V_{DDQ} and V_{TT} Termination Regulation for DDR DRAM Memory Power Utilizing the ISL6530

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Introduction

The ISL6530 and the ISL6531 are dual, voltage mode controllers with many functions that are needed for DDR DRAM Memory power applications. The ISL6530 and ISL6531 contain high performance error amplifiers, a high accuracy reference, an internal 50% tracking reference, a fixed 300kHz internal oscillator with a 90^{o} phase shift for dual synchronous buck regulators, over-current protection circuitry, Power Good indication, and two shut down options. There are two MOSFET drivers for use in both synchronous-rectified Buck converters. The ISL6530 and ISL6531 are also capable of regulating the output voltage while the tracking DC-DC converter is sinking current. All these features are packaged in a 24 lead SOIC or a small 32 Lead 4x4[mm] MLFP.

ISL6530 and ISL6531

The ISL6530 and ISL6531 are pin for compatible replacements to each other. All functions are identical between the two ICs. The difference between the ISL6530 and the ISL6531 lies in the compensation of the V_{TT} regulator. The ISL6531 features internal compensation for the V_{TT} regulator. More complete descriptions of both ICs can be found in their respective datasheets[1,2].

Reference Designs

There are four different evaluation boards that are included in the scope of this application note. Table 1 describes each of the boards.

Table 1 - Evaluation Boards

Board Name	IC	Package
ISL6530EVAL1	ISL6530CB	24 ld SOIC
ISL6530EVAL2	ISL6530CR	32 ld 4x4 MLFP
ISL6531EVAL1	ISL6531CB	24 ld SOIC
ISL6531EVAL2	ISL6531CR	32 ld 4x4 MLFP

The ISL6530EVAL1 is an evaluation board that highlights the operation of the ISL6530 in an embedded DDR DRAM Memory Power application. The V_{DDQ} supply has been designed to supply 2.5V at a maximum load of 10A. The V_{TT} termination supply will track the V_{DDQ} supply at 50% and was designed for a maximum load of 5A, sourcing or sinking. The schematic, Bill of Materials, and Board Layout for the ISL6530EVAL1 can be found in the Appendix. Customization of the reference design is discussed in this application note.

Quick Start Evaluation

The ISL6530/31EVAL1 board is shipped 'ready to use' right from the box. The ISL6530/31EVAL1 board will only accept 5V from a standard power supply. Both outputs can be exercised through external loads. The V_{TT} regulator has the ability to source or sink current while the V_{DDQ} regulator may only source current.

There are posts available on the board for introducing power to the board and also for drawing current from the regulated outputs. Two probe points are also available for use. These probe points provide Kelvin connections to the PGOOD (TP4) and VREF_OUT (TP3) pins.

An LED lights up to indicate that the output voltages are within regulation.

Recommended Test Equipment

To test the functionality of the ISL6530, the following equipment is recommended:

- A 5V, 10A capable bench power supply

- Two electronic loads

- Four channel oscilloscope with probes

- Precision digital multimeters

Power and Load Connections

There are 3 sets of jumpers that are used for the supplying the input voltage and loading the V_{DDQ} and V_{TT} outputs.

INPUT VOLTAGE

Connect the positive lead of the 5V bench power supply to the VCC post (J1). Connect the ground lead of the supply to GND post (J2).

LOADING V_{DDQ}

Connect the positive terminal of the first electronic load to the VDDQ post (J3). Connect the return terminal of the same load to the GND post (J4).

LOADING V_{TT} - SOURCING CURRENT

To test V_{TT} while the regulator sources current, connect the positive terminal of the second electronic load to the VTT post (J5). Connect the return terminal of the same load to the GND post (J6).

LOADING V_{TT} - SINKING CURRENT

To test V_{TT} while the regulator sinks current, connect the positive terminal of the second electronic load to the VDDQ post (J3). Connect the return terminal of the same load to the VTT post (J5).

CAUTION: The return terminal of the load must float for this to work properly.

Start Up

There are two distinct start up methods for the V_{DDQ} and V_{TT} regulators. The first method is invoked through the application of power to the IC. The Softstart feature allows for a controlled turn on of the outputs once the Power On Reset (POR) threshold of the input voltage has been reached. Figure 1 shows the start up profile of the two regulators in relation to the start up of the 5V input supply.

