

Analog Control DCM2322 ChiP™ Evaluation Board

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Introduction

The Analog Control DCM2322 ChiP evaluation board described in this document is designed to be used with the DCM family of isolated, DC-DC converters. The DCM2322 board is used for the analog control, low input voltage DCM2322 ChiP products.

The DCM evaluation board can be configured for various enabling and fault-monitoring schemes, as well as to exercise various modes of trimming, depending on the application requirements. The evaluation board can be used to evaluate DCMs in either a standalone configuration or as an array of modules.

Operation Mode Options

Operation mode of the DCM can be selected based on the voltage seen by the DCM at its EN pin at first start up following application of V_{IN} . Two operation modes that can be selected are:

1. **Array mode (default):** the EN pin is permitted to float at initial start up. The DCM enables the output and latches in array mode of operation.
2. **Enhanced V_{OUT} Regulation mode:** applying a specified voltage level on the EN pin during initial start up will latch the DCM in enhanced V_{OUT} regulation mode.

Enable options:

1. On-board mechanical switch (default)
2. External control

Trim options:

1. **Fixed trim operation (default):** the TR pin is permitted to float at initial start up. The DCM disables output trimming and the output trim is programmed to the nominal rated V_{OUT} .
2. **Variable trim operation, on-board variable resistor:** The trim pin voltage is ratiometric, with a rheostat working against a pull-up resistor inside the DCM to V_{CC} .
3. **Variable trim operation, off-board control:** The trim pin voltage is controlled via external programming control, which is referenced to the $-IN$ of each specific DCM in the system.

Fault monitor options:

1. **On-board LED:** the FT pin drives a visible LED for visual feedback on fault status.
2. **On-board optocoupler:** the FT pin drives an on-board optocoupler to bring fault status across the primary-secondary isolation boundary.

INFORMATION SUBJECT TO CHANGE WITHOUT NOTICE



IMPORTANT NOTICE:

Hazardous voltages are present on the DCM Evaluation Board under power.

PERSONAL CONTACT WITH LINE VOLTAGE MAY RESULT IN SEVERE INJURY, DISABILITY, OR DEATH. IMPROPER OR UNSAFE HANDLING OF THIS BOARD MAY RESULT IN SERIOUS INJURY OR DEATH.

Read the precautions below entirely BEFORE using the DCM Evaluation Board. Do not operate the evaluation board unless you have the appropriate safety precautions in place on your bench to guarantee safety.

The list below is not comprehensive and is not a substitute for common sense and good practice.

- During operation, the power devices and surrounding structures can be operated safely at high temperatures.
- Remove power and use caution when connecting and disconnecting test probes and interface lines to avoid inadvertent short circuits and contact with hot surfaces.
- Never use a jumper in place of the fuse.
- When testing electronic products always use approved safety glasses. Follow good laboratory practice and procedures.
- Avoid creating ground loops when making measurements of the isolated input or output voltage.
- Care should be taken to protect the user from accidental contact when under power.
- Care should be taken to avoid reversing polarities if connecting to the opposite (solder) side of the board.
- The product evaluation boards described in this document are designed for general laboratory evaluation, and are not suitable for installation in end user equipment.
- Refer to the specific DCM module data sheet for electrical, thermal, and mechanical product details.

This board provides a convenient way to evaluate/demonstrate the performance of Vicor DCM products. Kelvin connections are provided for accurate voltage measurements on power nodes. Sockets are provided to permit quick installation and changing of bulk filtering capacitors. The evaluation board also provides lugs for input/output connections, test points and sockets for easy connection to standard test equipment, and a high-performance air-cooled heat sink assembly.

Contents

The evaluation board arrives with the following contents:

- 1 x DCM evaluation board
- 1 x top heat sink assembly (pre-installed)
- 1 x hardware kit

Features

The DCM evaluation board has the following features:

1. Input and output lugs for source and load connections
2. Input fuse (appropriately rated)
3. Basic input filtering, including sockets to add through-hole input aluminum-electrolytic capacitors for additional source decoupling

Note: The filtering used in the evaluation board is for demonstration purposes only and might not be the optimal solution for all applications. For optimal filter design for parallel array application, consult the [DCM Design Guide](#), data sheet of the DCM in use and the online filter design tool at:

