

# TIDA-00194

# **TI Design: Skylake Power Delivery**

**Test Report** 



TI Design: Skylake Power Delivery



# 1. Description

*TI Design: Skylake Power Delivery* contains four DC-DC converters & seven TPS22993 load switches. The DC-DC converters used in the design are TPS62151 (x1), TPS62182 (x2), and TPS62130 (x1). TPS22993 is a quad channel load switch with each switch capable of supporting 1.2A of load current. Support for higher load currents is made possible by combining two or more channels together as is demonstrated in the design. The TPS22993 load switches are I2C programmable (ON\_delay, Rise Time, Discharge Resistance) and can be controlled by either I2C or GPIO. A PC based GUI was developed to communicate with the board via the USB2ANY which generates the I2C and GPIO control signals. The board is rated to operate with input supply voltages from 4.5V to 15V to emulate 2S & 3S battery topologies. LEDs are used to indicate the ON state of the DC-DC convertors (Blue) and 21 voltage rails (Green). A total of 21 rails can be switched using this design with load currents varying from 0.01A to 2.5A. Sense test points were used for taking the voltage measurements.



# 2. System Block diagram





# 3. <u>TI Design Voltage Rails</u>

UB_TPS62151         NBW         NBM         <	DC-DC Part#	Rail Voltage	DC-DC Load	Ultrabook Rail Name	TP S22993 LS Channel	LS Load	
U8_TPS62151U10_18 1.8VU10_18 1.8VU10_18 1.8VU10_18 1.8VU10_18 1.8VU10_18 1.8VU10_18 1.8DU10_18 1.8DU10_18 1.8DU10_18 				V1.88	U1_CH1	0.10A	
U8_TPS62151 U8_TPS621511.8V0.57A(V100_K100)(U10)(H3)0.11A1.8V0.57A(V100_K30)(U10)(H3)0.07A(V100_K96)(U10)(H4)(0.07A)(0.07A)(V100_K97)(U10)(H3)(U10)(H3)(0.07A)(V100_K97)(U10)(H4)(0.07A)(0.07A)(V100_K97)(U10)(H3)(U10)(H3)(0.07A)(V100_K97)(U10)(H4)(0.07A)(0.07A)(V100_K97)(U10)(H3)(U10)(H3)(0.07A)(V100_K97)(U10)(H4)(U10)(H4)(0.07A)(V100_K97)(U10)(H3)(U10)(H3)(U10)(H3)(V100_K97)(U10)(H4)(U10)(H4)(U10)(H4)(V100_K97)(U10)(H4)(U10)(H4)(U10)(H4)(V100_K97)(U10)(H4)(U10)(H4)(U10)(H4)(V100_K97)(U10)(H4)(U10)(H4)(U10)(H4)(V100_K97)(U10)(H4)(U10)(H4)(U10)(H4)(V100_K97)(U10)(H4)(U10)(H4)(U10)(H4)(V100_K97)(U10)(H4)(U10)(H4)(U10)(H4)(V100_K97)(U10)(H4)(U10)(H4)(U10)(H4)(V100_K97)(U10)(H4)(U10)(H4)(U10)(H4)(V100_K97)(U10)(H4)(U10)(H4)(U10)(H4)(V100_K97)(U10)(H4)(U10)(H4)(U10)(H4)(V100_K97)(U10)(H4)(U10)(H4)(U10)(H4)(V100_K97)(U10)(H4)(U10)(H4)(U10)(H4)(V100_K97)(U10)(H4)(U10)(H4)(U10)(H4)(V100_K97)(U10)(H4)				V1.8Dx_SEN SOR S	U1_CH2	0.07A	
HB_TPS62151         HBV         OURD_SB0         OUT_CRUM         OUT_CRUM         OUT_CRUM           V18D_UBBIDO         0.02,CH1         0.004         0.004           V18D_USG00         0.02,CH2         0.004           V10_UTS60         0.02,CH2         0.004           V				V1.8Dx_AUDIO	U1_CH3	0.13A	
US_TH302101LBV LBV_5026V130V_UB8500U2_CH10.05A(U120,V180,V180,V180,V180,V180,V180,V180,V18	110 TDS62454	4.91/	0.57.6	V1.8Dx_\$\$D	U1_CH4	0.07A	
U100_5046U100_5046U120_5130.007AU100_5046U120,4930.017AV100_V1MU102,6930.012,6930.014V100_V1MV100_C610U12,6930.016AV100_C610U12,6930.012,6930.013AV100_C610U12,6930.012,6930.013AV100_C610U12,6930.012,6930.013AV100_C610U12,6930.012,6930.012,693V100_C610U12,6930.012,6930.012,693V100_C610U12,6930.012,6930.022,493V100_C611V100_C610U12,6930.022,493V100_C752182J10V100_C6120.023,4000J11_T2F562130J10V1300_C616U12,693J11_T2F562130J10J10J10J11_T2F562130J10U12,693U12,693J11_T2F562130J10J10J10J11_T2F562130J10U12,693U12,693J11_T2F562130J10J10J10J11_T2F562130J10U12,693U12,693J11_T2F562130J10U12,693U12,693J11_T2F562130J10U12,693U12,693J11_T2F562130J10U12,693U12,693J11_T2F562130J11J11J11J11_T2F562130J11U12,693U12,693J11_T2F562130J11U12,693U12,693J11_T2F562130J11U12,693U12,693J11_T2F562130J11U12,693U12,693J11_T2F562130U	00_12302151	1.0 V	0.574	V1.8Dx_U \$B \$DIO	U2_CH1	0.05A	
