"- -"				

Screw Terminals		40 pin connector		Signal Description			TI TMDSDOCK28335 Board signals			
ID	Pin	ID	Pin	From	Signal Name	Pin	Signal Name	Connector	Pin	Description
"ST1B-1 ST2B-1"	1	"CN1-B CN2-B"	1	DB37 - IO	"DIn +00 DIn +16"	1	GPIO20_EAEP1A_MXDA_CANTXB	J1	40	
"ST1B-2 ST2B-2"	1	"CN1-B CN2-B"	2	DB37 - IO	"DIn -00 DIn -16"	20				
"ST1B-1 ST2B-1"	2	"CN1-B CN2-B"	3	DB37 - IO	"DIn +01 DIn +17"	2	GPIO21_EQEP1B_MDRA_CANRXB	J1	90	
"ST1B-2 ST2B-2"	2	"CN1-B CN2-B"	4	DB37 - IO	"DIn -01 DIn -17"	21				
"ST1B-1 ST2B-1"	3	"CN1-B CN2-B"	5	DB37 - IO	"DIn +02 DIn +18"	3	GPIO23_EQEP1I_MFSXA_SCIRXDB	J1	91	
"ST1B-2 ST2B-2"	3	"CN1-B CN2-B"	6	DB37 - IO	"DIn -02 DIn -18"	22				
"ST1B-1 ST2B-1"	4	"CN1-B CN2-B"	7	DB37 - IO	"DIn +03 DIn +19"	4	GPIO24_ECAP1_EQEP2A_MDXB	J1	35	
"ST1B-2 ST2B-2"	4	"CN1-B CN2-B"	8	DB37 - IO	"DIn -03 DIn -19"	23				
"ST1B-1 ST2B-1"	5	"CN1-B CN2-B"	9	DB37 - IO	"DIn +04 DIn +20"	5	GPIO25_ECAP2_EQEP2B_MDRB	J1	85	
"ST1B-2 ST2B-2"	5	"CN1-B CN2-B"	10	DB37 - IO	"DIn -04 DIn -20"	24				
"ST1B-1 ST2B-1"	6	"CN1-B CN2-B"	11	DB37 - IO	"DIn +05 DIn +21"	6	GPIO26/ECAP3/EQEP2I/MCLKXB	J1	36	
"ST1B-2 ST2B-2"	6	"CN1-B CN2-B"	12	DB37 - IO	"DIn -05 DIn -21"	25				
"ST1B-1 ST2B-1"	7	"CN1-B CN2-B"	13	DB37 - IO	"DIn +06 DIn +22"	7	GPIO27/ECAP4/EQEP2S/MFSXB	J1	86	
"ST1B-2 ST2B-2"	7	"CN1-B CN2-B"	14	DB37 - IO	"DIn -06 DIn -22"	26				
"ST1B-1 ST2B-1"	8	"CN1-B CN2-B"	15	DB37 - IO	"DIn +07 DIn +23"	8	GPIO28/SCIRXDA/XZCS6	J1	43	
"ST1B-2 ST2B-2"	8	"CN1-B CN2-B"	16	DB37 - IO	"DIn -07 DIn -23"	27				
"ST1B-3 ST2B-3"	1	"CN1-B CN2-B"	17	DB37 - IO	"DIn +08 DIn +24"	9	GPIO29/SCITXDA/XA19	J1	93	
"ST1B-4 ST2B-4"	1	"CN1-B CN2-B"	18	DB37 - IO	"DIn -08 DIn -24"	28				