<http://app2.vicorpower.com/filterDesign/intiFilter.do>

4. Basic output filtering, including sockets to add through-hole output aluminum-electrolytic capacitors
5. Toggle switch for enabling and disabling the DCM via the ENABLE pin
6. Trim control selection
 - a. Using potentiometer
 - b. Using external voltage source
 - c. Open, to disable trimming and latch the model nominal trim condition
7. Provisions to replace input and output differential mode inductors with wire loops, for oscilloscope/shunt based current measurements
8. Oscilloscope probe jack for accurate, high-frequency output voltage measurements
9. Dual paralleling connectors for ENABLE, TRIM, FAULT and PRI_SG signal connections, for daisy chaining control to other DCM evaluation boards in an array
10. Kelvin voltage test points for all power pins
11. Top heat sink assembly for the DCM

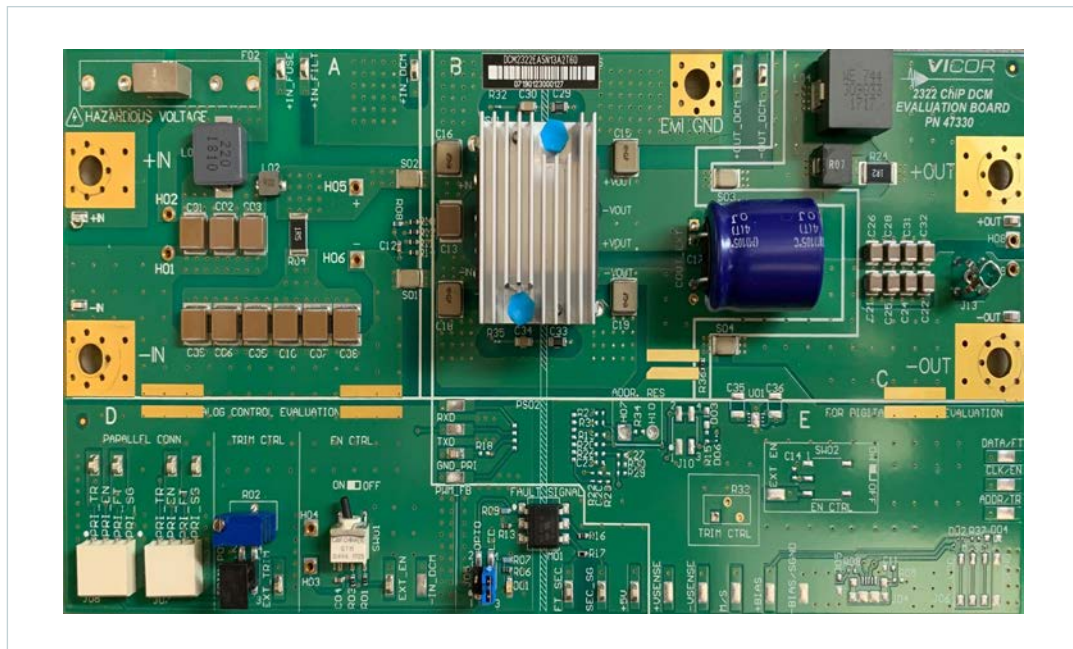
Board Description

The following section provides a detailed description of the evaluation board components, test points and sockets.

General Components

1. **DCM (PS01).**
2. **Input lugs:** Sized for #10 hardware. Use these for making connection to the input source. This board does not contain reverse polarity protection. Check for proper polarity before applying the power.
3. **Input fuse (F01 & F02):** Appropriately rated for the DCM model on the board.
4. **Input filter:** Ceramic input capacitors (C01 – C03, C05 – C10), filtering inductor (L01, L02) and damping resistor (R04) provide input filtering. Sockets (H01 – H02) can be used for easy installation of aluminum-electrolytic input capacitors. This board also adds H05 – H06 for additional input bypassing.
5. **Enable / Disable switch (SW01):** When actuator is in top position towards “ON” text on the board, the ENABLE pin will be open and the DCM will be enabled. When actuator is in bottom position towards “OFF” text on the board, the ENABLE pin will be connected to PRI_SG and the DCM will be disabled. When switch SW01 is ON, an external voltage source can control the ENABLE state.
6. **Header-jumper for trim control (J03):** Provides the option to enable the trim function to set the DCM programmed trim value via either the on board trim rheostat or an external voltage source:
 - a. Using potentiometer (R02)
 - b. Using external voltage source.
7. **Output lugs:** Sized for #10 hardware. Use these lugs to connect the output directly to the load.
8. **Output oscilloscope probe Jack (J13):** Used for making accurate scope measurements of the output voltage (e.g. ripple). The jack is directly compatible with many common passive voltage probes models. Remove the grounding lead and insulating barrel of the probe and insert the probe tip and barrel directly into the jack, ensuring that the probe tip seats in the center socket of the jack. To avoid the risk of an inadvertent short circuit, do not attempt to install while power is applied.
9. **Output filter:** Filtering inductor (L04) and damping network (L03, R24), and ceramic output capacitors (C21 – C22, C24 – 26, C28, C31 – C32) provide output filtering. Sockets H08 – H09 can be used for easy installation of aluminum-electrolytic output capacitors.
10. **Dual paralleling wire-to-board connectors (J07 and J08):** Used for bussing control signals and their reference (ENABLE, TRIM, FAULT and PRI_SG) across board assemblies during parallel operation. The connector style provides simple “strip and insert” use with 18 – 24AWG solid wires. Once inserted, a spring loaded barb retains each wire with no need for soldering. To release the wire, insert a thin bladed tool (AVX 06-9276-7001-01-000 or similar) into the slot above each wire entry point.

