

# ONS321A5VGEVB, ONS321B12VGEVB



## ONS321A5VGEVB/ ONS321B12VGEVB Evaluation Board User's Manual

ON Semiconductor®

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### EVAL BOARD USER'S MANUAL

#### Description

The ONS321G evaluation board is designed such that it can accommodate 4 SO8IC / SO8FL parts or 2  $\mu$ 8FL / WDFN8 parts or 4 DPAKs. Depending on the type of application and necessity, any combination of the above packages can also be used. The ONS321G evaluation board is designed to operate with an input voltage ranging from 8 V to 19 V, and to provide an output voltage of 0.8 V to 1.55 V for load currents of up to 25 A. The ONS321G can be ordered with either 5 V or 12 V drivers, but one can be installed at a time. The ONS321G evaluation board has a number of test points that can be used to evaluate its performance in any given application.

#### Features

- 8 V to 19 V Input Voltage
- 25 A of Steady State Load Current

- 330 kHz Switching Frequency
- Access to IC Features such as Enable, Switching Node and VID Settings for Output Voltage
- Convenient Test Points for Simple, Non-invasive Measurements of Converter Performance Including Input Ripple, Output Ripple, High Side and Low Side Gate Signals and Switching Node

#### Applications

- Synchronous Buck Converters
  - ◆ High Frequency Applications
  - ◆ High Current Applications
  - ◆ Low Duty Cycle Applications
- Multi-phase Synchronous Buck Converters
  - ◆ Evaluation board has only one phase implemented

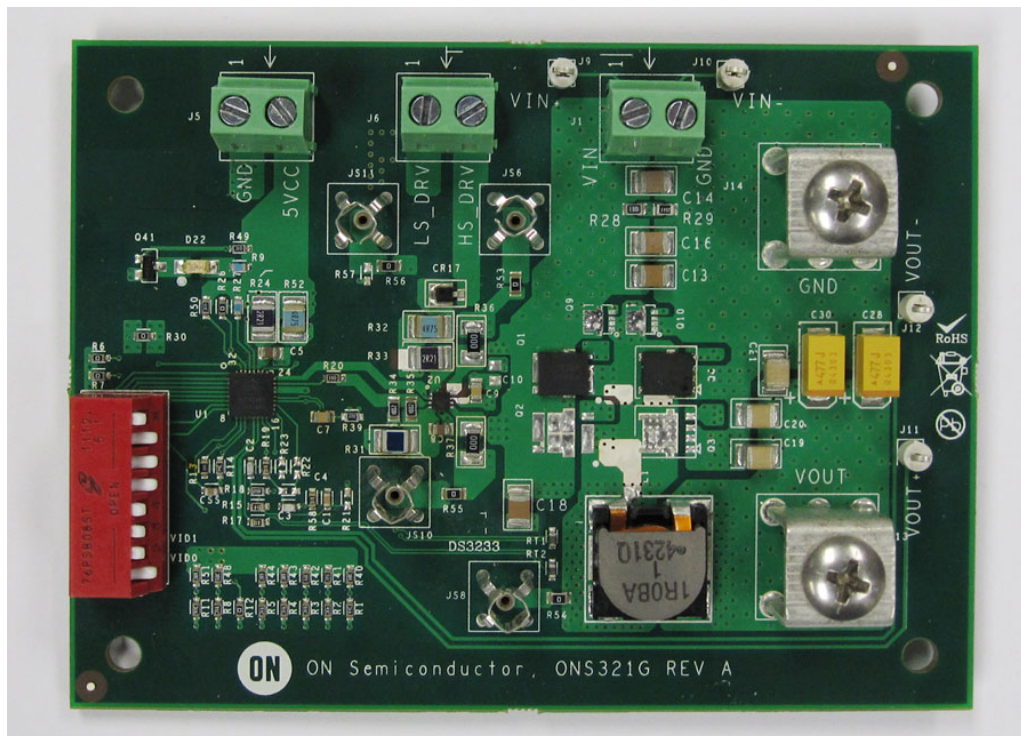


Figure 1. Evaluation Board Photo

# ONS321A5VGEVB, ONS321B12VGEVB

## SCHEMATIC OF THE ONS321G EVALUATION BOARD

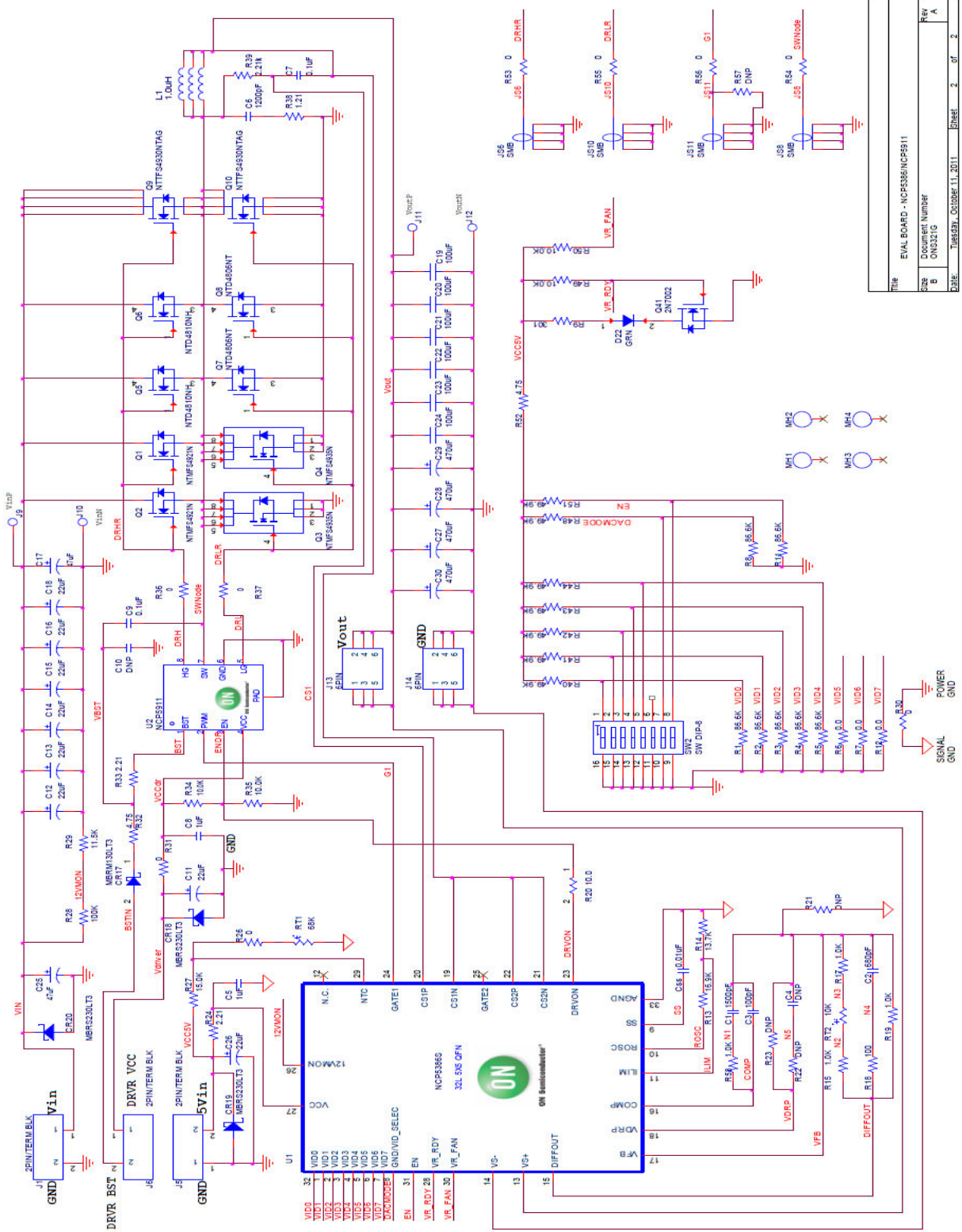


Figure 2. Schematic of ONS321G Evaluation Board

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## ELECTRICAL SPECIFICATIONS

