Using the LP8755EVM Evaluation Module

User's Guide

TEXAS INSTRUMENTS

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The LP8755 Evaluation Module

This user's guide describes the operation of the evaluation module for the LP8755 Multi-Phase 6-Core Step-Down Converter from Texas Instruments (TI). The user's guide also provides design information including the schematic and Bill of Materials (BOM).

1 Overview

The LP8755EVM customer evaluation module demonstrates the integrated circuit LP8755 from TI. The LP8755 is a high-performance, multi-phase step-down converter designed to meet the power management requirements of the latest applications processors in portable applications. The device contains six step-down converter cores, which are bundled together in a 6-phase buck converter. This document covers user software provided with the EVM and design documentation that includes schematics and parts list.
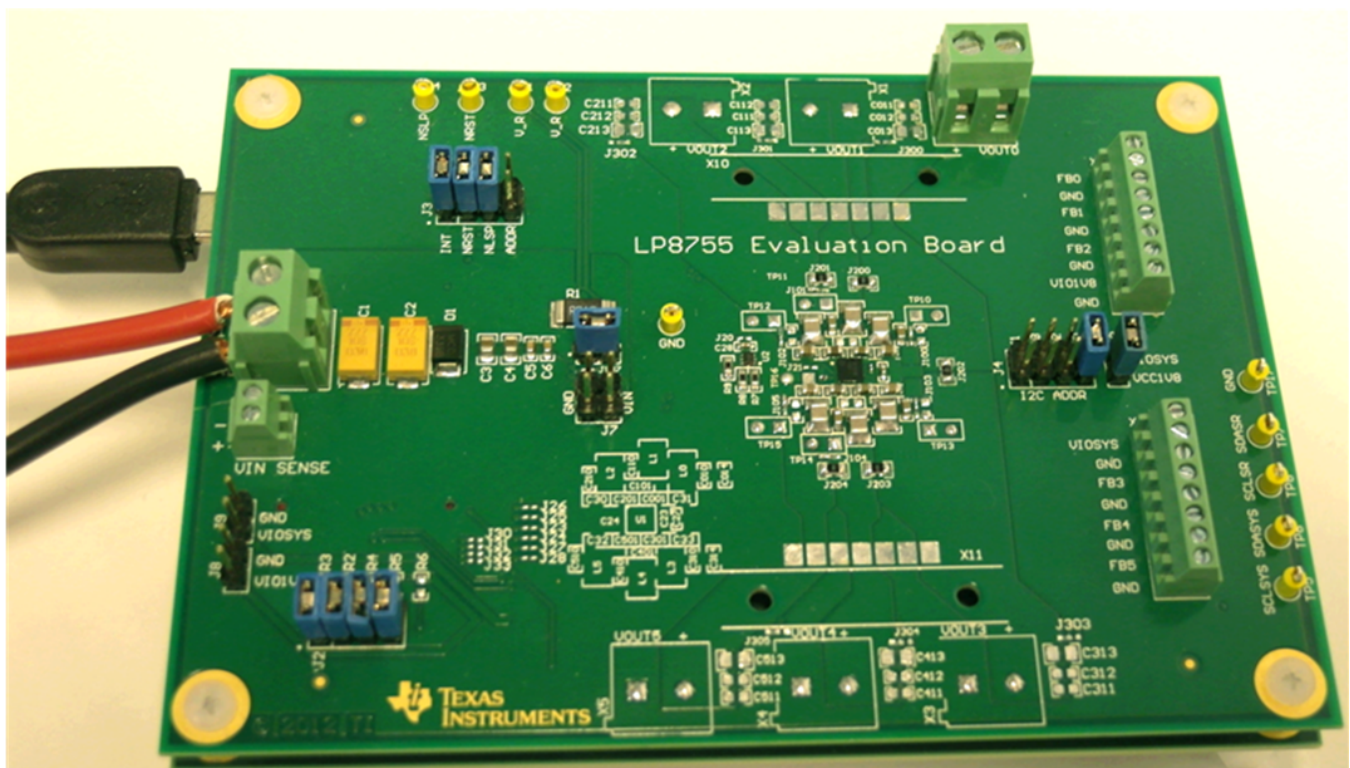

Figure 1. LP8755EVM

The evaluation module consists of two PCB boards, the LP8755 Evaluation Board, and the USB Interface Board. The boards are of the same size, and the LP8755 board is stacked on top of the USB Interface Board.