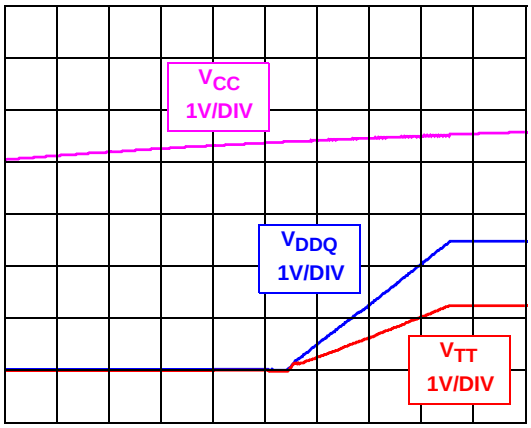


FIGURE 1. START UP FROM POR

The second method of start up is through the use of the Shutdown feature. Holding the OCSET/SD pin below 0.8V will disable both regulators by forcing both the upper and lower MOSFETs of both regulators off. Releasing the OCSET/SD pin allow the regulators to start up. Figure 2 show the start up profile of the two regulators with this method.

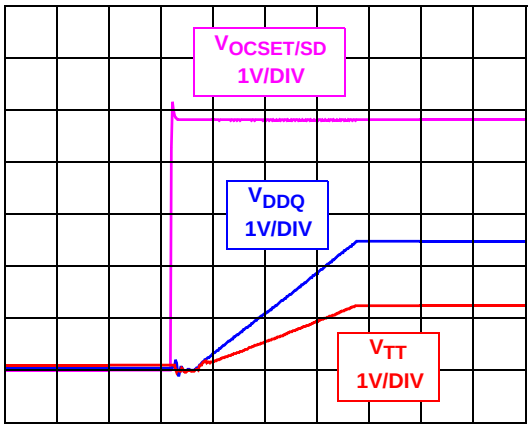


FIGURE 2. START UP FROM SHUT DOWN

Shutdown

Shutting Down Both V_{DDQ} and V_{TT}

As discussed in the previous section, if the OCSET/SD pin is pulled down and held below 0.8V, both the V_{DDQ} and V_{TT} regulators will be turned off. Figure 3 shows the shutdown profile of the regulators with no load applied. Figure 4 shows the shutdown of the regulators will their full loads applied.

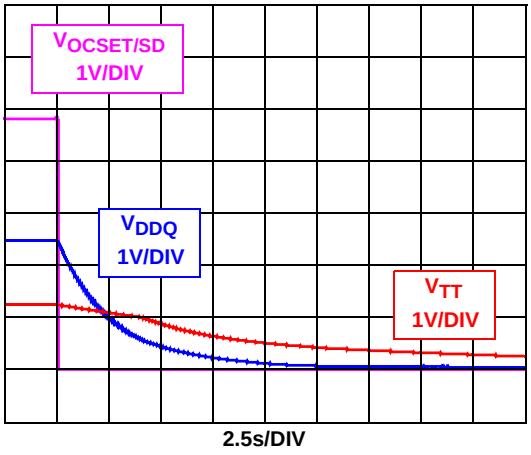


FIGURE 3. SHUTDOWN WITH NO LOAD

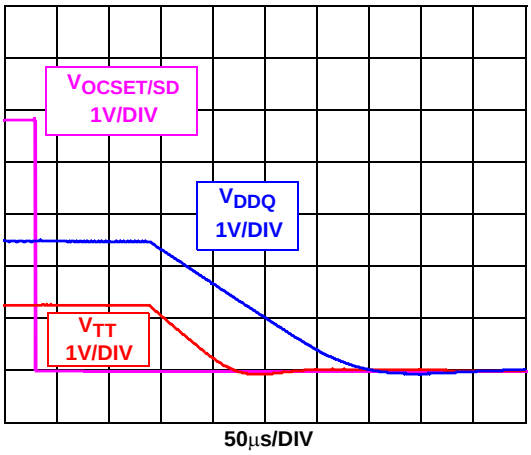


FIGURE 4. SHUTDOWN WITH FULL LOAD

V_{TT} Sleep State

The V_{TT} regulator can be placed in a sleep state where the output is regulated to a wider tolerance while V_{DDQ} continues to regulate. This is done by applying a logic high signal to the V2_SD pin. During this state, V_{DDQ} can support a load while V_{TT} cannot. This allows a very quick recovery back into synchronous buck mode. Once removed from this state by releasing the high signal on the V2_SD pin, the output rapidly returns to regulation. Figure 5 illustrates the VTT regulator going into sleep mode and Figure 6 shows the regulator being taken out of the sleep state.

