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VCO Current Calibration for Optimal Synthesizer Phase Noise

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APPLICATION NOTE

Introduction

The phase noise of the AX5043 VCO depends on the setting of the parameter VCOI (register PLLVCOI). There is an optimum setting for each carrier frequency. The optimum setting of VCOI can vary from device to device and from application board to application board. Depending on the regulatory environment being targeted by an application, a constant setting of VCOI for all devices/boards during TX operation may not be good enough. For those cases we suggest to follow the VCOI calibration scheme that is described in this Application Note.

In summary, the calibration routine consists of finding the VCOI setting that results in a local minimum of the voltage at node FILT for the desired carrier frequency. The voltage at node FILT is measured with the AX5043's on−chip GPADC. To be able to run the calibration a connection on the application board from pin FILT to pin GPADC1 needs to be available. The calibration can be run using device mode TX_SYNTH, meaning that there is no spurious emission generated during calibration as the PA need not be active. It is not required to re−run calibration for each data transmission, as dependencies on VDD_IO and temperature are not significant, it must only be re−run if the carrier frequency is changed.

Hardware Prerequisites

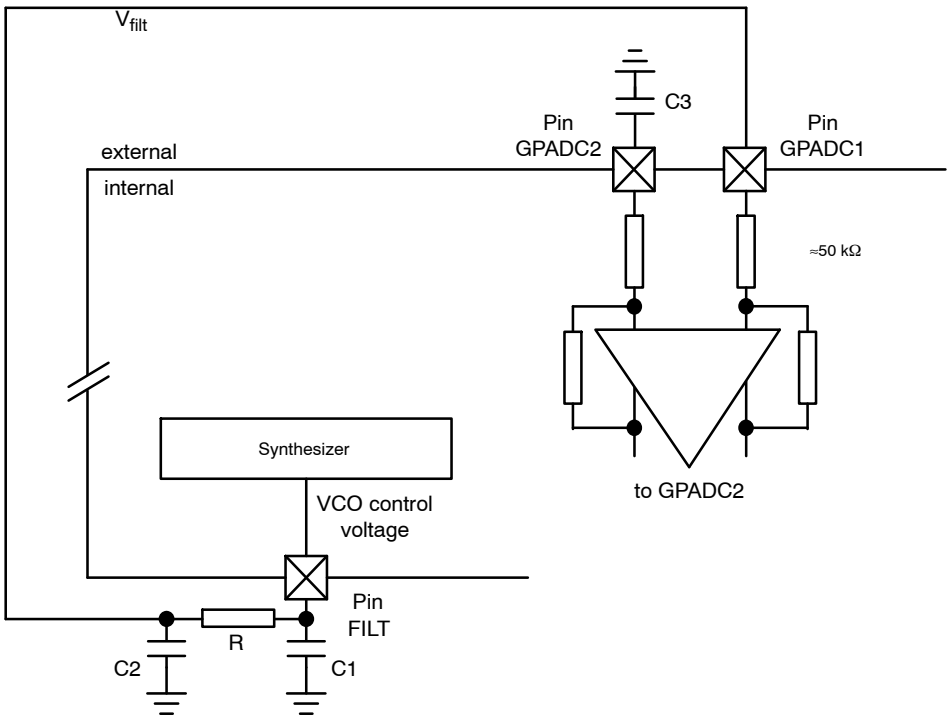

Figure 1. Configuration for VCOI Calibration

Table 1. COMPONENT VALUES FOR 868 MHz OPERATION

Component	C1	C2	C3	C4
Value	39 pF	10 nF	10 nF not mandatory	12 kΩ

Calibration Procedure

1. Setup the device for CW transmission at the desired carrier frequency.
2. Setup for GPADC operation, for an 48 MHz reference clock this is:
   Register 0xf34 = 0x81
3. Loop over VCOI values and take GPADC readings of the VCO control voltage for each VCOI setting:
   a. Set the PLLVCOI register.
   b. Set power mode TX_SYNTH, register PWRMODE = 0x0C.
   c. Run the VCO ranging routine; if PLL cannot be ranged for this VCOI value then go to the next one.
   d. Make the VCO control voltage available at device pin FILT, register PLLLLOOP |= 0x04.
   e. Trigger GPADC conversions and read the results; register GPADCCTRL = 0x84, wait for GPADCCTRL BUSY bit to clear; read GPADC13VALUE1 and GPADC13VALUE0. A suggestion is to run 100 − 1000 dummy conversions and then use the mean of the next 20 conversions.
   f. Set PLLLOOP back to its original value.
4. Find the local minimum in the GPADC readings, use the corresponding VCOI value for all RX and TX operation at this carrier frequency. Care must be taken to avoid mistaking a VCO range boundary as s local minimum, see the graphs in the next chapter.

