Analog Control 3623 and 4623 ChiP DCMs Evaluation Board

Arthur Russell
VI Chip® Applications Engineering
October 2014

Contents **Page**

Introduction 1
Contents 3
Features 3
Board Description 4
General Components 4
Test Points Description 6
Schematic, Assembly Drawing and Bill of Materials 7
Recommended Test Equipment 14
Basic Connections 14
Board Operation Details 14
Trim Control 15
Fault Monitoring 15
Chassis Ground 16
Paralleling 16

Introduction

The Analog Control 3623 and 4623 ChiP DCM evaluation boards described in this document are designed to be used with the DCM family of isolated, DC-DC converters. The 3623 DCM board is used for the analog control, low input voltage 3623 ChiP products, while the 4623 DCM board is used for the analog control, high input voltage (offline) 4623 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 stand-alone configuration, or as an array of modules.

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 startup. 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 VCC.
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.

These boards provide a convenient way to evaluate/demonstrate the performance of Vicor's 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 heatsink assembly.

Contents

The evaluation board arrives with the following contents:

- 1 x DCM evaluation board
- 1 x top and belly heatsink 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 eval 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 datasheet 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 SGND 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 and bottom heatsink assembly for the DCM

Figure 1
3623 DCM evaluation board photo, top side

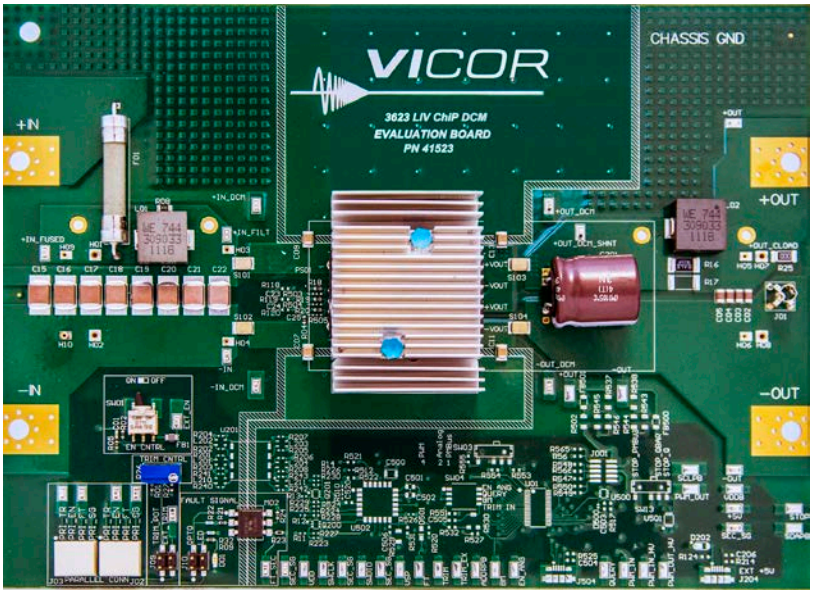
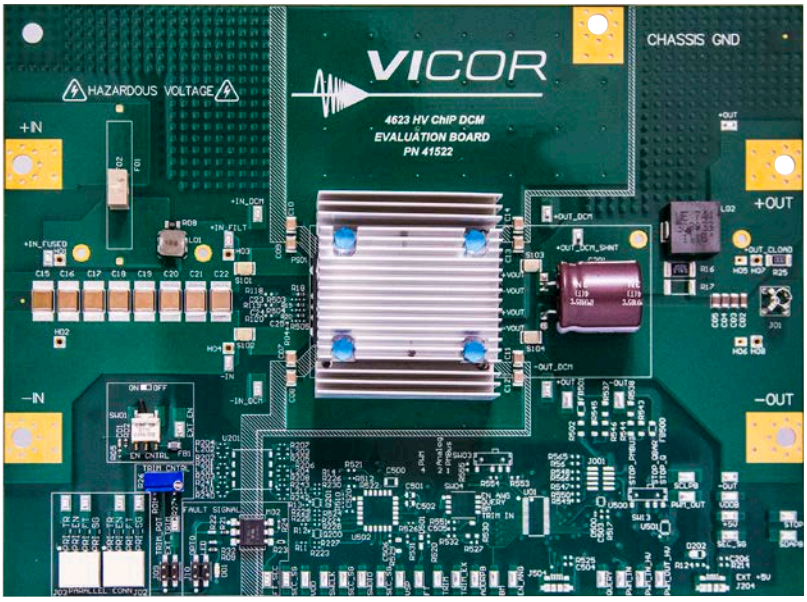