Reference Design Customization

The ISL6530/31EVAL1 board has a number of options that will allow the designer to customize the board. One modification that can be made is to overdrive the internal resistor divider which sets the reference voltage for the V_{TT} regulator in relation to V_{DDQ}. This may be done by populating resistors R5 and R6, as to create a tracking ratio

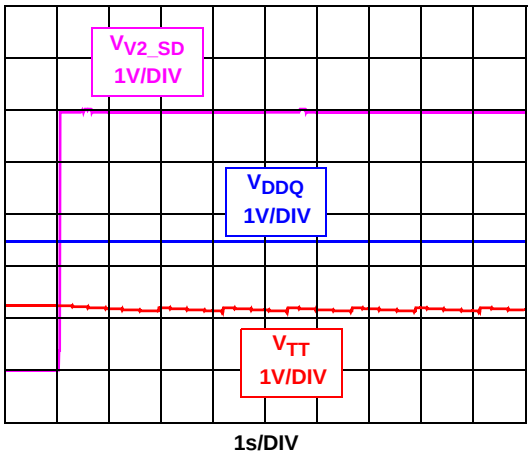


FIGURE 5. V_{TT} SLEEP MODE

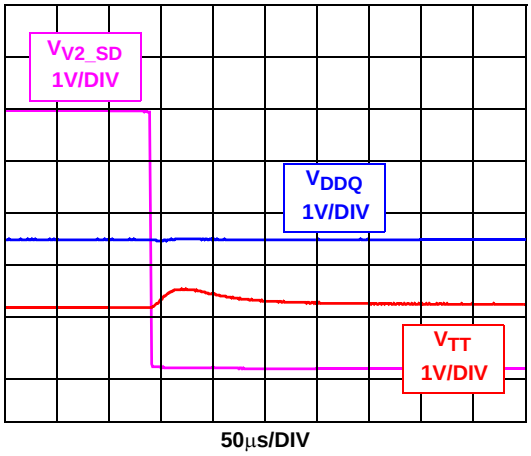


FIGURE 6. V_{TT} RETURN FROM SLEEP MODE

other than the internally generated 50%. Please refer to the datasheet for proper component selection.

In order to increase performance during a load transient on either output, two 0603 capacitor pads have been provided at each output. These pads allow the designer to add ceramic capacitors on the output. Ceramic capacitors help to decrease the overall output capacitance ESR while they have much lower lead inductance. The pad reference designators are C20 and C21 for the V_{TT} output and reference designators C13 and C14 for the V_{DDQ} output.

The VDDQ output also has two extra bulk capacitor pads, designated C11 and C12. The designer may wish to utilize these to decrease the ripple voltage, improve transient performance or both.

Ripple Voltage

Figure 7 shows the ripple voltage on both the V_{DDQ} output and the V_{TT} output.

Transient Performance

Figures 8, 9, 10 and 11 show the response of the outputs when subjected to a variety of transient loads. Figure 8

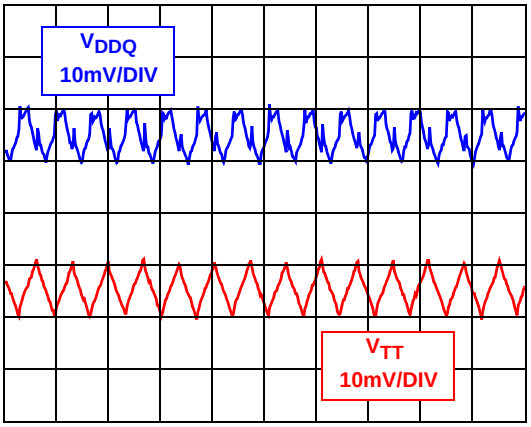


FIGURE 7. V_{DDQ} AND V_{TT} RIPPLE VOLTAGES

shows V_{DDQ} under transient loading. Figure 9 shows V_{TT} under a transient loading that causes V_{TT} to source current. Figure 10 shows V_{TT} under a transient that causes V_{TT} to sink current. Figure 11 shows both V_{DDQ} and V_{TT} under simultaneous transient loading.

