APPLICATION NOTE

for DJT090_DLynxII_Series_Parallel_Evaluation_Board

V1.2

Contents

DESCRIPTION

The DJT090A0X43-SRPZ (later refer as DJT090) Digital DLynxII™ power modules are non-isolated dc-dc converters that can deliver up to 90A of output current. These modules operate over a 7 to 14.4Vdc input range and provide a precisely regulated output voltage from 0.5 to 2Vdc. The module employs a novel charge mode control which ensures loop stability, provides fast transient response and reduces amount of required output capacitance. Up to eight modules can be connected in parallel to form a high current rail. The key features include: digital PMBus™ interface, remote ON/OFF, output voltage sequencing, tracking of an external analog signal, synchronization to an external clock, pre-biased start up, cycle-by-cycle output overcurrent protection, input and output under-voltage and over-voltage protections, under-temperature and over-temperature protections and more. The module has an extensive set of PMBus™ commands for both control and monitoring of the system parameters. System diagnostic is facilitated by a black-box event recorder that will log the selected fault events and will provide valuable inside for debugging. The DJT090 power module is highly configurable, and yet easy to use. For more details refer to the product datasheet. DJT090A0X43-SRPZ parallel evaluation board (later refer as EVM) provides user a quick start for DC and transient analysis up to 720A. For transient analysis, an on-board pulse load is provided for ease use. Alternatively, LoadSlammer™ can be used at user's choice.

PRECAUTION

The DJT090 parallel EVM can deliver up to 720A DC current. Any unintended connection can cause danger to both the EVM and user, user precaution is advised. DJT090 parallel EVM can only be evaluated at room temperature of 25 degree Celsius, and is assumed to have proper air flow for heat dissipating. DJT090 has its own over temperature protection, but the excess heat on the output terminal can potentially damage the PCB. Thus, for continuous 360A and below, user is recommended to use standard ring connectors for conducting current. Short time operation with ring connector along with sufficient air flow is tested for conducting 720A. Consult local FAEs for details. Do NOT apply reverse voltage, larger than -0.5V, on the output terminal, this will damage the EVM.

GETTING STARTED

Required Equipment and Accessory

DJT090 parallel EVM is preconfigured which provides maximum ease to evaluate. See below list for required equipment and accessory.

- Power supply (20V/100A and up is recommended)
- DC Load (Chroma 63600 Modular DC Electronics Load is recommended, 80V/80A/10-channel)
- ABB USB-I2C Dongle
- PC with DPI-CLI Tool