Figure 2
4623 DCM evaluation board photo, top side



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

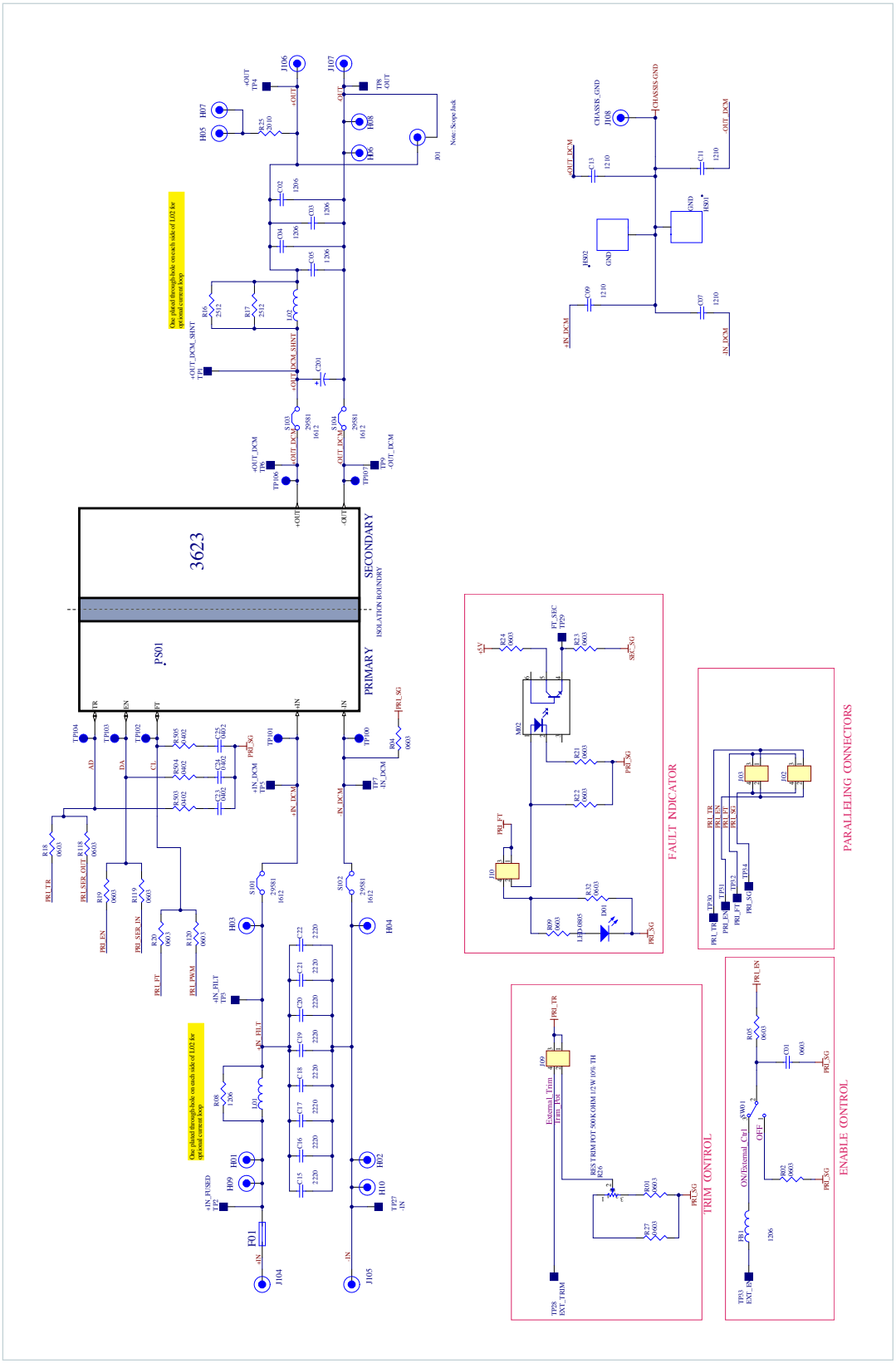
Name	Description
+IN_FUSED, +IN_FILT, –IN	Provide measurement testpoints for the input voltage to the board in various locations, relative to the –IN board lug. +IN_FUSED is taken after input fusing, +IN_FILT is taken after the input filtering network.
+IN_DCM, –IN_DCM	Provide Kelvin connection to input 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	Testpoint 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	Testpoint to drive the ENABLE signal (relative to PRI_SG) using an external source.
PRI_EN	Testpoint to measure the ENABLE signal (relative to PRI_SG).
EXT_TR	Testpoint to drive the TRIM signal (relative to PRI_SG) using an external source.
PRI_TR	Testpoint to measure the TRIM signal (relative to PRI_SG).
PRI_FT	Testpoint 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_DCM_SHNT, +OUT, –OUT	Provides measurement testpoints for the output voltage in various locations, relative to the –OUT board lug. +OUT_DCM_SHNT is taken before the output filtering, and +OUT is taken at the +OUT board lug.
SEC_SG	Testpoints for the +5V bias supply return, and for measuring the FT_SEC fault monitor output.
FT_SEC	Testpoint 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.
+5 V	Testpoint to provide a bias voltage (relative to secondary ground) for the fault opto-coupler, if used.

