# TSW3065EVM – Standalone LO Source

This document describes the steps to properly operate and understand the TSW3065EVM Evaluation Module. TSW3065EVM eliminates expensive signal generators and also acts as a demo enabler for TI solutions such as, TSW3725, TSW6011, GC5330, GC5325, etc. TSW3065EVM can be used as standalone source as the dip switch enables no GUI usage with four significant pre-programmed frequencies, and the GUI can be enabled for detailed control. It can either be powered up with a 6-V DC supply or 5-V DC USB supply from a laptop/computer. It operates from 300 MHz to 4.8 GHz and provides output power more than 15 dBm up to 2.7 GHz.

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## 1 Overview

TSW3065EVM is based on Texas Instruments integer-N / Fractional –N frequency synthesizer with integrated wideband VCO TRF3765. Its frequency ranges from 300 MHz to 4.8 GHz. It provides programmable output power with a combination of amplifier and programmable attenuator. TSW3065EVM has an option of on-board or off-board reference selection. The on-board reference is from 10 MHz crystal.

## 2 Hardware Description

TSW3065EVM uses a wideband synthesizer, TRF3765, which has four differentials LO outputs. The block diagram of the TSW3065EVM is shown in Figure 1.

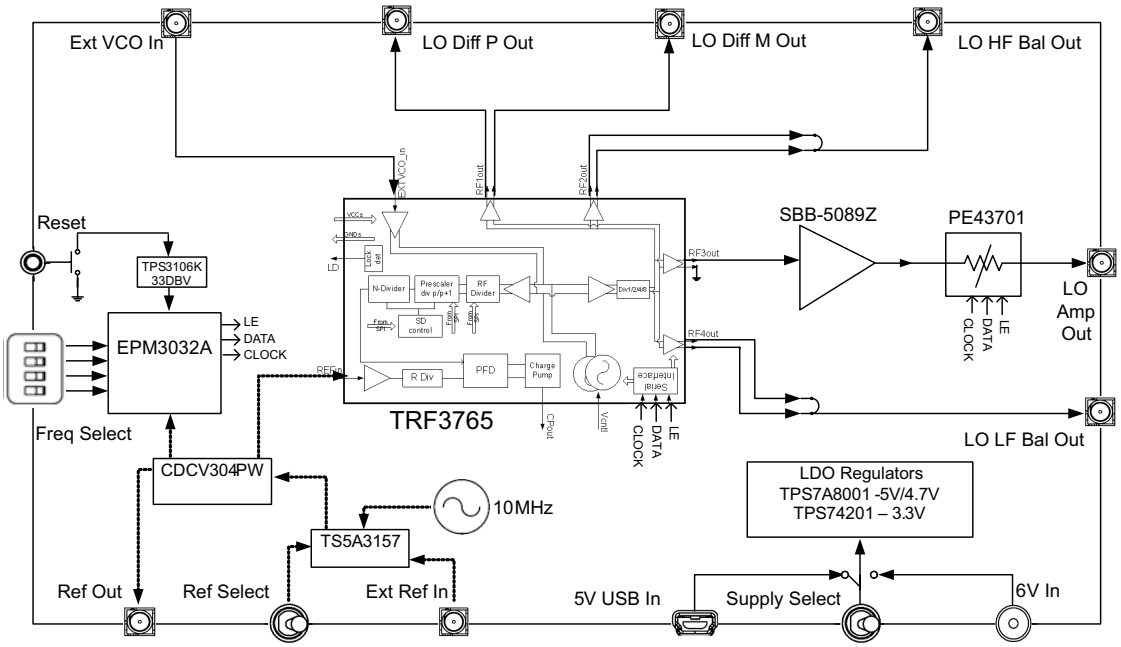



**Figure 1. TSW3065EVM Block Diagram**

The loop filter used is integer-N with $f_{pfd}$ and $f_{ref}$ 10 MHz. Loop filter details can be obtained from the TRF3765 data sheet (SLWS230). TSW3065EVM is enclosed within a metal housing with a plexi-glass top and is shown in Figure 2.

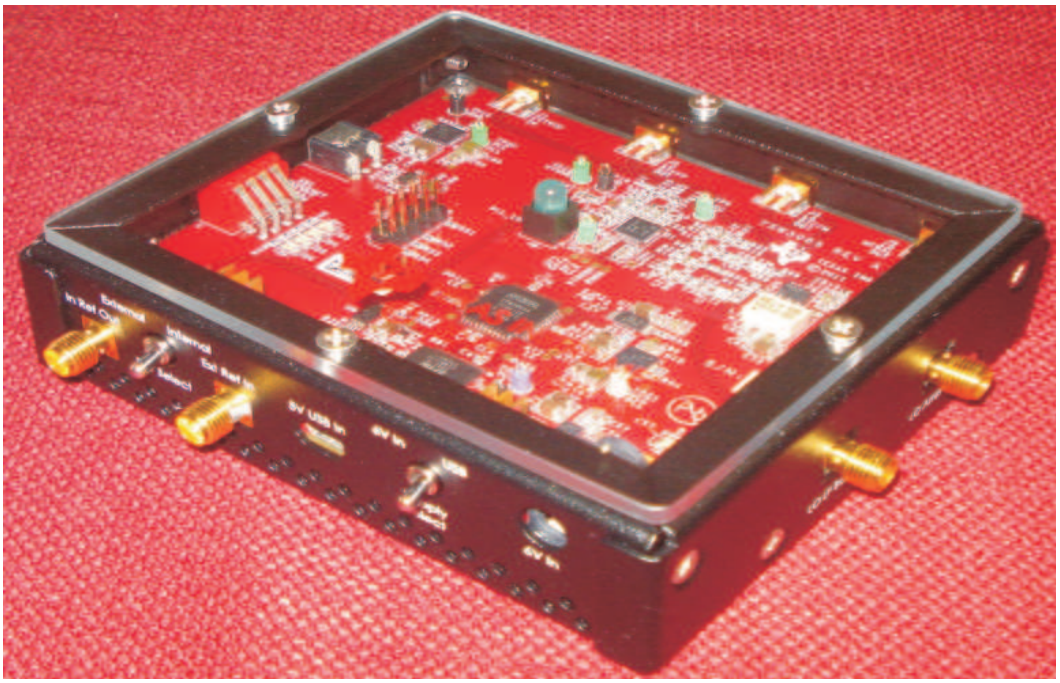


**Figure 2. Picture of TSW3065EVM**

## 2.1 LO Outputs

TSW3065EVM uses all four LO outputs of TRF3765. Figure 3 shows all the outputs along with 'Ext VCO In' connector.