Screw Terminals		40 pin connector		Signal Description			TI TMDSDOCK28335 Board signals			
ID	Pin	ID	Pin	From	Signal Name	Pin	Signal Name	Connector	Pin	Description
"ST1B-3 ST2B-3"	2	"CN1-B CN2-B"	19	DB37 - IO	"DIn +09 DIn +25"	10	GPIO30/CANRXA/XA18	J1	44	
"ST1B-4 ST2B-4"	2	"CN1-B CN2-B"	20	DB37 - IO	"DIn -09 DIn -25"	29				
"ST1B-3 ST2B-3"	3	"CN1-B CN2-B"	21	DB37 - IO	"DIn +10 DIn +26"	11	GPIO31/CANTXA/XA17	J1	94	
"ST1B-4 ST2B-4"	3	"CN1-B CN2-B"	22	DB37 - IO	"DIn -10 DIn -26"	30				
"ST1B-3 ST2B-3"	4	"CN1-B CN2-B"	23	DB37 - IO	"DIn +11 DIn +27"	12	GPIO32/SDAA/EPWMSYNCI/ ADCSOCAO	J1	45	
"ST1B-4 ST2B-4"	4	"CN1-B CN2-B"	24	DB37 - IO	"DIn -11 DIn -27"	31				
"ST1B-3 ST2B-3"	5	"CN1-B CN2-B"	25	DB37 - IO	"DIn +12 DIn +28"	13	GPIO33/SCLA/EPWMSYNCO/ ADCSOCBO	J1	95	
"ST1B-4 ST2B-4"	5	"CN1-B CN2-B"	26	DB37 - IO	"DIn -12 DIn -28"	32				
"ST1B-3 ST2B-3"	6	"CN1-B CN2-B"	27	DB37 - IO	"DIn +13 DIn +29"	14	GPIO34/ECAP1/XREADY	J1	46	
"ST1B-4 ST2B-4"	6	"CN1-B CN2-B"	28	DB37 - IO	"DIn -13 DIn -29"	33				
"ST1B-3 ST2B-3"	7	"CN1-B CN2-B"	29	DB37 - IO	"DIn +14 DIn +30"	15	GPIO16/SPISIMOA/CANTXB/TZ5	J1	38	
"ST1B-4 ST2B-4"	7	"CN1-B CN2-B"	30	DB37 - IO	"DIn -14 DIn -30"	34				
"ST1B-3 ST2B-3"	8	"CN1-B CN2-B"	31	DB37 - IO	"DIn +15 DIn +31"	16	GPIO17/SPISOMIA/CANRXB/TZ6	J1	88	
"ST1B-4 ST2B-4"	8	"CN1-B CN2-B"	32	DB37 - IO	"DIn -15 DIn -31"	35				
"ST1B-5 ST2B-5"	1	"CN1-B CN2-B"	33	DB9 - CAN	"CAN1 - LO CAN2 - LO"	2	GPIO18_SPICLKA_SCITXDB_ CANRXA	J1	39	
"ST1B-5 ST2B-5"	2	"CN1-B CN2-B"	34	DB9 - CAN	"CAN1 - HI CAN2 - HI"	7	GPIO19_SPISTEA_SCIRXDB_ CANTXA	J1	89	
"ST1B-5 ST2B-5"	3	"CN1-B CN2-B"	35	DB37 - IO	"Vuser1 Vuser2"	18				Referenced to 5V supply of TI board
"ST1B-5 ST2B-5"	4	"CN1-B CN2-B"	36	DB37 - IO	"Vuser1_RTN Vuser2_RTN"	37				Connected to GND

Screw Terminals		40 pin connector		Signal Description			TI TMDSDOCK28335 Board signals			
ID	Pin	ID	Pin	From	Signal Name	Pin	Signal Name	Connector	Pin	Description
"ST1B-5 ST2B-5"	5	"CN1-B CN2-B"	37	12V Power						
"ST1B-5 ST2B-5"	6	"CN1-B CN2-B"	38	12V Power						
"ST1B-5 ST2B-5"	7	"CN1-B CN2-B"	39	Power GND						
"ST1B-5 ST2B-5"	8	"CN1-B CN2-B"	40	Power GND						

Screw Terminals		40 pin connector		Signal Description			TI TMDSDOCK28335 Board signals			
ID	Pin	ID	Pin	From	Signal Name	Pin	Signal Name	Connector	Pin	Description
"ST1C-1 ST2C-1"	1	"CN1-C CN2-C"	1	DB37 - IO Connector	"DOut +00 DOut +16"	1	GPIO0_EPWM1A			
"ST1C-2 ST2C-2"	1	"CN1-C CN2-C"	2	DB37 - IO Connector	"DOut -00 DOut -16"	20				
"ST1C-1 ST2C-1"	2	"CN1-C CN2-C"	3	DB37 - IO Connector	"DOut +01 DOut +17"	2	GPIO1_EPWM1B/ECAP6/MFSRB			
"ST1C-2 ST2C-2"	2	"CN1-C CN2-C"	4	DB37 - IO Connector	"DOut -01 DOut -17"	21				
"ST1C-1 ST2C-1"	3	"CN1-C CN2-C"	5	DB37 - IO Connector	"DOut +02 DOut +18"	3	GPIO2_EPWM2A			
"ST1C-2 ST2C-2"	3	"CN1-C CN2-C"	6	DB37 - IO Connector	"DOut -02 DOut -18"	22				
"ST1C-1 ST2C-1"	4	"CN1-C CN2-C"	7	DB37 - IO Connector	"DOut +03 DOut +19"	4	GPIO3_EPWM2B_ECAP5_MCLKRB			
"ST1C-2 ST2C-2"	4	"CN1-C CN2-C"	8	DB37 - IO Connector	"DOut -03 DOut -19"	23				
"ST1C-1 ST2C-1"	5	"CN1-C CN2-C"	9	DB37 - IO Connector	"DOut +04 DOut +20"	5	GPIO4_EPWM3A			
"ST1C-2 ST2C-2"	5	"CN1-C CN2-C"	10	DB37 - IO Connector	"DOut -04 DOut -20"	24				
"ST1C-1 ST2C-1"	6	"CN1-C CN2-C"	11	DB37 - IO Connector	"DOut +05 DOut +21"	6	GPIO5_EPWM3B_MFSRA_ECAP1			
"ST1C-2 ST2C-2"	6	"CN1-C CN2-C"	12	DB37 - IO Connector	"DOut -05 DOut -21"	25				
"ST1C-1 ST2C-1"	7	"CN1-C CN2-C"	13	DB37 - IO Connector	"DOut +06 DOut +22"	7	GPIO6_EPWMN4A_EPWMSYNCI/ EPWMSYNCO			
"ST1C-2 ST2C-2"	7	"CN1-C CN2-C"	14	DB37 - IO Connector	"DOut -06 DOut -22"	26				
"ST1C-1 ST2C-1"	8	"CN1-C CN2-C"	15	DB37 - IO Connector	"DOut +07 DOut +23"	8	GPIO7_EPWM4B_MCLKRA_ECAP2			
"ST1C-2 ST2C-2"	8	"CN1-C CN2-C"	16	DB37 - IO Connector	"DOut -07 DOut -23"	27				
"ST1C-3 ST2C-3"	1	"CN1-C CN2-C"	17	DB37 - IO Connector	"DOut +08 DOut +24"	9	GPIO8_EPWM5A_CANTXB_ ADCSOCA0nP3			
"ST1C-4 ST2C-4"	1	"CN1-C CN2-C"	18	DB37 - IO Connector	"DOut -08 DOut -24"	28				