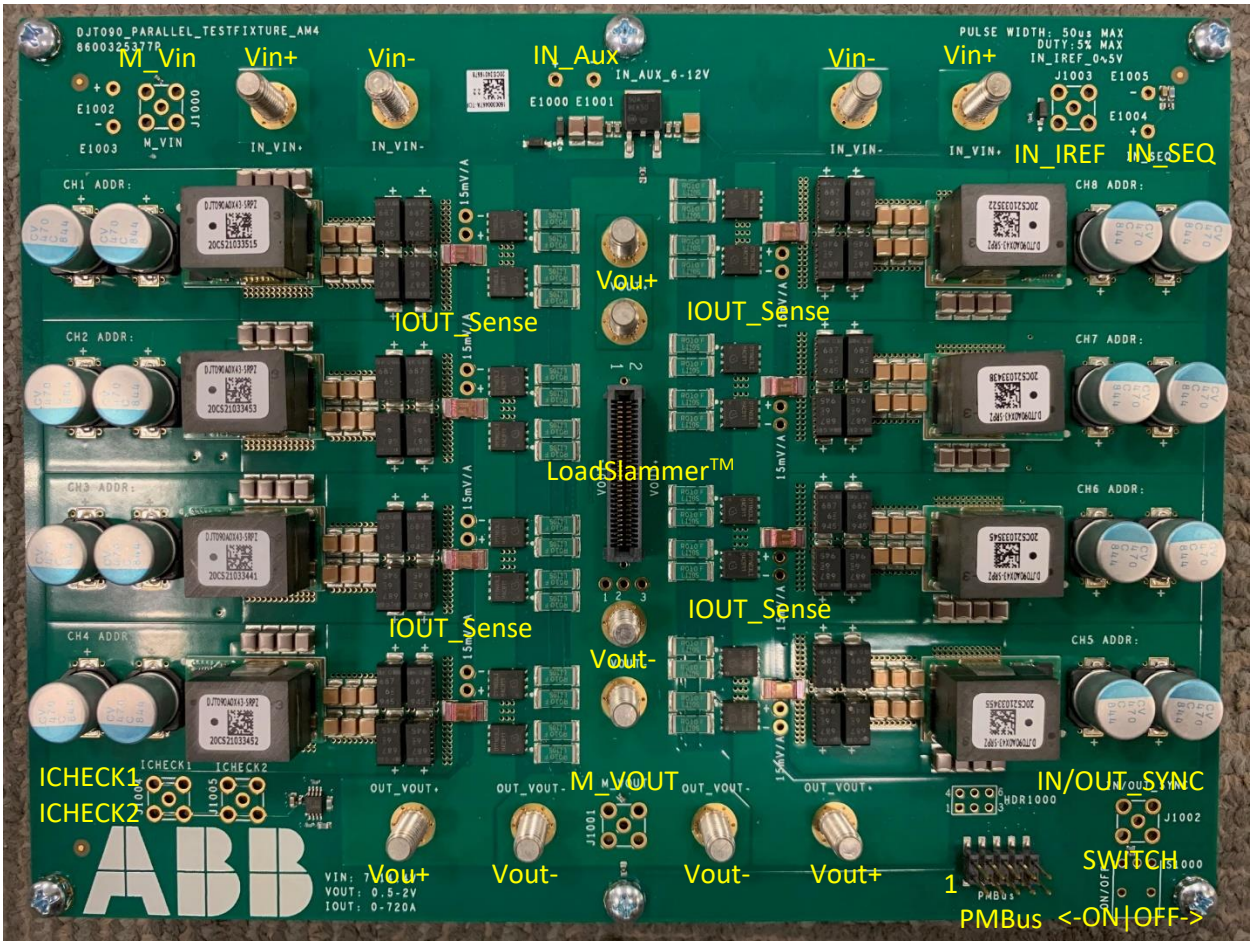
Optional Equipment and Accessory

Standard probing technics can be performed, ABB encourages user to use co-axial cable for output signal measurement in order to examine the ideal performance of DJT090. User is recommended to prepare following equipment and accessory for proper measurement and on-board pulse load control.

- SMA connector (Digikey PN: ARF1963-ND or equivalent)
- SMA to BNC cable (Digikey PN: ACX1717-ND or equivalent)
- Toggle switch (Digikey PN: CKN1073-ND or equivalent)
- Function Generator
- Multimeter
- LoadSlammer™

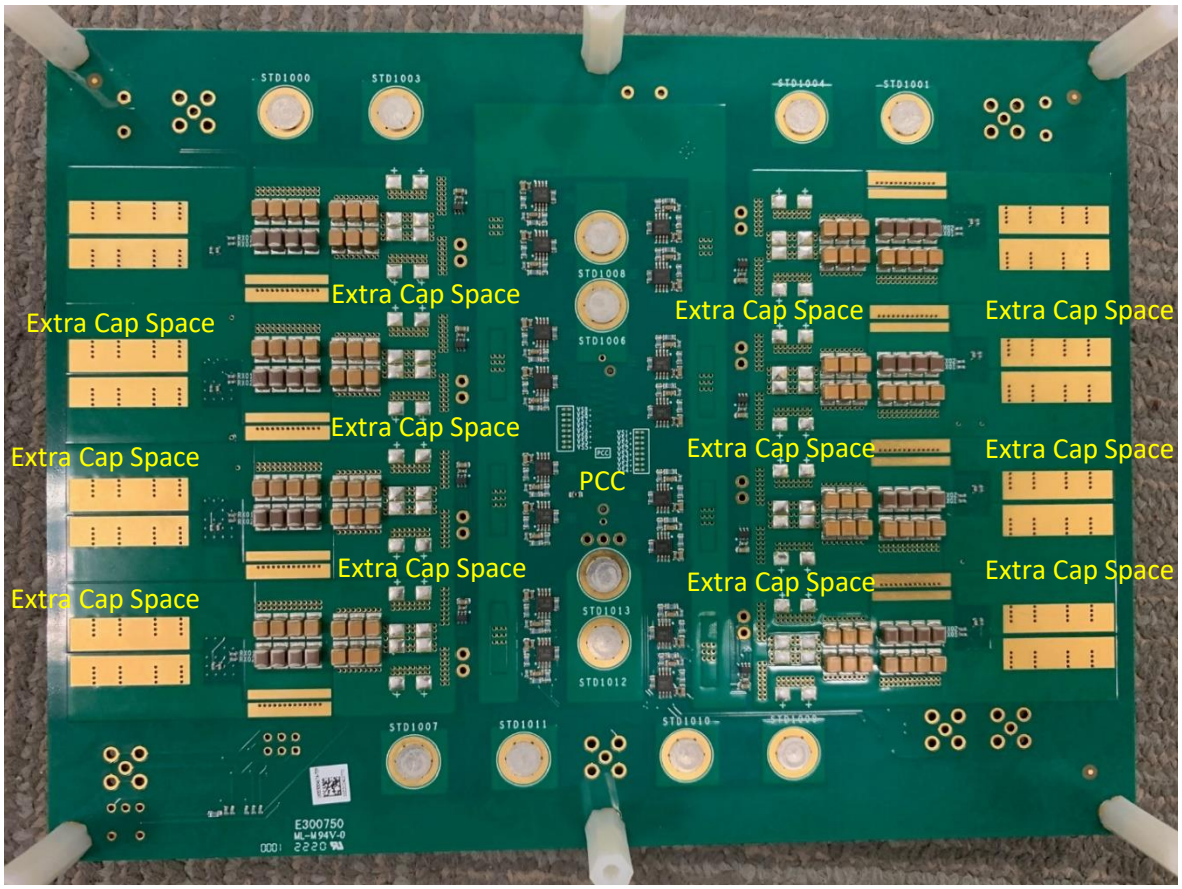
Eval Board Terminals/Ports

Following table and diagram illustrates all locations and purposes of all terminals/ports.