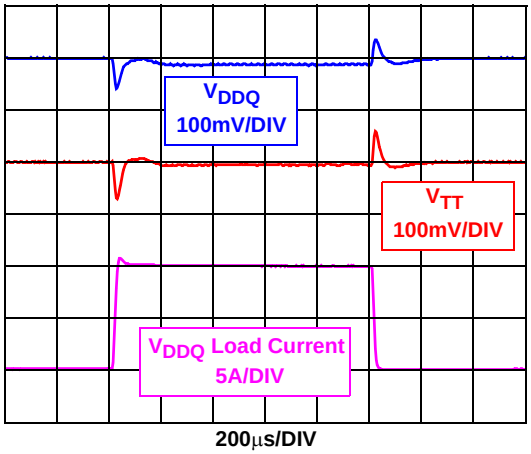


FIGURE 8. TRANSIENT ON V_{DDQ}

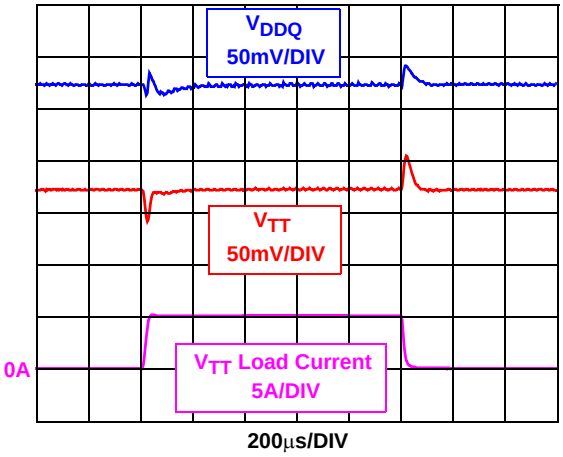


FIGURE 9. SOURCING TRANSIENT ON V_{TT}

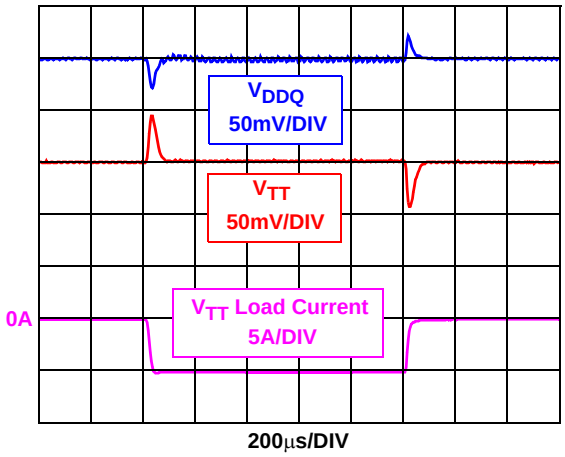


FIGURE 10. SINKING TRANSIENT ON V_{TT}

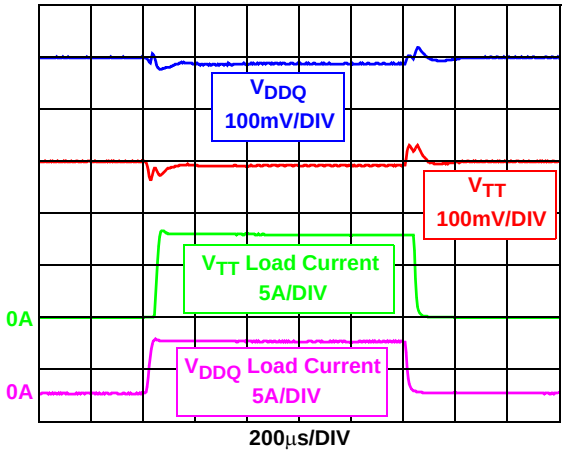


FIGURE 11. TRANSIENTS ON V_{DDQ} AND V_{TT}

Efficiency

Each channel of the ISL6530 is highly efficient which leads to a high overall system efficiency. The efficiency of the V_{TT} regulator in current sourcing and current sinking modes is shown in Figures 12. Figure 13 illustrates the efficiency of the VDDQ regulator.