Screw Terminals		40 pin connector		Signal Description			TITMDSDOCK28335 Board signals			
ID	Pin	ID	Pin	From	Signal Name	Pin	Signal Name	Connector	Pin	Description
"ST1C-3 ST2C-3"	2	"CN1-C CN2-C"	19	DB37 - IO Connector	"DOut +09 DOut +25"	10	GPIO9_EPWM5B_SCITXDB_ECAP3			
"ST1C-4 ST2C-4"	2	"CN1-C CN2-C"	20	DB37 - IO Connector	"DOut -09 DOut -25"	29				
"ST1C-3 ST2C-3"	3	"CN1-C CN2-C"	21	DB37 - IO Connector	"DOut +10 DOut +26"	11	GPIO10_EPWM6A_CANRXB_ ADCASOCB0n			
"ST1C-4 ST2C-4"	3	"CN1-C CN2-C"	22	DB37 - IO Connector	"DOut -10 DOut -26"	30				
"ST1C-3 ST2C-3"	4	"CN1-C CN2-C"	23	DB37 - IO Connector	"DOut +11 DOut +27"	12	GPIO11_EPWM6B_SCIRXDB_ ECAP4			
"ST1C-4 ST2C-4"	4	"CN1-C CN2-C"	24	DB37 - IO Connector	"DOut -11 DOut -27"	31				
"ST1C-3 ST2C-3"	5	"CN1-C CN2-C"	25	DB37 - IO Connector	"DOut +12 DOut +28"	13	GPIO12/TZ1/CANTXB/MDXB			
"ST1C-4 ST2C-4"	5	"CN1-C CN2-C"	26	DB37 - IO Connector	"DOut -12 DOut -28"	32				
"ST1C-3 ST2C-3"	6	"CN1-C CN2-C"	27	DB37 - IO Connector	"DOut +13 DOut +29"	14	GPIO13/TZ2/CANRXB/MDRB			
"ST1C-4 ST2C-4"	6	"CN1-C CN2-C"	28	DB37 - IO Connector	"DOut -13 DOut -29"	33				
"ST1C-3 ST2C-3"	7	"CN1-C CN2-C"	29	DB37 - IO Connector	"DOut +14 DOut +30"	15	GPIO16/SPISIMOA/CANTXB/TZ5			
"ST1C-4 ST2C-4"	7	"CN1-C CN2-C"	30	DB37 - IO Connector	"DOut -14 DOut -30"	34				
"ST1C-3 ST2C-3"	8	"CN1-C CN2-C"	31	DB37 - IO Connector	"DOut +15 DOut +31"	16	GPIO17/SPISOMIA/CANRXB/TZ6			
"ST1C-4 ST2C-4"	8	"CN1-C CN2-C"	32	DB37 - IO Connector	"DOut -15 DOut -31"	35				
"ST1C-5 ST2C-5"	1	"CN1-C CN2-C"	33	NC						
"ST1C-5 ST2C-5"	2	"CN1-C CN2-C"	34	DB9 - RS232	"RS232-1 GND RS232-2 GND"	5				
"ST1C-5 ST2C-5"	3	"CN1-C CN2-C"	35	DB37 - IO Connector	"Vuser1 Vuser2"	18				

