

## ***AFE707xEVM Evaluation Module***

This is the user's guide for the AFE707xEVM evaluation module (EVM). The AFE7070/71 is a dual 14-bit 65-MSPS digital-to-analog converter with an integrated quadrature modulator. The NCO and LVDS output functions are not available with the AFE7071 but the AFE7070 has both functions. This is the sole difference between the AFE7070 and the AFE7071. Hereafter, the AFE707x is referred to as AFE7070. The EVM also includes the CDCM7005 clock synchronizer, which provides the necessary clocks for the AFE and pattern generator. This EVM is ideally suited for mating with the TSW1400 pattern generation card for evaluating WCDMA, LTE, or other high-performance modulation schemes.

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## 1 Hardware Overview

This section describes the EVM hardware and how it can be modified to evaluate the AFE7070 in various configurations.

### 1.1 EVM Block Diagram

Figure 1 shows a simplified block diagram of the EVM in its default configuration.

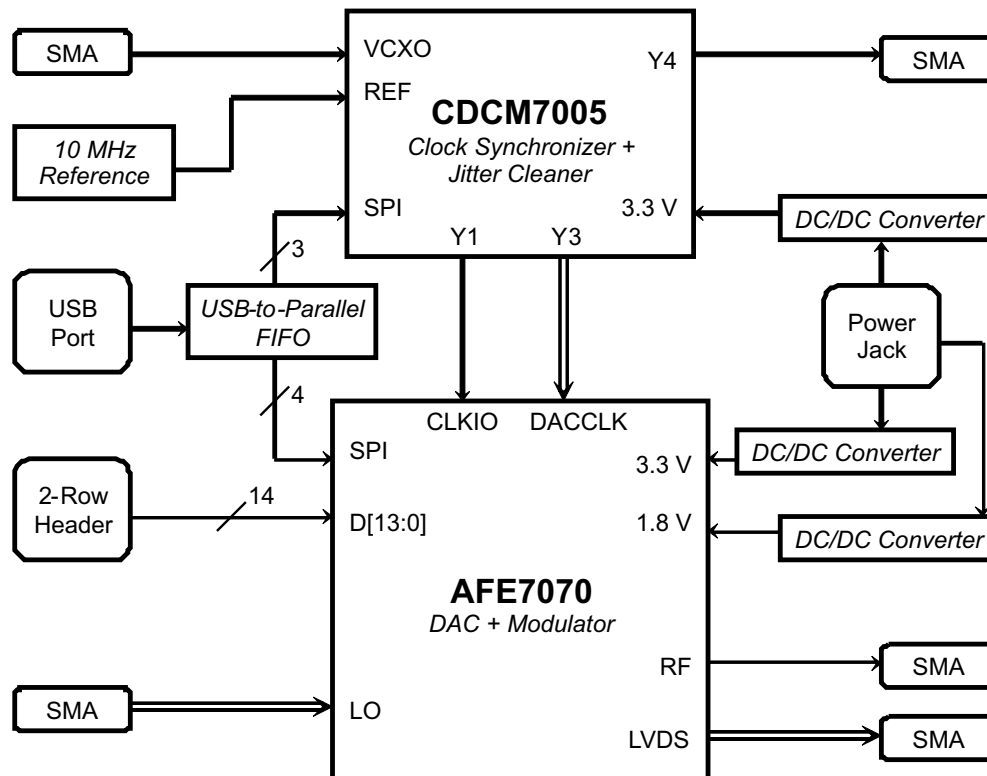


Figure 1. EVM Block Diagram

### 1.2 Parallel Input Data

Parallel input data is supplied to the EVM by header J8. This header can be connected to the TSW1400 CMOS outputs by a parallel CMOS connector board.

### 1.3 Analog Inputs/Outputs

#### 1.3.1 Local Oscillator

A local oscillator (LO) signal must be provided via the SMA connector J10. This signal's amplitude must be between  $-5$  dBm and  $5$  dBm with a frequency between  $100$  MHz and  $2.7$  GHz. The signal at the SMA connector is ac-coupled into the AFE7070's LOP pin; LON is ac-terminated with  $50\ \Omega$ .

#### 1.3.2 External Clock Input

Provide an external clock signal by the SMA connector J4. By default, this signal is ac-coupled by a  $0.01\ \mu\text{F}$  capacitor and then rebiased to a common-mode dc voltage of  $1.3$  V at the CDCM7005's VCXO\_IN input. The ac load impedance is  $50\ \Omega$ . The input signal level can be between  $1$  V and  $2.6$  V peak-to-peak.

### 1.3.3 RF Out

The AFE7070's RF output (pin RFOUT) is ac-coupled by a 100 pF capacitor to the SMA connector J3. This output can be connected directly to a 50-Ω spectrum analyzer or other test equipment.

### 1.3.4 LVDS Output

In the EVM's default configuration, the AFE7070's LVDS\_P and LVDS\_N outputs are routed directly to SMA connectors J1 and J2, respectively. If desired, onboard termination can be added by populating resistor R53; otherwise, properly terminate the signal with 100-Ω differential impedance at its sink.