2   Quick Setup Guide

Many of the components on the LP8755 are susceptible to damage by electrostatic discharge (ESD). Customers are advised to observe proper ESD handling precautions when unpacking and handling the EVM, including the use of a grounded wrist strap at an approved ESD workstation.

On opening the LP8755EVM package, ensure that the following items are included:

- LP8755 Evaluation Board
- USB Interface Board
- USB Cable

If any of the items are missing, contact the closest Texas Instruments Product Information Center to inquire about a replacement.

2.1   Installing/Opening the Software

The EVM software is controlled through a graphical user interface (GUI). The software communicates with the EVM through an available USB port. The minimum hardware requirements for the EVM software are:

- IBM PC-compatible computer running a Microsoft Windows® XP or newer operating system
- Available USB port
- Mouse

The latest downloadable software is available at http://www.ti.com/tool/lp8755evm. Download the zip file onto your local hard drive, then unzip this folder. Make sure the USB Interface Board is connected to the Evaluation Board, and connect the USB Interface Board to the PC with the USB cable. Refer to Figure 1.

1. With the power supply disconnected from the unit under test (UUT), open the un-zipped folder, and click on lp8755_nnn.exe (nnn is the version number) to start the software.

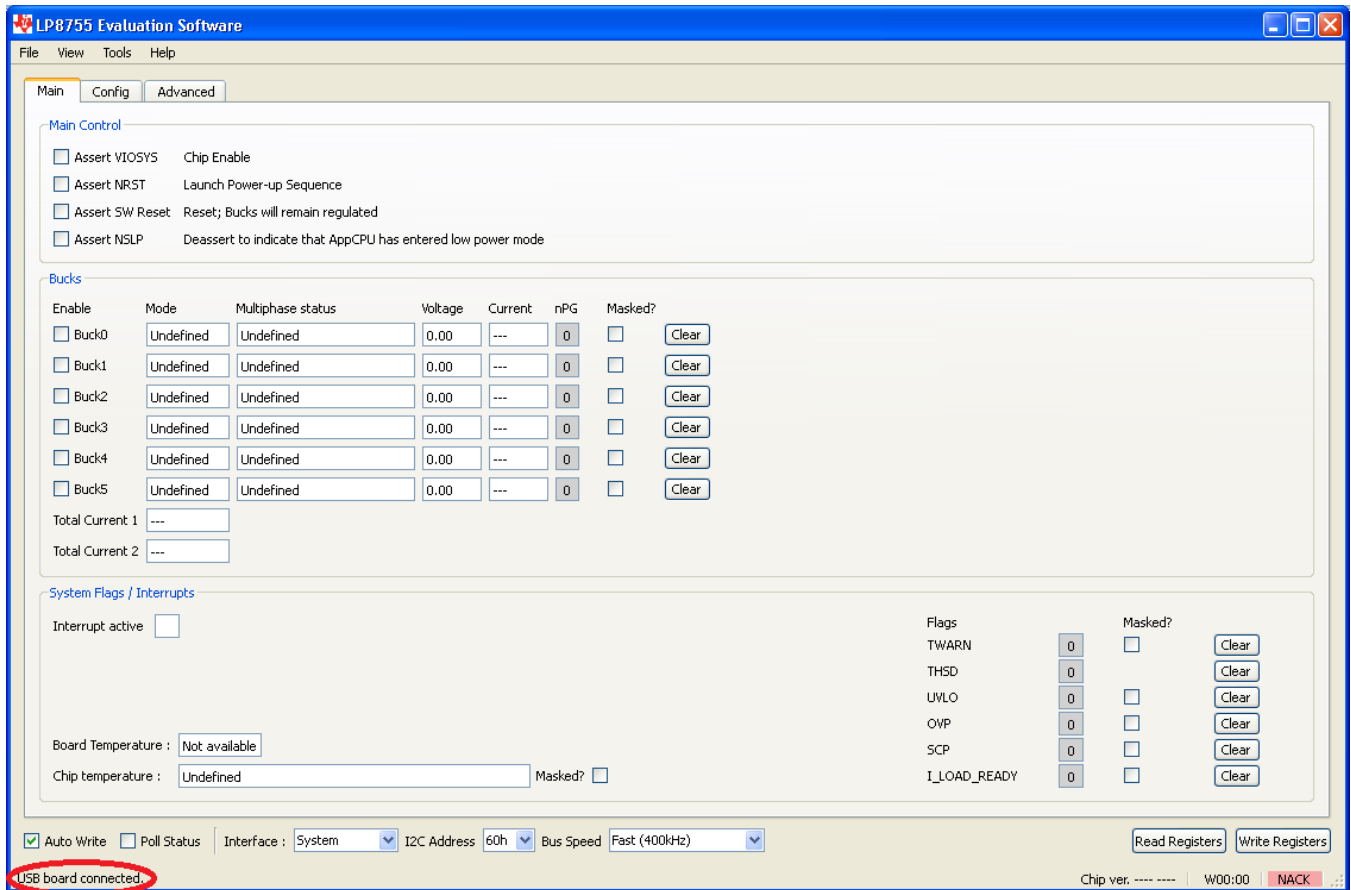2. On the Evaluation SW window bottom right corner you should see text "USB Board connected". Refer to Figure 2.