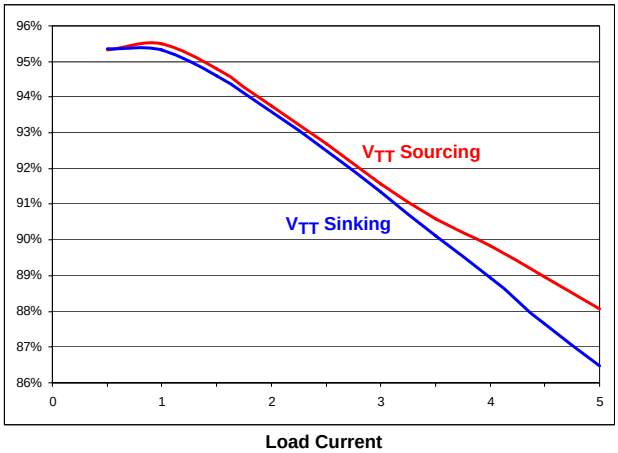


FIGURE 12. V_{TT} EFFICIENCY (SOURCING CURRENT)

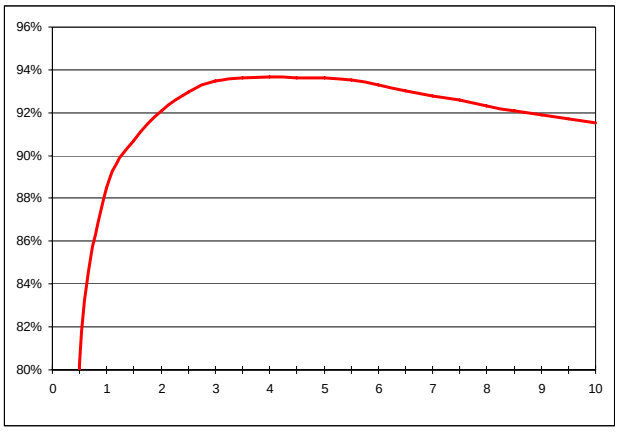


FIGURE 13. V_{DDQ} EFFICIENCY

Conclusion

The ISL6530/31EVAL1 board is a dual DC-DC converter reference design for DDR Memory Power applications that require up to 10A on V_{DDQ} and up to 5A on V_{TT}. In addition, the design may be modified for applications with different requirements.