Example Results

In the following adjacent channel power measurements for two application boards are shown along with the corresponding VCOI calibration data. It can be seen that the optimum adjacent channel power is obtained where the VFILT has a local minimum. The VCOI calibration outlined in this Application Note is an algorithm to find the VCOI at the VFILT local minimum by measuring the VFILT values using the GPADC.

Jumps that can be seen both in the adjacent channel measurements and in the calibration data are caused by VCO range changes. The internal VCO auto ranging was run for each VCOI setting. In a microcontroller implementation of the local minimum search care has to be taken to avoid mistaking a range boundary for a local minimum.

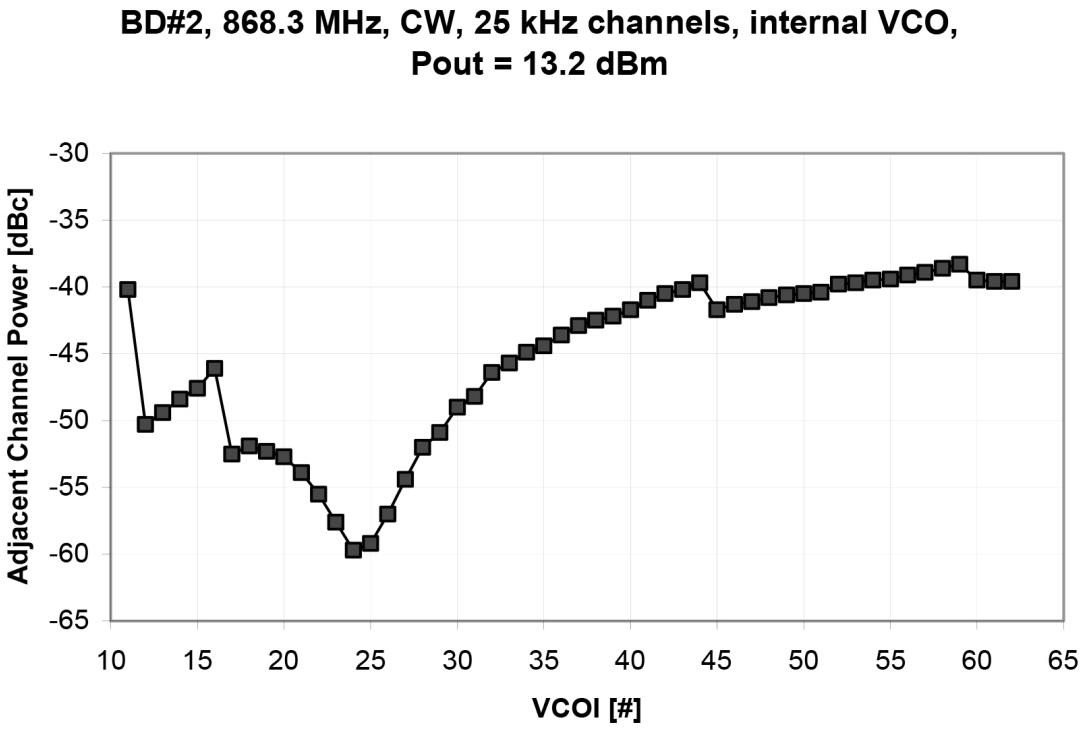

Figure 2. Adjacent Channel Power vs. VCOI for Board #3

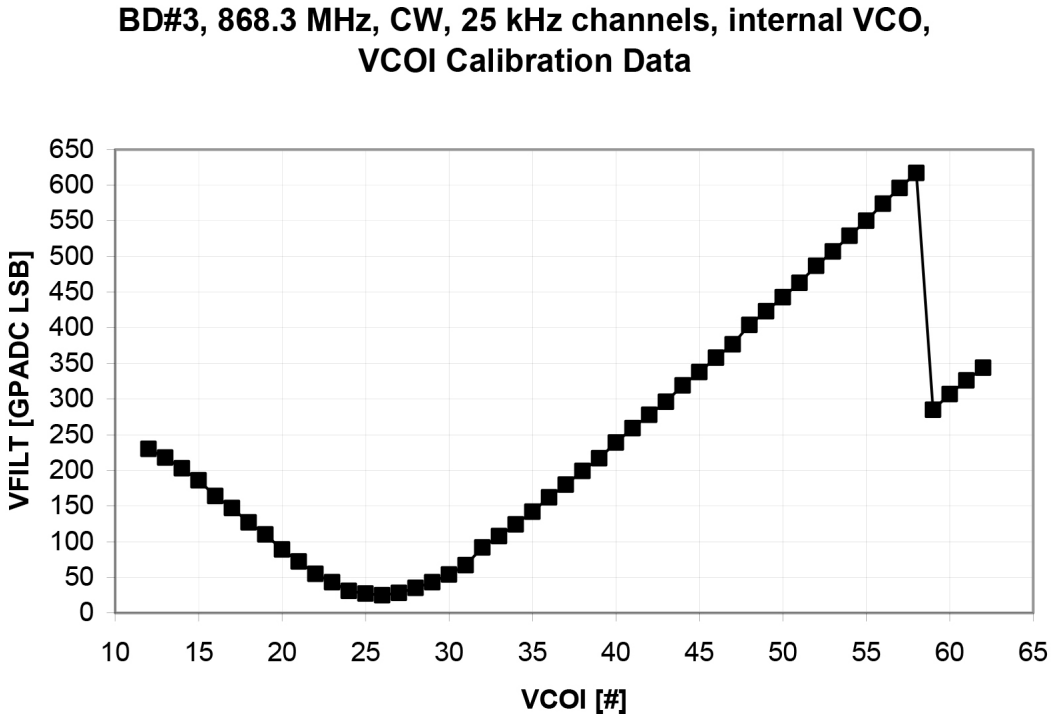

Figure 3. VFILT Value Measured with the GPADC vs. VCOI for Board #3, the Local Minimum can be seen at VCOI = 26, a VCO Range Boundary can be seen at VCOI = 59