TOP View

Name	Description
VIN+	M5*0.8 stud, positive input voltage terminals, two M5 jam nuts are included.
VIN-	M5*0.8 stud, negative input voltage terminals, two M5 jam nuts are included.
VOUT+	M5*0.8 stud, positive output voltage terminals, two M5 jam nuts are included.
VOUT-	M5*0.8 stud, negative output voltage terminals, two M5 jam nuts are included.
IN_AUX	Auxiliary power input for pulse load if needed (by default, pulse load takes power from input power rail directly)
M_VIN	SMA socket for input voltage measurement
IN_IREF	SMA socket for pulse load current input reference
IN_SEQ	External sequence/track signal
IOUT_Sense	Measurement port for output current of each channel, total 8
LoadSlammer™	Socket for LoadSlammer™
CHECK1	SMA socket for pulse load current read back
CHECK2	Redundant SMA socket for pulse load current read back (DNP)
M_VOUT	SMA socket for output voltage measurement
PMBus	PMBus port for connecting to ABB USB to I2C dongle, notice Pin1 location
IN/OUT_SYNC	SMA socket for measure SYNC signal
SWITCH	Mechanical switch for turn on/off EVM, notice on/off direction



Bottom View

Name	Description
Extra Cap Space	Solder mask free area for populating extra capacitors
PCC	Point of common coupling, common remote sense point for all DJT090s. M_VOUT is routed from this point.

Input/Output Cable

The EVM provides M5x0.8 stud for external connections. Two M5 jam nuts are included. The maximum input current for parallel EVM can go over 200A, user must choose proper input cable size. The output voltage of the parallel EVM can range from 0.5V to 2V, and is capable of delivering up to 720A. Cable voltage drop must be controlled in this application. For continuous 360A and above operation, ABB recommends user to develop proper bus bar to distribute currents. Multiple DC load in parallel is a must for sinking 720A. In general, output connection should be kept as short as possible by means of reducing voltage drop on each cable. Cable length/size should be the same in order to evenly distribute current. Avoid scratching the surface of the PCB when fasten the cable assemblies, exposed PCB can potentially create damage.

Input/Output Measurement

To measure Input/Output voltage properly, SMA connectors are recommended to be populated at M_VIN and M_VOUT. Ideally oscilloscope should use 50Ω input impedance for measuring output voltage ripple, or use a 50Ω attenuator in series with 1MΩ input impedance. Set the oscilloscope to 5mV/div or below to examine ultra-low ripple performance of DJT090s in parallel. M_VOUT is very sensitive to ground loop noise, thus while measuring the output voltage ripple, the oscilloscope should be floating and can only be connect to M_Vout. Don't connect the rest of oscilloscope channels.

On-Board Pulse Load

To use on-board pulse load, SMA connectors are recommended to be populated at IN_IREF and ICHECK1.

Input/Output Capacitor

The parallel EVM comes with limited amount of input and output capacitors. Although the amount of capacitors is sufficient to evaluate the basic performance, user needs to decide whether to change/add more capacitors to unleash superior performance of DJT090. For output impedance matching purposes, all channel should equip equal amount of capacitors. POSCAP is recommended. Each channel contains following amount of capacitors,

- Input capacitor: 2x470uF (Aluminum Polymer) + 8x22uF (Ceramic)
- Output capacitor: 4x680uF (Tantalum Polymer) + 12x47uF (Ceramic)

Address Resistor

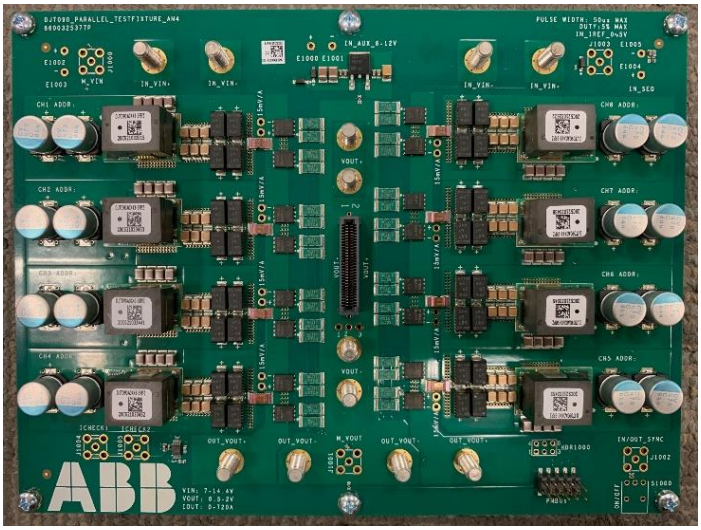
By default, the PMBus address resistors are pre-installed, see below diagram to see the addresses associated to each channel (RX01 and RX02, X refer to channel index). Any need to change the address must be done prior powering up the EVM. For PMBus address resistor selection, please refer to DJT090A0X43-SRPZ datasheet. Each paralleled channel must have a unique address.

0x10 (master)