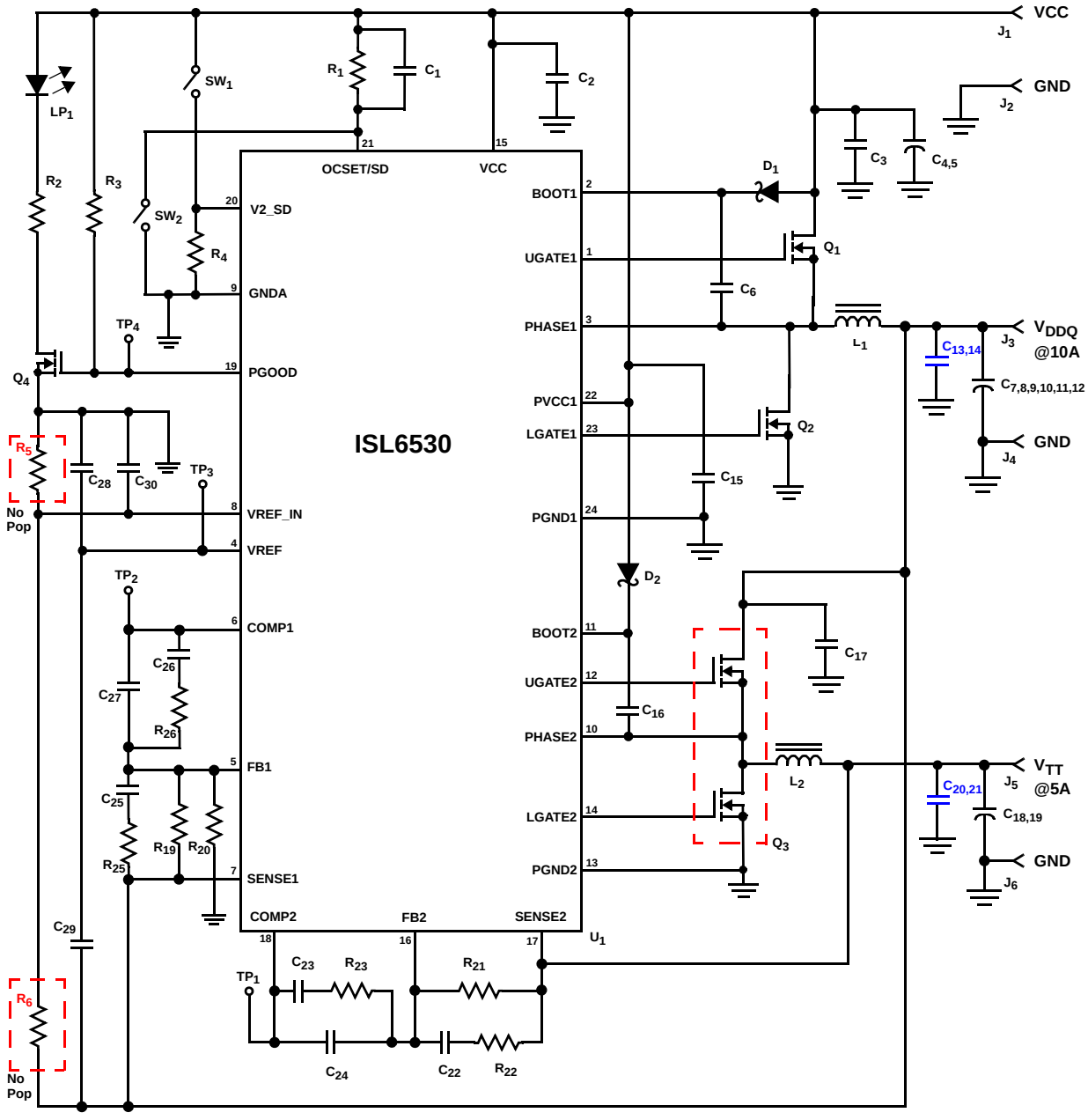
References

For Intersil documents available on the web, see http://www.intersil.com/

[1] *ISL6530 Data Sheet,* Intersil Corporation, FN9052

[2] *ISL6531 Data Sheet,* Intersil Corporation, FN9053

ISL6530EVAL1 Schematic



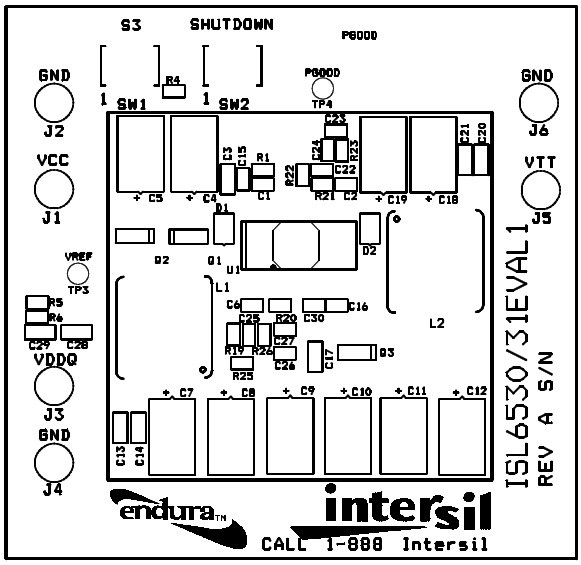
ISL6530EVAL1 Bill of Material

Ref Des	Description	Vendor	Vendor P/N	Qty
C1	1nF Capacitor, 0603	Various	---	1
C2,6,15,16	0.1μF Capacitor, 0603	Various	---	4
C3,17	1μF Capacitor, 0805	Various	---	3
C4,5,7,8,9, 10,18,19	150μF Capacitor	Panasonic	EEFUE0J151R	8
C11,12	Not Populated (Reserved for 150μF Panasonic SP Capacitor)	---	---	---
C22	10nF Capacitor, 0603	Various	---	1
C24	68pF Capacitor, 0603	Various	---	1
C23	2700pF Capacitor, 0603	Various	---	1
C25	15nF Capacitor, 0603	Various	---	1
C27	100pF Capacitor, 0603	Various	---	1
C26	5600pF Capacitor, 0603	Various	---	1
C28,29	0.1μF Capacitor, 0805	Various	---	2
C13,14,20, 21	0805 Capacitor (Not Populated)	---	---	0