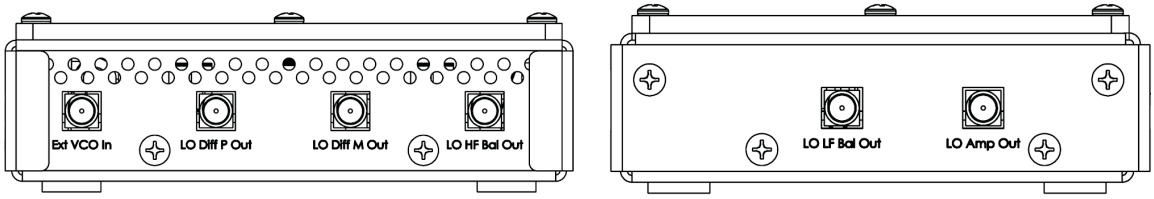



**Figure 3. LO outputs and Ext VCO in**

First, 'LO LF Bal Out' - SMA output uses a low frequency (900 MHz) balun to one of the four differential outputs of TRF3765.

Second, 'LO Amp out' - the main SMA output, is an amplified single ended line of TRF3765 second LO output. This chain uses a wide band amplifier and programmable attenuator.

Third, 'LO HF Bal Out' - SMA output uses high frequency (1900 MHz) balun to third TRF3765 LO output.

Finally, 'LO Diff P Out' and 'LO Diff M Out' - SMA outputs are the fourth differential output of TRF3765. 'Ext VCO In' - SMA is the external VCO input to TRF3765. Details of these outputs and 'Ext VCO In' are provided in TRF3765 data sheet (SLWS230).

## 2.2 Supply

A power supply cable and a USB cable have been supplied along with the TSW3065EVM. The TSW3065EVM can either be powered up with 6-V DC supply or 5-V DC USB supply from laptop/computer using 'Supply Select' switch. When USB powered, the USB version should be either USB 2.0, USB 3.0 or higher i.e., with 5-V DC and ≥ 500 mA. TSW3065EVM uses Texas Instruments linear regulators TPS7A8001 and TPS74201, which regulates the supply voltage to 5-V DC (for adaptor supply) / 4.7-V DC (for USB supply) and 3.3-V DC, respectively. The TSW3065EVM consumes 430 mA of current from a 6-V supply.

**CAUTION**

To minimize risk of damage to EVM and/or continued EVM compliance, use only the power supply provided with this EVM as stated above.

## 2.3 Reference

TSW3065EVM can be locked either using an on board 10 MHz reference clock or an external 10 MHz, 12 dBm to 13 dBm reference using the 'Reference Select' switch. When 'Ref Select' switch is at the 'internal' position, it selects the internal reference, and when at the 'external' position, it selects the external reference. External reference signal is applied at the 'Ext Ref' connector. The reference used to lock TSW3065EVM is available at the 'Ref Out' SMA connector and can be used to lock other devices or instruments.

## 2.4 Frequency Selection

The TSW3065EVM has four significant pre-programmed frequencies. These frequencies can be selected using dip switch. Table 1, shows the positions of dip-switch with LED's D3, D4, D5, and D6 and respective programmed frequency. GUI could be used for advanced options or other desired frequency selections. Whenever the dip switch position is changed to one of the first four settings in Table 1, the respective frequency registers are loaded after resetting the board (i.e. by pressing 'Reset' push button). When the dip switch position 1111 is selected, the TSW3065EVM is in GUI controlled mode. Figure 4, shows the dip switch and 'reset' push button location.

**Table 1. Dip Switch Frequency Selection**

| Dip Switch Position D6-D5-D4-D3 | Frequency (MHz) |
|---|---|
| 0001 | 950 |
| 0010 | 1960 |
| 0100 | 2140 |
| 1000 | 3500 |
| 1111 | USB Control |

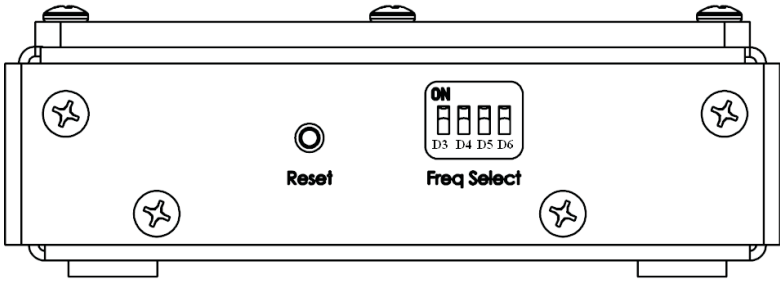



**Figure 4. Dip Switch and Push Button**

### *2.5 Regulatory Compliance*

EMC Directive: 2004/108/EC relating to electromagnetic compatibility.

CE

## 3 GUI Details

A TSW3065EVM GUI screen shot is shown in Figure 5. For the board to be GUI controlled, the dip switch position should be set to 1111. The frequency in the 'Frequency (Hz)' tab can be selected from 300 MHz to 4.8 GHz, and clicking the 'right' button enables the selected frequency. The attenuation settings can be varied from 0 to 31.75, and attenuation up to 30 dB can applied to the 'LO Amp Out' signal.

'LO LF BAL OUT' can be enable or disabled by turning ON and OFF the LO LF BAL OUT button. Similarly, others outputs can be turned ON and OFF. Turning ON and OFF 'LO DIFF OUT' enables and disables the 'LO DIFF P Out' and 'LO DIFF M Out' outputs, respectively. To modify the advance settings of TRF3765, the 'TRF3765 Advance Settings' tab can be used. See the TRF3765 data sheet for TRF3765 detailed settings. As shown in Figure 5, the GUI also displays the TSW3065EVM block diagram.

**NOTE:**

1. When the TSW3065 GUI is launched, it displays only 'LO AMP OUT' turned ON, but by default at the initial start-up, all the output buffers are turned ON.
2. While operating TSW3065 between 2.06 GHz to 2.18 GHz, always turn OFF 'LO_LF_BAL_Out' output buffer.