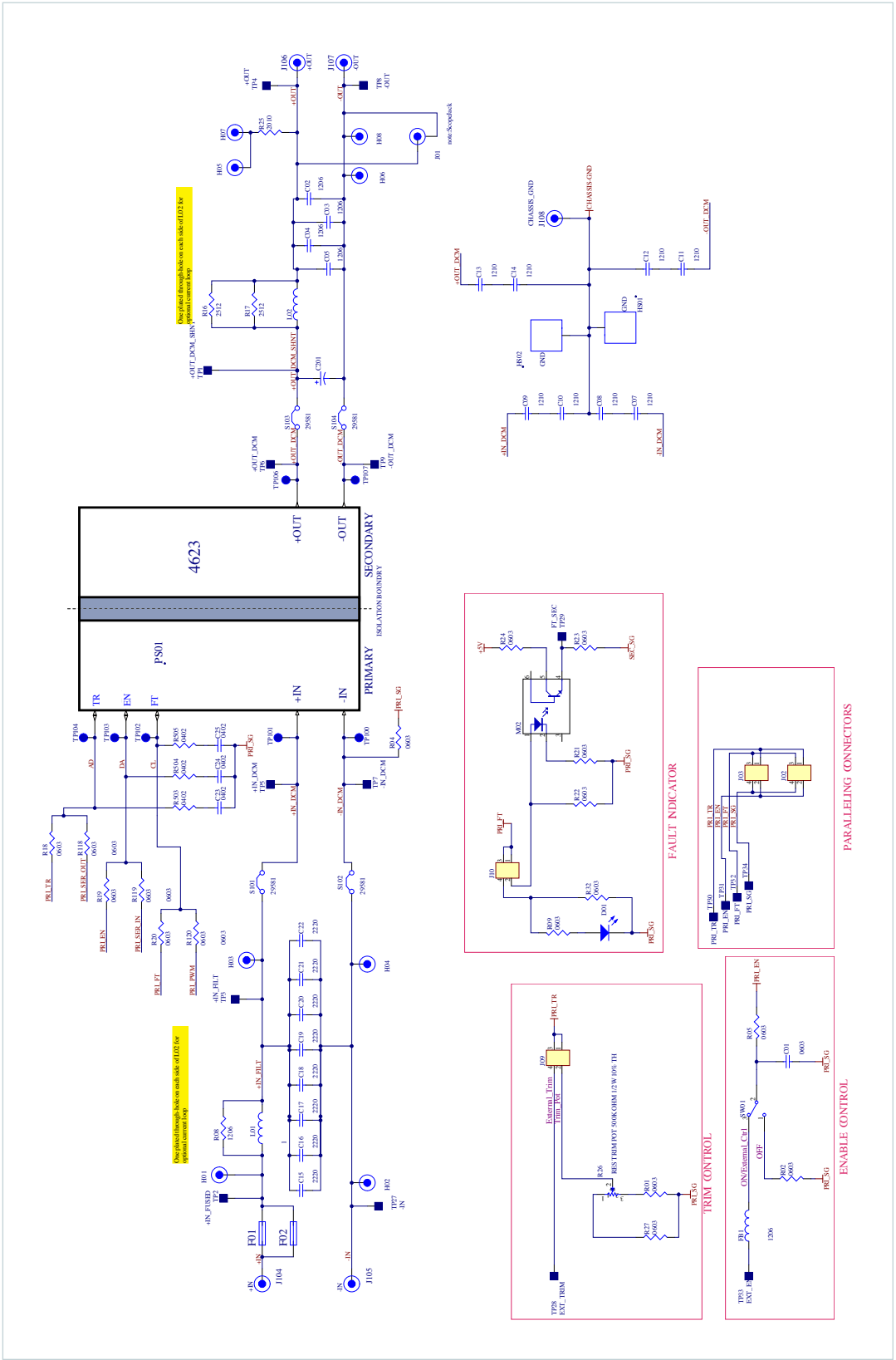
Schematic, Assembly Drawing and Bill of Materials