D1,2	Diode, 30mA, 30V	Digikey	MA732	2
L1, L2	1μH Inductor	Panasonic	ETQP6F1R0SFA	2
Q1,2	MOSFET, 8 Pin SOIC	Fairchild	ITF86130	2
Q3	Dual MOSFET, 8 Pin SOIC	Fairchild	ITF86110	1
Q4	2N7002 MOSFET, SOT23	Various	---	1
R1	3.48kΩ 1% Resistor, 0603	Various	---	1
R2	750Ω 1% Resistor, 0603	Various	---	1
R3,4	10kΩ 1% Resistor, 0603	Various	---	2
R5,6	0603 Resistor (Not Populated)	---	---	0
R19,21	3.01kΩ 1% Resistor, 0603	Various	---	1
R22	158Ω 1% Resistor, 0603	Various	---	1
R23	8.87kΩ 1% Resistor, 0603	Various	---	1
R20	1.43kΩ 1% Resistor, 0603	Various	---	1
R26	6.34kΩ 1% Resistor, 0603	Various	---	1
R25	100Ω 1% Resistor, 0603	Various	---	1
SW1,2	Pushbutton, miniature	Digikey	CKN1100-ND	2

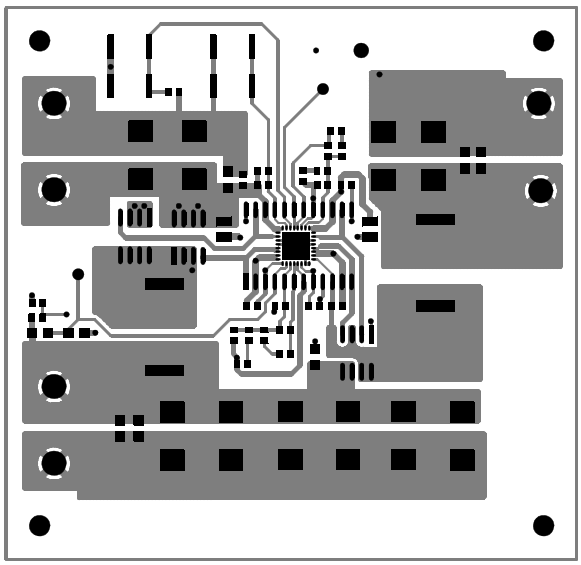
Ref Des	Description	Vendor	Vendor P/N	Qty
LP1	LED	Digikey	L63111CT-ND	1
U1	Dual Synchronous Buck PWM Controller for DDR Applications	Intersil	ISL6530CB	1
TP3,4	Test Points	Digikey	5002K-ND	2
J1,2,3,4, 5,6	Test Points	Keystone	1514-2	6