0x12

0x14

0x16



0x1E

0x1C

0x1A

0x18

Default PMBus Address

Enable Switch

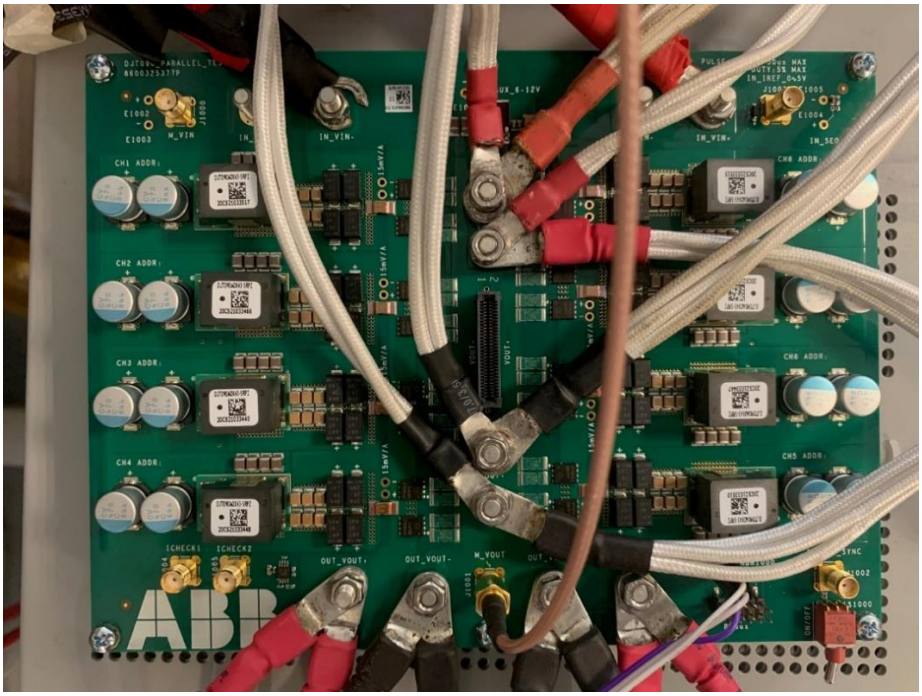
By default, DJT090s are set to PMBus start up mode. To use external switch turn on/off the modules, ensure the EVM is operating properly with PMBus control FIRST, then user can set the DJT090s to EN pin start up mode and operate with a mechanical switch. For changing the startup mode, refer to PMBus commands. For the toggle switch, toggle left is ON, toggle right is OFF.

SYNC

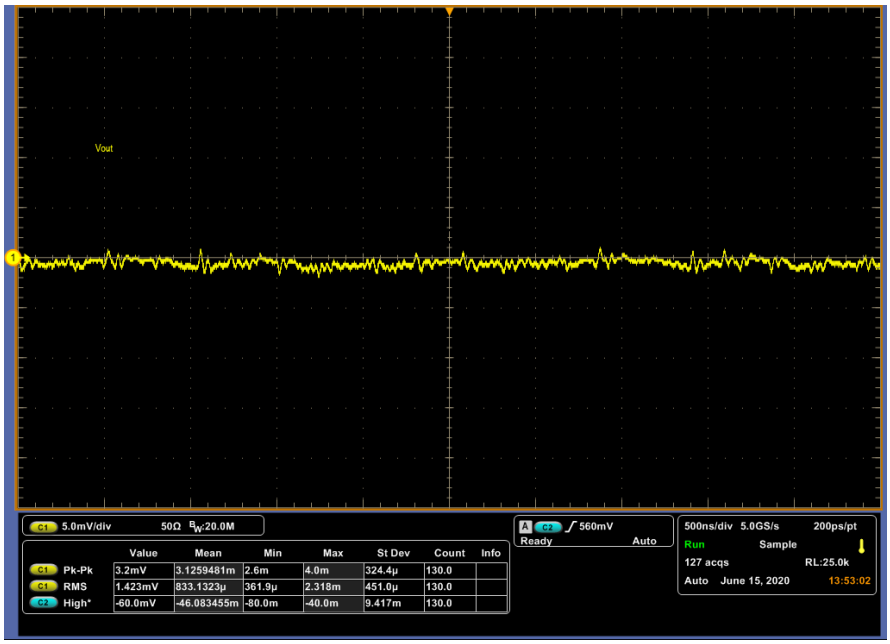
To measure SYNC signal, SMA connector is recommended to be populated at IN/OUT_SYNC. For use external SYNC, consult local ABB FAEs for more info.

START EVM

The input voltage for the EVM is from 7V to 14.4V, and the input voltage must not exceed 15V. The in current must be limited. Choose the current limitation properly based on the output power and input voltage. All ABB measurement are evaluated at 12V rated input. The default output of DJT090 EVM is set to be 1.2V. Connect ABB USB to I2C dongle to PMBus port (notice pin 1 location) with PC, then use ABB DPI-CLI tool to start the DJT090 (PMBus turn on is required for the first time, it can be changed to EN turn on via PMBus once the EVM is confirmed to be functional correctly). All EVM board is pre-configured in the factory, user doesn't require to perform any additional configuration before turning on the EVM. Refer to DPI-CLI User Guide for detailed PMBus commands. The standby turn-on power along with pulse load leakage can go up to 20W. To achieve ideal transient performance, input power and output power must feed in symmetrically. User is recommended to use all the on-board terminals to pass power and distribute current evenly (use same length/size cable for input/output). See following diagram for one example of connections. By default, the 8 channels are set to interleaving and have a phase shift of 45 degree from each other. Channel 0x10 is the master device (360 degree) and output the SYNC signal. Master can be set to any device. If less than 8 units paralleling is desired, refer to channel reduction section for detailed steps.



Connection



Output Ripple @Vin=12V, Vout=1.2V

ON-BOARD CHANNEL CURRENT MEASUREMENT

Each channel of DJT090 contains a shunt measurement circuit to sense output current for user to check current sharing capability. Use a Multimeter mV range to measure exact output current of each channel. The conversion ratio for voltage to current is 15mV/A. Take extra caution while probing, do not short the shunts to the measurement points.