V100_WIFIU102_CH30.027.43U10_U10_WIFIU102_CH40.01AV130_U10100U10_CH40.01AV130_U10100U10_CH40.01AV130_U1010U10_CH40.01AV130_U1010U10_CH40.01AV130_U1010U10_CH40.01AV130_U1010U10_CH40.01AV130_U1010U10_CH40.02AV10_U1010V130_U1010U10_CH4V10_U10100V130_U1010U10_CH4V10_U10100V130_U1010U10_CH4V10_U10100V130_U1010U10_CH4V10_U10100V130_U1010U10_CH4V10_U10100V130_U1010U10_CH4V10_U10100V130_U1010U10_CH4V11_U10100V130_U1010U10_CH4V11_U10100V130_U1010U10_CH4V11_U10100V130_U1010U10_CH4V11_U10100V130_U1010U10_CH4V11_U10100V130_U1010U10_CH4V11_U10100V130_U1010U10_CH4V11_U10100V130_U1010U10_CH4V11_U10100V130_U1010U10_CH4V11_U10100V130_U1010U10_CH4V11_U10100V130_U1010U10_CH4V11_U10100V130_U1010U10_CH4V11_U10100V130_U1010U10_CH4V11_U10100V130_U1010U10_CH4V11_U10100V130_U1010U10_CH4V11_U10100V130_U1010U10_CH4V11_U10100V130_U1010U10_CH4V11_U10100V130_U1010U10_CH4				V1.8Dx_3G4G	U2_CH2	0.07A	
VEMVEMU2,CH4001AU9_TPS62182NG003A003A09_TPS621823.3V4.66AVI30x_ERNOR003AVI30x_ERNOR004CH10.02AVI30x_ERNOR004CH10.02AVI30x_ERNOR004CH20.02AVI30x_ERNOR004CH20.02AVI30x_ERNOR004CH20.02AVI30x_INDIO004CH20.02AVIII_TPS62130IV0.02AINTIV0.02AINTIV0.02AINTIV0.02AINTIV0.02AINTIV0.02AINTIV0.02AINTIV0.02A </td <td></td> <td></td> <td></td> <td>V1.8Dx_WIFI</td> <td>U2_CH3</td> <td>0.07A</td>				V1.8Dx_WIFI	U2_CH3	0.07A	
<ul> <li>Harrison and the second secon</li></ul>				V1.8M	U2_CH4	0.01A	
U9_TPS62182N3.VNAME 4.56AN3.00, EPD (N3.0, EPD OR) (N3.00, EPD OR)U0_CP1 (OPA (OPA)) (N3.00, EPD OR)0.00, A100_TPS621823.3.V4.56A(N3.00, EPD OR) (N3.00, AUDIO)0.00, CPA (OPA) (N3.00, AUDIO)0.00, CPA (OPA) (N3.00, CPA (OPA))0.00, CPA (OPA)100_TPS621823.3.V4.56A(N3.00, CPA (OPA)) (N3.00, CPA (OPA))0.00, CPA (OPA) (N3.00, CPA (OPA))0.00, CPA (OPA)100_TPS621823.3.V4.56A(N3.00, CPA (OPA)) (N3.00, CPA (OPA))0.00, CPA (OPA) (N3.00, CPA (OPA))0.00, CPA (OPA)100_TPS621823.3.V4.56A(N3.00, CPA (OPA)) (N3.00, CPA (OPA))0.00, CPA (OPA) (N3.00, CPA (OPA))0.00, CPA (OPA)101_TPS621301.1				V3.3Dx_U \$B \$DIO	US_CH1	0.804	
U9_TP\$62182 H9_TP\$621823.3V4.56A(V33A_EC)(U3,CR1SOR B(U3,CR1SOR B <td></td> <td></td> <td></td> <td>V3.3DX_EDP</td> <td>US_CH2</td> <td>0.75A</td>				V3.3DX_EDP	US_CH2	0.75A	
U9_TPS62182 U9_TPS621823.3V4.56AV33D4V33D4U3_CH40.08AV33D4V33MU4_CH10.02AV33D4,ADD0U4_CH20.02AV33D4,ADD0U4_CH20.02AV33D4,ADD0U4_CH30.02AV33D4,ADD0U4_CH30.02AV33D4,0DD0U4_CH30.02AV33D4,0DD0U4_CH30.02AV33D4,0DD0V33D40.02AV33D4,0DD0U4_CH30.02AV33D4,0DD0U4_CH30.02AV33D4,0DD0U4_CH30.02AV33D4,0DD0V33D40.02AV10_TPS621823.3V5.23AV11_TPS62130IV2.4AIV1_TPS62130IV2.4A		3.3V	4.56A -	V3.3A_EC	US_CHS	0.10A	
US_IF302162US_SAVNSAVNSAVNSAVNSAVU0.02A00.03010.04010.02A00.03010.03010.02A00.03010.03010.02A00.03010.03010.02A00.03010.02A0.02A00.02A0.02A0.02A00.02A0.02A0.02A00.02A0.02A0.02A00.05CH0.05CH0.02A00.05CH0.05CH0.05A00.05CH0.05CH0.05A00.05CH0.05CH0.05A00.05CH0.05CH0.05A00.05CH0.05CH0.05A00.05CH0.05CH0.05A00.05CH0.05CH0.05A00.05CH0.05CH0.05A00.05CH0.05CH0.05A00.05CH0.05CH0.05A00.05CH0.05CH0.05A00.05CH0.05CH0.05CH00.05CH0.05CH0.05CH00.05CH0.05CH0.05CH00.05CH0.05CH0.05CH00.05CH0.05CH0.05CH00.05CH0.05CH0.05CH00.05CH0.05CH0.05CH00.05CH0.05CH0.05CH00.05CH0.05CH0.05CH00.05CH0.05CH0.05CH00.05C	10 70562492			V3.3Dx_SEN SOR S	U3_CH4	0.09A	