Figure 1
DCM2322 evaluation
board photo, top side



Test Points Description

Test nodes are labeled and include a SMT test point for attaching miniature probes, clips or hooks.

Table 1
Primary referred
test point descriptions

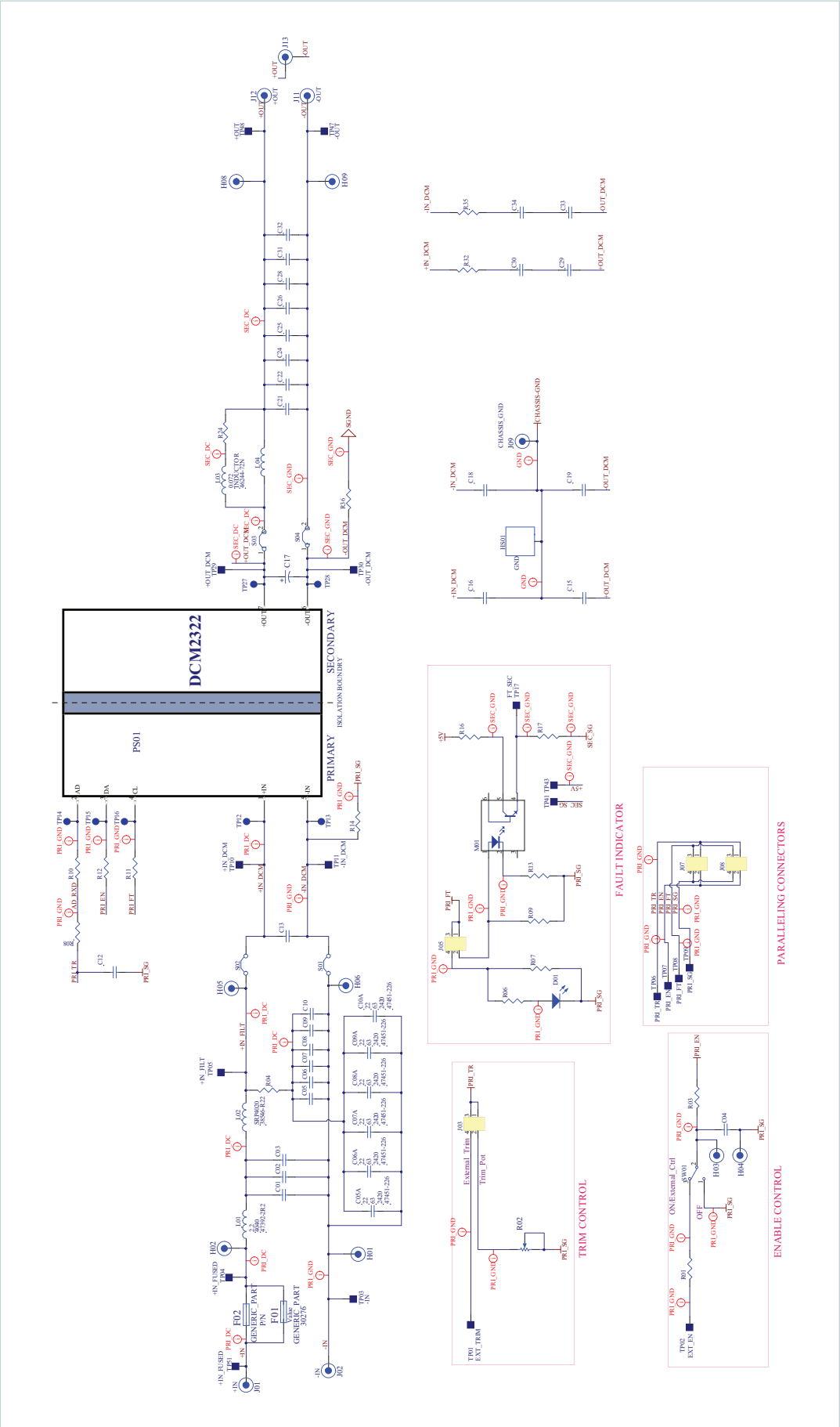
Name	Description
+IN_FUSED, +IN_FILTER, -IN	Provide measurement test points for the input voltage to the board in various locations, relative to the -IN board lug. +IN_FUSED is taken after input fusing, +IN_FILTER is taken after the input filtering network.
+IN_DCM, -IN_DCM	Provide Kelvin connection to input pins of the DCM. Use these test points for measuring the input voltage at the module, excluding errors due to finite connection resistance leading up to the module.
PRI_SG	Test point for Signal Ground on the primary/input side of the isolation boundary. This is the reference for all primary side control circuitry and all control pins of the DCM.
EXT_EN	Test point to drive the ENABLE signal (relative to PRI_SG) using an external source.
PRI_EN	Test point to measure the ENABLE signal (relative to PRI_SG).
EXT_TRIM	Test point to drive the TRIM signal (relative to PRI_SG) using an external source.
PRI_TR	Test point to measure the TRIM signal (relative to PRI_SG).
PRI_FT	Test point to measure the FAULT signal (relative to PRI_SG).