Screw Terminals		40 pin connector		Signal Description			TITMDSDOCK28335 Board signals			
ID	Pin	ID	Pin	From	Signal Name	Pin	Signal Name	Connector	Pin	Description
"ST1C-5 ST2C-5"	4	"CN1-C CN2-C"	36	DB37 - IO Connector	"Vuser1_RTN Vuser2_RTN"	37				
"ST1C-5 ST2C-5"	5	"CN1-C CN2-C"	37	DB9 - RS232	"RS232-1 TXD RS232-2 TXD"	3	GPIO36/SCIRXDA/XZCS0	J1	2	
"ST1C-5 ST2C-5"	6	"CN1-C CN2-C"	38	DB9 - RS232	"RS232-1 RXD RS232-2 RXD"	2	GPIO35/SCITXDA/XR/W	J1	52	
"ST1C-5 ST2C-5"	7	"CN1-C CN2-C"	39	DB9 - RS232	"RS232-1 CTS RS232-2 CTS"	8				
"ST1C-5 ST2C-5"	8	"CN1-C CN2-C"	40	DB9 - RS232	"RS232-1 RTS RS232-2 RTS"	7				

LIMITED WARRANTY

LIMITED WARRANTY

OPAL-RT Technologies Inc. warrants to the original purchaser and/or ultimate customer ("Purchaser") of OPAL-RT products ("Product") that if any part thereof proves to be defective in material or workmanship within one (1) year, such defective part will be repaired or replaced, free of charge, at OPAL-RT Technologies' discretion, if shipped prepaid to OPAL-RT Technologies Inc. at 1751 Richardson, suite 2525, Montreal, Quebec, Canada, H3K 3G6, in a package equal to or in the original container. The Product will be returned freight prepaid and repaired or replaced if it is determined by OPAL-RT Technologies Inc. that the part failed due to defective materials or workmanship. Otherwise, the fees will be charged to the client (see article "warranty limitation and exclusion"). The repair or replacement of any such defective part shall be OPAL-RT Technologies' sole and exclusive responsibility and liability under this limited warranty.

Purchaser must request an RMA number before shipping any Product for repair:

1. Access the OPAL-RT website (www.opal-rt.com/support/return-merchandise-authorization-rma-request), click on support and select Return Merchandise (RMA).
2. Fill out the online form and submit. You will receive a notification with a thread-ID that will be used for further exchange with support.
3. OPAL-RT's Support department will evaluate the return and either issue an RMA number via email using the same thread-ID.
 - If the Product is returned for repair more than 12 months after purchase, the Purchaser is responsible for the cost of repair. OPAL-RT will assess the repair and prepare a quote. The RMA number will be sent with the quote.
4. Only when the Purchaser receives the RMA number, may they ship the Product, prepaid, to OPAL-RT.

RETURN POLICY

the following fees will apply when customers return products for credit:

A full credit, less a 15% fee and less return fee will only be issued if the product is in perfect working condition and if the product is returned within 1 month following the shipping date. If repairs are required on the returned product, the cost of these repairs will be deducted from the credit to be issued.

No credits will be issued beyond the one month period.

EXCLUSIONS

If third party products are part of the Product, OPAL-RT will honor the original manufacturer's warranty.

This limited warranty does not cover consumable items, such as batteries, or items subject to wear or periodic replacement, including lamps, fuses or filter elements.

WARRANTY LIMITATION AND EXCLUSION

OPAL-RT Technologies will have no further obligation under this limited warranty. All warranty obligations of OPAL-RT Technologies are void if the Product has been subject to abuse, misuse, negligence, or accident or if the Purchaser fails to perform any of the duties set forth in this limited warranty or if the Product has not been operated in accordance with instructions, or if the Product serial number has been removed or altered.

DISCLAIMER OF UNSTATED WARRANTIES

the warranty printed above is the only warranty applicable to this purchase. All other warranties, express or implied, including, but not limited to, the implied warranties of merchantability or fitness for a particular purpose are hereby disclaimed.

LIMITATION OF LIABILITY

it is understood and agreed that OPAL-RT Technologies' liability, whether in contract, in tort, under any warranty, in negligence or otherwise shall not exceed the amount of the purchase price paid by the purchaser for the product and under no circumstances shall OPAL-RT Technologies be liable for special, indirect, or consequential damages. The price stated for the product is a consideration limiting OPAL-RT Technologies' liability. No action, regardless of form, arising out of the transactions under this warranty may be brought by the purchaser more than one year after the cause of actions has occurred.

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