U10_TPS62182IV <td>09_12302102</td> <td>V3.3M</td> <td>U4_CH1</td> <td>0.22A</td>	09_12302102			V3.3M	U4_CH1	0.22A	
N302 304G         U4_CH3         24A           U10_TPS62182         N302         U302_COUCH SCREEN         U302_CH4         0.00A           100_TPS62182         N30X         U10_SCH2         0.00A           100_TPS62182         N30X         U10_SCH3         0.00A           100_TPS62130         N1         N1         0.00A           100_TPS62130         N1         N1         0.00A           100_TPS62130         N1         N1         N1				V3.3DX_AUDIO	U4_CH2	0.20A	
NINE CONSTRUCT         U4_CH4         U4_CH4           V33DX_0000         U4_CH4         0.020A           V33DX_10UCHSCREEN         U5_CH1         0.20A           V33DX_0000         U5_CH2         0.56A           V33DX_0000         U5_CH3         0.56A           V33DX_0000         U5_CH4         0.56A           V33DX_0000         U5_CH4         0.56A           V33DX_0000         U6_CH1         0.56A           V33DX_0000         U6_CH1         0.56A           V33DX_0000         U6_CH1         0.56A           V33DX_0000         U6_CH1         0.56A           U1_0000         U6_CH1         0.56A           U1_0000         U1_0000         U1_0000           U1_0000         U1_0000         U1_0000           U1_00000         U1_00000         U1_00000				V2 2Dx 2C4C	U4_CH3	244	
$\begin{tabular}{ c c c c c } & & & & & & & & & & & & & & & & & & &$				V3.3DX_3343	U4_CH4	244	
U10_TPS621823.3VNSDV3.3DX_DPVPU15_CH20.50A3.3V5.23A $N^3.3DX_WH1$ $N^3.3DX_WH1$ $N^3.3DX_WH1$ $N^3.3DX_WH1$ $N^3.3DX_WH1$ V3.3DX_WH1V3.3DX_WH1 $N^3.3DX_WH1$ $N^3.3DX_WH1$ $N^3.3DX_WH1$ $N^3.3DX_WH1$ V3.3DX_SSD $N^3.3DX_WH1$ $N^3.3DX_WH1$ $N^3.3DX_WH1$ $N^3.3DX_WH1$ $N^3.3DX_WH1$ V11_TPS62130 $N^3.3DX_WH1$ $N^3.3DX_WH1$ $N^3.3DX_WH1$ $N^3.3DX_WH1$ $N^3.3DX_WH1$ V11_TPS62130 $N^3.3DX_WH1$ $N^3.3DX_WH1$ $N^3.3DX_WH1$ $N^3.3DX_WH1$ $N^3.3DX_WH1$ V11_TPS62130 $N^3.3DX_WH1$				V3.3DX_TOUCH SCREEN	U5_CH1	0.20A	
$\begin{array}{l} \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \$				V3.3Dx_DPWP	U5_CH2	0.50A	
U10_TP \$62182         3.3V         5.23A         Initial Constraints         U15_CH4         ODSA           V338         U6_CH1         0.03A         0.05A           V330x_\$\$8D         U6_CH2         400         400           V10_TP \$62130         V         V         400         400           V11_TP \$62130         V         V         24A         400         400				V3.3Dx WIFI	U5_CH3	2.00A	
U11_TP S62130         IV         IV <thiv< th="">         IV         IV</thiv<>	U10 TP\$62182	3 3V	5 234	-	U5_CH4		
Image: bit image: bi		0.01	0.2014	V3.3S	U6_CH1	0.03A	
Image: bit washing					U6_CH2		
Image: https://document         Image: https://document <thtps: document<="" th="">         Image: https://document</thtps:>	U11_TPS62130	1V		V3.3Dx_\$\$D	U6_CH3	2.50A	
U11_TPS62130         IV         2.4A         ModPHY         III         III         24A           U11_TPS62130         IV         IV         III         IIII         IIIII         IIIIII         IIIII         IIIIIII         IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII					U6_CH4		
U11_TPS62130         IV         2.4A         ModPHY         U7_CH2         2.4A           U7_CH3         U7_CH3         U7_CH4					U7_CH1		
UT_TP 302130         TV         Z.4A         M00PHY         U7_CH3         Z4A           U7_CH3         U7_CH4			2.4A	ModPHY	U7_CH2	2.44	
U7_CH4					U7_CH3		
					U7_CH4		