ON-BOARD PULSE LOAD

The on-board pulse loads provide user a quick and easy way to measure transient performance of paralleling DJT090s. Basically, the pulse load would track an external arbitrary current reference and apply it on the output rail. Total sixteen channel of pulse load can operate together to achieve 16x pulse capability. For using on-boar pulse load,

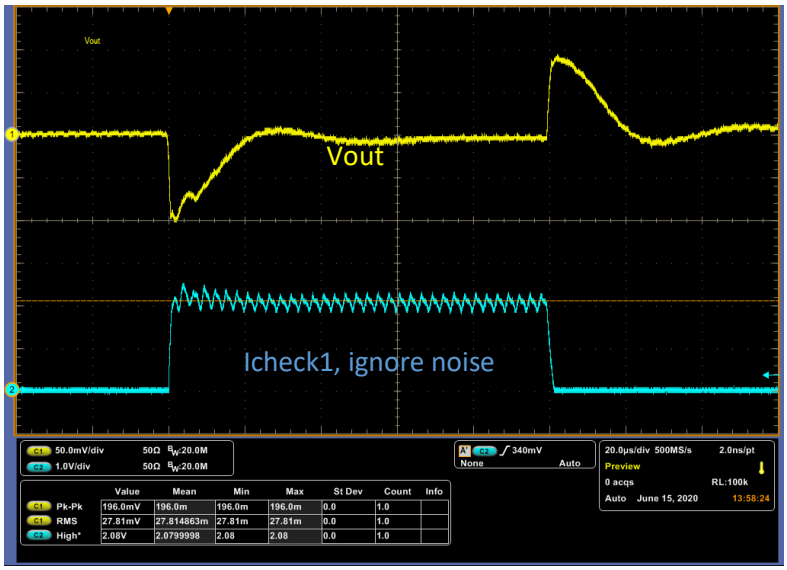
- Connect input power
- Connect output DC load if needed (the pulse load can operate on top of external DC load. e.g. use external DC load to sink 300A and use on-board pulse load to pulse additional 300A current)
- Connect IN_IREF to function generator
- Connect M_VOUT to Oscilloscope Channel 1 via co-axil cable, use 50Ω input impedance or use 50Ω attenuator in series with 1MΩ input impedance.
- Connect ICHECK1 to oscilloscope Channel 2 via co-axil cable, use 1MΩ input impedance

Now the EVM setup is ready to perform transient analysis. User can simply control the pulse load by applying an external arbitrary voltage reference on IN_IREF by function generator. Parameters to setup on the function generator,

- Switch to pulse mode
- Set frequency to 100Hz
- Set duty to 5% MAX! (on-board pulse load can take maximum 40W loss, reduce duty if pulse load exceeds 40W loss)
- Set output voltage high level to desired current value using roughly 100A/V ratio (1.0V = 100A) for 8 channel parallel EVM. 5V maximum. Due to cable losses and other issues, use ICHECK1 as reference to verify actual output current waveform.
- Set output voltage low level to 10mV (a small current will be applied)
- Set rising/falling edge of the pulse to the desired value, 100ns minimum.

Upon complete, power the EVM and enable the output of the function generator. Use oscilloscope to exam the performance.

- Use M_VOUT to examine undershoot/overshoot of the output, adjust horizontal/vertical axis to proper range.
- Use ICHECK1 to see actual load current waveform. Use 166A/V conversion ratio for 8 channel EVM to interpreting the pulse load current. ICHECK1 is a more accurate way to determine output current characteristics. For example, regardless high level voltage setting, if ICHECK1 shows a 1V step with a 1us rising time, it is equivalent to apply a 166A/us trainset on the output rail. To be noted, noise can be seen on the measurement due to nearby DJT090, use average value to measure high level voltage.



Transient @Vin=12V, Vout=1.2V, 180A DC Load + 332A@360A/us Pulse Load

LoadSlammer™

DJT090 parallel EVMs supports LoadSlammer™. Simply plug LoadSlammer™ to the socket can achieve transient analysis. Refer to https://loadslammer.com/ for details or consult local ABB FAEs for more info.

CHANNEL REDUCTION

ABB supplies 4 and 8 parallel EVM by default. If 2,3,5,6,7 DJT090 operation is desired, PMBus reconfiguration is a must and board modification is recommended. Each channel contains an output shunt resistor. By removing the shunt resistor, the associated DJT090 and its output capacitors will be disconnected to the loading point. Although PMBus command can be used to disable the unused channel, the existence of the unused DJT090 and its capacitance can potentially cause unwanted oscillation since all DJT090 and its output capacitance are shared a common point of load. Thus, use below table as a guide to disconnect unused channels. (Mismatched output impedance doesn't affect current sharing capability but has an impact for transient performance).

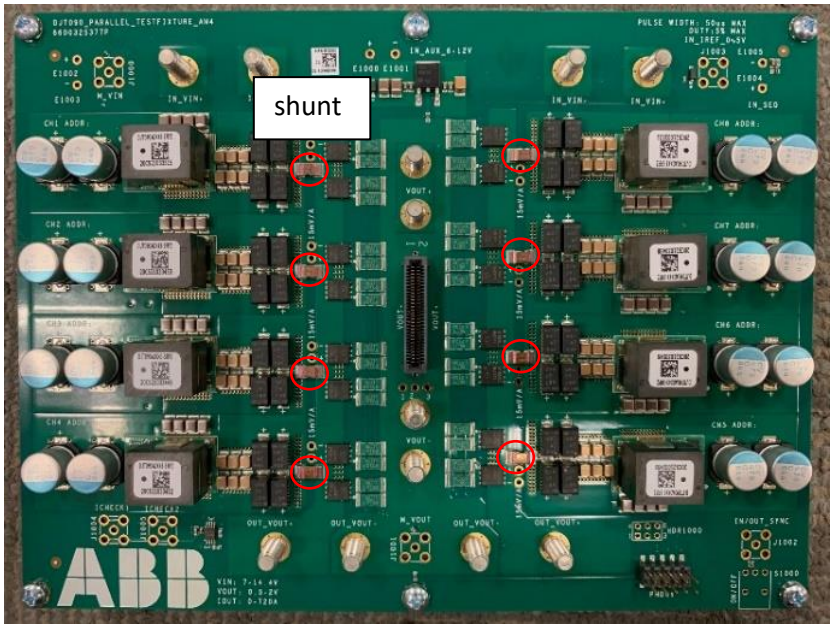
Number of DJT090 to parallel	EVM to use	Suggested channel(s) to disconnect
3	4-channel	3 or 6 or 7
5	8-channel	4,5,8
6	8-channel	4,8
7	8-channel	8