The complementary LVDS outputs also can be converted to a single-ended signal for ease of measurement. To do this, remove resistors R17 and R50, and place 0-Ω resistors at R21 and R38. This routes the LVDS outputs to transformer T6 (connected to SMA connector J14) and disconnects them from connectors J1 and J2. Place a resistor at position R53 to make the differential impedance **seen** by the LVDS outputs equal to 100 Ω. If the SMA connector J14 is connected to 50-Ω test equipment, the value of R53 must be 200 Ω, because the 50-Ω impedance is transformed to 200 Ω on the primary side due to transformer T6's 4-to-1 impedance ratio.

The AFE7071 does not have this function.

## 1.4 Clocking Options

This EVM accommodates a wide range of clocking options. The AFE7070 has four clocking modes: Dual Input Clock, Dual Output Clock, Single Differential DDR Clock, and Single Differential SDR Clock. See the device data sheet for a detailed description of these four modes. The clock signals on the EVM can be generated with the CDCM7005 or supplied externally. Similarly, the reference and VCXO inputs to the CDCM7005 can come from onboard oscillators or other sources.

### 1.4.1 Default Configuration

By default, the CDCM7005 is configured to use an onboard 10-MHz reference and external VCXO input signal to generate the AFE7070's DACCLK and CLKIO signals. This is suitable for evaluating the AFE7070's Dual Input Clock, Single Differential DDR, and Single Differential SDR modes. A third CDCM7005 output is routed to SMA connector J5. This signal can be sent to the TSW1400's CMOS clock input to align and synchronize the input data bus. Note that external equipment may be needed to add a delay to this clock signal such that proper setup and hold times are maintained.

### 1.4.2 Dual Output Clock Mode

In Dual Output Clock mode, the AFE7070's CLKIO pin becomes an output that can be used to drive a digital source such as the TSW1400. To use this mode, the user must remove resistor R18 connecting CLKIO to the CDCM7005's output and instead populate resistor R25. This routes the CLKIO signal to SMA connector J11. This output then can be connected to the TSW1400 CMOS clock input.

### 1.4.3 Onboard VCXO

If desired, a VCXO can be installed on the board at position VCXO1 to provide an input clock source to the CDCM7005. In addition to populating the VCXO, remove resistor R13 and populate C29 with a 0-Ω resistor. This allows for dc-coupling a differential LVPECL-output VCXO (such as the TCO-2111) to the VCXO\_IN and VCXO\_INB inputs of the CDCM7005.

### 1.4.4 External Reference Clock

The CDCM7005's reference clock can be supplied externally as well. Because the CDCM7005 has two reference inputs (primary and secondary), it is possible to simply connect an external CMOS-level clock to SMA connector J6. The applied signal is ac-coupled and rebiased to a dc common-mode voltage of 1.65 V (midsupply), then applied to the CDCM7005's PRI\_REF input. If required, add a termination resistor to position R26. Depending on the software settings, the CDCM7005 may automatically switch to the external clock signal (automatic mode), or require the use of jumper JP3 to select it (manual mode).