**Figure 2. Evaluation Software Graphical User Interface (GUI)
When USB Board Connected**

2.2 Power Supply Setup

To power up the EVM, one power supply is needed. For full-load testing of the LP8755EVM, a DC-power supply capable of at least 10A and 4V is required. 5A is suggested as a practical minimum for partial load. The power supply is connected to the EVM using connector X6. The power supply and cabling must present low impedance to the UUT; the length of power supply cables must be minimized. Remote sense, using connector X7, can be used to compensate for voltage drops in the cabling.

With the power supply disconnected from the UUT, set the supply to 3.7V DC and the current limit to 5A minimum. Set the power supply output OFF. Connect the power supply's positive terminal (+) to VIN and negative terminal (-) to GND on UUT (X6 Power-in terminal block). Check that jumpers on the boards are set as shown in Figure 1 (factory default jumper configuration).

Set power supply output ON, and then continue with the following steps.

1. On Evaluation software GUI, click on Assert VIOSYS. See Figure 3: Marking "1".
2. Click on Assert NRST. See Figure 3: Marking "2".
3. Click on Read Registers button. You should see ready message on green background next to the Read Registers button. See Figure 3: Marking "3".
4. Check that the GUI indicates "PFM" under "Mode" and "Master; 1/6 Phases Active" under "Multi-phase" status. See Figure 3: Marking "4".The EVM is now ready for testing with default register settings loaded.
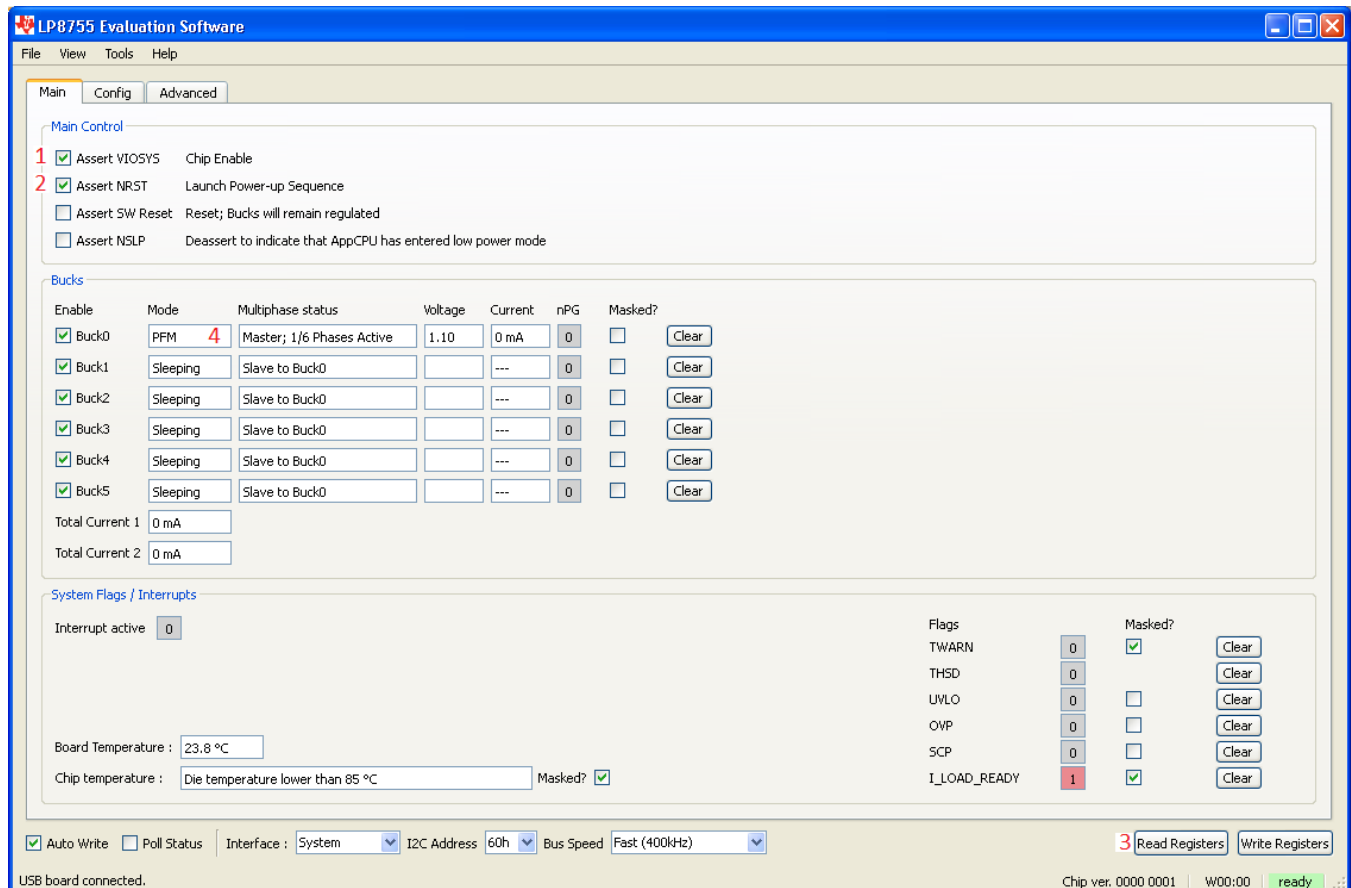

Figure 3. Evaluation Software GUI Showing Steps Needed to Power up the LP8755

2.3 Notes on Efficiency Measurement Procedure

Output Connections: An appropriate electronic load or high-power system source meter instrument, specified for operation down to 500 mV, is desirable for loading the UUT. The maximum load current is specified as 15A. Be sure to choose the correct wire size when attaching the electronic load. A wire resistance that is too high will cause a voltage drop in the power distribution path which becomes significant compared to the absolute value of the output voltage. Connect an electric load to X0. It is advised that, prior to connecting the load, it be set to sink 0A to avoid power surges or possible shocks.

Voltage drop across the PWB traces will yield inaccurate efficiency measurements. For the most accurate voltage measurement at the EVM, use TP16 to measure the input voltage and TP10 to measure the output voltage.