Table 2
Secondary referred
test point descriptions

Name	Description
+OUT_DCM, -OUT_DCM	Output voltage test points provide Kelvin connection to output pin group of the DCM. Use these test points for measuring the output voltage at the module, excluding voltage errors due to finite connection resistance and the module output current.
+OUT, -OUT	Provides measurement test points for the output voltage in various locations, relative to the -OUT board lug. +OUT is taken at the +OUT board lug.
SEC_SG	Test points for the +5V bias supply return, and for measuring the FT_SEC fault monitor output.
FT_SEC	Test point to measure the FAULT signal relative to SEC_SG once it has passed through the opto-coupler, if used. Bias power must be supplied to +5V for voltage output to appear here.
+5V	Test point to provide a bias voltage (relative to secondary ground) for the fault opto-coupler, if used.

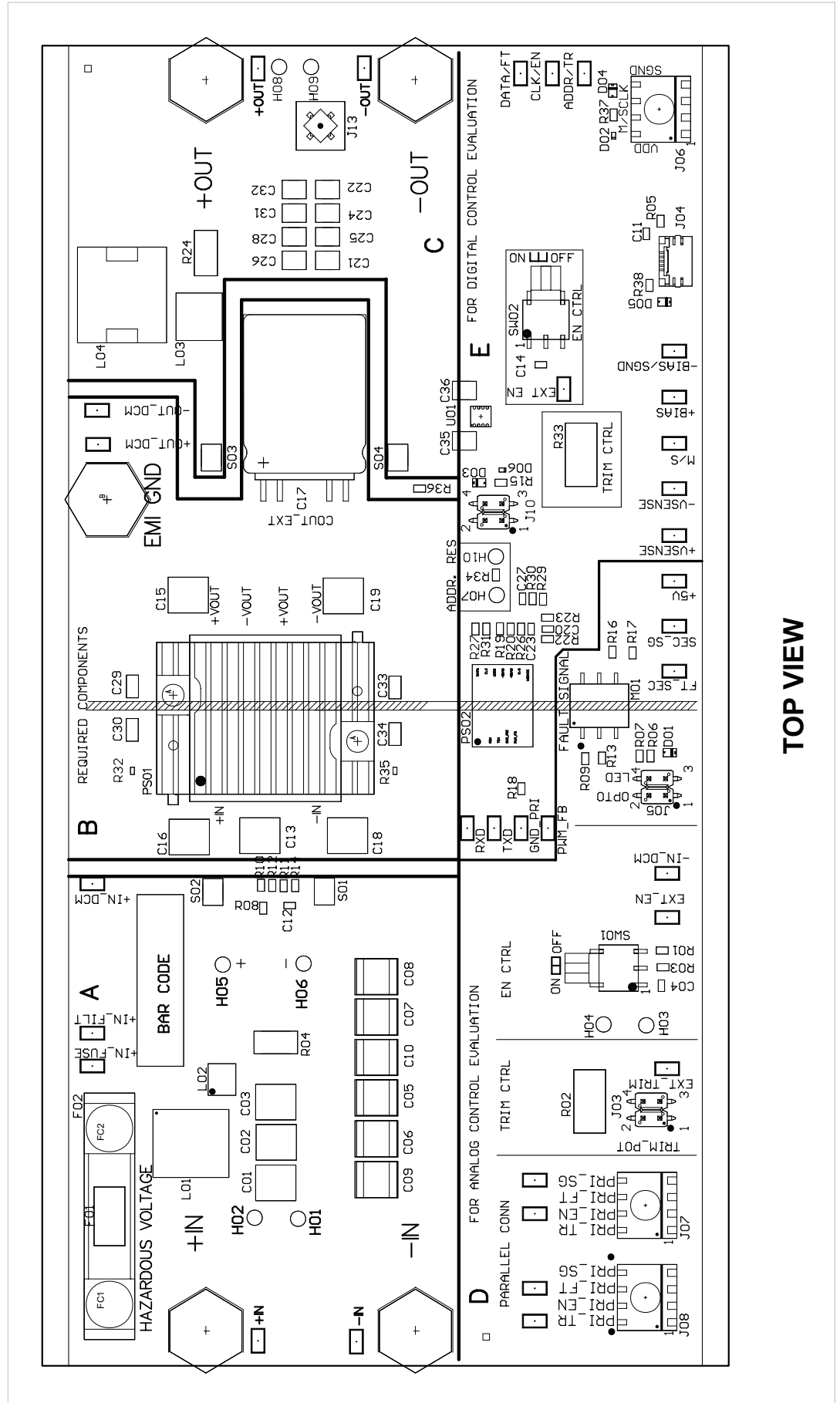
Schematic

Figure 2
DCM2322 evaluation board schematic



Assembly Drawing

Figure 3
DCM2322 evaluation board,
assembly drawing, top side



TOP VIEW

Bill of Materials

Table 3
DCM evaluation board BOM

Reference Designator	Description	Manufacturer	Manufacturer Part Number
Common Components			
C01, C02, C03, C05, C06, C07, C08, C09, C10, C13	CAP X7T 2.2 μ F 20% 250V 2220	TDK	C5750X7T2E225M250KA
C04	CAP X7R 0.10 μ F 10% 16V 0603	AVX	0603YC104KAT2A
C12	CAP X7R 0.001 μ F 10% 50V 0603	TDK	C1608X7R1H102K080AE
C15, C16, C18, C19	CAPY2 X7R 4700pF 10% 250V 2220 0.079MAXHT	Murata Manufacturing	GA355DR7GF472KW01L
C21, C22, C24, C25, C26, C28, C31, C32	CAP X7S 10 μ F 10% 100V 1210	Murata Manufacturing	GRM32EC72A106KE05L
C29, C33	RES 0 Ω JUMPER 2A 1206	Vishay	CRCW12060000Z0EC