**Table 1. ELECTRICAL SPECIFICATIONS FOR ONS321G**

Parameter		Notes and Conditions	Min	Typ	Max	Units
<b>Input Characteristics</b>						
$V_{in}$	Input Voltage	-	8	12	19	V
$V_{drv}$	Driver Voltage	-	5	-	12	V
$I_{in}$	Input Current	$V_{in} = 12\text{ V}; I_{out} = 25\text{ A}$	0	-	3	A
	No load input current	$V_{in} = 12\text{ V}; I_{out} = 0\text{ A}; V_{drv} = 5\text{ V}$	0	9	-	mA
		$V_{in} = 12\text{ V}; I_{out} = 0\text{ A}; V_{drv} = 10\text{ V}$	0	12	-	mA
<b>Output Characteristics</b>						
$V_{out}$	*Output Voltage	$V_{in} = 12\text{ V}; I_{out} = 25\text{ A}$	0.8	1.2	1.55	V
$V_{p-p}$	Maximum Switch Node Voltage	$V_{in} = 12\text{ V}; I_{out} = 20\text{ A}; V_{drv} = 5\text{ V} \& 10\text{ V}$	-	18	-	V
$I_{out}$	Output Current	$V_{in} = 8\text{ V to } 19\text{ V}$	0	-	25	A
<b>System Characteristics</b>						
$F_{sw}$	Switching Frequency	Note 1	-	330	-	kHz
$\eta_{Peak}$	Peak Efficiency	$V_{in} = 12\text{ V}; V_{out} = 1.2\text{ V}; V_{drv} = 5\text{ V}$	-	93	-	%
$\eta$	Full load efficiency	$V_{in} = 12\text{ V}; V_{out} = 1.2\text{ V}; V_{drv} = 5\text{ V}; I_{out} = 25\text{ A}$	-	84	-	%

\*The output voltage can be changed by changing the VID settings. For example, to get an output voltage of  $V_o = 1.2\text{ V}$ , the Pins 2 (VID1), 3 (VID2) and 4 (VID3) should be set to 1. See Appendix for more information on setting the output voltage. The pins 1 (VID0), 5 (VID4) and 6 (VID5) should always be set to 0 and the pins 7 (VID6) and 8 (VID7) should always be set to 1.

1. The switching frequency is defined by the resistors R13 and R14 and can only be changed only by changing the resistors R13 and R14.

## CONNECTORS AND TEST POINTS DESCRIPTIONS

### Input Power

Connect the input voltage positive probe to Pin 1 at J1 and sense probe at J9, negative probe to the GND at Pin 2 at J1 and sense probe at J10. The input voltage can range from 8 V to 19 V.

### Output Power

Connect the output voltage positive probe to J13 (large screw connector) and sense probe at J11, ground probe at J14 (large screw connector) and the sense probe to J12. The output voltage is set by the VID settings (Refer to Appendix, Section 1).

### Controller Biasing

Connect the positive probe to Pin 2 at J5 and the negative probe to the GND at Pin 1 at J5. Please keep this as a separate supply to avoid damage to the controller especially when other drive voltages are used. Controller  $V_{IN\ MAX}$  specification is 7 V.

### Driver Biasing

The driver positive voltage probe  $V_{cc}$  should be connected to both pin 1 and 2 at J6. The driver voltage is defined depending on the type of driver installed (i.e.) a 12 V driver or a 5 V driver. The ONS321G evaluation board is set up to accept DFN8 footprints of ON Semiconductor 5 V and 12 V drivers.

### Switching Frequency

The converter switching frequency is set by the voltage divider setup of R13 and R14 between the pins 10 (ROSC) and 33 (AGND) of the NCP5386 controller. In order to change the frequency, these resistors have to be changed. Changing the frequency also changes the  $I_{lim}$  (Over Current shutdown threshold) settings.

### Test Points Description

#### Monitoring the Input Voltage

The input voltage can be monitored by using the test points at J9 and J10 on the ONS321G evaluation board. This allows the user to find out the exact value of input voltage since there will be no losses from the cables or connectors.

#### Monitoring the Output Voltage

The ONS321G evaluation board provides two test points for measuring the output voltage without any losses from the cables or connectors. The output voltage can be measured at the points J11 and J12 on the evaluation board.

#### Monitoring the Switch Node Waveforms

The ONS321G evaluation board provides the opportunity to monitor the switch node waveforms. The probe socket at test point JS8 provides the switch node waveforms.

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### Monitoring the High Side and Low Side Waveforms

The high side waveforms can be obtained from the probe socket at test point JS6 and the low side waveforms can be obtained from the probe socket at test point JS10.

The probe sockets that are provided on the evaluation board for monitoring the waveforms are such that the oscilloscope probes can be inserted into the probe socket and are held in place. The Test Point and the Probe Socket are shown in Figure 3.

### Monitoring the PWM Signal

The PWM signal from the controller to the driver can be monitored from the probe socket provided at JS11.

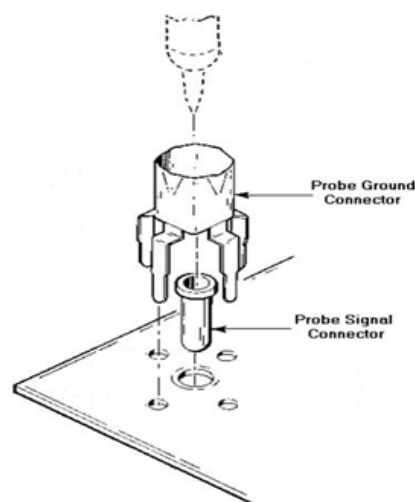


Figure 3. Tektronix Test Point & Probe Socket  
Part #: 700503100

## TEST EQUIPMENT REQUIRED

### Voltage Sources

#### (i) DC Supply Source for Input Voltage

The input voltage source should be a 0 to 20 V DC source. The input voltage may be increased further depending on the parts that are being used on the ONS321G evaluation board such that the part can withstand the applied voltage. Hence, based on the required input voltage to be applied, the requirement of the DC power supply varies.

#### (ii) DC Supply Source for Driver Voltage

The supply source for the driver should be a 0 to 20 V DC source. The driver voltage varies depending on the type of driver used (i.e.) For NCP5911 driver, the driver voltage is 5 V and for NCP5901 driver, it is 12 V.

### Electronic Load

The electronic load supplied to the ONS321G evaluation board ranges from 0 A to 25 A. Hence a DC current source of 0 A to 30 A is needed for the evaluation board.