1

2

3

4



8

7

6

5

Channel Illustration

Then, user must configure following registers

- Configure USER_CONFIG(0xD1) to re-assign master and slaves
- Configure INTERLEAVE (0x37) to rearrange interleave phases
- Configure DDC_CONFIG(0xD3) and DDC_GROUP(0xE2) to assign different group number for disconnected channels other than used channels. This will prevent unused channel to spread fault signal.
- Configure ON_OFF_CONFIG(0x02) to give different start up method for used and unused channels. For example, configure used channels as PMBus startup and configure unused channels as EN startup. This potentially will prevent unused channels to operate.

Consult local ABB FAEs for more details.

PMBUS COMMANDS

In this application note, only limited commands are included. All settings must be saved to user NVM before power cycle, otherwise all changes will be lost. Refer to DPI-CLI User Guide for detailed procedures.

PMBus Turn-on/Turn-off

- Turn-on: write 0x80 to OPERATION (0x01) for slave devices first then master
- Turn-off: write 0x00 to OPERATION (0x01) for master device

Switch between PMBus and EN control

- write 0x16 to ON_OFF_CONFIG(0x02) for all devices (EN control)
- write 0x1A to ON_OFF_CONFIG(0x02) for all devices (PMBus control)

Parallel configuration (8 parallel)

Default manufacturing setting of DJT090 is configured as solo operation, therefore modification is required to achieve parallel operation. The parallel EVM is already configured as parallel operation, following example shows the steps to reconfigure the 8-channel EVM from manufacturing setting. See appendix for CLI-DPI script examples. To be noted, master device USER_CONFIG(0x01) must be configured before slave devices. Consult local ABB FAEs for more info.

Register to be modified:

- USER_CONFIG(0xD1)
- DDC_CONFIG (0xD3)
- INTERLEAVE (0x37)
- DDC_GROUP (0xE2)

PMBus Address	USER_CONFIG(0xD1)		DDC_CONFIG(0xD3)		INTERLEAVE (0x37)	
	Default	Modified	Default	Modified	Default	Modified
0x10	0x0C04	0x0C05(master)	0x0000	0x0007	0x0000	0x0000(360 degree)
0x12	0x0C04	0x0C06(slave)	0x0000	0x2007	0x0000	0x0002(45 degree)
0x14	0x0C04	0x0C06(slave)	0x0000	0x4007	0x0000	0x0004(90 degree)
0x16	0x0C04	0x0C06(slave)	0x0000	0x6007	0x0000	0x0006(135 degree)
0x18	0x0C04	0x0C06(slave)	0x0000	0x8007	0x0000	0x0008(180 degree)
0x1A	0x0C04	0x0C06(slave)	0x0000	0xA007	0x0000	0x000A(225 degree)
0x1C	0x0C04	0x0C06(slave)	0x0000	0xC007	0x0000	0x000C(270 degree)
0x1E	0x0C04	0x0C06(slave)	0x0000	0xE007	0x0000	0x000E(315 degree)

- 0x10 is the master device, the rest devices are slave.
- 0x10 has a phase ID of 0, 0x12 has a phase ID of 1…
- All devices are group to Rail 0
- Total 8-phase is configured together for Rail 0
- 0x10 has a phase angle of 360 degree, 0x12 has a phase angle of 45 degree…
- Refer to DJT090 datasheet to modify DDC_GROUP, the default value can work in parallel
- In general, any device within the same DDC_GROUP must have unique rail ID.

Parallel configuration (4 parallel)

Following example shows the steps to reconfigure the 4-channel EVM from manufacturing setting. Consult local ABB FAEs for more info.

Register to be modified:

- USER_CONFIG (0xD1)
- DDC_CONFIG (0xD3)
- INTERLEAVE (0x37)
- DDC_GROUP (0xE2)

PMBus Address	USER_CONFIG(0xD1)		DDC_CONFIG(0xD3)		INTERLEAVE (0x37)	
	Default	Modified	Default	Modified	Default	Modified
0x10	N/A	N/A	N/A	N/A	N/A	N/A
0x12	0x0C04	0x0C05(master)	0x0000	0x0003	0x0000	0x0000(360 degree)
0x14	0x0C04	0x0C06(slave)	0x0000	0x2003	0x0000	0x0004(90 degree)
0x16	N/A	N/A	N/A	N/A	N/A	N/A
0x18	N/A	N/A	N/A	N/A	N/A	N/A