# 4. TI Design: Skylake Power Delivery – Board Overview



- = DC-DC converter
- = TPS22993 Load Switch
- = USB2ANY Connector
- = PWR & GND connections of the board
- = Solution size (excluding debug circuitry)

TI Design: Skylake Power Delivery



# 5. PC Board Layout



# 6. Important Thermal Notice

This board is not optimized for thermal performance.



# 7. Bench Set Up

PWR & GND are delivered to the board as shown below.



The USB2ANY is connected to the board as shown in the below picture.



TI Design: Skylake Power Delivery





A USB cable is connected from USB2ANY to the computer with installed GUI software.

The GUI CONTROL tab is used to program and control the 7 load switches.

		I2C	Load S	witch D	evice G	IUI		
n ^ re GUI DNTROL ATUS t	Switch - CONTROL	ALL™ STATUS	FW Ver: 1.15.	sion 0.8		GPIO		Go to About
Level Configuration		RAIL NAME	ON DELAY	SLEW RATE	QOD	I2C ON/OFF	GPIO ON/OFF	
		ModPHY	11us	150us/V	951 Ohm	OFF	OFF ModPHY	
	Ī	V3P3Dx_DPWP	11us	460us/V	951 Ohm	OFF	OFF V3P3Dx_DPWP	
		V3P3Dx_TOUCH SCREEN	11us	460us/V	951 Ohm	OFF	OFF V3P3Dx_TOUCHSCREEN	
	Ē	V1P8Dx_AUDIO	11us	460us/V	9510hm	OFF	V1P8Dx_AUDIO &	
		V3P3Dx_AUDIO	11us	460us/V	951 Ohm	OFF	OFF V3P3Dx_AUDIO	
		V1P8Dx_SENSORS	11us	460us/V	951 Ohm	OFF	V1PRDx SENSORS &	
		V3P3Dx_SENSORS	11us	460us/V	951 Ohm	OFF	OFF V3P3Dx_SENSORS	
		V1P8Dx_USBDIO	11us	460us/V	951 Ohm	OFF	V1P8Dx USBSDIO &	
		V3P3Dx_USBDIO	11us	460us/V	951 Ohm	OFF	V3P3Dx_USBSDIO	
		V1P8Dx_3G4G	11us	460us/V	951 Ohm	OFF		
		V1P8Dx_WIFI	11us	460us/V	951 Ohm	OFF	V1P8Dx_3G4G & V1P8Dx_WIFI & V1P8Dx_2G4C &	
		V3P3Dx_3G4G	11us	460us/V	951 Ohm	OFF	V3P3Dx_WIFI	
		V3P3Dx_WIFI	11us	460us/V	951 Ohm	OFF	7	



DC-DC power good is indicated by the Blue LED's turning on as shown in below picture.