### Meters to Measure Voltages and Currents

In the ONS321G Evaluation Board, the voltages that are to be measured are  $V_{in}$ ,  $V_{out}$  and  $V_{drv}$ . Similarly, the currents that are to be measured are  $I_{in}$ ,  $I_{out}$  and  $I_{drv}$ . The set

up for measuring these voltages and currents, and the meters required are shown in Figure 4. The currents are measured across the shunt resistances that are connected across each of the terminals of input, output and driver voltages as shown in Figure 4. For example, the output current is

measured as,  $I_{out} = V_{out} / R_{sh}$ . Similarly the input and driver current can also be measured. The connecting wires from the output terminal to the electronic load should be thicker in order to avoid losses and to measure the exact voltage at the end of the terminals.

### Oscilloscope

The oscilloscope is used to monitor the switch node waveforms. This should be an analog or digital oscilloscope set for DC coupled measurement with 50 MHz bandwidth. The resolution can be set at 5 V/division vertically and 20ns/division horizontally. The oscilloscope channels can be connected at various test points such as High Side Driver (JS6), Low Side Driver (JS10), Switch Node (JS8), G1 PWM Signal (JS11),  $V_{in}$  (sense) (J9 & J10) and  $V_{out}$  (sense) (J11 & J12).

## TEST SET UP AND PROCEDURE

### Test Setup

The test set up, test points and components present on the ONS321G Evaluation Board are shown in Figure 4.

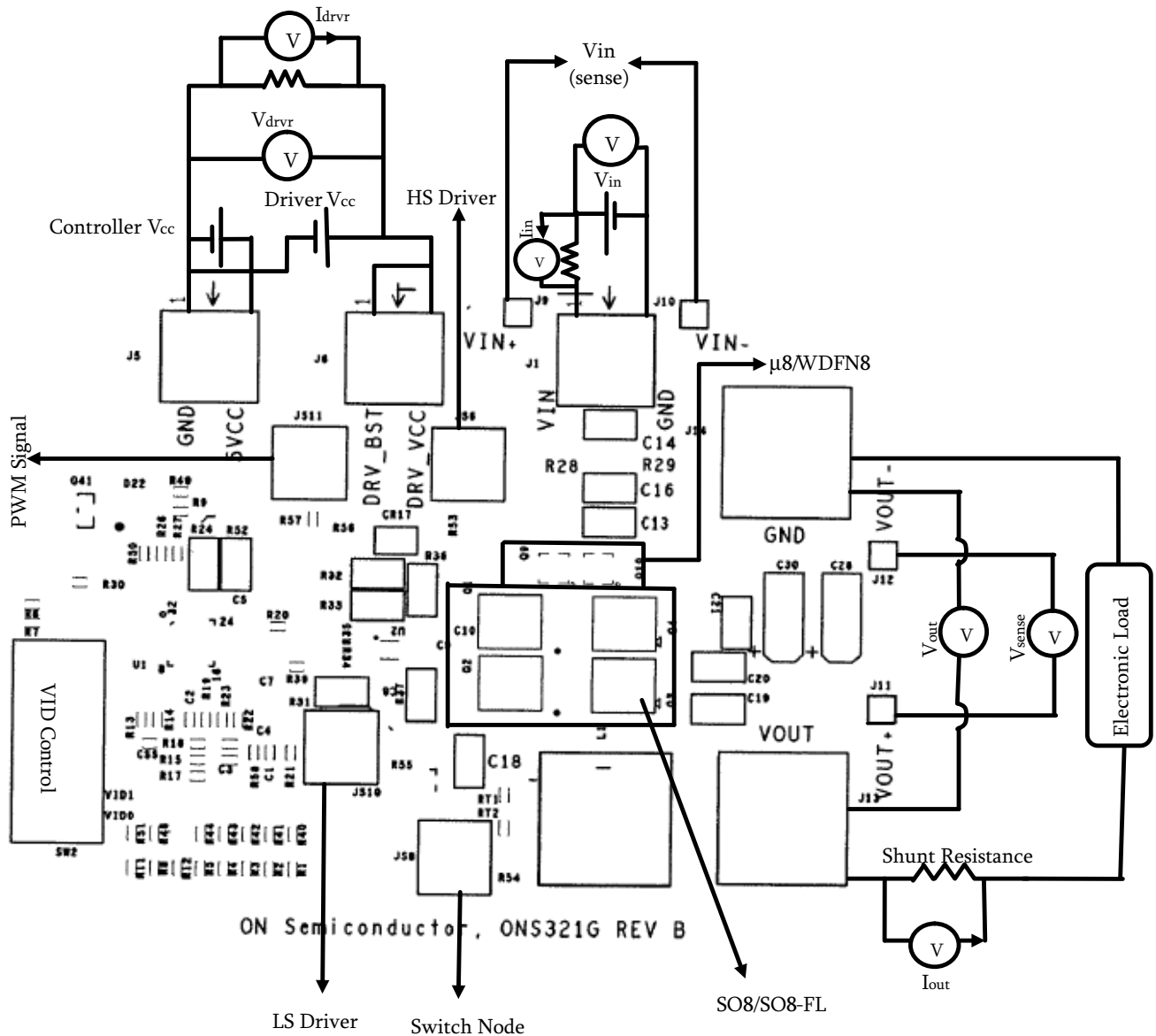


Figure 4. Schematic of the Test Setup

The SO-8 parts placed on the evaluation board are the Q1, Q2, Q3 and Q4; the  $\mu$ -8 parts placed on the evaluation board are the Q9 and Q10 and the DPAKs placed on the board right below the SO-8 parts are Q5, Q6, Q7 and Q8 shown in the schematic of ONS321G. (Refer to Section 2-Figure 1).

#### Start up and Shut down Procedures

Before starting the test, the oscilloscope probes should be connected. IR or k-type thermo-couples can be used to monitor the temperature of the parts to make sure that they are still within the limits. IR monitoring requires the removal of the oscilloscope probes due to the IR beam interference.

#### Start up Procedure:

1. Initially set all the power supplies to 0 V.
2. Set the output voltage by changing the VID settings. The output voltage should not be changed with either the controller or driver active.
3. Set the driver voltage and then set the input voltage.
4. Set the load current to required value. The load current must be incremented slowly to prevent the transient spikes at CS1/CS2 thereby shutting down the controller. If the controller shuts down, the input voltage must be set to zero, then the input power supply has to be turned off, then turned on and  $V_{in}$  re-established.

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### Shut down Procedure:

1. Shut down the Load.
2. Reduce the input voltage to zero and then shut down the input power supply.
3. Reduce the driver voltage to zero and then shut down the driver power supply.

### Test Procedure

1. Before making any connections, make sure to set the power supplies for input voltage and the driver voltage at 0 V. Also make sure that the load current is at 0 A.
2. Connect the Oscillator probes at the desired test points.
3. Set the driver voltage to the required value (For example,  $V_{\text{drv}} = 5 \text{ V}$ ).

4. After reaching the required driver voltage, set the input voltage as required. (For example,  $V_{\text{in}} = 12 \text{ V}$ ).
5. Set the load current slowly to the desired value. For example,  $I_{\text{out}} = 2.5 \text{ A}$ . (Refer to *Start Up Procedure #4*).
6. The frequency is already set to 330 kHz. If a different switching frequency is required, R13 and R14 have to be changed as per the data sheet of NCP5386. (Refer to *Appendix*).
7. Connect the voltmeters/multi-meters to monitor the required parameters. (Refer to Figure 4).
8. Obtain the required data and waveforms.