C30, C34	CAP X7R 4700pF 10% 1kV 1206 Note: Capacitors are not rated for 3kV. See product data sheet for recommended capacitor.	KEMET Corporation	C1206C472KDRACTU
D01	DLED RED 0805	Rohm	SML-211UTT86
H01, H02, H03, H04, H05, H06, H08, H09	PIN RECPT .032/.046 DIA 0327 SER TH	Mill-Max	0327-0-57-15-34-27-1
J03, J05	HEADER 4 PIN STRAIGHT SMT	FCI	95278-101A04LF
J07, J08	CONN 4 POS WIRE TO BOARD SMD	AVX	009276004021106
L01	IND 22 μ H 20% 5A 4040	Bourns	SRP1038A-220M
L02	IND 220nH 20% 10A SMD	Bourns	SRP4020-R22M
L03	IND 72nH 20% 45A 2727	Vishay	IFLR2727EZER72NM01
L04	IND 0.33 μ H 20% 50A SMD	Würth Elektronik Group	744309033
M01	IC 6 PIN OPTO SMD	Vishay	CNY17-3X017T
R01, R03, R10, R11, R12, R14, R16, R36	RES 0 Ω JUMPER 1A 0603	KOA Speer Electronics	RK73Z1JTTD
R02	RES TRIM POT 500k Ω 1/2W 10% TH	NIDEC Copal Electronics	CT-94EW504
R04	RES 1.5 Ω 1W 5% 2512	KOA Speer Electronics	RK73B3ATTE1R5J
R06, R13	RES 1k Ω 1/10W 5% 0603	KOA Speer Electronics	RK73B1JTTD102J
R07, R09	RES 49.9k Ω 1/10W 1% 0603	KOA Speer Electronics	RK73H1JTTD4992F
R08	RES 1k Ω 1/10W 1% 0603	KOA Speer Electronics	RK73H1JTTD1001F
R17	RES 4.99k Ω 1/16W 0.1% 0603	Susumu	RG1608P-4991-B-T5
R24	RES 0.050 Ω 1W 1% 2512	Yageo	RL2512FK-070R05L
R32, R35	RES 1 Ω 1/16W 1% 0402	KOA Speer Electronics	RK73H1ETTP1R00F
S01, S02, S03, S04	1612 COPPER SHUNT	EXCEL TOOL & DIE CO, INC.	29581
SW01	SW Horizontal SPDT 1 POS SMD	C&K Components	GT11MSABETR
TP01, TP02, TP03, TP04, TP05, TP06, TP07, TP08, TP09, TP10, TP11, TP17, TP29, TP30, TP41, TP43, TP47, TP48, TP51	TEST POINT, SURFACE MOUNT	Keystone Electronics	5017
HTSNK	BOM ASSY 2223 XF PUSH PIN HTSINK NO TIM	MALICO INC	40478
J13	JACK VERTICAL MECH THRU HOLE	Tektronix	131-5031-00

Bill of Materials (Cont.)