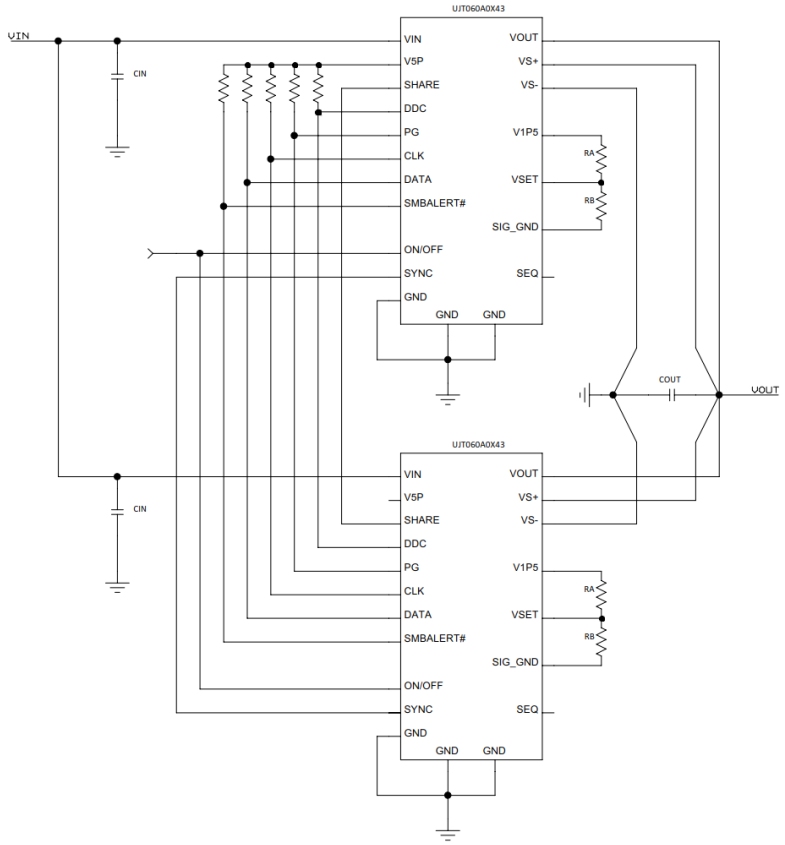
0x1A	0x0C04	0x0C06(slave)	0x0000	0x4003	0x0000	0x0008(180 degree)
0x1C	0x0C04	0x0C06(slave)	0x0000	0x6003	0x0000	0x000C(270 degree)
0x1E	N/A	N/A	N/A	N/A	N/A	N/A

- 0x10,0x16,0x18,0x1E are not populated
- 0x12 is the master device, the rest devices are slave.
- 0x12 has a phase ID of 0, 0x14 has a phase ID of 1…
- All devices are group to Rail 0
- Total 4-phase is configured together for Rail 0
- 0x12 has a phase angle of 360 degree, 0x14 has a phase angle of 90 degree…
- Refer to DJT090 datasheet to modify DDC_GROUP, the default value can work in parallel
- In general, any device within the same DDC_GROUP must have unique rail ID.

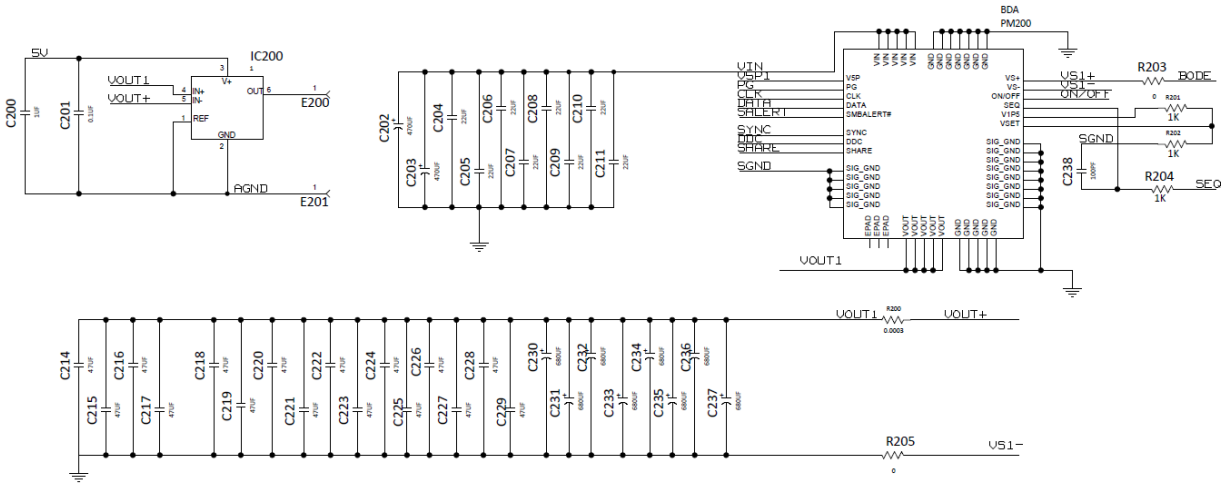
Q&A

Q: Is remote sensing supported?
A: No, optimized sense point is chosen. All measurement is based on this point. Refer to PCC location.
Q: How to connect ring connector?
A: Use one nut as a space to the board, use the other one to fasten the connection.
Q: My DC load doesn't sink the target current, why?
A: Check your DC load manual for minimum voltage for conducting target current. e.g. Chroma 63640-80-80 typical min operating voltage (DC) is 0.4V@80A.
Q: How to conduct full load at low output voltage?
A: Cable voltage drop is recommended to control under 0.2V.
Q: How to use DPI-CLI script?
A: Under DPI-CLI installing folder, create a txt file. Copy/paste the example script in the txt file. In DPI-CLI command line, enter "i Filename.txt".