## TEST RESULTS

### Efficiency Comparison between the Standard In-house and ONS321G Evaluation Boards

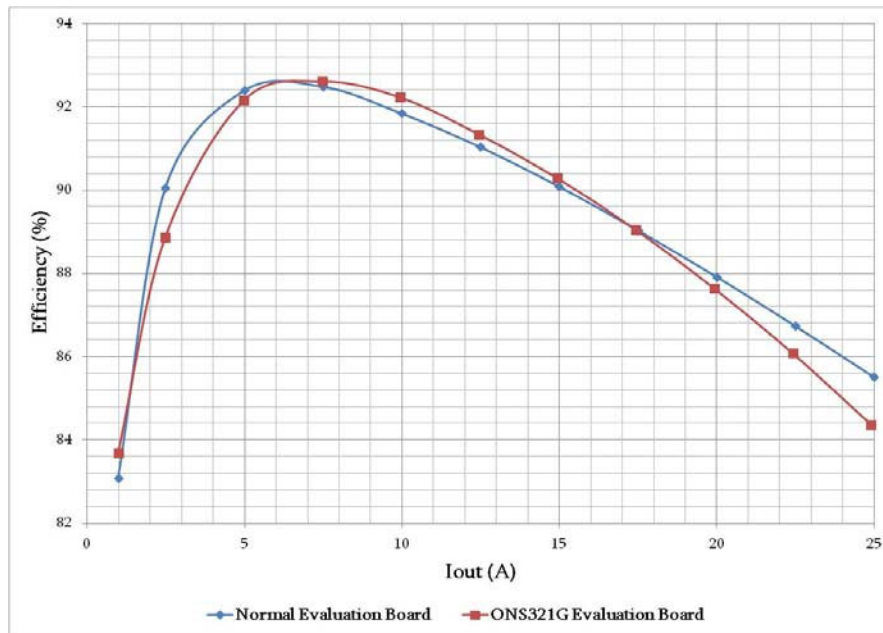


Figure 5. Comparison of Efficiency for Standard In-house and ONS321G Boards

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Efficiency Comparison of ONS321G Evaluation Board for  $V_{\text{dvr}} = 5 \text{ V}$  &  $10 \text{ V}^{**}$

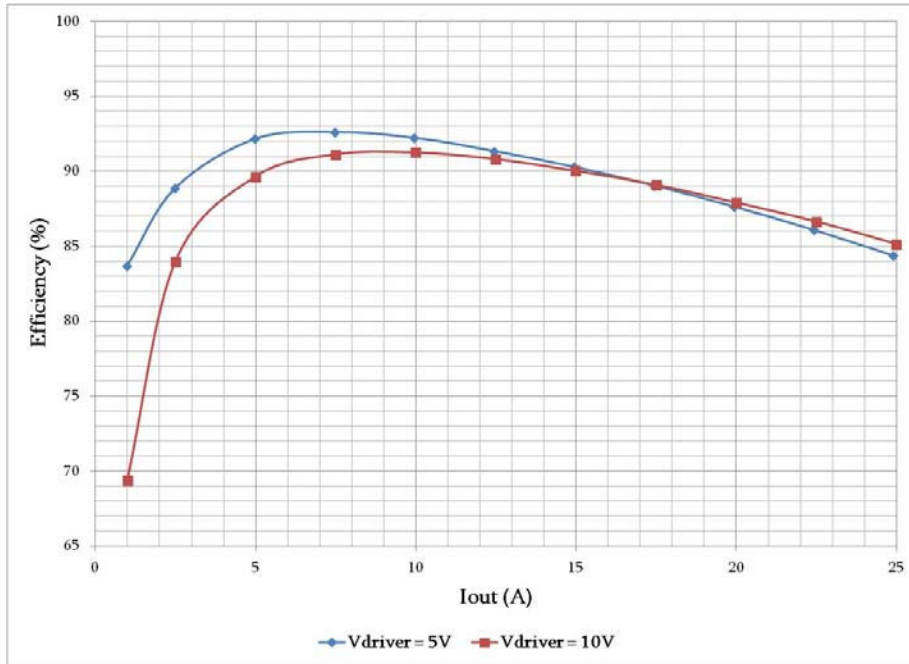


Figure 6. Comparison of Efficiency for ONS321G Board for  $V_{\text{dvr}} = 5 \text{ V}$  &  $10 \text{ V}$

Power Loss Comparison between the Standard In-house and ONS321G Evaluation Boards

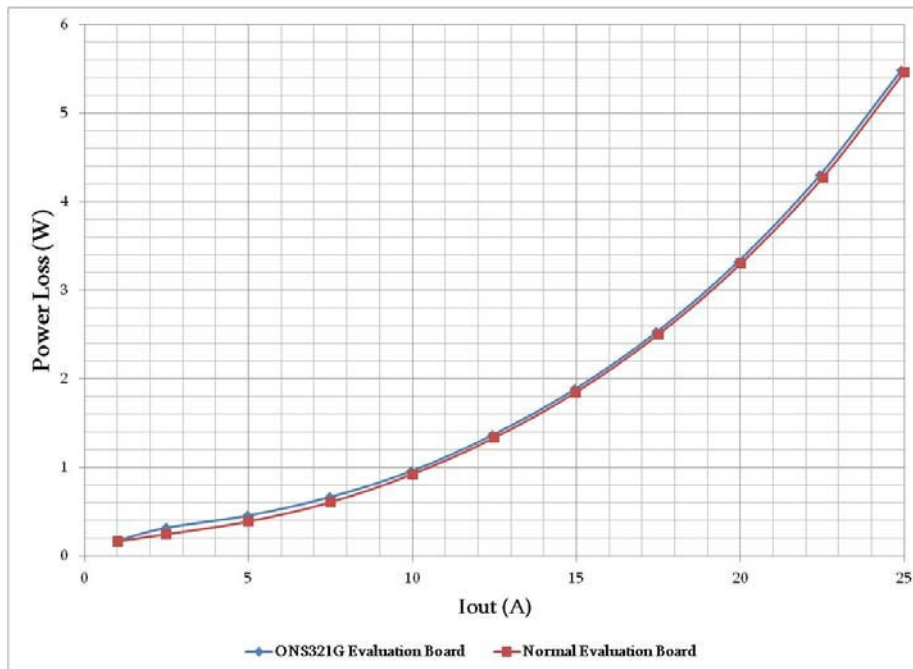


Figure 7. Comparison of Power Loss for Standard In-house and ONS321G Boards

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Power Loss Comparison of ONS321G Evaluation Board for  $V_{drvr} = 5\text{ V}$  &  $10\text{ V}^{**}$