Table 4

Example: BOM additions,
components which are
model-specific

Reference Designator	Description	Manufacturer	Manufacturer Part Number
Evaluation board number: DCM2322EA5N13A2T60			
C17	CAP ALEL 680 μ F 20% 63V RADIAL 18x20	United Chemi Con	ELXZ630ELL681MM20S
F01	FUSE 5A 125V PCD-5-R	Eaton	BK/PCD-5-R
PS01	DCM 2322	VICOR	DCM2322TA5N13A2T60

General BOM rules for various DCM Evaluation Boards

- **PS01:** This is the Vicor DCM, whose part number is coded in the evaluation board part number. For example, evaluation board DCM2322EA5N13A2T60 uses DCM2322TA5N13A2T60.
- **F01:** This is the input fuse. See the data sheet for the specific DCM for appropriate fuse needed to meet listed safety agency approvals.
- **C17:** This is the external output capacitor for the DCM. It is an Aluminum electrolytic with value that satisfies the DCM data sheet $C_{OUT-EXT}$ minimum.

Recommended Test Equipment

The following is a list of recommended test equipment.

1. Safety glasses
2. DC power supply: Refer to the specific DCM model data sheet to ensure the supply has sufficient power and current capability, especially at low line, to satisfy current inrush when the DCM is started
3. Electronic load: Refer to the specific DCM model data sheet to ensure the load has sufficient power handling and current capability for testing
4. Cooling fan
5. Digital multi-meters (DMMs)
6. Oscilloscope and probes
7. Function generator
8. Auxiliary bench voltage supply (optional, for bias of secondary side fault monitor opto-coupler)
9. Interconnect wires, cables and fastening hardware
10. Calibrated input and output shunts, appropriately rated
11. Thin bladed tool for extracting wires from paralleling connectors (AVX 06-9276-7001-01-000 or similar)

Basic Connections

- Confirm bench equipment is powered off.
- Connect the input DC power supply positive lead to the +IN input lug of the evaluation board, connect the input power supply negative lead to the -IN input lug of the evaluation board.
- Connect the EMI-GND lug of the evaluation board to a safety “green wire” earth ground.
- Connect the +OUT lug of the evaluation board to the electronic load positive input, connect the -OUT lug of the evaluation board to the electronic load negative input.
- Direct airflow from the cooling fan through the DCM heat sink fins.
- Have the latest DCM data sheet on hand for reference.

Board Operation Details

- SW01 provides control over enable.
 - In the “OFF” position, the switch will connect PRI_SG the EN net, which disables the DCM.
 - In the “ON” position, PRI_SG is disconnected from the EN net.
- External connection to EN is permitted using the PRI_EN test point. SW01 should be set to “ON” to permit external control.
- The J07 & J08 paralleling connectors can be used to connect EN nets across different boards.
Note: to enable the DCMs in a parallel array, all boards need SW01 set to “ON” to avoid pulling the EN node low.

EN (Enable)

The EN pin provides two functionalities:

- Enables and disables the DCM converter.
- Selects Array mode or Enhanced V_{OUT} Regulation mode.