21 Unique rails can be turned ON/OFF using I2C, GPIO and SWITCHALL<sup>™</sup> commands.



TI Design: Skylake Power Delivery

TEXAS INSTRUMENTS

# 8. Graphical User Interface

The GUI contains two main tabs, CONTROL & STATUS. The CONTROL tab has buttons to turn on/off different channels in I2C or GPIO modes. The CONTROL tab also has drop down selection options to change ON DELAY, SLEW RATE, and Quick Output Discharge (QOD) resistance for each individual rail. Navigate to the desired page just by clicking on the CONTROL or STATUS tabs.

In the below picture, the CONTROL tab is shown in GPIO mode. Please note that I2C ON/OFF buttons are grayed out indicating that the board is in GPIO mode.

File Script Debug Help										
			I2C	Load Sv	vitch D	evice Gl	JI			
Selection  Pevice GUI CONTROL STATUS	Switch	h ALL™ STATUS	FW Ver 1.15.	ion ).8		GPIO			Go to A	About
About	ĺ	RAIL NAME	ON DELAY	SLEW RATE	QOD	I2C ON/OFF	GPIO ON/	OFF		
		ModPHY	11us	150us/V	951 Ohm	OFF	OFF	ModPHY		
	İ	V3P3Dx_DPWP	11us	460us/V	951 Ohm	OFF	OFF	V3P3Dx_DPWP		
		V3P3Dx_TOUCH SCREEN	11us	460us/V	951 Ohm	OFF	OFF	V3P3Dx_TOUCHSCREEN		
		V1P8Dx_AUDIO	11us	460us/V	9510hm	OFF	OFF	V1P8Dx_AUDIO &		
		V3P3Dx_AUDIO	11us	460us/V	951 Ohm	OFF		V5F50X_R0010		
		V1P8Dx_SENSORS	11us	460us/V	951 Ohm	OFF	OFF	V1P8Dx_SENSORS &		
		V3P3Dx_SENSORS	11us	460us/V	951 Ohm	OFF		TST SDX_SENSORS		
		V1P8Dx_USBDIO	11us	460us/V	951 Ohm	OFF	OFF	V1P8Dx_USBSDIO &		
		V3P3Dx_USBDIO	11us	460us/V	951 Ohm	OFF		V3P3DX_05B5DI0		
		V1P8Dx_3G4G	11us	460us/V	951 Ohm	OFF	]			
		V1P8Dx_WIFI	11us	460us/V	951 Ohm	OFF	OFF	V1P8Dx_3G4G & V1P8Dx_WIFI & V3P3Dx_3G4G &		
		V3P3Dx_3G4G	11us	460us/V	951 Ohm	OFF		V3P3Dx_WIFI		
		V3P3Dx_WIFI	11us	460us/V	951 Ohm	OFF				
		V1P8S	11us	460us/V	951 Ohm	OFF				
		V1P8Dx_SSD	11us	460us/V	951 Ohm	OFF				
•		V1P8M	11us	460us/V	951 Ohm	OFF		V1P8S & V1P8Dx_SSD &		
		V3P3Dx_EDP	11us	460us/V	951 Ohm	OFF	OFF	V1P8M & V3P3Dx_EDP & V3P3A_EC &		
		V3P3Dx_EC	11us	460us/V	951 Ohm	OFF		V3P3M & V3P3S &		
		V3P3M	11us	460us/V	951 Ohm	OFF	1	A3L30220		
		V3P3S	11us	460us/V	950 Ohm	OFF	]			
Main.vi -> Write		V3P3DX_35D	11us	6/23/2014 1:09	951 Ohm	/ersion:1.0.0.16		IECTED Idle	<b>- b</b> T	exas Instrumen

Switch to I2C mode by clicking on GPIO button on the top (highlighted in red oval).