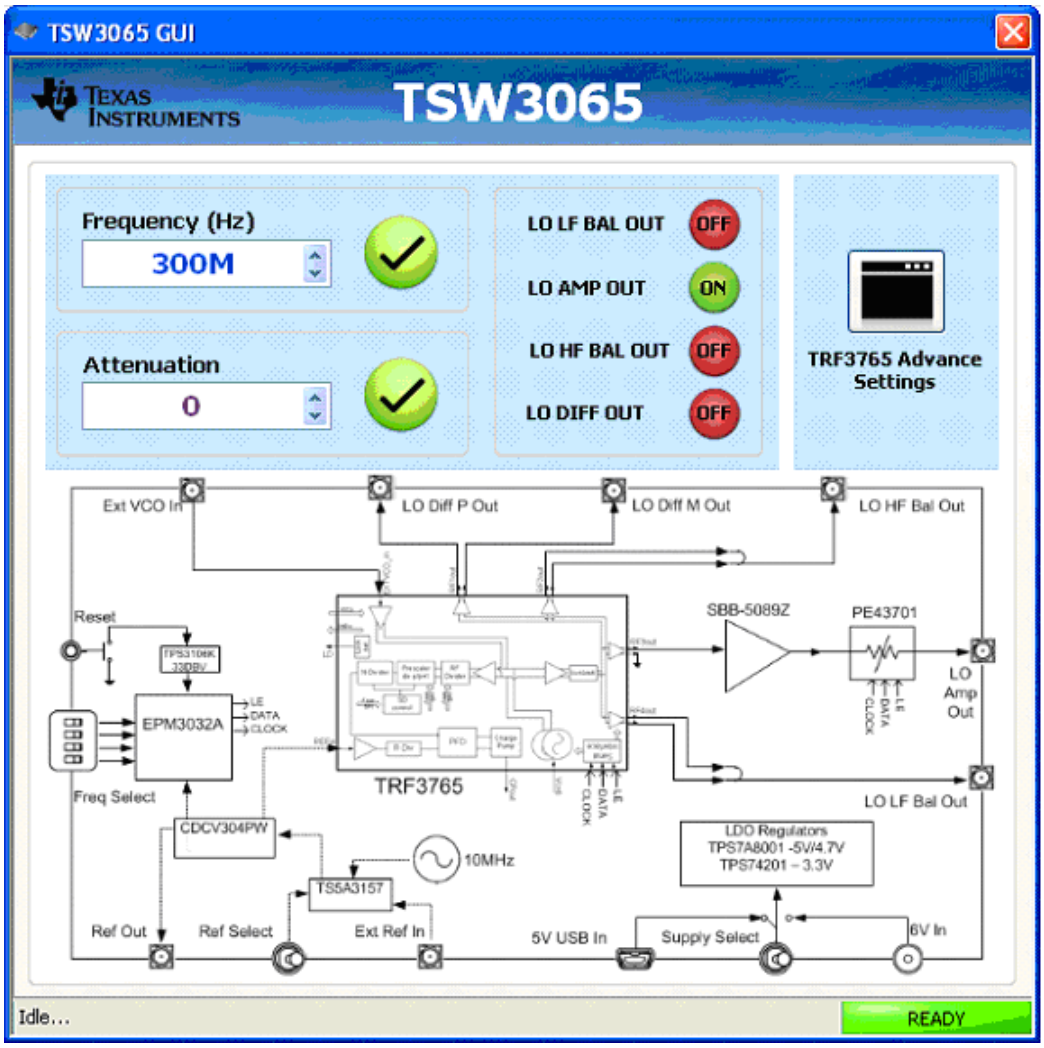



**Figure 5. Screen shot of TSW3065EVM GUI**

## 4 Setup Steps

Step 1. To power up the board using a 5 V USB, connect one end of USB (USB2.0, USB3.0 or higher versions) cable to '5V USB In' and other end to a laptop/computer. Power from the USB is indicated when the yellow LED 'D2 USB Supply' is turned ON. Select the 'Supply Select' switch to the 'USB' location as shown in Figure 6. Figure 7(b) shows the TSW3065EVM setup with USB supply.

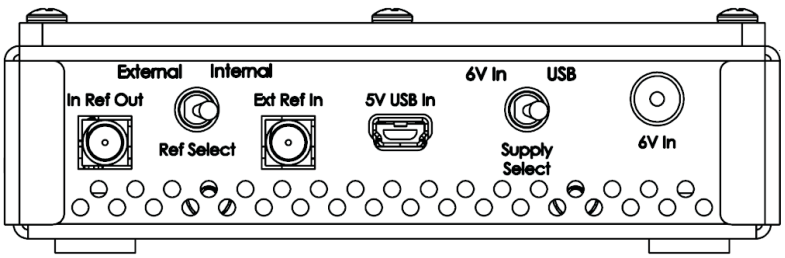
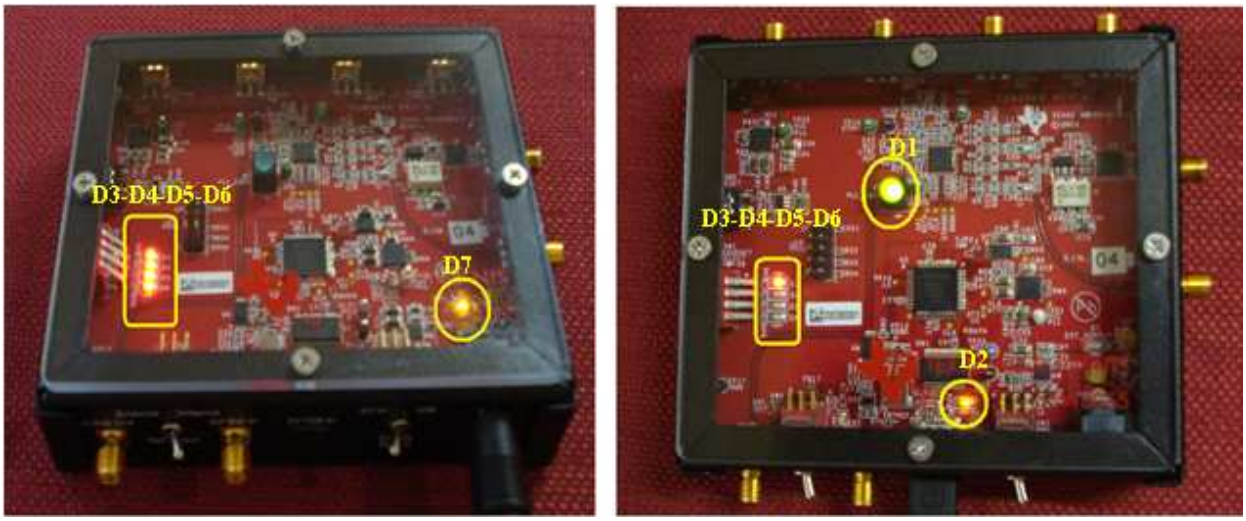



**Figure 6. Supply and Reference**

Step 2. To power up the TSW3065EVM using a 6-V supply, connect the power cable at '6V In' connector. Yellow LED "D7 Ext Supply" turns on once power is engaged. Select the 'Supply Select' switch to the '6V In' position. Figure 7(a) shows the TSW3065EVM setup.