To measure the current flowing to/from the UUT, use the current meter of the DC power supply/electric load as long as it is accurate. Some power source ammeters may show offset of several milliamps and thus will yield inaccurate efficiency measurements. In order to perform very accurate I_q measurements on the UUT, remove the input protective Zener diode D1 from the board. When assembled, this diode will cause some leakage, especially on high VIN voltages. Also, the output voltage ADC on the USB Interface Board will load the output of LP8755 with a resistance in order of a hundred of kΩ. The 0Ω resistors between the pads of J23 to J28 on the lower left corner of the EVB may also be removed (see Section 5).

3 GUI Overview

The evaluation software has the following tabs: Main, Config, and Advanced. The three tabs together provide the user access to the whole register map of LP8755.

3.1 Main Tab

The Main tab has the elemental controls for the EVM and provides a view to the chip status. Starting from top, the main controls are:

- Assert VIOSYS: This checkbox will assert 1.8V voltage to LP8755 VIOSYS pin (provided that jumper J6 is placed). This pin will enable the chip internal voltage reference and LDO, release POR, and launch OTP read cycle. The VIOSYS voltage is the reference voltage for the System I²C bus.
- Assert NRST: This checkbox will assert 1.8V voltage to LP8755 NRST pin. Asserting NRST will launch power-up sequence.
- Assert SW Reset: To perform a complete SW reset to the chip, assert and de-assert this checkbox. See the LP8755 datasheet for explanation of LP8755 reset scenarios.
- Assert NSLP: When this bit is asserted it tells LP8755 that the device it is powering is in a high-load condition state. On LP8755 this effectively prevents the bucks from entering the Low-Power PFM Mode (ECO).

NOTE: The recommended startup sequence for LP8755 is to first assert VIOSYS, then write all needed configuration bits by using the GUI, and then to assert NRST.

NOTE: The NRST pin is the reference for the DVS (Dynamic Voltage Scaling) bus (that is, SmartReflex™ bus). NRST needs to be asserted before the chip will acknowledge any transmission on the DVS bus.

The Bucks section provides status information for all the 6 buck cores. The Mode field provides information on each of the buck core and can have any of the values given in Table 1:

Table 1. Mode Information

Buck Mode	
Disabled	Buck state machine in 'disable'
Soft Startup	Buck state machine in 'soft startup'. May occur when too much loading is present when powering-up the buck.
PWM	Pulse Width Modulation
PFM	Pulse Frequency Modulation
ECO	PFM with 'low power coasting' mode enabled. This means that lots of analog resources are disabled between PFM bursts. Reaction time to load transients is compromised, while Iq is minimized.
Sleeping	Multi-phase slave is passive.

The "Multi-phase Status" info field tells whether a buck core is configured as a master or slave. The field also tells how many phases are active.

An ADC on the USB interface card is connected to measure the output voltage of the buck converter, and this is displayed on GUI.

The "System Flags / Interrupts" section gives data on system faults and warnings. If the interrupt is set for any reason the Interrupt active field shall show '1' on red background. The flag causing the interrupt will also be set on the Main tab. Interrupts on LP8755 can only be cleared by writing '0' to associated registers. Any individual flag can be cleared by clicking the Clear button next to each flag field. The USB Interface Board uses an I^2C-accessible temperature sensor IC to sense the EVB temperature near the LP8755 IC. This information is presented in the "Board Temperature" field. LP8755 register 0x0D provides a coarse temperature indication of the chip. This info is interpreted into the "Chip Temperature" field when the "Poll Status" option is selected.

At the bottom of the GUI window is the "Auto Write" checkbox. If "Auto Write" is checked (default) any checking, un-checking or pull-down menu selections will immediately launch I^2C writes to the chip register(s). If not checked, the user can update the chip registers to correspond the configuration selected on the GUI by clicking "Write Registers".

If "Poll Status" is selected the software sends a query to the LP8755 at a fixed interval in order to detect the status of the chip, including operation mode, multi-phase status, and output current. If not selected, user can read the registers by applying "Read Registers". On the EVM both System I^2C and DVS (Dynamic Voltage Scaling) (that is, SmartReflex) buses can be used to interface the chip. The interface to be used can be selected from the Interface pull-down menu. "Bus Speed" pull-down menu selections are given in Table 2 below and are instantly applied for both buses. Notice that for DVS bus to work, NRST needs to be high.