Script Debug Help										
			I2C	Load Sv	vitch D	evice Gl	JI			
evice GUI CONTROL STATUS	Switch	ALL™	FW Ver: 1.15.	iion D.8		12C			Go to A	bout
out	CONTROL	STATUS								
	- r		ON DELAY	SLEW RATE	QOD	IZC ON/OFF	GPIO ON/	ModPHY		
		ModPHY	11us	150us/V	951 Ohm	Orr	OFF			
		V3P3Dx_DPWP	11us	460us/V	951 Ohm	OFF	OFF	V3P3Dx_DPWP		
		V3P3Dx_TOUCH SCREEN	11us	460us/V	951 Ohm	OFF	OFF	V3P3Dx_TOUCHSCREEN		
		V1P8Dx_AUDIO	11us	460us/V	9510hm	OFF	OFF	V1P8Dx_AUDIO & V3P3Dx_AUDIO		
		V3P3Dx_AUDIO	11us	460us/V	951 Ohm	OFF				
		V1P8Dx_SENSORS	11us	460us/V	951 Ohm	OFF	OFF V1P8Dx, SENSORS & V3P3Dx, SENSORS OFF V1P8Dx, USBSDIO & V3P3Dx, USBSDIO &	V1P8Dx_SENSORS & V3P3Dx_SENSORS		
		V3P3Dx_SENSORS	11us	460us/V	951 Ohm	OFF				
		V1P8Dx_USBDIO	11us	460us/V	951 Ohm	OFF		V1P8Dx_USBSDIO & V3P3Dx_USBSDIO		
		V3P3Dx_USBDIO	11us	460us/V	951 Ohm	OFF				
		V1P8Dx_3G4G	11us	460us/V	951 Ohm	OFF				
		V1P8Dx_WIFI	11us	460us/V	951 Ohm	OFF	OFF	V1P8Dx_3G4G & V1P8Dx_WIFI & V3P3Dx 3G4G &		
		V3P3Dx_3G4G	11us	460us/V	951 Ohm	OFF		V3P3Dx_WIFI		
		V3P3Dx_WIFI	11us	460us/V	951 Ohm	OFF				
		V1P8S	11us	460us/V	951 Ohm	OFF				
		V1P8Dx_SSD	11us	460us/V	951 Ohm	OFF				
~		V1P8M	11us	460us/V	951 Ohm	OFF		V1P8S &		
		V3P3Dx_EDP	11us	460us/V	951 Ohm	OFF	OFF	V1P8M & V3P8Dx EDP &		
		V3P3Dx_EC	11us	460us/V	951 Ohm	OFF		V3P3A_EC & V3P3M & V3P3S &		
		<b>V3P3M</b>	11us	460us/V	951 Ohm	OFF		V3P3Dx_SSD		
		V3P3S	11us	460us/V	950 Ohm	OFF				
		V3P3Dx_SSD	11us	460us/V	951 Ohm	OFF				
-> Write				6/23/2014 1:09	:47 PM V	ersion:1.0.0.16	CONN	IECTED Idle	t Te	XAS INSTRUM

Below picture shows the CONTROL page with the mode changed to I2C (highlighted in red oval). The GPIO ON/OFF buttons are *grayed out* to indicate that the board is in GPIO mode.

In each mode different rails or group of rails (GPIO) can be turned on/off by clicking on the ON/OFF button. GPIO control or I2C control is selectable on a per rail basis.





Below graphic shows the GUI STATUS tab with indicators for each of 21 power rails.

File Script Debug Help									
			I2C	Load Sv	vitch D	evice Gl	UI		
Selection *	Switch	ALL	FW Vers	ion		_			^
	-		1.15.0	0.8		GPIO		Go to Abo	ut
About	CONTROL	STATUS							
		RAIL NAME	ON DELAY	SLEW RATE	QOD	I2C ON/OFF	GPIO ON/OFF		
		ModPHY	11us	150us/V	951 Ohm	OFF	OFF ModPHY		
		V3P3Dx_DPWP	11us	460us/V	951 Ohm	OFF	OFF V3P3Dx_DPWP		
		V3P3Dx_TOUCH SCREEN	11us	460us/V	951 Ohm	OFF	OFF V3P3Dx_TOUCHSCREEN		E
		V1P8Dx_AUDIO	11us	460us/V	9510hm	OFF	V1P8Dx_AUDIO &		
		V3P3Dx_AUDIO	11us	460us/V	951 Ohm	OFF			
		V1P8Dx_SENSORS	11us	460us/V	951 Ohm	OFF	V1P8Dx_SENSORS &		
		V3P3Dx_SENSORS	11us	460us/V	951 Ohm	OFF	V3P3DX_SENSORS		
		V1P8Dx_USBDIO	11us	460us/V	951 Ohm	OFF	OFE V1P8Dx_USBSDIO &		
		V3P3Dx_USBDIO	11us	460us/V	951 Ohm	OFF	V3P3Dx_USBSDIO		
		V1P8Dx_3G4G	11us	460us/V	951 Ohm	OFF			
		V1P8Dx_WIFI	11us	460us/V	951 Ohm	OFF	V1P8Dx_3G4G & V1P8Dx_WIFI & V3P3Dx_3G4G &		
		V3P3Dx_3G4G	11us	460us/V	951 Ohm	OFF	V3P3Dx_WIFI		
		V3P3Dx_WIFI	11us	460us/V	951 Ohm	OFF			
		V1P8S	11us	460us/V	951 Ohm	OFF			
		V1P8Dx_SSD	11us	460us/V	951 Ohm	OFF			
		V1P8M	11us	460us/V	951 Ohm	OFF	V1P8S & V1P8Dx_SSD &		
		V3P3Dx_EDP	11us	460us/V	951 Ohm	OFF	V1P8M & V3P3Dx_EDP & V3P3A EC &		
		V3P3Dx_EC	11us	460us/V	951 Ohm	OFF	V3P3M & V3P3S & V3P3Dx SSD		
		V3P3M	11us	460us/V	951 Ohm	OFF			
		V3P3S	11us	460us/V	950 Ohm	OFF			
		V3P3Dx_SSD	11us	460us/V	951 Ohm	OFF			
Main.vi -> Write				6/23/2014 1:09	:47 PM V	ersion:1.0.0.16	CONNECTED	dle 🐺 TEXA	S INSTRUMENTS

Below shows CONTROL tab when several grouped rails are turned ON when in GPIO mode.