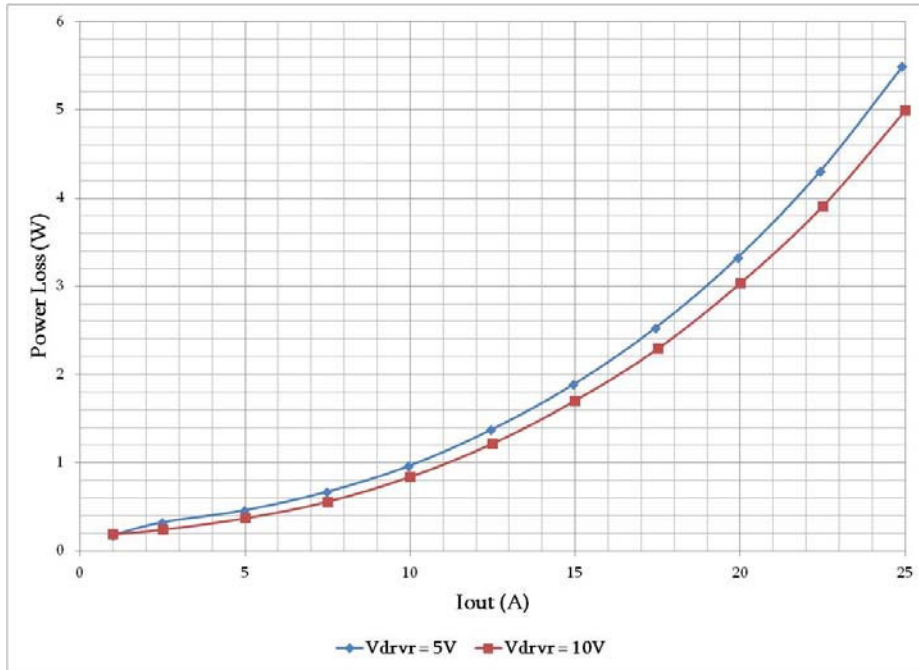


Figure 8. Comparison of Power Loss for ONS321G Board for  $V_{drvr} = 5\text{ V}$  &  $10\text{ V}$

Switch Node Voltage Waveforms of ONS321G Evaluation Board for  $V_{drvr} = 5\text{ V}$  &  $10\text{ V}^{**}$

(i) At  $I_{out} = 20\text{ A}$  and  $V_{drvr} = 5\text{ V}$  ( $V_{in} = 12\text{ V}$ ;  $V_{out} = 1.2\text{ V}$ ; Freq = 330 kHz)

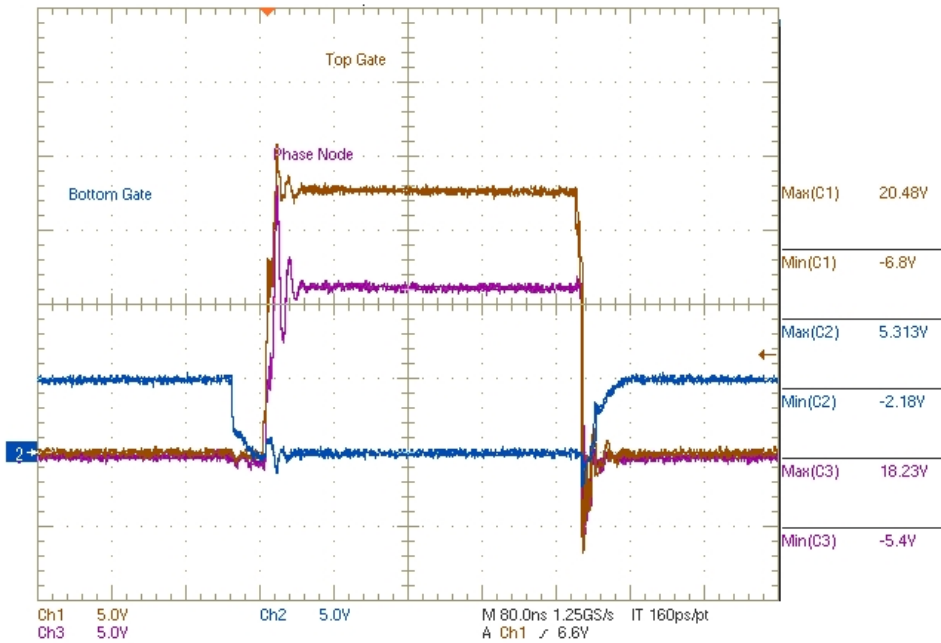
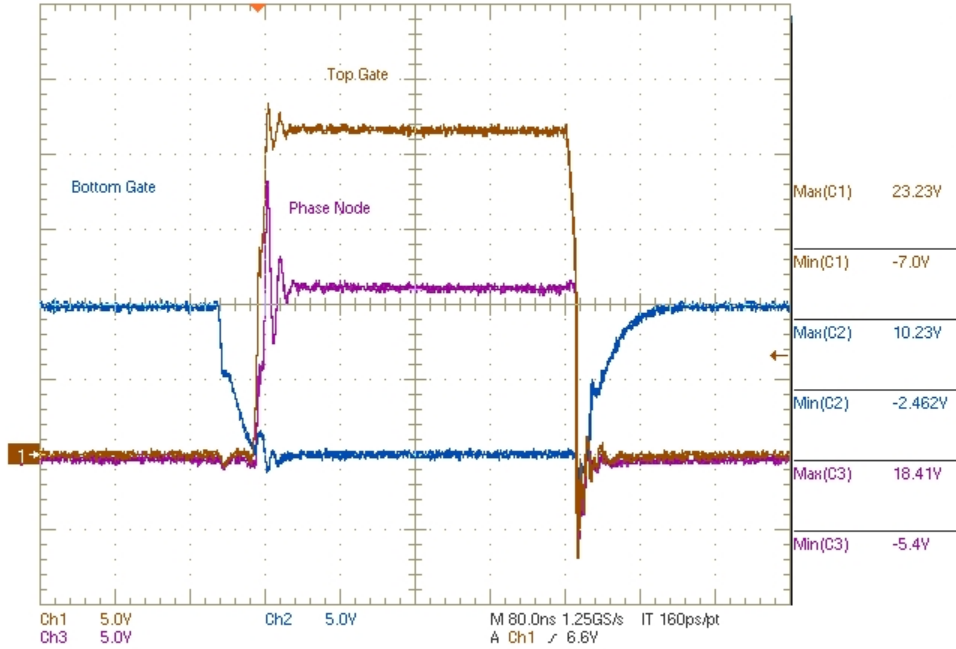