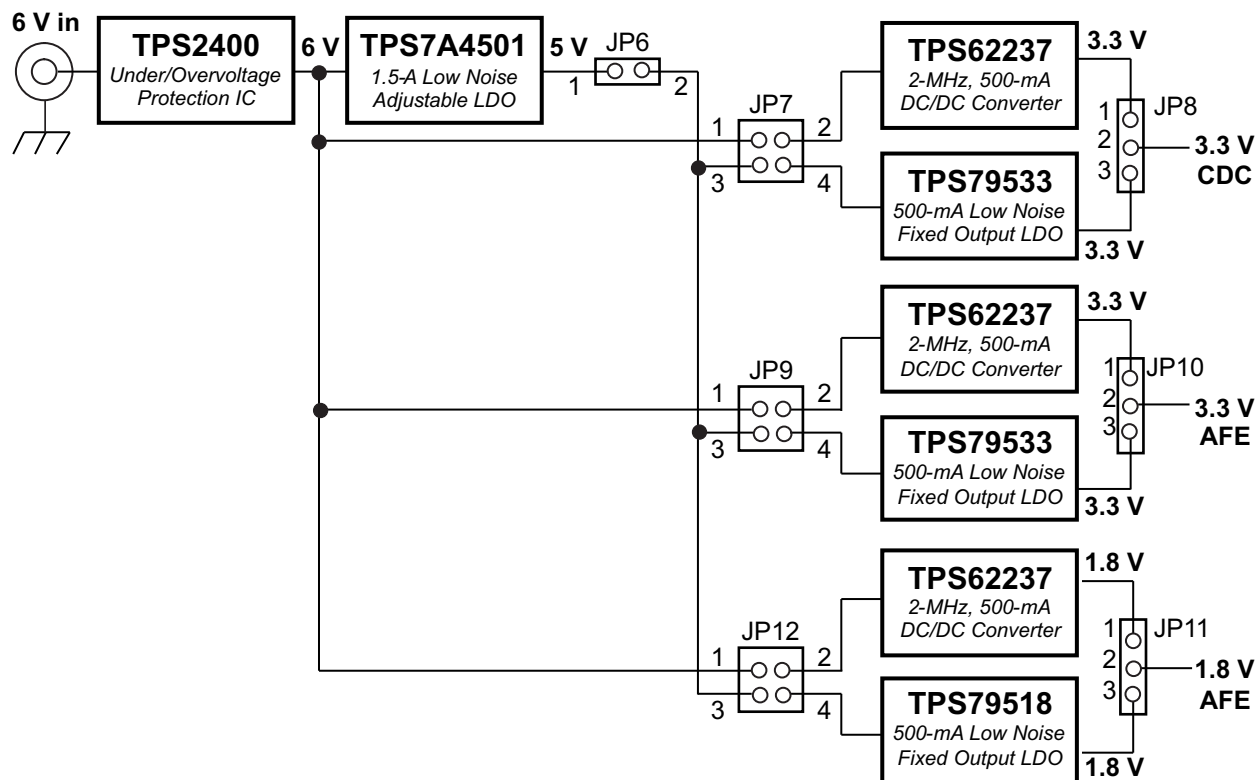
### 1.4.5 Bypass CDCM7005

Bypassing the CDCM7005 entirely and simply supplying external clocks to the AFE7070 is possible. You can use the SMA connector J12 to supply the LVPECL-level DACCLK signal if you install capacitors C129 and C130 and remove C102 and C103. A termination resistor may be placed at position R54, although resistor R55 provides 100- $\Omega$  differential termination at the AFE7070's DACCLK P and N inputs. When setting the external clock's amplitude, keep in mind the 2-to-1 impedance ratio of the transformer used for single-ended-to-differential conversion.

Note that depending on the AFE7070's clock mode, you may need to send separate clock signals to CLKIO or to the digital source as well. The SMA connector J11 can supply CLKIO, providing that you install resistor R25 and remove R18. Connecting the TSW1400 CMOS clock input to an external clock source is possible as well. Ensure that these various clock signals are synchronized and do not drift with respect to one another.

## 1.5 Power Supply Options

The EVM provides multiple options for powering the AFE7070 and CDCM7005 integrated circuits (IC). By default, users can power the board with a 6-Vdc adapter. Switched-mode dc/dc (buck) converters step down this voltage to the necessary 3.3-V and 1.8-V rail voltages. If desired, users can use LDOs or bench supplies rather than switching power supplies. Figure 2 provides a simplified block diagram of the EVM's power architecture showing how jumper settings can be used to enable and disable various power supply ICs. Also, disconnecting all jumpers and providing the necessary rail voltages directly to test points TP7, TP6, and TP8 is possible.



**Figure 2. EVM Power Architecture**

For a detailed illustration of the EVM's power supplies, see the circuit schematic included in the *Design Files* on the [AFE7070EVM](#) and [AFE7071EVM](#) tool pages.

## 2 Software Control

### 2.1 Installation Instructions

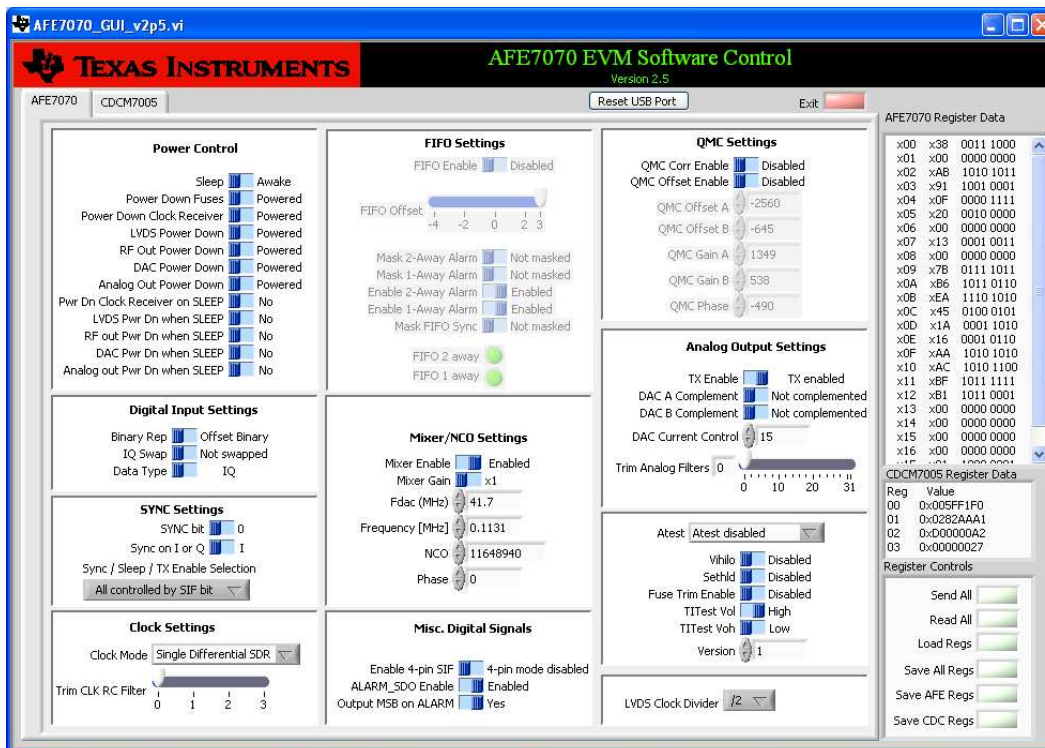
- Open the folder named AFE7070\_Installer\_vxpx (xpx represents the latest version).
- Run Setup.exe.
- Follow the on-screen instructions.
- Once installed, launch the software by clicking on the AFE7070\_GUI\_vxpx program in Start → Texas Instruments DACs
- When plugging in the USB cable for the first time, you are prompted to install the USB drivers.
  - When a pop-up screen opens, select *Continue Downloading*.
  - Follow the on-screen instructions to install the USB drivers
  - If needed, you can access the drivers directly in the install directory

### 2.2 Software Operation

The user interface is divided into two tabs, one containing controls for the AFE7070 and the other containing controls for the CDCM7005.