Table 2. I^2C-Compatible Bus Support

Bus Speed Selection	Explanation
Fast (400 kHz)	Fast I^2C-compliant operation at 400 kHz
Fast++ (3.4 MHz)	I^2C protocol data transfer with 3.4 MHz clock rate. No writing of master code needed, but can done. Input filters correspond to HS lengths – 10 ns minimum filter length for SCL and SDA:
High-Speed (3.4 MHz)	HS I^2C-compliant data transfer with master codes.

3.2   Other Tabs and Menus

The "Tools" pull-down menu hosts another way of accessing the LP8755 registers. The "Direct Register Access" tool can be used to read or write any register. When using direct register access, un-checking the poll status checkbox is recommended. This way the GUI will only do the reads and writes commanded from the direct access dialog.

The "Config" and "Advanced" tabs provide the user with pull-down menus and check-boxes for the part of the register space that is not covered by the Main tab, such as output voltage control. These controls are self-explanatory. **Note that for the six-phase converter, only the Buck0 (Master) controls are effective.** Please refer to the LP8755 datasheet for explanation of the functions.

3.3 Console

To show or hide the console, toggle the option in View pull-down menu. The console can be used to access the LP8755 registers. Registers can be read or written simply by referring to the logical registers by their name. The console has a number of integrated macros that are listed in Table 3.

Table 3. Console Macros

Command	Parameters	Explanation
register_name	= register value | -	Write a value to writable I^{2}C register or logical register. If no parameter given, will return the current register value. The logical register names are the same as given in the datasheet, and must be in uppercase.
		Example: VSET_B0 = 40
wait	(time)	Wait for time given in ms. Useful in loops.
advanced		Change to advanced user mode.
user		Return from advanced to regular user mode.
vout	(buck number)	Use the ADC on the USB Interface Board to measure any buck output voltage. Return result to console in volts.
iout	(buck number)	Returns the measured load current of the chosen buck core.
i2c_bus	sr | sys | -	Change serial bus communications from the console and the GUI to be made with the specified bus. If called with no parameter treated as query and current selection is returned.
0x	address = data or address[bits] = data	I^{2}C read or write command. addr = value examples: 0x12 = 0xaa 0x12[7] = 1 0x12[3:0] = 15

The console supports use of scripts. If a text file containing commands supported by the console is stored in the same folder with the evaluation software executable, then the script can be launched from the console by typing the text file name, like script.txt. For demonstration purposes, the evaluation software comes with a set of scripts, which are loaded when Power Saver, Balanced, or High Performance buttons on the "Advanced" tab are clicked. These scripts (saved as script1.txt, script2.txt and script3.txt) will load a collection of register settings that will save energy, maximize load transient performance, or achieve a balance between the two. Clicking the User button will load a script "script4.txt". By default this file contains a demo which loops through all output voltage settings (VSET_B0). User can modify this file for specific register settings.