Figure 3
3623 DCM evaluation board schematic



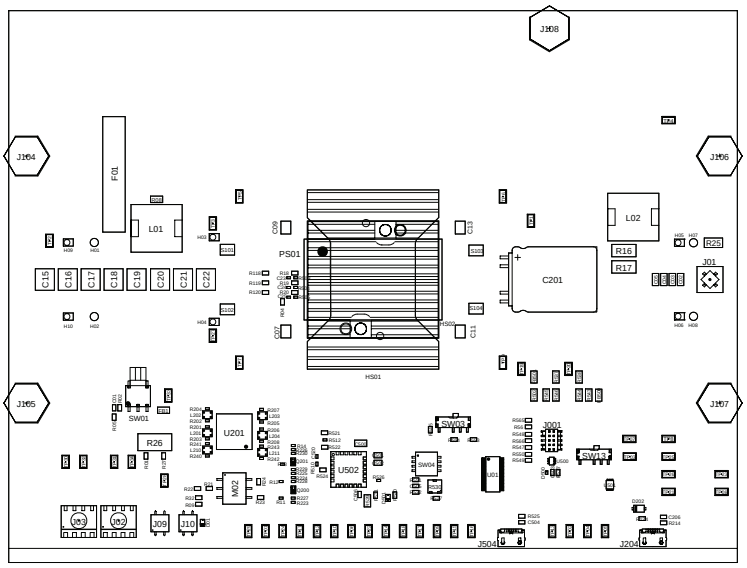
Schematic, Assembly Drawing and Bill of Materials (Cont.)