#### 2.2.1 AFE7070 Controls

A screen shot of the AFE7070 tab is shown in [Figure 3](#).



**Figure 3. Screen Shot of AFE7070 Tab**

The controls for the AFE7070 are divided into the following sections:

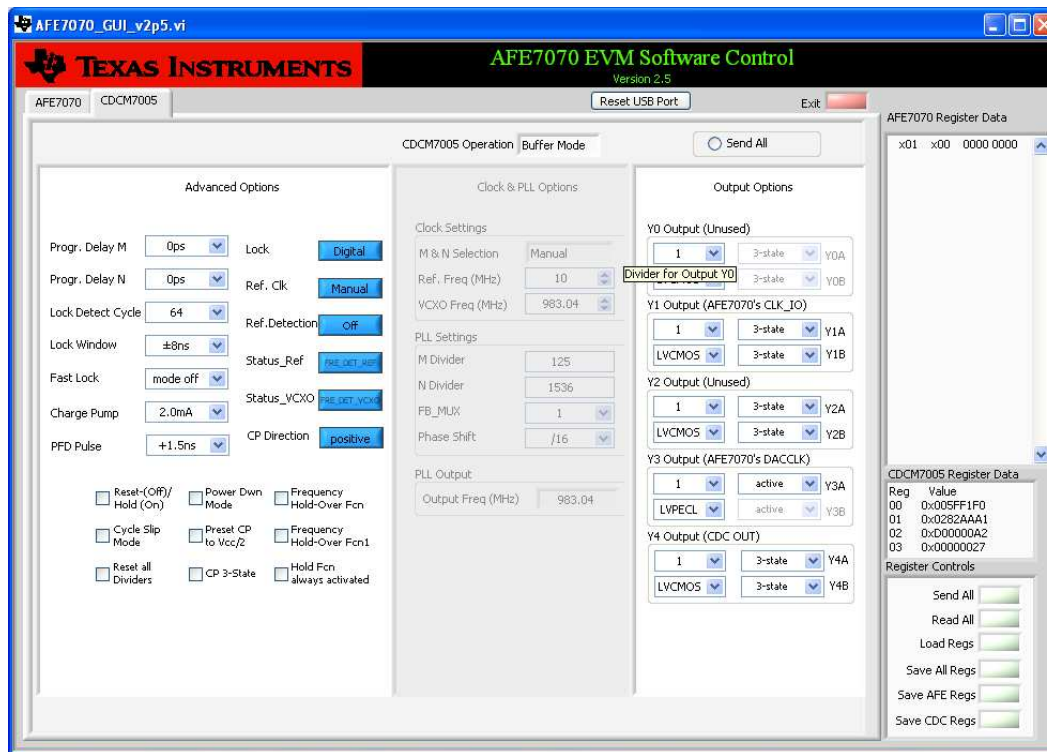
- **Power.** These controls consist of binary switches that toggle various power-down and sleep states.
- **SYNC Settings.** These settings control the device synchronization. The switch marked *Synchronize* corresponds to the SYNC bit in the AFE7070 register map, and activating this switch writes a 1 to this bit.
- **FIFO Settings.** This section is only active when the device is in Dual Input Clock mode. It controls the

- FIFO pointer offset and various FIFO alarms.
- **Clock Settings.** This section allows the user to specify which clock mode is desired as well as trim the clock RC filter. Ensuring that the other AFE7070 settings and CDCM7005 settings are consistent with the choice of clock mode is important. For reference, the following is a summary of the relevant settings for each mode:
    - **Dual Input Clock** – Configure CLKIO on the CDCM7005 tab to be an active CMOS signal at either 1x or 2x the desired sampling rate. Set DACCLK to active, LVPECL levels, and 2x the desired sampling rate. Set the data type in the AFE7070 tab's *Digital Input Settings* section to either IQ or Phase data. Configure the FIFO as desired. Connect the CDC OUT output via the SMA to the TSW1400, and configure as an active CMOS output at the same frequency as DACCLK.
    - **Dual Output Clock** – In this mode, CLKIO is an output and must not be connected to the CDCM7005 (see [Section 1.4.2](#) for the necessary hardware modifications). DACCLK must be an active LVPECL clock at 2x the desired sampling rate. Set the data type in the AFE7070 tab's *Digital Input Settings* section to either IQ or Phase data. In this mode, the FIFO is disabled automatically.
    - **Single Differential DDR Clock** – CLKIO is not used in this mode, so it can be disabled in the CDCM7005 settings. An LVPECL-level DACCLK must be provided at 1x the desired sampling rate. Either IQ or Phase data is allowed, and the FIFO is disabled automatically. Connect the CDC OUT output to the TSW1400 by way of the SMA, and configure it as an active CMOS output at 2x the DACCLK frequency.
    - **Single Differential SDR Clock** – CLKIO is unused and can be disabled. Provide an LVPECL-level DACCLK at 1x the desired sampling rate. Only use this mode for Phase data. Connect the CDC OUT output to the TSW1400 by way of the SMA, and configure it as an active CMOS output at 1x the DACCLK frequency.
  - **Mixer/NCO Settings.** Use these controls to enable or disable the AFE7070's mixer stage as well as adjust its frequency and initial phase. Note that the frequency values input must be the actual desired NCO frequency in MHz, not the value to be stored in the frequency registers. The AFE7071 does not have this function.
  - **Digital Input Settings.** These controls affect the way the AFE7070 interprets its input data.
  - **Misc. Digital Signals.** These controls affect the way the AFE7070 interprets other digital data. Note that the GUI generates SPI commands based on a 3-wire serial interface (SIF).
  - **QMC Settings.** These controls allow the user to adjust QMC offset (to reduce carrier feedthrough) and gain/phase (to improve sideband suppression).
  - **LVDS Clock Divider.** This section sets the divide ratio for the LVDS output. Note that this output's frequency can range from 100 MHz to 800 MHz.
  - **Analog Output Settings.** These controls affect the internal DAC outputs. The full-scale current setting is 15. The *Trim Analog Filters* slider can adjust the corner frequency of the baseband low-pass filter. The maximum filter corner is 10 MHz.
  - **Atest.** These controls activate various test modes and are not useful to most users.