(a) 6 V supply powered and dipswitch in GUI controlled position

(b) USB powered and dipswitch in pre-programmed frequency position

**Figure 7. TSW3065EVM Setup**

Step 3. Select 'Ref Select' switch to 'Internal' position as shown in Figure 6. This selects the internal onboard 10 MHz crystal oscillator as reference. To select an external reference select the 'Ref Select' switch to 'External' position. This turns on the yellow LED 'D8 Ext_Ref.' Apply 10 MHz, 13 dBm of the external reference signal at the 'Ext Ref In' connector. 'Ref Out' which is one of the buffered outputs of the reference used to lock TSW3065EVM can be used to lock other instruments or boards. Figure 7(a) and Figure 7(b) shows TSW3065EVM setup with internal reference selected.

**NOTE:** To obtain the best performance, operating the TSW3065 using an internal 10 MHz onboard crystal is recommended because crystal oscillators usually have a better performance than laboratory signal generators.

Step 4. To use pre-programmed frequencies, select the 'Freq Select' dip switch in one of the first four positions in Table 1 and press 'Reset' push button. This locks the TSW3065EVM to the respective frequency of dip switch position and the green LED 'D1 PLL LOCK' is turned ON. Figure 7(b) shows the TSW3065EVM setup in the first dip switch position of Table 1 with D1 turned ON, which indicates TSW3065EVM is locked. To use the board in GUI controlled mode, turn the dip switch to 1111 position as shown Figure 7(a).

## 5 Performance Plots

This section provides typical performance plots of the TSW3065EVM. Figure 8, shows the maximum output power at ‘LO Amp Out’ across frequencies 300 MHz to 4.8 GHz. TSW3065EVM provides output power more than 15 dBm up to 2.7 GHz and more than 11 dBm up to 4.5 GHz. Figure 9, shows the output phase noise response for each pre-programmed frequency of DIP switch at minimum attenuation settings. In-band phase noise performance is slightly degraded using a USB supply and is shown in Figure 10.

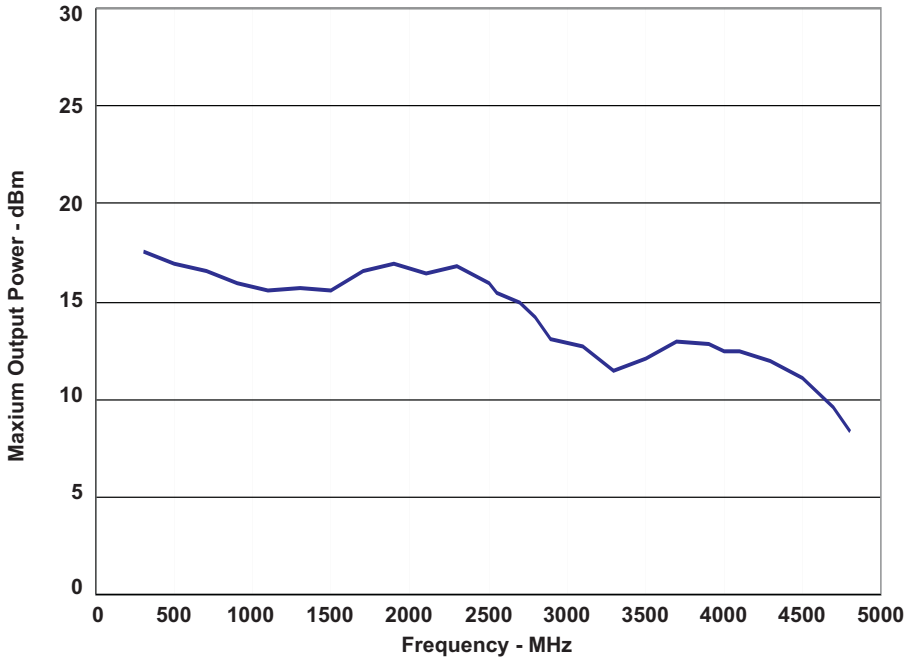
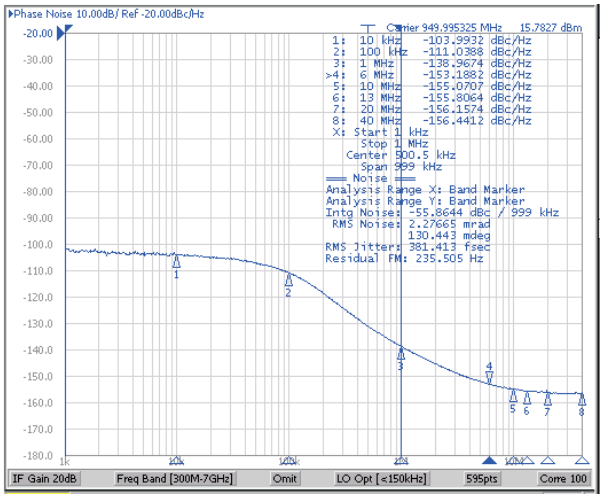
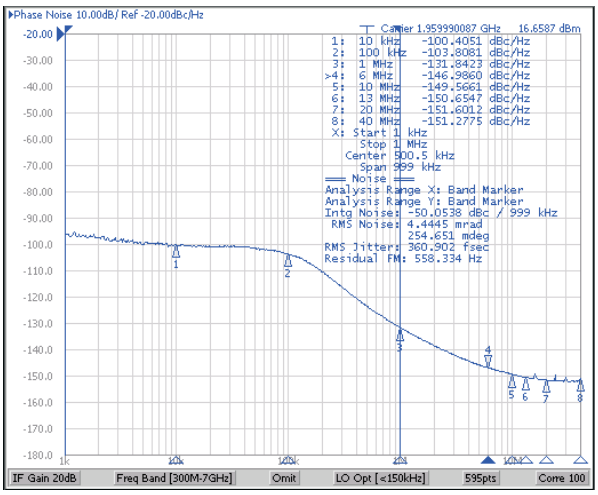