ISL6530EVAL1 Layout

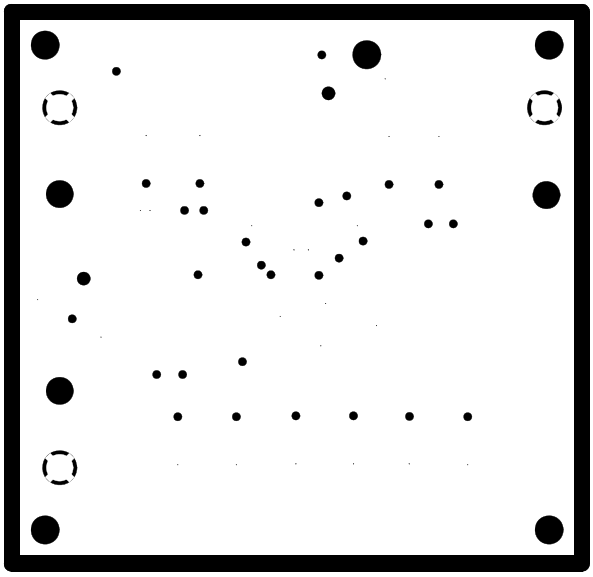
TOP SILK SCREEN



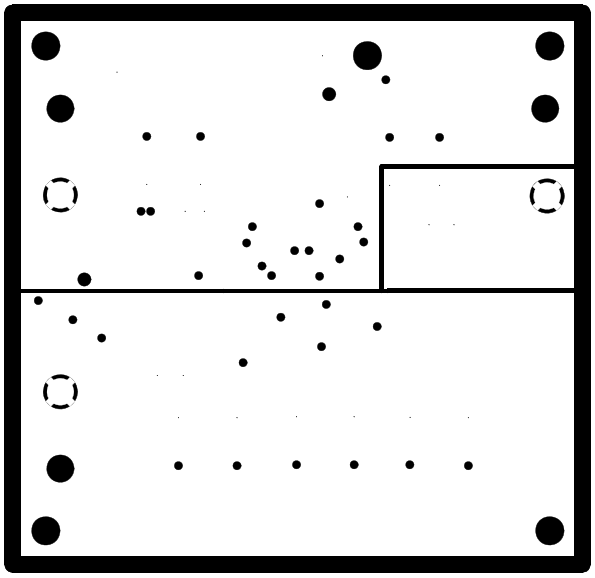
TOP



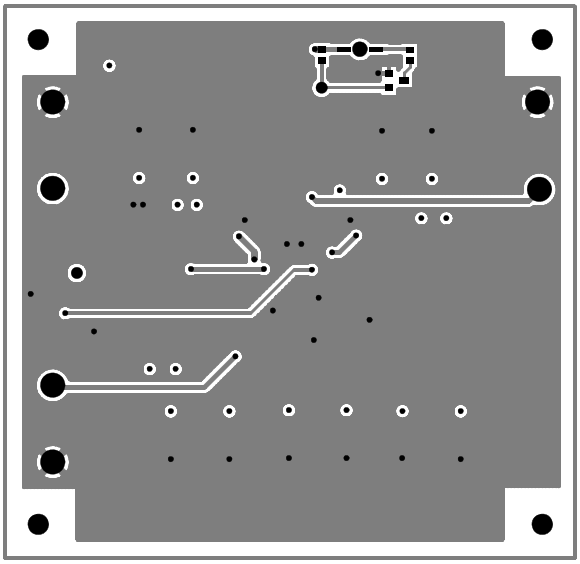
INTERNAL 1 GROUND



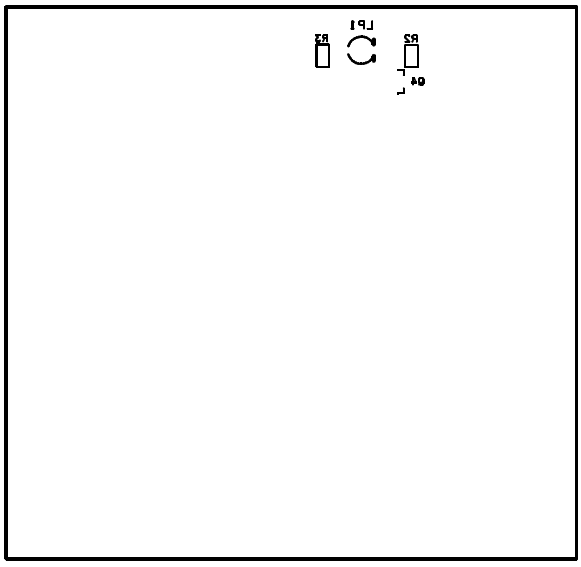
INTERNAL 2 POWER



BOTTOM



BOTTOM SILK SCREEN



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