Below shows STATUS tab when several grouped rails are turned ON when in GPIO mode.

Groups of rails can be also be controlled with a single I2C command when using the TPS22993 Switch  $ALL^{TM}$  feature.

File Script Debug	Help							
				I2C	Load Sv	vitch D	evice Gl	JI
Selection	· · · ·	Switch	ALL™	FW Vers	ion			
CONTROL STATUS About		POWER MO POWER MO	DE 1 (ALL OFF) DE 2 (ALL ON)	1.15.0	).8	12C		
		POWER MO		ON DELAY	SLEW RATE	QOD	I2C ON/OFF	GF
		POWER MO	DE 5	11us	150us/V	951 Ohm	OFF	
			V3P3Dx_DPWP	11us	460us/V	951 Ohm	OFF	
			V3P3Dx_TOUCH SCREEN	11us	460us/V	951 Ohm	OFF	



### 9. Test Data

# 9.1 TPS22993 Load Switches

#### 9.1.1 Timing measurements

VOUT x ON delay time =  $t_D$ , VOUT x turn-on time =  $t_{ON}$ , VOUT x turn-off time =  $t_{OFF}$ ,

VOUT x rise time =  $t_R$ , VOUT x fall time =  $t_F$ ,

V1P8S delay time, turn-on time & rise time

 $t_D$  = 212us,  $t_{ON}$  = 475.8us,  $t_R$  = 505.1us





V1P8S turn-off & fall time

 $t_{OFF} = 2.366$ us,  $t_F = 3.4$ us



V1P8Dx\_SENSORS delay time, turn-on time & rise time

t<sub>D</sub> = 224us, t<sub>ON</sub> = 448.6us, t<sub>R</sub> = 571.7us





V1P8Dx\_SENSORS turn-off & fall time

t<sub>OFF</sub> = 2.966us, t<sub>F</sub> = 5.1us



V1P8Dx\_AUDIO delay time, turn-on time & rise time

 $t_D$  = 224us,  $t_{ON}$  = 466.6us,  $t_R$  = 566.1us





V1P8Dx\_AUDIO turn-off & fall time

t<sub>OFF</sub> = 2.22us, t<sub>F</sub> = 2.54us



V1P8Dx\_SSD delay time, turn-on time & rise time

 $t_D$  = 224us,  $t_{ON}$  = 451.4us,  $t_R$  = 562.8us





V1P8Dx\_SSD turn-off & fall time

 $t_{OFF} = 2.857 us, t_F = 5.073 us$ 



V3P3Dx\_3G4G delay time, turn-on time & rise time



 $t_{D}$  = 356us,  $t_{ON}$  = 793.4us,  $t_{R}$  = 923.2us



V3P3Dx\_3G4G turn-off & fall time

 $t_{OFF} = 2.32us, t_F = 2.5us$ 



V3P3Dx\_AUDIO delay time, turn-on time & rise time

 $t_D$  = 300us,  $t_{ON}$  = 649.6us,  $t_R$  = 846.7us





#### V3P3Dx\_AUDIO turn-off & fall time

 $t_{OFF} = 2.6 us, t_F = 3.4 us$ 



V3P3Dx\_SSD delay time, turn-on time & rise time

 $t_D$  = 356us,  $t_{ON}$  = 771.4us,  $t_R$  = 962.7us





V3P3Dx\_SSD turn-off & fall time

 $t_{OFF} = 7.2 us, t_F = 17.5 us$ 



V3P3Dx\_WIFI delay time, turn-on time & rise time



t<sub>D</sub> = 356us, t<sub>ON</sub> = 770us, t<sub>R</sub> = 941us



V3P3Dx\_WIFI turn-off & fall time

 $t_{OFF}$  = 2.5us,  $t_{F}$  = 3.3us



V3P3M delay time, turn-on time & rise time

t<sub>D</sub> = 296us, t<sub>ON</sub> = 693us, t<sub>R</sub> = 895us





#### V3P3M turn-off & fall time





ModPHY delay time, turn-on time & rise time

 $t_{D}$  = 8.7us,  $t_{ON}$  = 9.1us,  $t_{R}$  = 0.97us