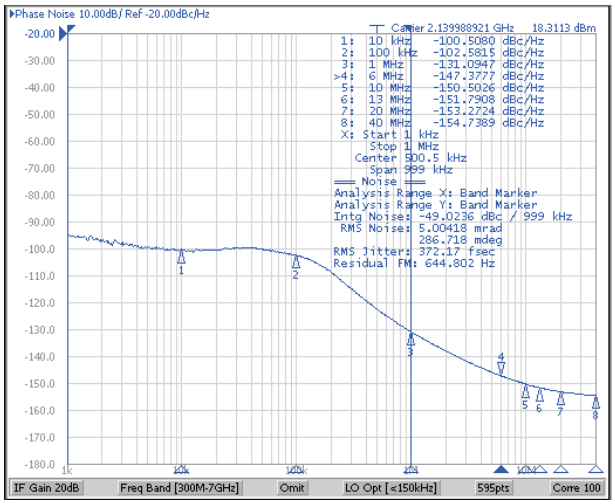

**Figure 8. 'LO Amp Out’ Maximum Output Power**



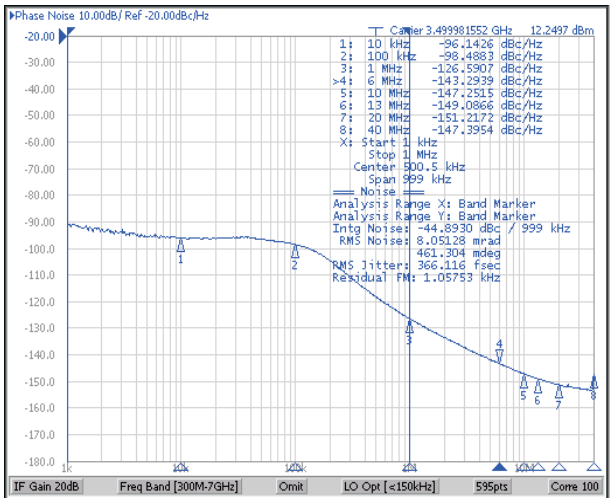

**(a) Dip switch position at 0001 position - 950 MHz**




**(b) Dip switch