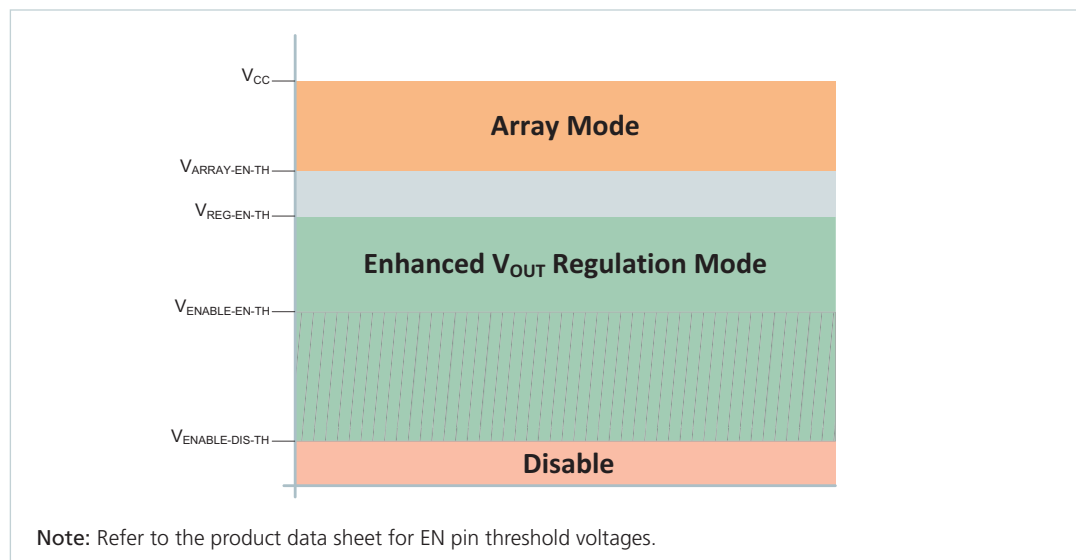
The EN pin is referenced to the $-IN$ pin of the converter. It has an internal pull up to V_{CC} through a $10k\Omega$ resistor.

EN is an input only, it does not pull low in the event of a fault.

Enable/Disable Control

- **Output disable:** when EN is pulled down externally below the disable threshold ($V_{ENABLE-DIS-TH}$), the DCM converter will be disabled.
- **Output enable:** when EN is allowed to pull up above the enable threshold ($V_{ENABLE-EN-TH}$) through the internal pull up to V_{CC} , the DCM converter will be enabled.

Figure 4
EN pin voltage thresholds



Selecting Array Mode or Enhanced V_{OUT} Regulation Mode

The EN pin can also be used to select Array mode operation or Enhanced V_{OUT} Regulation mode operation. The DCM mode of operation is dependent on the voltage seen by the DCM at its EN pin at first start up following application of V_{IN} . The DCM will latch in selected mode of operation at the end of soft start, and persist in that same mode until loss of input voltage.

At the first start up after application of V_{IN} , if EN is allowed to float to:

- A value above $V_{ENABLE-EN-TH}$, but below $V_{REG-EN-TH}$, the DCM will implement Enhanced V_{OUT} Regulation mode.
- A value above $V_{ARRAY-EN-TH}$ and up to V_{CC} , the DCM will implement Array mode operation.

Note that the selected mode of operation is not changed when a DCM recovers from any fault condition, or after a disable event through EN. The operation mode is reset only with cycling of input power.

Trim Control

- Jumper block J03 configures trimming.
 - With no jumpers installed, neither the trim potentiometer nor the test point for external trim control is connected to the TR net. Note that the paralleling connectors always connect to the TR net.
 - With a jumper loaded across J03.1 and J03.2, the trim potentiometer R02 is connected as a rheostat between the TR node and PRI_SG.
 - With a jumper loaded across J03.3 and J03.4, the external trim test point is connected to the TR node.
- The DCM contains an internal pull-up resistor to V_{CC} (3.3V nominal). When V_{IN} is applied to the DCM it samples the TR node voltage. If it has pulled up to V_{CC} , the DCM disables trimming as long as it has input power, and the programmed trim condition will be nominal rated V_{OUT} of the DCM model.
- If the TR node is not permitted to pull up to V_{CC} when V_{IN} is applied, trimming is enabled for as long as the DCM has input power.
- Note: Any load on the TR node may cause the DCM to select trim mode when V_{IN} is applied, including: the external trim test point (if selected with the jumper block), the trim potentiometer (if selected with the jumper block), and other DCM evaluation boards attached to the paralleling connectors.
- The trim potentiometer adds a variable resistance between the TR node and PRI_SG, from between 0Ω nominal, to the value of the potentiometer (500k Ω). This resistance range will generate TR pin voltages which cover the entire functional range of the TR pin. Care should be taken to ensure the programmed trim condition is within the rated trim range of the DCM in order for the DCM to meet specifications.
- In a parallel set up using the J07 & J08 paralleling connectors, all boards besides the top one should have the trim jumper select block at J03 open.
- In a parallel set up with multiple DCM evaluation boards, each DCM contributes another internal pull-up resistor to a 3.3V nominal rail. With any resistive based trimming of the TR node, the resultant trim condition will be modified by the number of DCMs which are attached and have V_{IN} applied. Conversely with a voltage source applied to the TR node, adding additional DCMs to the system has minimal impact on the resultant trim condition.