Figure 4
4623 DCM evaluation board schematic



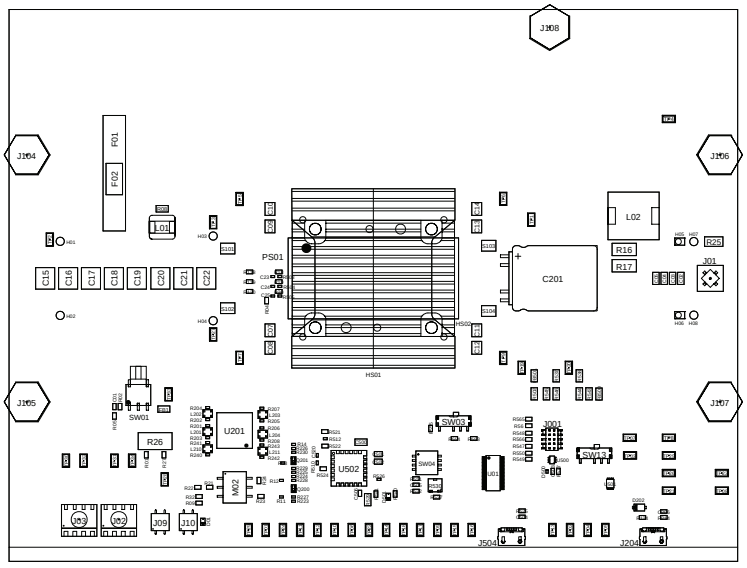
Schematic, Assembly Drawing and Bill of Materials (Cont.)

Figure 5
3623 DCM evaluation board, assembly drawing, top side



TOP VIEW

Figure 6
4623 DCM evaluation board assembly drawing, top side



TOP VIEW

Table 3
DCM evaluation board BOM, components common to all boards

Reference Designator	Description	Manufacturer	Manufacturer Part Number
Common Components			
C01	CAP X7R 0.10µF 10% 16V 0603	AVX	0603YC104KAT2A
C02 – C05	CAP X7S 4.7µF 10% 100V 1206	AVX	12061Z475KAT2A
C07 – C14	Board specific - See table 4 BOMs		
C15 – C22	Board specific - See table 4 BOMs		
C201	Design specific - See table 5 BOMs		
D01	LED RED 0805	ROHM	SML-211UTT86
FB1	FERRITE BEAD 33 OHM 6A 1206	MURATA	BLM31PG330SN1L
F01, F02	Design specific - See table 5 BOMs		
HS01 – HS02	Board specific - See table 4 BOMs		
J02 – J03	CONN 4 POS WIRE TO BOARD	AVX	009276004021106
J01	PCB TP ADAPTER, 3.5mm PROBE	TESTPATH	131-5031-00
L01	Board specific - See table 4 BOMs		
L02	IND 0.33µH 20% 50A	WURTH	744309033
M02	IC 6 PIN OPTO	VISHAY	CNY17-3X017T
R02, R04, R05, R18, R19, R20	RES 0 OHM JUMPER 0603	KOA	RK73Z1JTTD
PS01	Design specific - See table 5 BOMs	VICOR	
R08	RES 1 OHM ¼ W 5% 1206	KOA	RK73B2BTTE1R0J
R16	RES 250 mOHM 1W 2512	VISHAY	WSL2512R2500FEA
R09, R21	RES 1 KOHM 1/10W 5% 0603	KOA	RK73B1JTTD102J
R22, R32	RES 49.9 KOHM 1/10W 1% 0603	KOA	RK73H1JTTD4992F
R23	RES 4.99 KOHM 1/1W 0.1% 0603	THIN FILM TECH	CR0603E4991B-T5
R24, R01	RES 0 OHM JUMPER 0603	KOA	RK73Z1JTTD
R25	RES 0 OHM JUMPER 2010	VISHAY	CRCW20100000Z0EF
R26	RES TRIM POT 500 kOHM 1/2W 10%	COPAL	CT-94EW504
S102 - S104	RES 0 OHM JUMPER 1612 COPPER	EXCELTOOL & DIE	29581
SW01	SW TOGGLE SPDT 1 POS	C&K COMPONENTS	GT11MSABE
JMPSOK for J09 – J10	JUMPER SOCKET XJ8A	OMRON	XJ8A-0211

Schematic, Assembly Drawing and Bill of Materials: (Cont.)