### 2.2.2 CDCM7005 Controls

The CDCM7005 tab provides full programming control of the CDCM7005 device. [Figure 4](#) displays a screen shot of this tab. . Not all of the functions may be of interest in evaluating AFE7070 performance. The tab is divided into three sections:

- **Advanced Options.** These settings provide advanced control of the CDCM7005 device. Their functions are beyond the scope of this document. For a detailed description of these settings, consult the CDCM7005 data sheet ([SCAS793](#)).
- **Clock & PLL Options.** This section is only enabled when the CDCM7005 is in PLL mode and allows the user to specify (manually or automatically) the necessary M and N divider settings to produce a desired VCXO frequency output.
- **Output Options.** These controls allow configuration for various CDCM7005 outputs. The only outputs of interest are Y1 (the AFE7070's CLK\_IO), Y3 (the AFE7070's DACCLK), and Y4 (CDC OUT, which can be used to provide a clock to the TSW1400). The user can specify the output levels (LVPECL or LVCMOS), a divide ratio, and whether or not each signal is active or high-impedance.



**Figure 4. Screen Shot of CDCM7005 Tab**

### 2.2.3 General GUI Controls

The following is a summary of the various other GUI controls:

- **Reset USB Port.** This button assigns a new handle for the USB connection. Use it whenever a device communication failure occurs.
- **One Shot.** This button can be enabled to run the program only once rather than as a loop.
- **Exit.** This buttons exits the GUI.
- **Display Pane.** This pane takes up most of the right side of the GUI and is used to display which register settings are being written to or read from the AFE7070.
- **Register Controls**
  - **Send All.** This command sends all the GUI settings to the AFE7070 and CDCM7005 registers.
  - **Read All.** This command reads back the register values of the AFE7070 and display them in the display pane.
  - **Load Regs.** This command loads the contents of a text file into both the AFE7070 and CDCM7005 registers (as applicable).
  - **Save All Regs.** This command saves the AFE7070 and CDCM7005 register settings to a text file.
  - **Save AFE Regs.** This command saves the AFE7070 register settings to a text file.
  - **Save CDC Regs.** This command saves the CDCM7005 register settings to a text file.

### 3 Basic Test Procedure

This section outlines the basic procedure for testing the EVM.

#### 3.1 Test Block Diagram

Figure 5 displays the test setup for general testing of the AFE7070 with the TSW1400 pattern generation card.

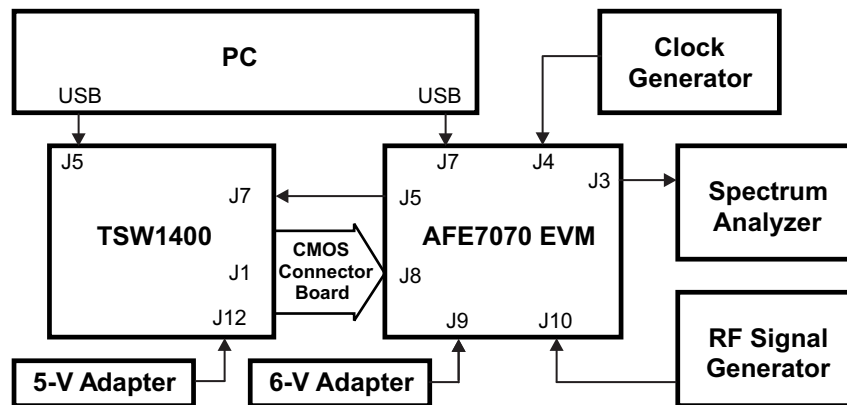


Figure 5. Test Setup Block Diagram

#### 3.2 Test Setup Connections

- Connect the AFE7071 EVM to the computer via USB cable.
- Connect 6-V adapter to J9.
- Launch the AFE7071EVM GUI and click *Reset USB Port*.

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**NOTE:** Always connect the AFE7071 EVM and click *Reset USB Port* before connecting the TSW1400, otherwise, you will not be able to connect with the AFE7071 EVM board.