position at 0010 position - 1960 MHz**




**(c) Dip switch position at 0100 position - 2140 MHz**




**(d) Dip switch position at 1000 position - 3500 MHz**

**Figure 9. Phase Noise Response at 'LO Amp Out' at Maximum Output Power With (a), (b), (c) and (d)**

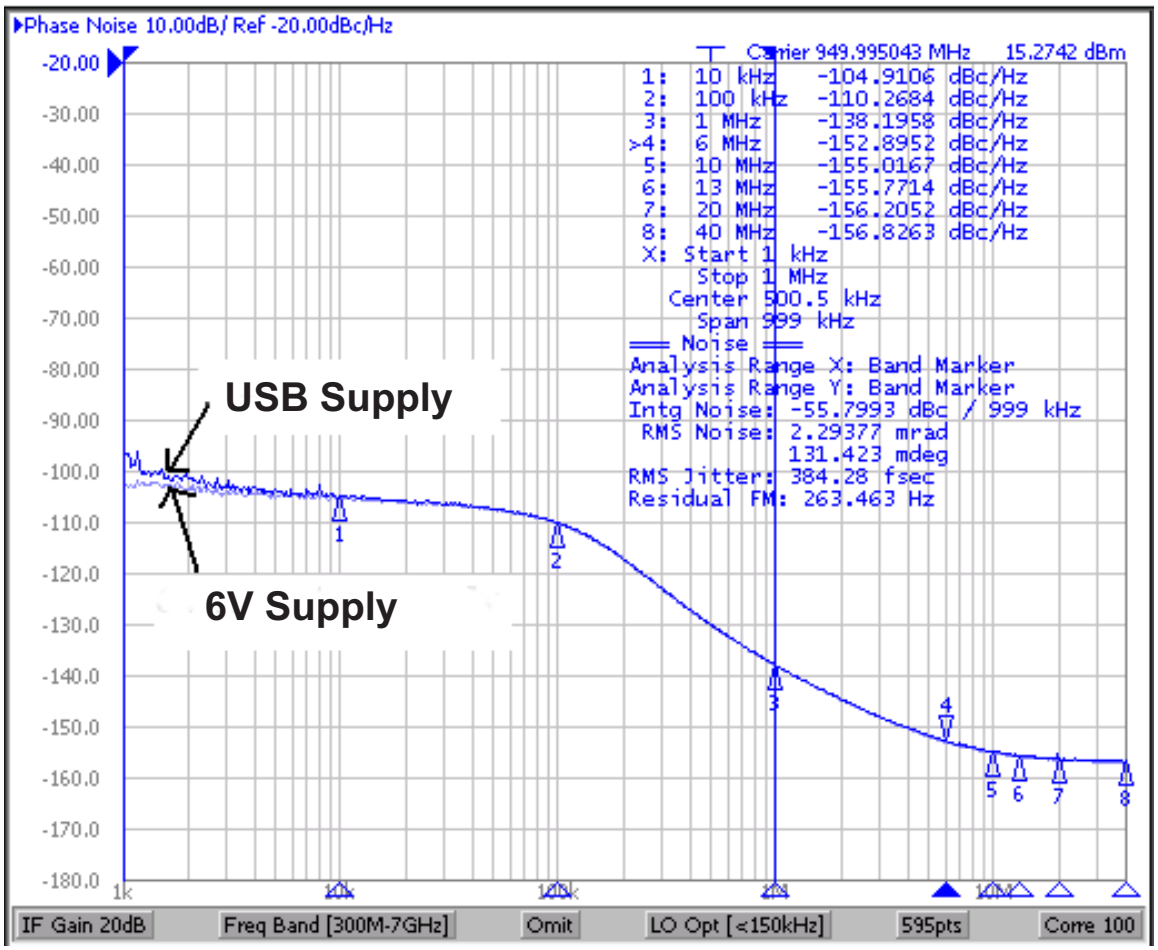
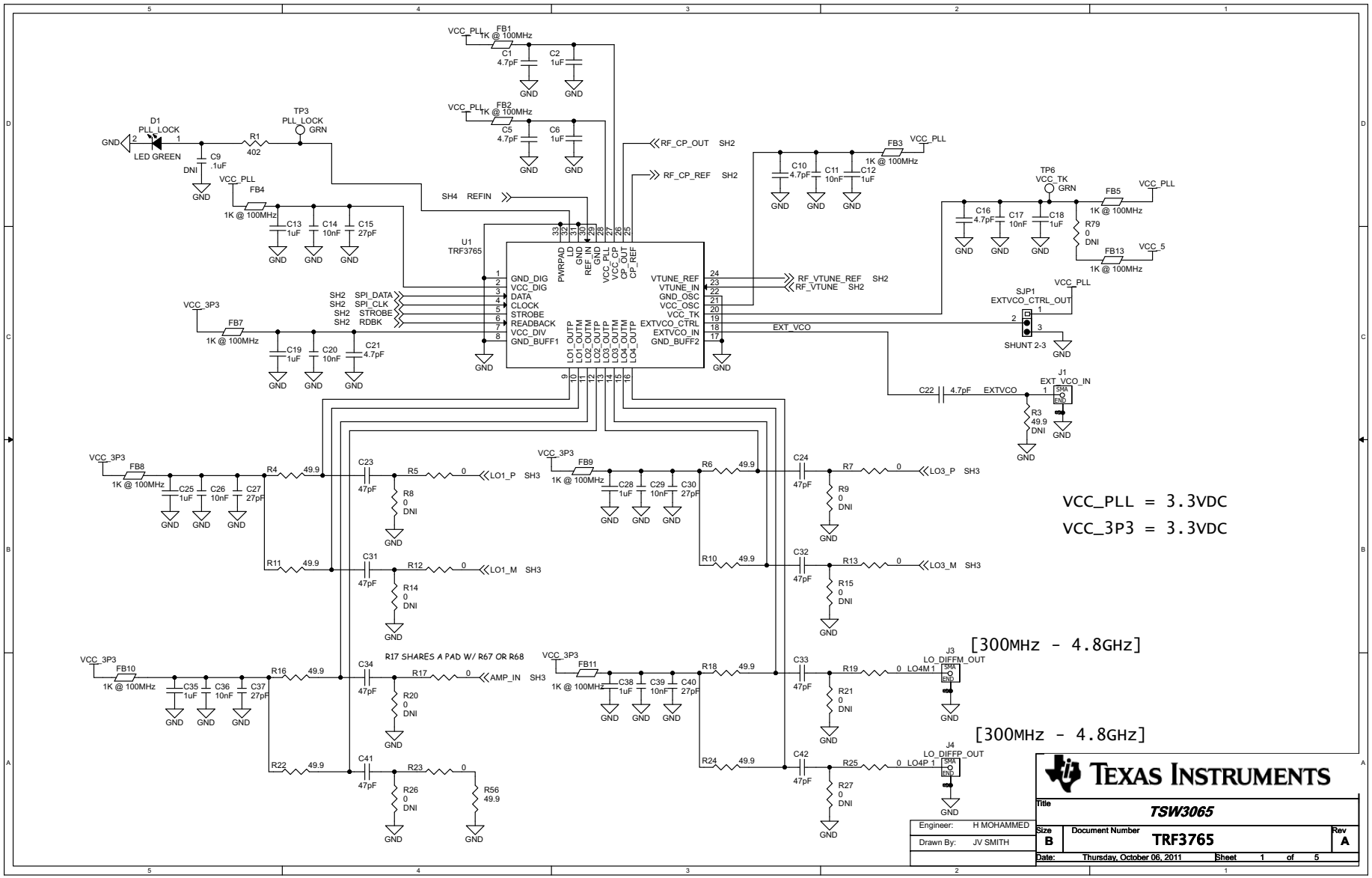
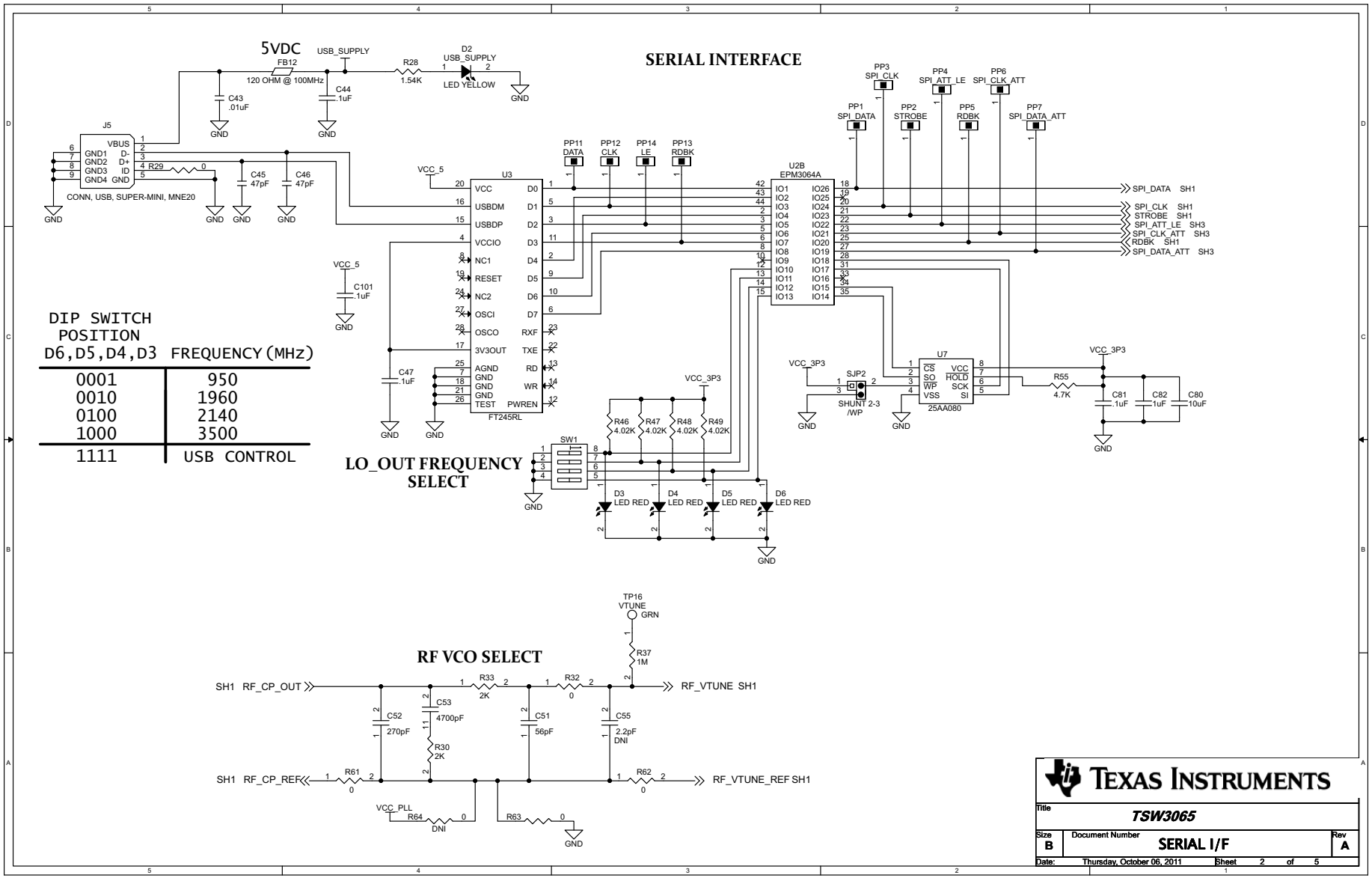
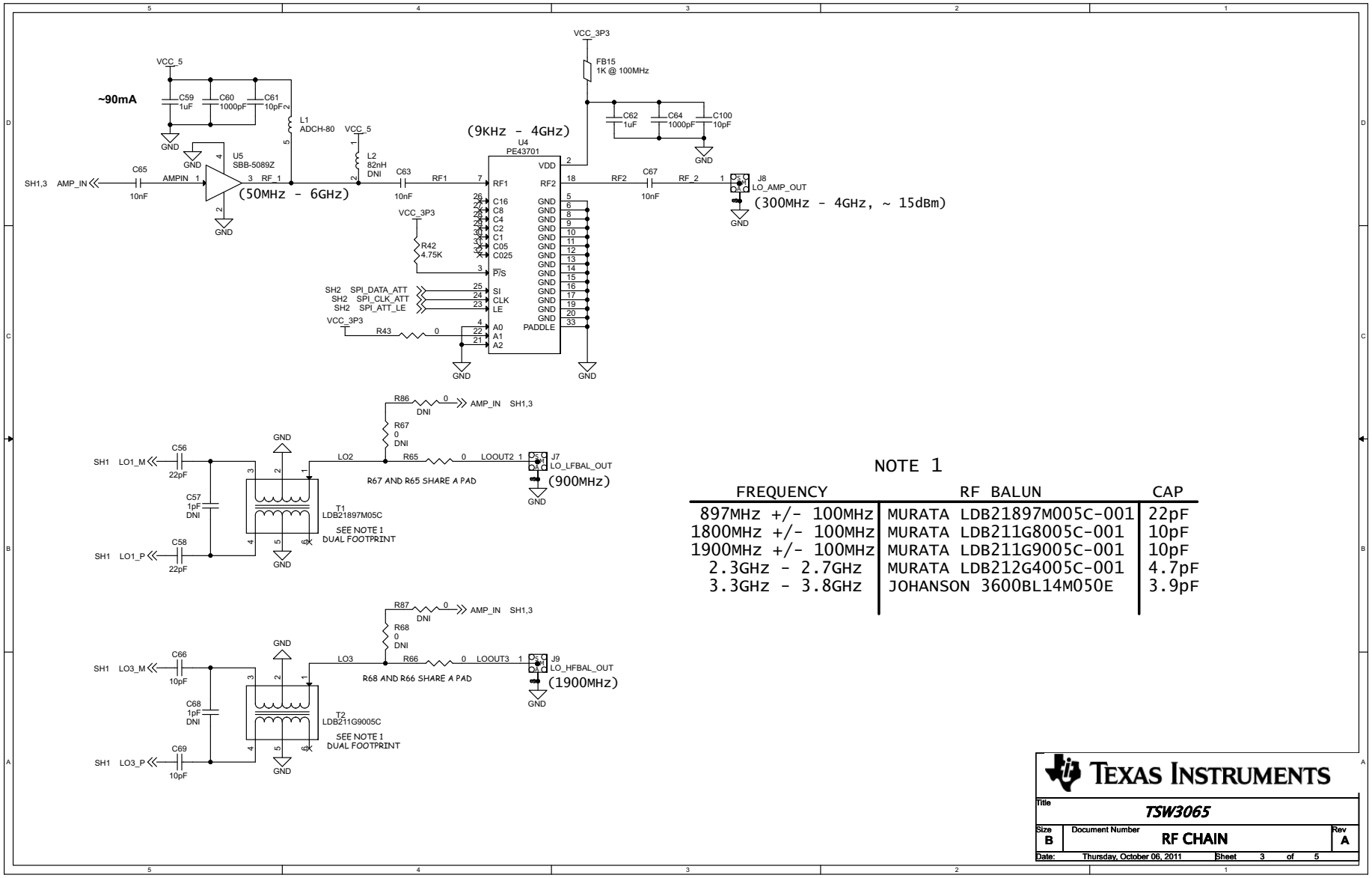