4   Bill of Materials

Designator	Description	Manufacturer	Part Number	Qty.
!PCB	Printed Circuit Board	Any	SV600763-001 REV A	1
C001, C201, C301, C501	CAP, CERM, 10µF, 10V, ±10%, X5R, 0603	TDK	C1608X5R1A106M	4
C1, C2	CAP, TANT, 220µF, 10V, ±10%, 0.05Ω, 7343-31 SMD	AVX	TPSD227K010R0050	2
C3, C4	CAP, CERM, 22µF, 10V, ±20%, X5R, 0805	Taiyo Yuden	LMK212BJ226MG-T	2
C5, C6	CAP, CERM, 0.1µF, 10V, ±10%, X7R, 0603	Kemet	C0603C104K8RACTU	2
C010, C30, C31, C32, C33, C110, C310, C410, C510	CAP, CERM, 22µF, 10V, ±20%, X5R, 0603	Samsung	CL10A226MP8NUNE	9
C23, C24	CL03 Series 0201 1000nF 6.3 V 20 % X5R SMD	Samsung	CL03A105MQ3CSNH	2
C27, C28	CAP, CERM, 0.1µF, 10V, ±10%, X5R, 0402	MuRata	GRM155R61A104KA01D	2
D1	Diode, Zener, 5.1V, 5W, SMB	Micro Commercial Co	SMBJ5338B-TP	1
H1, H2, H3, H4	MACHINE SCREW PAN PHILLIPS 4-40	B&F Fastener Supply	NY PMS 440 0050 PH	4
H5, H6, H7, H8	Standoff, Hex, 0.5"L #4-40 Nylon	Keystone	1902C	4
H19, H20, H21, H22	M4 CIRC CLEARANCE SPACER 5MM	Harwin Inc	R40-6710594	4
J1, J6, J8, J9	Header, TH, 100mil, 2x1, Gold plated, 230 mil above insulator	Samtec, Inc.	TSW-102-07-G-S	4
J2, J3, J4	Header, TH, 100mil, 4x2, Gold plated, 230 mil above insulator	Samtec, Inc.	TSW-104-07-G-D	3
J5	Connector, SMT, High Speed, 20 pairs	Samtec, Inc.	QTE-020-01-L-D-A	1
J7	Header, TH, 100mil, 2x2, Gold plated, 230 mil above insulator	Samtec, Inc.	TSW-102-07-G-D	1
J25, J100A, J101B, J102B, J103B, J104B, J105B	RES, 0 ohm, 5%, 0.063W, 0402	Vishay-Dale	CRCW04020000Z0ED	7
J200, J201, J202, J203, J204, J205, J206, J207, J208, J209	RES, 0 ohm, 5%, 0.333W, 0805	Vishay-Dale	CRCW08050000Z0EAHP	10
L0, L1, L2, L3, L4, L5	Inductor, Shielded, Powdered Iron, 470nH, 3.9A, 0.028 ohm, SMD	TOKO	1276AS-H-R47M	6
R1	RES, 0.01Ω, 1%, 3W, 2512 High Power Current Sense Chip Resistor	Bourns	CRA2512-FZ-R010ELF	1
R7, R8, R9	RES, 1.8kΩ, 5%, 0.1W, 0603	Vishay-Dale	CRCW06031K80JNEA	3
SH-J9, SH-J10, SH-J11, SH-J12, SH-J13, SH-J14, SH-J15, SH-J16, SH-J17, SH-J18	Shunt, 100mil, Gold plated, Black	3M	969102-0000-DA	10
TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP17	Test Point, TH, Miniature, Yellow	Keystone	5004	10
U1	LP8755 Multi-phase 6-Core Step-Down Converter, YFQ0049AEAK	Texas Instruments	LP8755KME/NOPB	1
U2	Low Power Digital Temperature Sensor With SMBus/Two-Wire Serial Interface in SOT563, DRL0006A	Texas Instruments	TMP102AIDRL	1
X0, X6	PC terminal block, Pitch: 5.08 mm, Number of positions: 2	Phoenix Contact	1715721	2
X7	Phoenix Contact screw terminal 2 way, 2.54mm pitch	Phoenix Contact	1725656	1
X8, X9	Phoenix Contact screw terminal 8 way, 2.54mm pitch	Phoenix Contact	1725711	2