Table 4a
BOM additions, components common to all 3623 DCM evaluation boards

Reference Designator	Description	Manufacturer	Manufacturer Part Number
3623 board components			
C07, C09, C11, C13	CAP X7R 4700pF 10% 2kV 1210	KEMET	C1210C472KGRAC7800
C08, C10, C12, C14	N/A (not present in design)	N/A	N/A
C15 – C22	CAP X7R 4.7µF 20% 100V 2220	TDK	C5750X7R2A475M230KA
L01	IND 0.33µH 20% 50A	WURTH	744309033
HS01 - HS02	3623 DUAL HTSNK	VICOR	40526
S101	RES 0 OHM JUMPER 1612 COPPER	EXCELTOOL & DIE	29581
C_{IN} @ H01 - H02	CAP ALEL 680µF 20% 63V RADIAL 18 X 20	UNITED CHEMI CON	ELXZ630ELL681MM20S

Table 4b
BOM additions, components common to all 4623 DCM evaluation boards

Reference Designator	Description	Manufacturer	Manufacturer Part Number
4623 board components			
C07 – C14	CAP X7R 4700pF 10% 2kV 1210	KEMET	C1210C472KGRAC7800
C15 – C22	CAP X7T 0.47µF 10% 630V 2220	TDK	C5750X7T2J474K250KC
L01	IND 1.0µH 20% 13A	BOURNS	SRP7030-1R0FM
HS01 - HS02	4623 DUAL HTSNK	VICOR	40519
S101	BEAD 680 OHM 4A 1812	TAIYO YUDEN	FBMH4532HM681-T
C_{IN} @ H01 - H02	AP ALEL 10µ 20% 450V RAD	UNITED CHEMI CON	EKXG451ELL100MK20S

Schematic, Assembly Drawing and Bill of Materials: (Cont.)

Table 5
Example: BOM additions, components which are DCM model specific.

Reference Designator	Description	Manufacturer	Manufacturer Part Number
Evaluation board number: DCM3623E50M06A8M00			
PS01	DCM - 3623	VICOR	DCM3623T50M06A8M00
F01	FUSE 30A 125V AXIAL	LITTELFUSE	324 030P
C201	CAP ALEL 10000µF 20% 10V RADIAL 18 x 26.5	NICHICON	URS1A103MHD1TN
Evaluation board number: DCM3623E50M13C2M00			
PS01	DCM - 3623	VICOR	DCM3623T50M13C2M00
F01	FUSE 30A 125V AXIAL	LITTELFUSE	324 030P
C201	CAP ALEL 4700µF 20% 25V RADIAL 16 x 25	NICHICON	UVY1E472MHD
Evaluation board number: DCM3623E50M17C2M00			
PS01	DCM - 3623	VICOR	DCM3623T50M17C2M00
F02	FUSE 30A 125V AXIAL	LITTELFUSE	324 030P
C201	CAP ALEL 2200µF 20% 25V RADIAL 16 x 25	NICHICON	UPW1E222MHD
Evaluation board numbers: DCM3623E50M26C2M00, DCM3623E50M31C2M00			
PS01	DCM - 3623	VICOR	One of DCM3623T50M26C2M00 DCM3623T50M31C2M00
F01	FUSE 30A 125V AXIAL	LITTELFUSE	324 030P
C201	CAP ALEL 1000µF 20% 50V RADIAL 18 x 20	UNITED CHEMICON	EKY-500ELL102MM20S
Evaluation board number: DCM3623E50M53C2M00			
PS01	DCM - 3623	VICOR	DCM3623T50M53C2M00
F01	FUSE 30A 125V AXIAL	LITTELFUSE	324 030P
C201	CAP ALEL 220µF 20% 80V RADIAL 18 x 16.5	NICHICON	UPJ1K221MHD6TN
Evaluation board numbers: DCM4623EC8G16F0T00, DCM4623ED2J13D0X00, DCM4623ED2H26F0X00			
PS01	DCM - 4623	VICOR	One of DCM4623TC8G16F0T00 DCM4623TD2J13D0T00 DCM4623TD2J13D0M00 DCM4623TD2H26F0T00 DCM4623TD2H26F0M00
F01	FUSE 5A 450V FAST 6.3 X 32 RADIAL	COOPER BUSSMANN	BK/PCD-5-R
C201	CAP ALEL 1000µF 20% 50V RADIAL 18 x 20	UNITED CHEMICON	EKY-500ELL102MM20S