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- Connect the signal generator to the J4 connector (EXT VCXO) on the AFE7071 EVM. Set the frequency of the signal generator to 130 MHz and amplitude to 0 dBm.
- Connect LO signal from the second signal generator to the J10 connector (LO IN). Set the frequency of the signal generator to 2.1 GHz and amplitude to 5 dBm.
- Connect J3 (RFOUT) to the spectrum analyzer.
- Connect the TSW1400 to the computer via USB cable.
- Connect the J1 (CMOS\_INTERFACE) connector on the TSW1400 to AFE7071 EVM's J8 connector. Make sure pin 1 of the J1 connector is aligned with pin 1 on the J8 connector before connecting.
- Connect the J7 (CMOS\_CLK) on TSW1400 to J5 (CDC OUT) connector on AFE7071 EVM.
- Connect 5-V adapter to J12 on TSW1400.
- Turn the switch (SW7) to the *On* position.



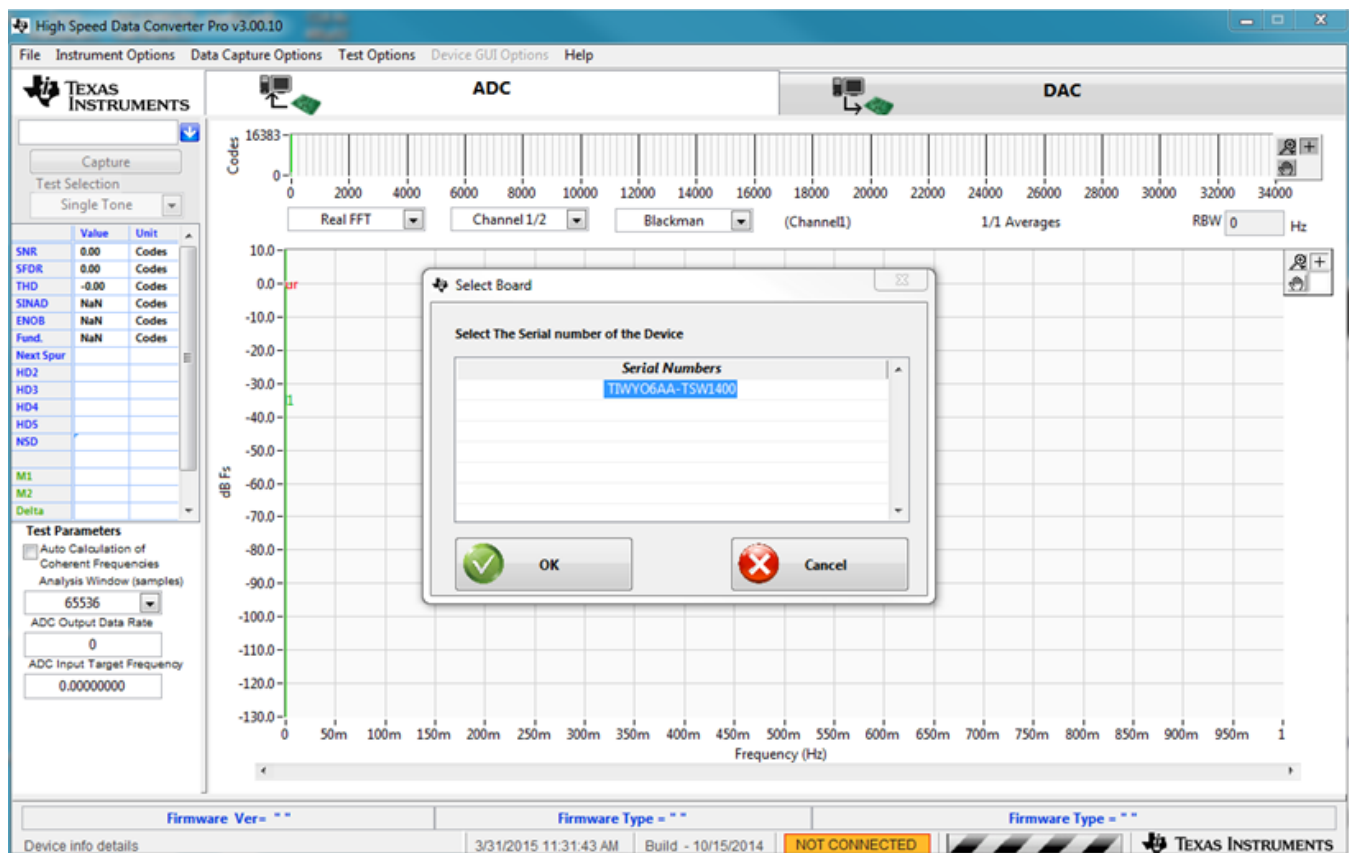
### 3.3 TSW1400 Quick-Start Operation

The TSW1400 is a high speed data capture and pattern generator board used to evaluate performances of a wide range of TI high-speed analog-to-digital converters (ADC) and digital-to-analog converters (DAC).

See the TSW1400 user's guide ([SLWU079](#)) for a more detailed explanation of the TSW1400 setup and operation. This document assumes that High Speed Data Pro software is installed and functioning properly. The front panel of TSW1400 is shown in [Figure 6](#) and [Figure 7](#). Change the following parameters from the default settings.