Figure 9. Switch Node Waveforms for  $V_{drvr} = 5\text{ V}$



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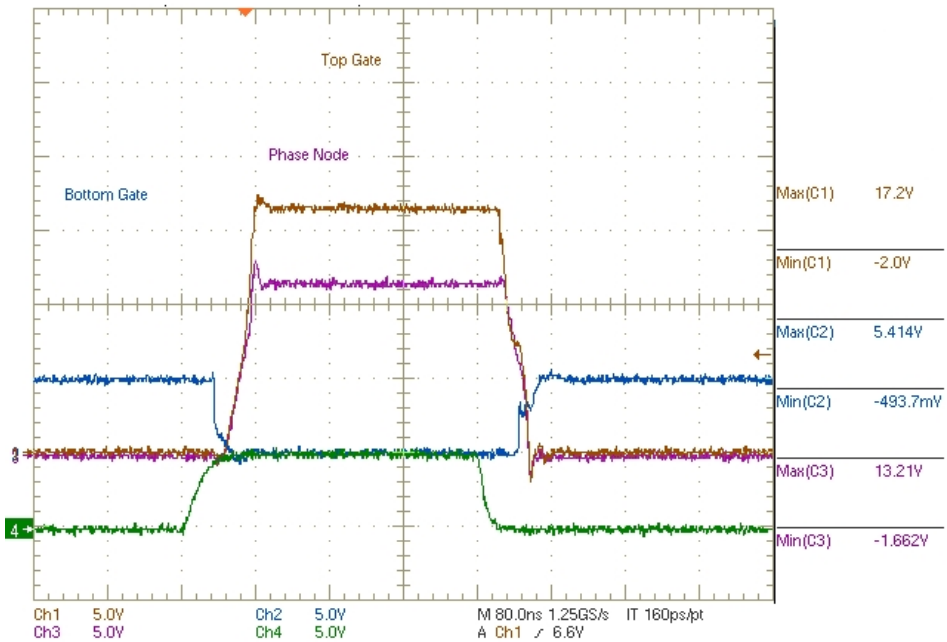
(ii) At  $I_{out} = 20\text{ A}$  and  $V_{drvr} = 10\text{ V}$  ( $V_{in} = 12\text{ V}$ ;  $V_{out} = 1.2\text{ V}$ ; Freq = 330 kHz)



**Figure 10. Switch Node Waveforms for  $V_{drvr} = 10\text{ V}$**

### 7.4 PWM Signals from the Controller to the Driver at G1 of ONS321G Evaluation Board for $V_{drvr} = 5\text{ V}$ & $10\text{ V}^{**}$

(i) At  $I_{out} = 0\text{ A}$  ( $V_{in} = 12\text{ V}$ ;  $V_{out} = 1.2\text{ V}$ ;  $V_{drvr} = 10\text{ V}$ ; Freq = 330 kHz)



**Figure 11. PWM Signal at G1 for  $I_{out} = 0\text{ A}$**

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(ii) At  $I_{out} = 20\text{ A}$  ( $V_{in} = 12\text{ V}$ ;  $V_{out} = 1.2\text{ V}$ ;  $V_{drv} = 10\text{ V}$ ; Freq = 330 kHz)

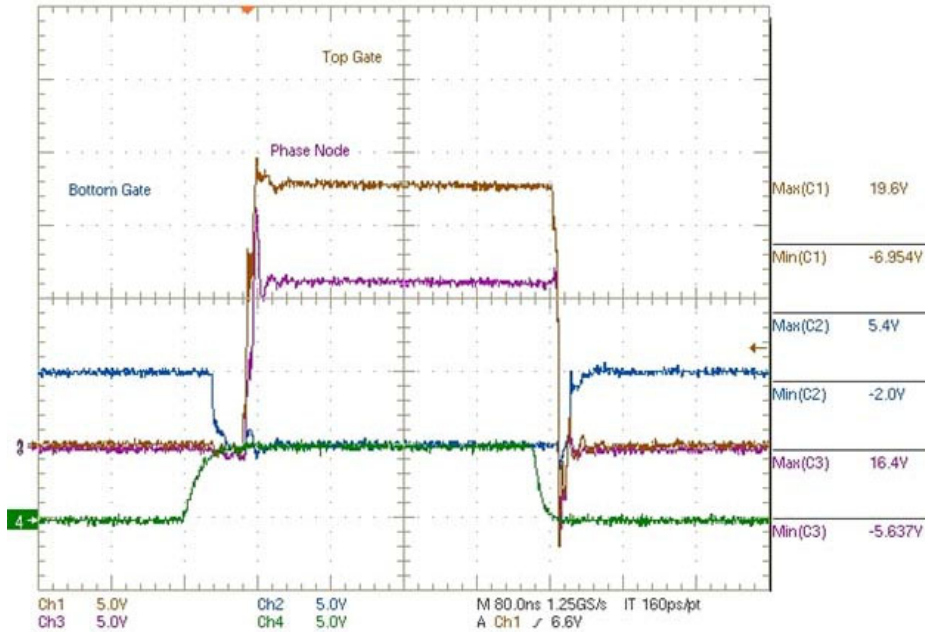


Figure 12. PWM Signal at G1 for  $I_{out} = 20\text{ A}$

NOTE: \*\* The efficiency, power loss, switch node and the PWM signal waveforms presented above are obtained with the 12 V driver (NCP5901) but by setting the driver voltage at 10 V.

## CIRCUIT BOARD LAYOUT

### Top Component Placement

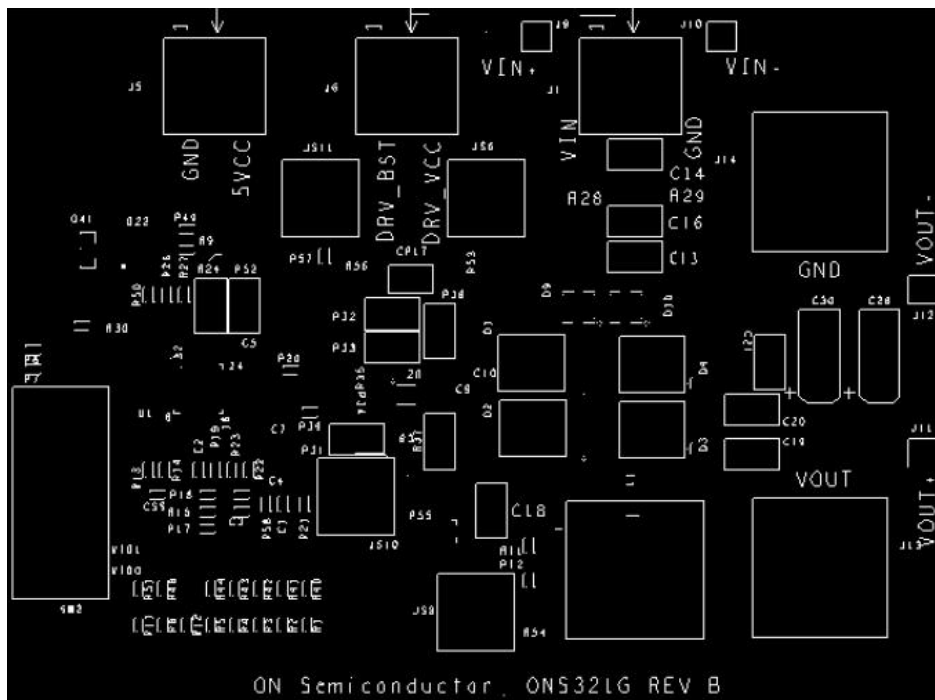


Figure 13. Top View of the ONS321G Evaluation Board

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## Bottom Component Placement