Schematic, Assembly Drawing and Bill of Materials: (Cont.)

Table 5 (Cont.)
Example: BOM additions, components which are DCM model specific.

Reference Designator	Description	Manufacturer	Manufacturer Part Number
Evaluation board numbers: DCM4623ED2H31E0X00, DCM4623ED2H53E0X00			
PS01	DCM - 4623	VICOR	One of DCM4623TD2H31E0T00 DCM4623TD2H31E0M00 DCM4623TD2H53E0T00 DCM4623T02H53E0M00
F01	FUSE 5A 450V FAST 6.3 X 32 RADIAL	COOPER BUSSMANN	BK/PCD-5-R
C201	CAP ALEL 220µF 20% 80V RADIAL 18 x 16.5	NICHICON	UPJ1K221MHD6TN

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, eval board DCM4623ED2K53E0M00 uses DCM4623TD2K53E0M00.
- **F01:** This is the input fuse. See the datas heet for the specific DCM for appropriate fuse needed to meet listed safety agency approvals.
- **C201:** This is the external output capacitor for the DCM. It is an Aluminum electrolytic with value that satisfies the DCM datasheet $C_{OUT\text{-}TRANS}$ 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 datasheet 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 datasheet 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 CHASSIS_GROUND 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 heatsink fins.
- Have the latest DCM datasheet on hand for reference.

Board Operation Details

- SW01 provides control over enable.
  - In the "OFF" position, the switch will connect SG the EN net, which disables the DCM.
  - In the "ON" position, SG is disconnected from the EN net.
- External connection to EN is permitted using the PRI_EN testpoint. SW01 should be set to "ON" to permit external control.
- The J02 & J03 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.

Trim Control

- Jumper block J09 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 J09.1 and J09.2, the trim potentiometer R26 is connected as a rheostat between the TR node and SG.
  - With a jumper loaded across J09.3 and J09.4, the external trim test point is connected to the TR node.
- The DCM contains an internal pull-up resistor to VCC (3.3V nominal). When V_{IN} is applied to the DCM it samples the TR node voltage. If it has pulled up to VCC, the DCM disables trimming as long as it has input power, and the programmed trim condition will be nominal rated VOUT of the DCM model.
- If the TR node is not permitted to pull-up to VCC 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 testpoint (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 SG, from between 0Ω nominal, to the value of the potentiometer (500kΩ). 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 setup using the J02 & J03 paralleling connectors, all boards besides the top one should have the trim jumper select block at J09 open.
- In a parallel setup 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 J10 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 J10.3 and J10.4, the visible LED at D01 and its bias resistor network R09 & R32 are connected to the FT node.
  - With a jumper loaded across J10.1 and J10.2, the opto-coupler at M02 and its bias resistor network R21 & R22 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 opco-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 J10 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 datasheet ratings.
- In a parallel setup using the J02 & J03 paralleling connectors, all boards besides the top one should have the fault jumper select block at J10 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" testpoints. 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

The heatsink assembly of the DCM is connected to the CHASSIS_GND node of the board, as well as the y-caps from each power connection of the DCM. A connection from the CHASSIS_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. 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 stand-alone 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 datasheet for more detail on load line and tempco. DCMs in an array require no derating 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.
- The boards should be physically stacked using metal standoffs at the +IN & –IN lugs, the +OUT & –OUT lugs, and the CHASSIS_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.