**Figure 10. Phase Noise Comparison at 'LO Amp Out' at Maximum Output Power Using USB Supply and 6V Supply with Dip Switch at Position 0001–950MHz**

# 6 Schematics





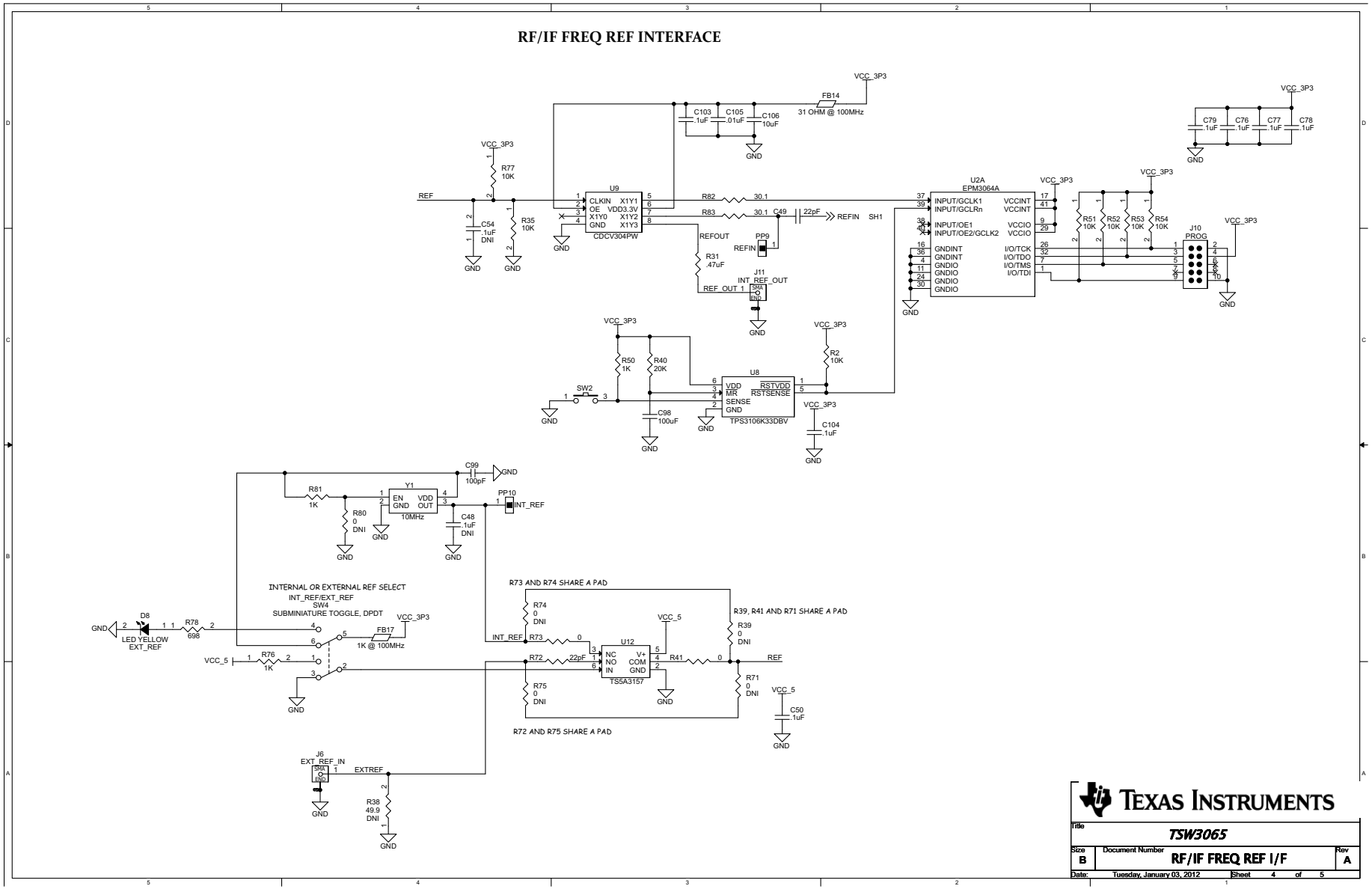


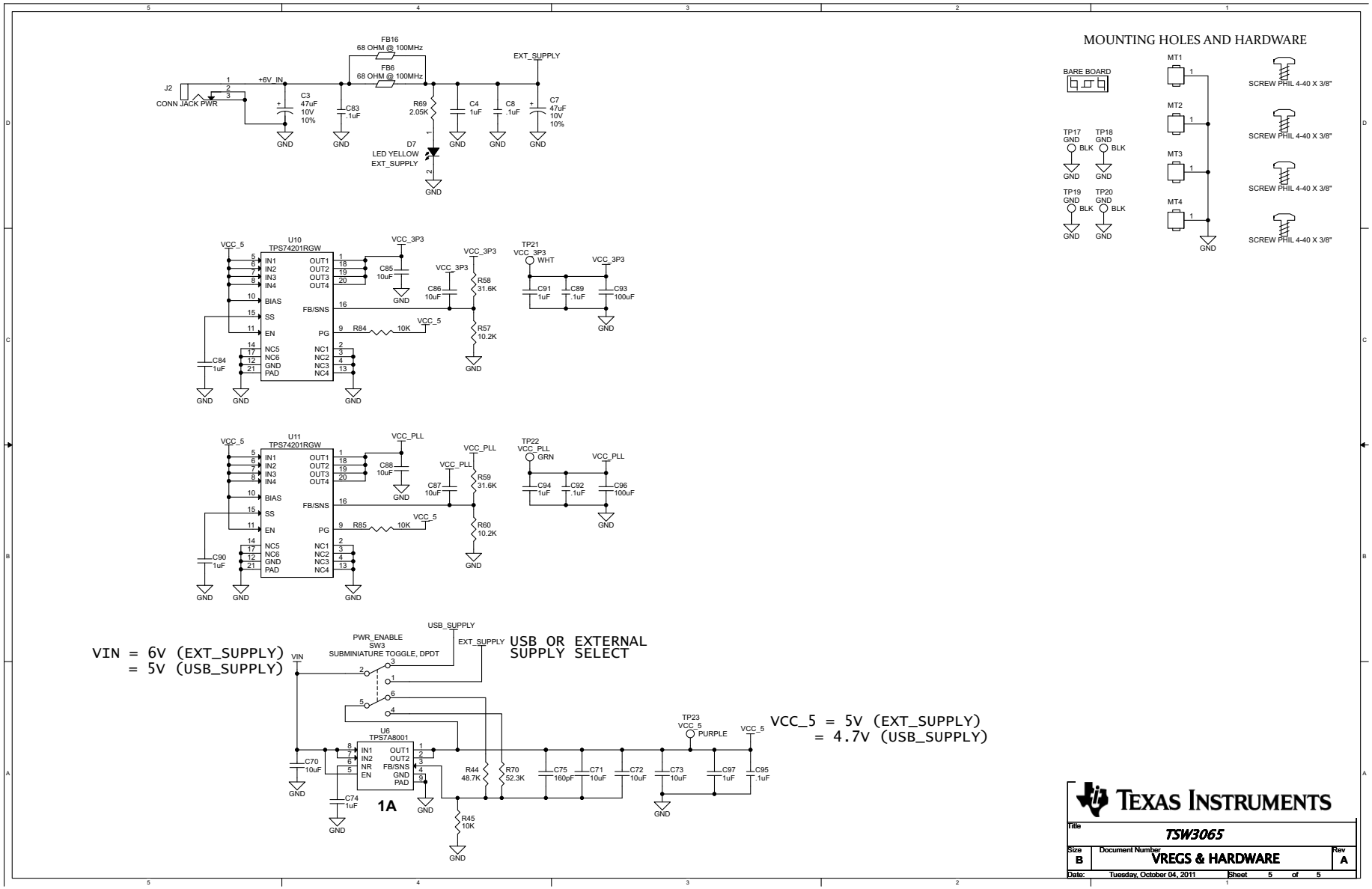

NOTE 1

| FREQUENCY | RF BALUN | CAP |
|---|---|---|
| 897MHz +/- 100MHz | MURATA LDB21897M005C-001 | 22pF |
| 1800MHz +/- 100MHz | MURATA LDB211G8005C-001 | 10pF |
| 1900MHz +/- 100MHz | MURATA LDB211G9005C-001 | 10pF |
| 2.3GHz - 2.7GHz | MURATA LDB212G4005C-001 | 4.7pF |
| 3.3GHz - 3.8GHz | JOHANSON 3600BL14M050E | 3.9pF |

TEXAS INSTRUMENTS

| | | |
|---|---|---|
| Title: TSW3065 | | |
| Size: B | Document Number: RF CHAIN | Rev: A |
| Date: Thursday, October 06, 2011 | Sheet 3 of 5 | |





## Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

**Changes from A Revision (January 2012) to B Revision** **Page**

- Abstract, changed text From: "6-V DC adaptor supply" To: "6-V DC supply" ..... 1
- Changed Section 2.2 ..... 3
- Section 4, changed step 2 ..... 6
- Changed Figure 7(a) title, From: "6 V adaptor supply" To: "6 V supply" ..... 6
- Changed Figure 10 title, From: "6V Adaptor Supply" To: "6V Supply" ..... 9

## Revision History

**Changes from Original (October 2011) to A Revision** **Page**

- Changed Section 2.2 ..... 3
- Added Section 2.5 ..... 4
- Section 3, added NOTE ..... 4
- Section 4, added NOTE after Step 3 ..... 6

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      3.1.2 *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.

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- *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.*

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2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

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4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

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