#### Multitone Setup from Default Configuration

- Launch the *High Speed Data Converter Pro* software. Click *OK* on the *Select Board* pop up message.
- Select the *DAC* tab.
- Select *CMOS\_AFE7070* from the top left drop-down menu.
- Set the Data rate to "65" MHz and DAC Option to *Offset Bin*.
- Set *I/Q Multitone Generator* → *Tone BW* to "1M", set # (of tones) to "2", and *Tone Center* to "5M".
- Under *Tone selection*, select *Complex*.
- Click the *Create Tones* button.
- Click *Send*.



**Figure 6. TSW1400 Programming GUI**

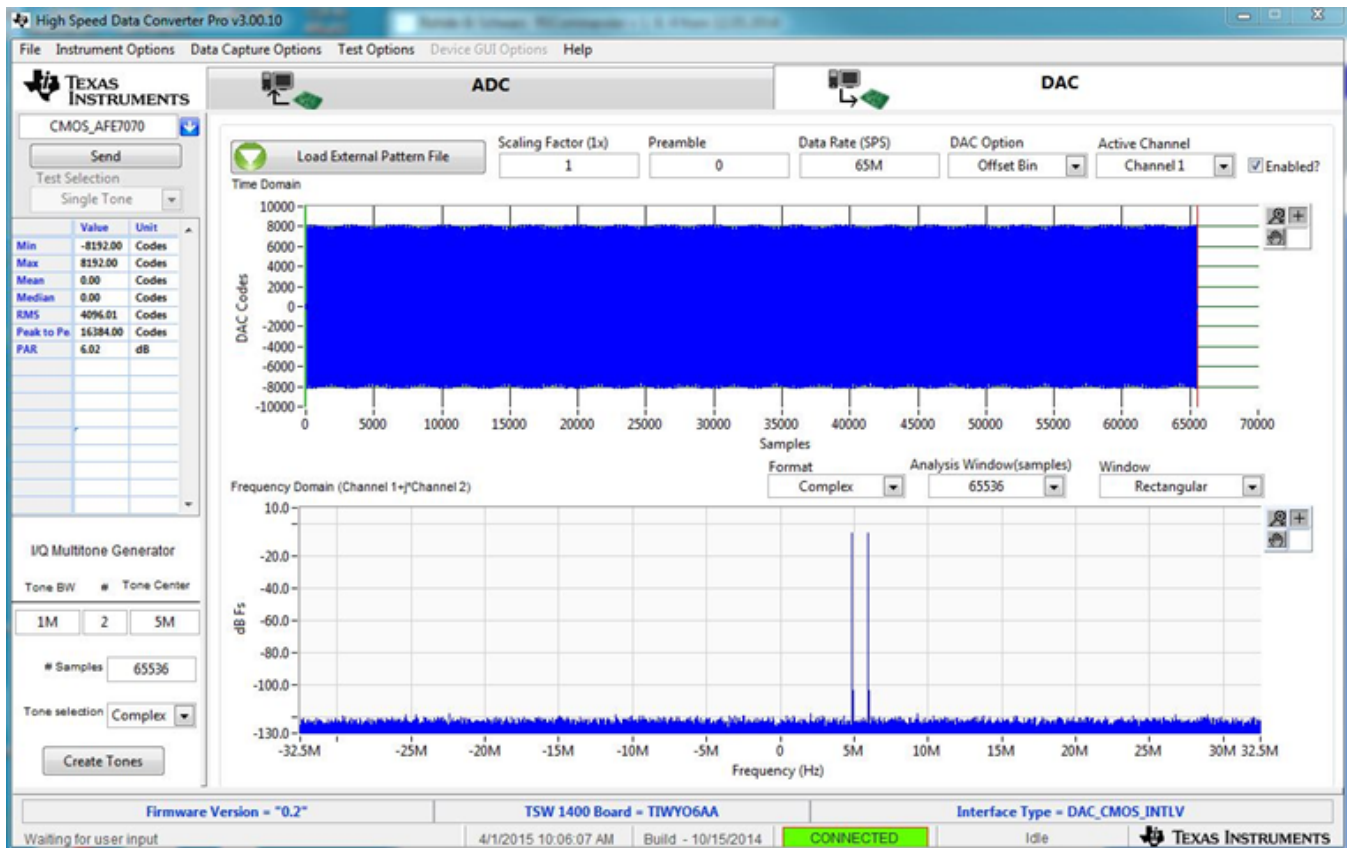


Figure 7. TSW1400 Multitone Pattern

### 3.4 AFE7070 Software Quick-Start Guide

- In the *Clock Settings* section, set the clock mode to *Dual Input Clock*.
- If the LVDS output is not connected to anything, disable it using the *LVDS Power Down* switch under the *Power* heading.
- Select the CDCM7005 tab to adjust the output clock signals:
  - Y1 (AFE7070's CLK\_IO) must be LVCMOS, with Y1A set to active rather than 3-state.
  - Y3 (AFE7070's DACCLK) must be LVPECL, with both Y3A and Y3B set to active.
  - Y4 (CDC Out) must be LVCMOS, with Y4A set to active.
- Press the *Send All* button in the *Register Controls* section.
- Monitor the RF output signal on a spectrum analyzer.
- Monitor the output signal at the RF output connector. If the LO input frequency is set to 2.1 GHz and the digital inputs are configured to be tones at 4.5 MHz and 5.5 MHz, the RF output looks like two tones placed at 2004.5 MHz and 2005.5 MHz as seen in [Figure 8](#).