Fault Monitoring

- Jumper block 05 configures how the FT node is monitored.
 - With no jumpers installed, neither the visible LED nor the opto-coupler is connected to the FT net. Note that the paralleling connectors always connect to the FT net.
 - With a jumper loaded across J05.3 and J05.4, the visible LED at D01 and its bias resistor network R09 & R32 are connected to the FT node.
 - With a jumper loaded across J05.1 and J05.2, the opto-coupler at M01 and its bias resistor network R16 & R17 is connected to the FT node.
- The DCM FT output is intended to be directly paralleled with the FT output of other DCMs in an array. The FT node in an array forms a “wired-OR”, where any DCM can drive the FT node high.
- Both the visible LED and the opto-coupler draw current from the FT node in a fault condition. The FT pin on the DCM has limited drive-high capabilities, and so care must be taken to avoid excess loading of the pin. To avoid overload, do not configure J05 to use both the LED and opto-coupler indicators simultaneously. When connecting external circuitry or test equipment to the FT test point, ensure that the maximum load on the FT node is within the DCM data sheet ratings.
- In a parallel set up using the J07 & J08 paralleling connectors, all boards besides the top one should have the fault jumper select block at J05 open.
- When using the opto-coupler, the status of the FT node can be easily transferred to the secondary side of the DCM(s) isolation boundary. To resolve the fault state on the secondary side, the collector side of the opto requires a bias voltage. A 5V bench supply should be connected between the “+5V” and “SEC_SG” test points. With no fault present, “FT_SEC” will be at 0V, and when a fault occurs and the opto-coupler is active, “FT_SEC” will pull up to 5V, relative to SEC_SG.

Chassis Ground / EMI_GND

The heat sink assembly of the DCM is connected to the EMI_GND node of the board, as well as the y-caps from each power connection of the DCM. A connection from the EMI_GND lug to earth ground is required.

Paralleling

The paralleling and sharing performance of multiple DCMs can be easily demonstrated by stacking multiple evaluation boards and interconnecting the inputs and outputs with standoffs to create a parallel array. When operated in Array mode, the DCM uses a negative load-line to implement wireless droop-sharing in an array. Each DCM in an array operates in the same way as it does as a standalone Array-mode unit. With equal trim conditions, the load is effectively shared across multiple DCMs. Mismatches in this case are modest, and are further canceled by an effective negative voltage vs. temperature coefficient. See the DCM data sheet for more detail on load line and temperature coefficients. DCMs in an array require no de-rating of maximum output power or current.

DCMs in an array with mismatched trim conditions will not share the load equally at light- to moderate-load conditions. As the load increases, one or more DCMs (starting with those with the highest programmed output trim voltage) will go into current limit and their contribution to the overall output current will plateau. For DCMs, current limit is not a fault condition, rather it is a valid constant-current mode of operation and a DCM in current limit will provide constant current to the load. As long as the load does not exceed the maximum load rating of the array of DCMs, the output voltage will continue to be regulated by any remaining DCMs still in constant voltage mode. Even with mismatched trim conditions, the array can be safely loaded up to the full rated array capacity.

The following connections and settings should be used for an array of DCM evaluation boards:

- All DCMs in a parallel array must be the same model and must be configured to operate in Array mode.
- The boards should be physically stacked using metal standoffs at the +IN & –IN lugs, the +OUT & –OUT lugs, and the EMI_GND lug. This also connects these nodes electrically so that a single source, single load and earth ground connection can be made to the system.
 - The +IN lugs are not required to be connected together for an array of DCMs. The wireless sharing does not require the same differential input voltage be present on all DCMs in the array. In some applications dissimilar input voltages may be needed, which is fully supported. The –IN lugs must be connected together if the paralleling connector is used, or if the EN, TR, or FT pins are interconnected in any fashion. However if all control signals of all DCMs are fully isolated from one another, then both the +IN and –IN lugs can remain independent across the evaluation boards, and the DCMs can be operated with fully independent input supplies.
 - Standoffs must be sufficient in length to avoid contact between boards, and to permit airflow to all DCMs in the system.
- If coordinated enable control, trimming or fault monitoring is desired, then the paralleling connectors J07 & J08 can be used to easily interconnect the PRI_FT, PRI_EN, PRI_TR_ and PRI_FT nodes across boards.

The paralleling connectors at J07 & J08 can be used for coordinated enable and trim control and fault monitoring. The enable, trim and fault monitor features of the top most board should be used for convenience, while the remaining boards should have their jumper blocks depopulated and enable switches set to enable.

The paralleling wire-to-board connectors (at J07 and J08) are provided to daisy chain control signals and PRI_SG, with a simple strip and insert option. They will accept 18 – 24AWG solid wires.

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