5 LP8755 Schematic
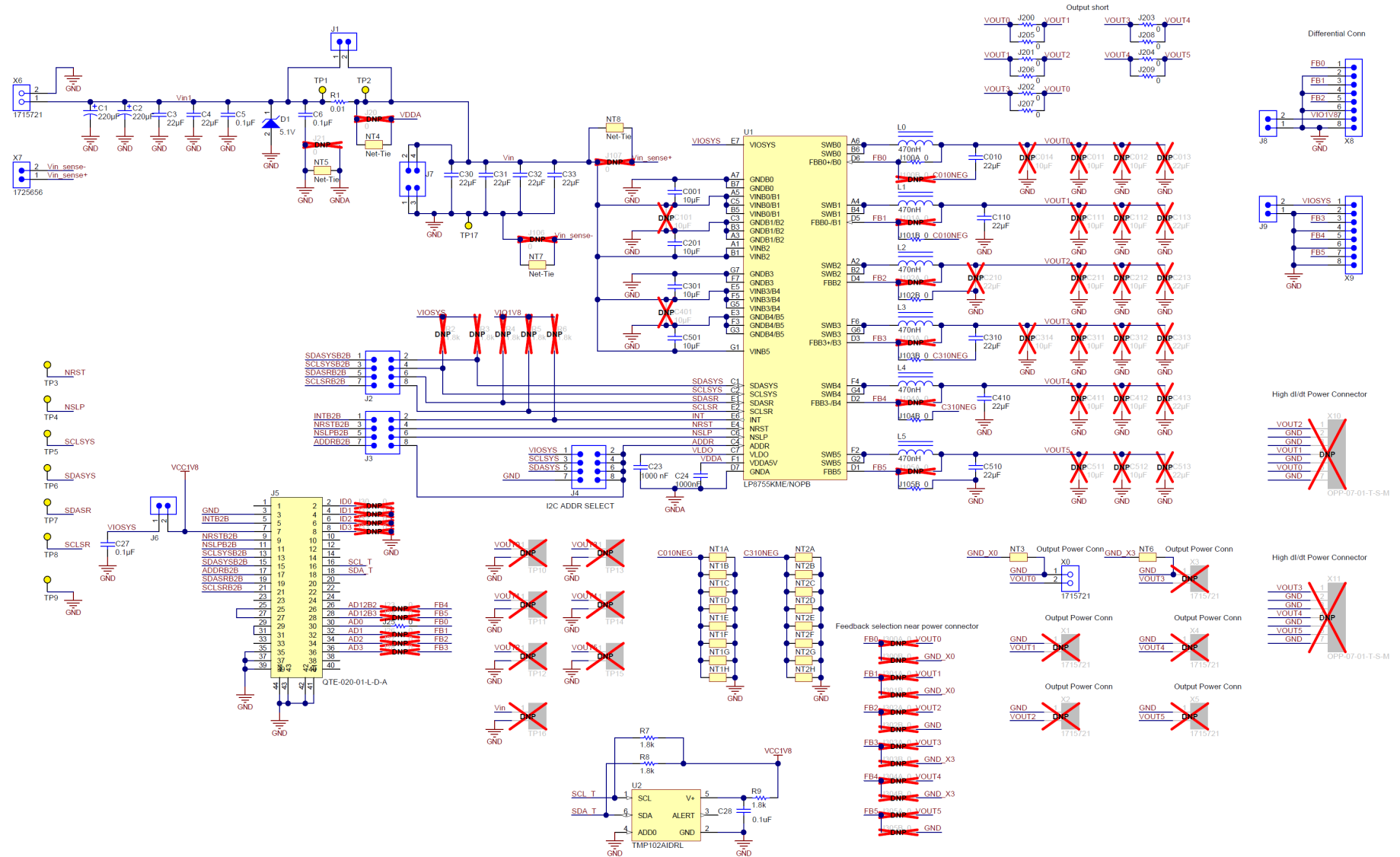
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General Statement for EVMs including a radio

User Power/Frequency Use Obligations: This radio is intended for development/professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability of this EVM and its development application(s) must comply with local laws governing radio spectrum allocation and power limits for this evaluation module. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by Texas Instruments unless user has obtained appropriate experimental/development licenses from local regulatory authorities, which is responsibility of user including its acceptable authorization.

For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant

Caution

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

For EVMs annotated as IC – INDUSTRY CANADA Compliant

This Class A or B digital apparatus complies with Canadian ICES-003.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Concerning EVMs including radio transmitters

This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concerning EVMs including detachable antennas

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.

This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada.

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

Concernant les EVMs avec appareils radio

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante.

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If you use this product in Japan, you are required by Radio Law of Japan to follow the instructions below with respect to this product:

1. Use this product in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,

2. Use this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or

3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

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