If no output is observed on the spectrum analyzer, reset the AFE7071 by pressing the SW1 switch on the AFE7071 EVM.

### 3.5 AFE7070 Performance Results

Figure 8 shows the typical two-tone performance of the AFE7070 EVM from the preceding setup.

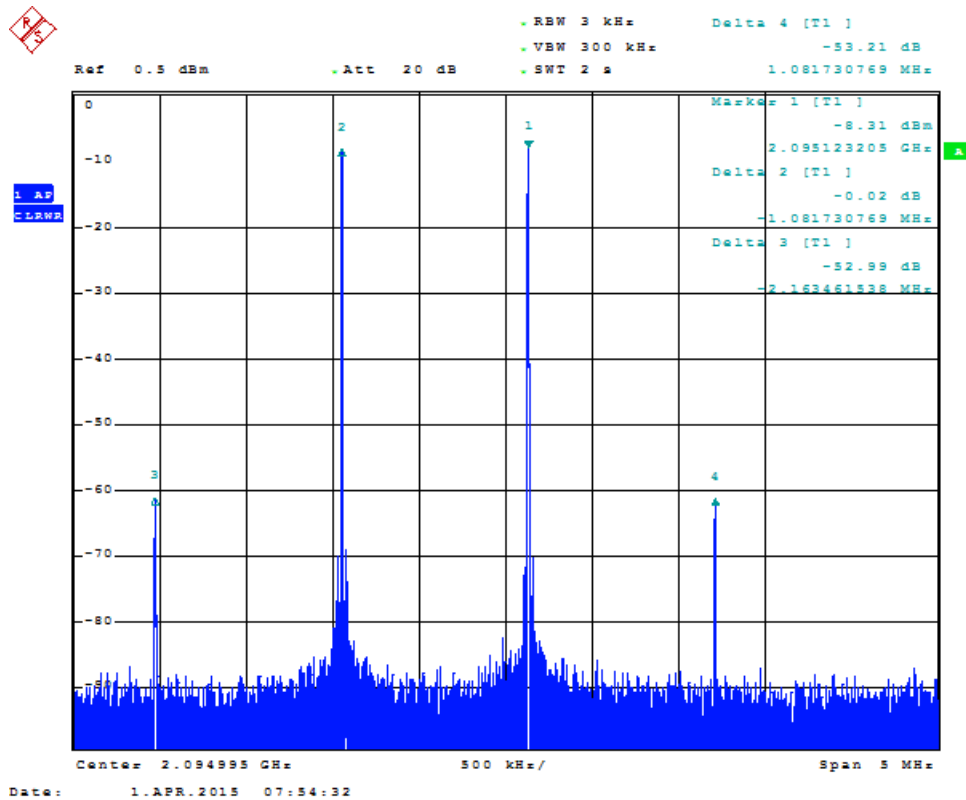


Figure 8. Two-Tone IMD Performance: LO = 2.1 GHz, DAC Rate = 65 MSPS, IF = 4.5 MHz and 5.5 MHz

Note that some part-to-part variations can yield significantly improved two-tone IP3 performance. The performance plots in this document show typical responses.

### Revision History

Changes from Original (March 2012) to A Revision	Page
Changed TSW3100 to TSW1400 in text and images throughout the entire document.	1
Changed <i>Test Setup Block Diagram</i> image, replaced Ethernet with USB and changed the TSW3100 block to TSW1400.	8
Changed entire <i>Test Setup Connections</i> section.	8
Changed entire <i>TSW1400 Quick-Start Operation</i> section.	9
Changed <i>TSW1400 Programming GUI</i> image.	9
Changed <i>TSW1400 Multitone Pattern</i> image.	10
Deleted first bullet in <i>AFE7070 Software Quick-Start Guide</i> section.	10
Changed all the values in the last bullet of the <i>AFE7070 Software Quick-Start Guide</i> section.	10
Added paragraph to the end of the <i>AFE7070 Software Quick-Start Guide</i> section.	10
Changed <i>Two-Tone IMD Performance</i> : image. Also changed IF values to 4.5 MHz and 5.5 MHz.	11
Deleted <i>WCDMA ACPR: LO = 2 GHz, DAC Rate = 57.6 MHz, 0-MHz Offset</i> image.	11

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

## STANDARD TERMS AND CONDITIONS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, or documentation (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms and conditions set forth herein. Acceptance of the EVM is expressly subject to the following terms and conditions.
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3. *Regulatory Notices:*
  - 3.1 *United States*
    - 3.1.1 *Notice applicable to EVMs not FCC-Approved:*

This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.
    - 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.

### FCC Interference Statement for Class A EVM devices

*NOTE: 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

*NOTE: 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.

### 3.2 Canada

#### 3.2.1 For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210

##### **Concerning EVMs Including Radio Transmitters:**

This device complies with Industry Canada license-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.

##### **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.

##### **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.

##### **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. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

### 3.3 Japan

3.3.1 *Notice for EVMs delivered in Japan:* Please see [http://www.tij.co.jp/lstds/ti\\_ja/general/eStore/notice\\_01.page](http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_01.page) 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。  
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3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

1. Use EVMs 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 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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