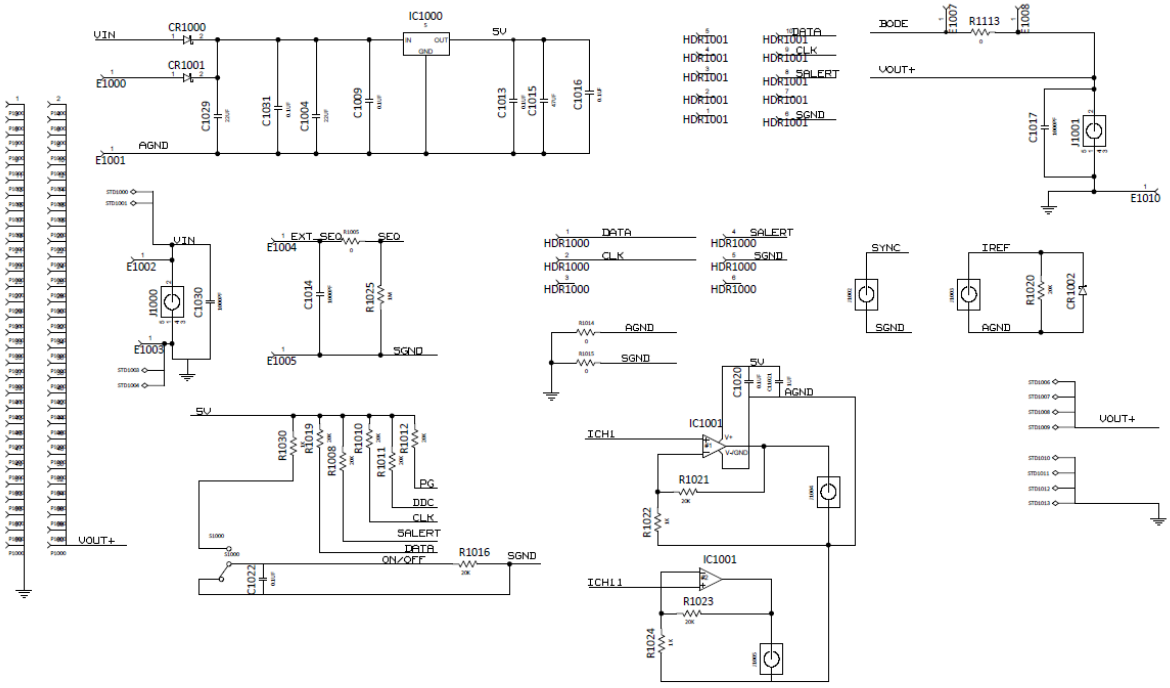
SCHEMATIC



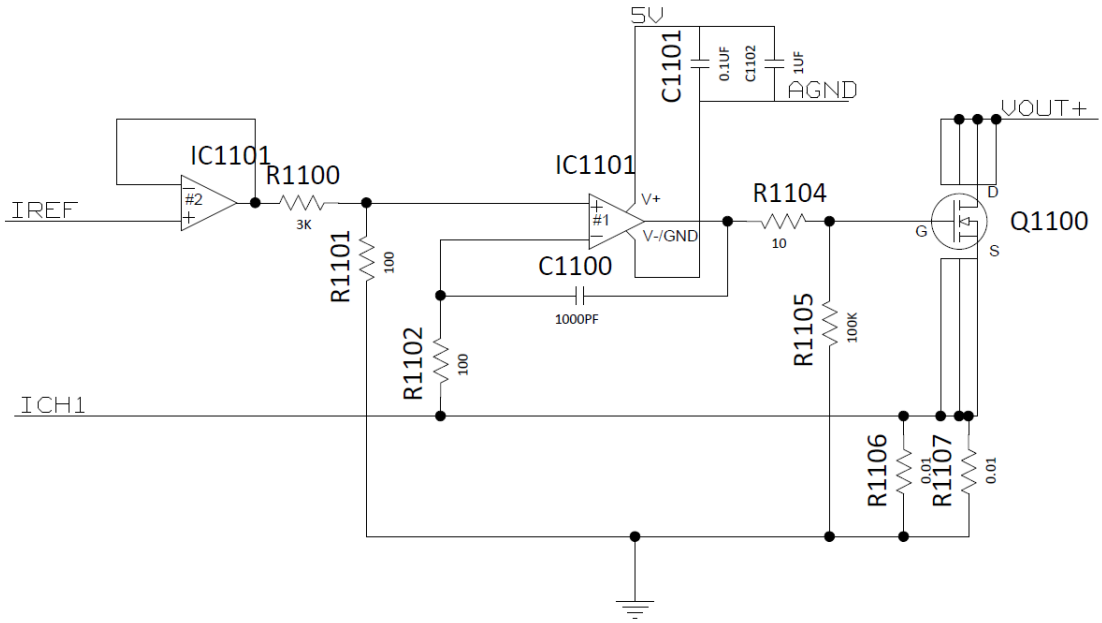
Example of 2 channel Parallel Configuration Diagram



Main Power Train, only one channel is shown (1 out of 8)
The rest channels are duplicated



Aux circuitry



Pulse Load, only one channel is shown (1 out of 16)
The rest channels are duplicated

Change History (excludes grammar & clarifications)

Version	Date	Description of the change
Draft	06/12/2020	Draft
V1.0	07/10/2020	Initial Release
V1.1	09/29/2020	Minor Revision
V1.2	11/10/2020	Minor Revision

Contact Us

For more information, call us at

USA/Canada: **+1 888 546 3243**, or

+1 972 244 9288

Asia-Pacific: +86 021 54279666

Europe, Middle-East and Africa:

+49 89 878067-280

Go.ABB/Industrial