#### ModPHY turn-off & fall time

t<sub>OFF</sub> = 1.56us, t<sub>F</sub> = 0.32us



Rail name	t <sub>D</sub> (μs)	t <sub>on</sub> (μs)	t <sub>R</sub> (μs)	t <sub>off</sub> (μs)	t <sub>F</sub> (μs)
V1P8S	212	475.8	505.1	2.37	3.4
V1P8Dx_SENSORS	224	448.6	571.7	2.97	5.1
V1P8Dx_AUDIO	224	466.6	566.1	2.22	2.5
V1P8Dx_SSD	224	451.4	562.8	2.86	5.1
V3P3M	296	693	895	2.4	3.0
V3P3Dx_AUDIO	300	649.6	846.7	2.6	3.4
V3P3Dx_3G4G	356	793.4	923.2	2.32	2.5
V3P3Dx_WIFI	356	770	941	2.5	3.3
V3P3Dx_SSD	356	771.4	962.7	7.2	17.5
ModPHY	8.7	9.1	0.97	1.56	0.32

# 9.1.2 R<sub>ON</sub> measurements:

Setup: 
$$R_{ON} = (V_{IN} - V_{OUT})/I_{load}$$



Rail name	Voltage (V)	Current (mA)	V <sub>IN</sub> -V <sub>OUT</sub> (mV)	R <sub>on</sub> (mohm)	Pout (W)
V1P8S	1.8	100	2.27	22.7	0.180
V1P8Dx_SENSORS	1.8	70.6	1.38	19.5	0.127
V1P8Dx_AUDIO	1.8	131.4	2.49	18.9	0.237
V1P8Dx_SSD	1.8	70.6	1.34	19.0	0.127
V1P8Dx_USBSDIO	1.8	50	0.94	18.8	0.090
V1P8Dx_3G4G	1.8	70.6	1.32	18.7	0.127
V1P8Dx_WIFI	1.8	70.6	1.38	19.5	0.127
V1P8M	1.8	10	0.19	19.0	0.018
V3P3Dx_USBSDIO	3.3	750	15.55	20.7	2.475
V3P3Dx_EDP	3.3	750	15.36	20.5	2.475
V3P3A_EC	3.3	100	1.9	19.0	0.330
V3P3Dx_SENSORS	3.3	90.4	2.04	22.6	0.298
V3P3M	3.3	220	4.36	19.8	0.726
V3P3Dx_AUDIO	3.3	200	4.55	22.8	0.660
V3P3Dx_3G4G	3.3	2292	26.02	11.4	7.564
V3P3Dx_TOUCHSCREEN	3.3	200	4.98	24.9	0.660
V3P3Dx_DPWP	3.3	500	12.5	25.0	1.650
V3P3Dx_WIFI	3.3	1964	24.27	12.4	6.481
V3P3S	3.3	30	0.72	24.0	0.099
V3P3Dx_SSD	3.3	2500	22.02	8.8	8.250
ModPHY	1.0	2381	12.13	5.1	2.381

# **Total combined Output Power = 35W**

**Note:** This board is not optimized for thermal performance.

# 9.1.3 System Quiescent and Shutdown Current

Quiescent Current  $(I_Q)$ :

 $I_Q$  on BATT at 12V = 215uA

Shutdown Current (I<sub>SD</sub>):

 $I_{SD}$  on BATT at 12V = 49.2uA

# 9.2 TPS621xx DC-DC converters

### 9.2.1 Start-up waveforms

U8\_TPS62151 (1.8V)





#### U11\_TPS62130 (1.0V)



U9\_TPS62182 (3.3V) & U10\_TPS62182 (3.3V)





# 9.2.2 Output Ripple

# No load Ripple



U8\_TPS62151 (1.8V) & U11TPS62130 (1.0V)

#### U9\_TPS62182 (3.3V) & U10\_TPS62182 (3.3V)





# **Light load Ripple**

#### U8\_TPS62151 (1.8V) V1P8M ON



U9\_TPS62182 (3.3V) EC ON & U10\_TPS62182 (3.3V) V3P3S ON





# **Full load Ripple**

### U8\_TPS62151 (1.8V)



### U11TPS62130 (1.0V)



### U9\_TPS62182 (3.3V) & U10\_TPS62182 (3.3V)





# 9.2.3 Load step Response

### V1P8Dx\_AUDIO





### V3P3Dx\_USBDIO





#### V3P3Dx\_EDP







### V3P3Dx\_3G4G







### V3P3Dx\_WIFI





### V3P3Dx\_SSD





### ModPHY





# 9.2.4 Efficiency







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