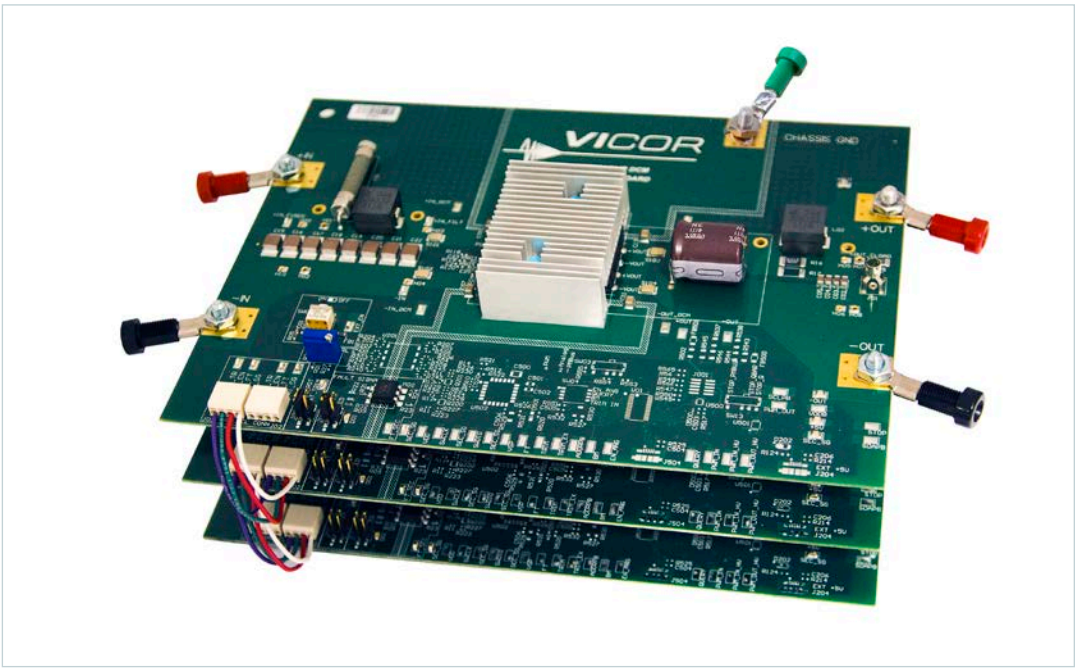
- The –IN lugs must be connected together if the paralleling connector is used, or if the EN, TR, or FT pins are interconnected in any fashion. However if all control signals of all DCMs are fully isolated from one another, then both the +IN and –IN lugs can remain independent across the evaluation boards, 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 J09 & J10 can be used to easily interconnect the PRI_FT, PRI_EN, PRI_TR_ and PRI_FT nodes across boards.

The paralleling connectors at J02 & J03 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 J02 and J03) are provided to daisy chain control signals and PRI_SG, with a simple strip and insert option. They will accept 18 – 24 AWG solid wires.

Figure 7
DCM evaluation boards stacked to form a high power parallel array, using common -IN and the paralleling connectors.



Information furnished by Vicor is believed to be accurate and reliable. However, no responsibility is assumed by Vicor for its use. Vicor components are not designed to be used in applications, such as life support systems, wherein a failure or malfunction could result in injury or death. All sales are subject to Vicor's Terms and Conditions of Sale, which are available upon request.

Specifications are subject to change without notice.