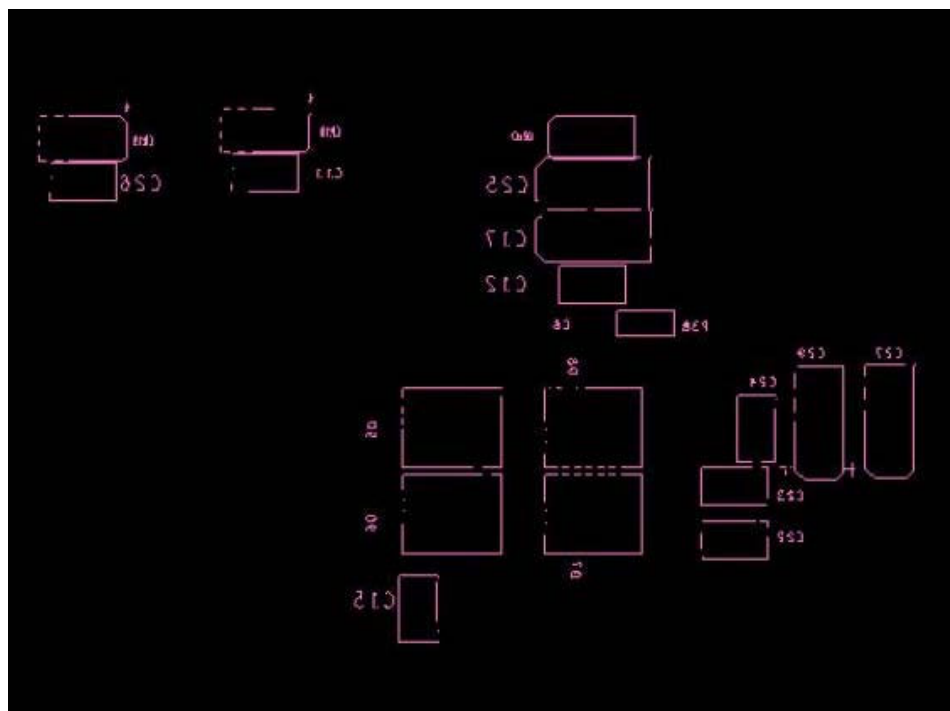


Figure 14. Bottom View of the ONS321G Evaluation Board

## Top Copper Layer

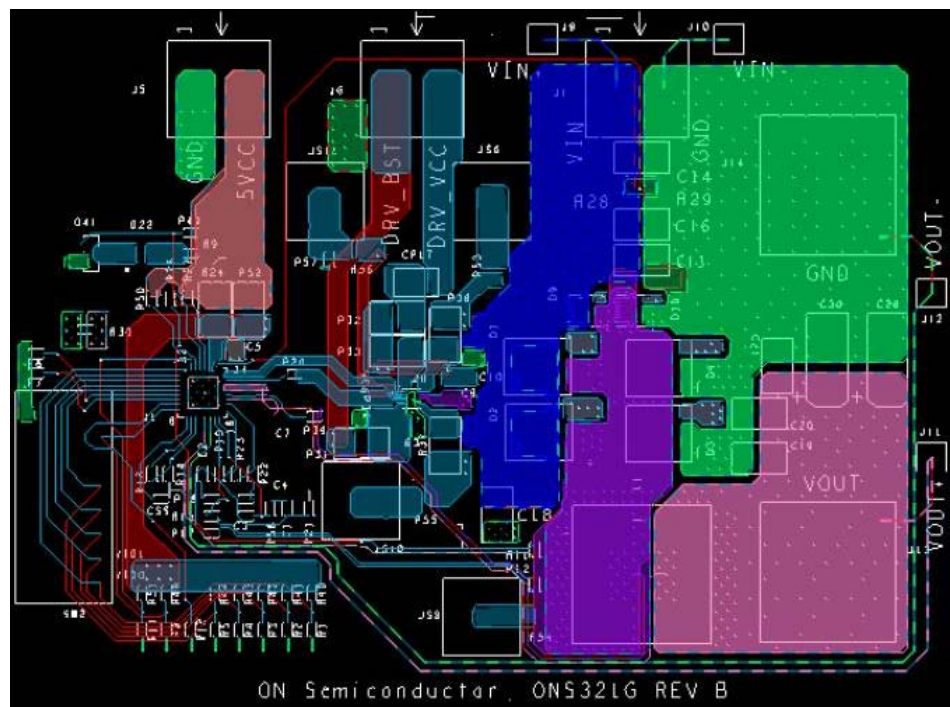


Figure 15. Copper Layer on the Top of ONS321G Evaluation Board

Internal Copper Layer 2

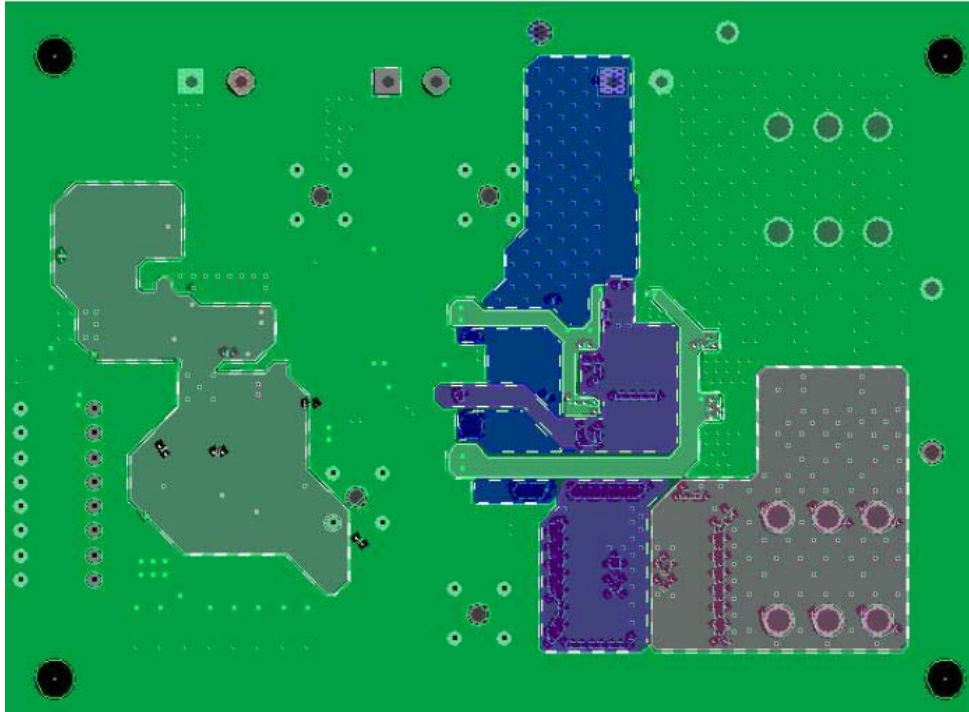


Figure 16. Internal Copper Layer 2 of ONS321G Evaluation Board

Internal Copper Layer 3

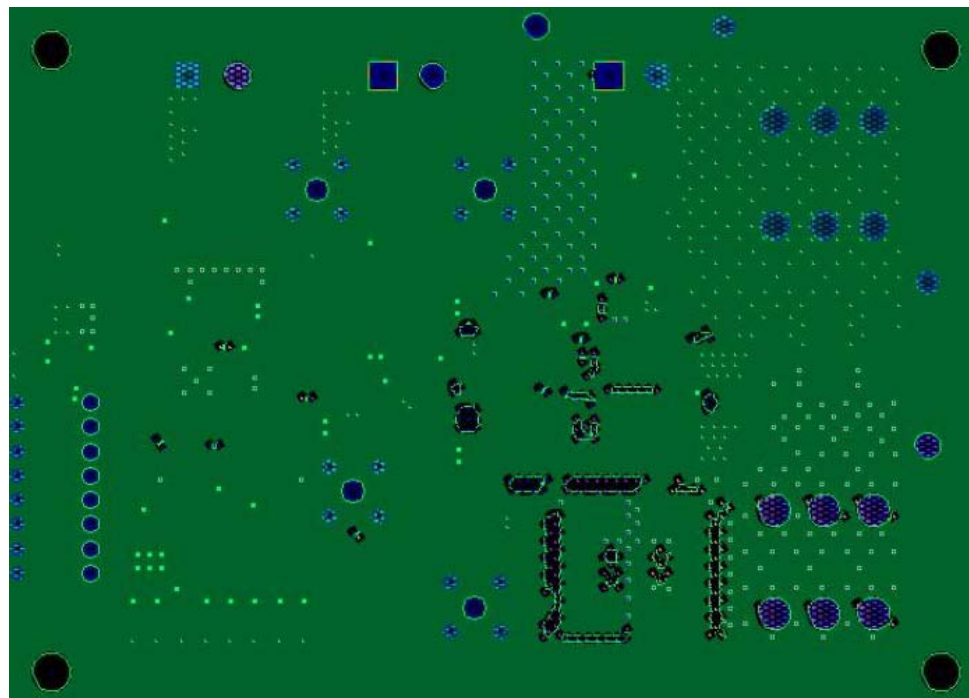


Figure 17. Internal Copper Layer 3 of ONS321G Evaluation Board

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## Bottom Copper Layer

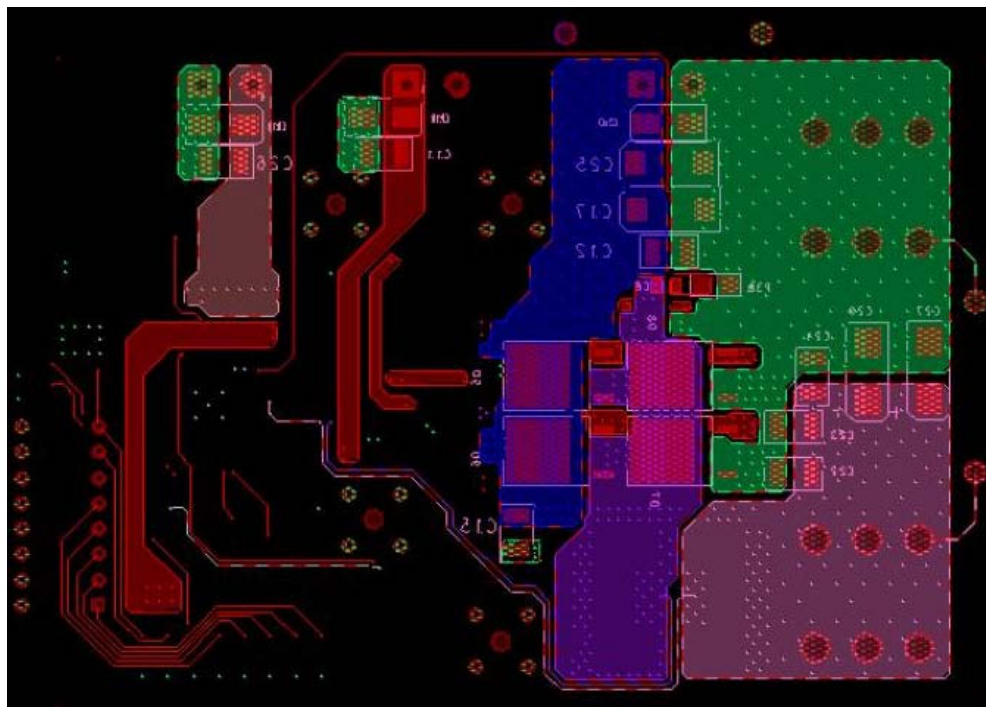


Figure 18. Copper Layer on the Bottom of ONS321G Evaluation Board

## APPENDIX

### Table of AMD VID Settings for NCP5386B Controller

Table 2. VID CONTROL SETTINGS FOR OUTPUT VOLTAGE

VID4	VID3	VID2	VID1	VID0	Nominal Vout (V)	Tolerance
0	0	0	0	0	1.550	±0.5%
0	0	0	0	1	1.525	±0.5%
0	0	0	1	0	1.500	±0.5%
0	0	0	1	1	1.475	±0.5%
0	0	1	0	0	1.450	±0.5%
0	0	1	0	1	1.425	±0.5%
0	0	1	1	0	1.400	±0.5%
0	0	1	1	1	1.375	±0.5%
0	1	0	0	0	1.350	±0.5%
0	1	0	0	1	1.325	±0.5%
0	1	0	1	0	1.300	±0.5%
0	1	0	1	1	1.275	±0.5%
0	1	1	0	0	1.250	±0.5%
0	1	1	0	1	1.225	±0.5%
0	1	1	1	0	1.200	±0.5%
0	1	1	1	1	1.175	±0.5%
1	0	0	0	0	1.150	±0.5%
1	0	0	0	1	1.125	±0.5%

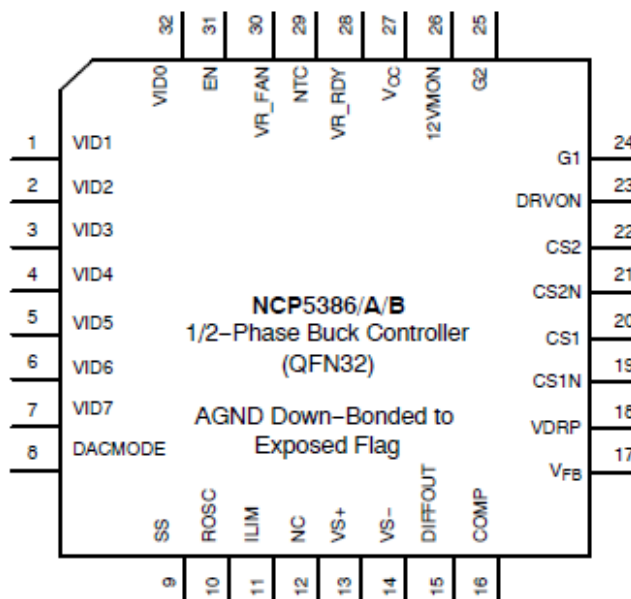
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**Table 2. VID CONTROL SETTINGS FOR OUTPUT VOLTAGE**

VID4	VID3	VID2	VID1	VID0	Nominal Vout (V)	Tolerance
1	0	0	1	0	1.100	±0.5%
1	0	0	1	1	1.075	±0.5%
1	0	1	0	0	1.050	±0.5%
1	0	1	0	1	1.025	±0.5%
1	0	1	1	0	1.000	±0.5%
1	0	1	1	1	0.975	±5.0 mV
1	1	0	0	0	0.950	±5.0 mV
1	1	0	0	1	0.925	±5.0 mV
1	1	0	1	0	0.900	±5.0 mV
1	1	0	1	1	0.875	±5.0 mV
1	1	1	0	0	0.850	±5.0 mV
1	1	1	0	1	0.825	±5.0 mV
1	1	1	1	0	0.800	±5.0 mV
1	1	1	1	1	Shutdown	-

### Pin Diagram of NCP5386B Controller

## NCP5386, NCP5386A, NCP5386B



**Figure 19. Top View of the Pin Diagram of NCP5386B**

### Switching Frequency of the Oscillator

The switching frequency of the oscillator can only be changed by changing the resistors R13 and R14.

For more information on NCP5386B: see Data Sheet of NCP5386B.

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