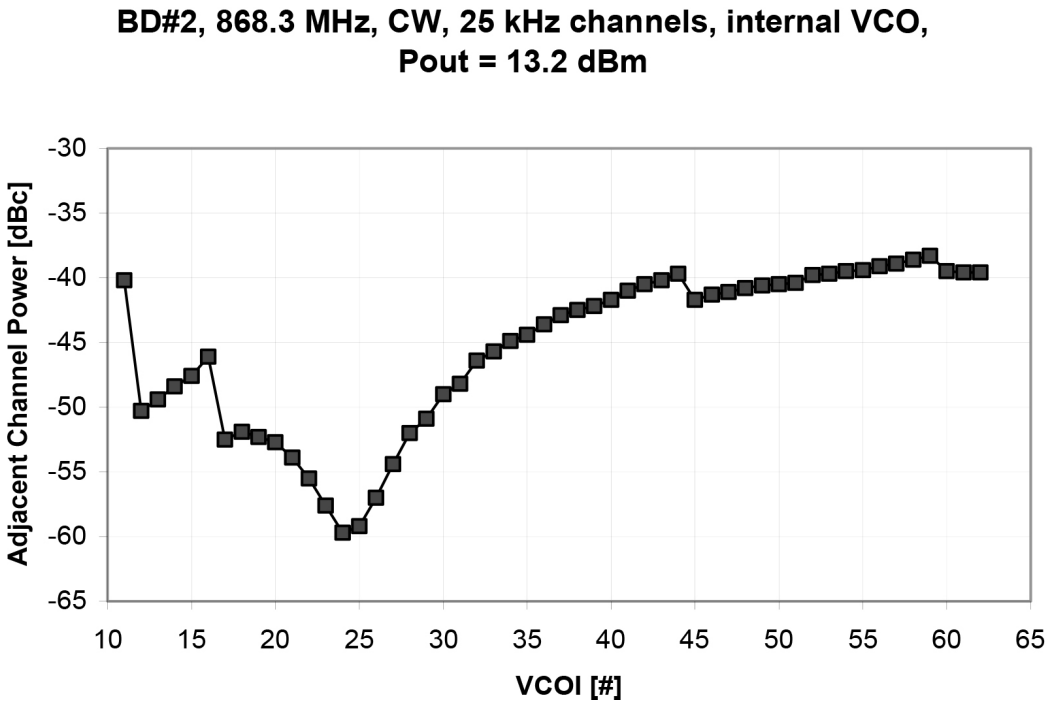

Figure 4. Adjacent Channel Power vs. VCOI for Board #2

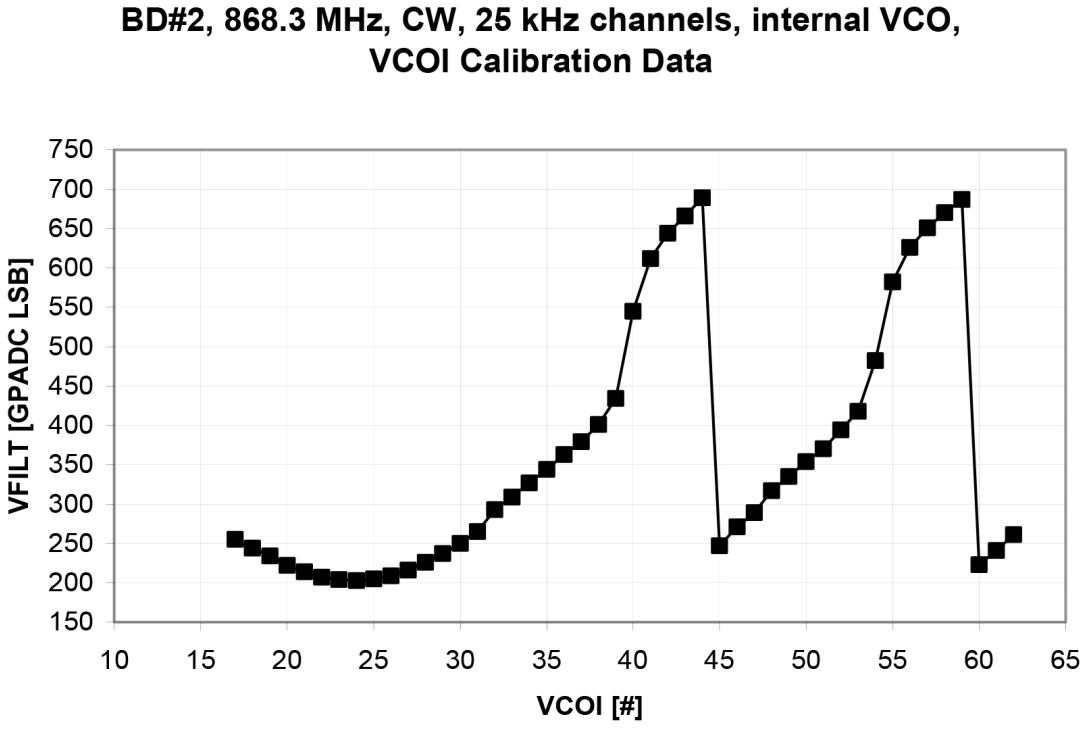

Figure 5. VFILT Value Measured with the GPADC vs. VCOI for Board #2, the Local Minimum can be seen at VCOI = 24, VCO Range Boundaries can be seen at VCOI = 45 and VCOI = 60

Implementation in AX−RadioLab

The VCOI calibration procedure described above has been implemented in AX−RadioLab for AX5043, AX8052F143, and AXM0F243 development kits. The calibration algorithm can be found in the axradio_init() function of easyAX5043.c. By default, this is disabled, but can be easily enabled in the Pin Configuration panel of AX−RadioLab by selecting “VCO Calibration” in the “VCO Cal Config” field.

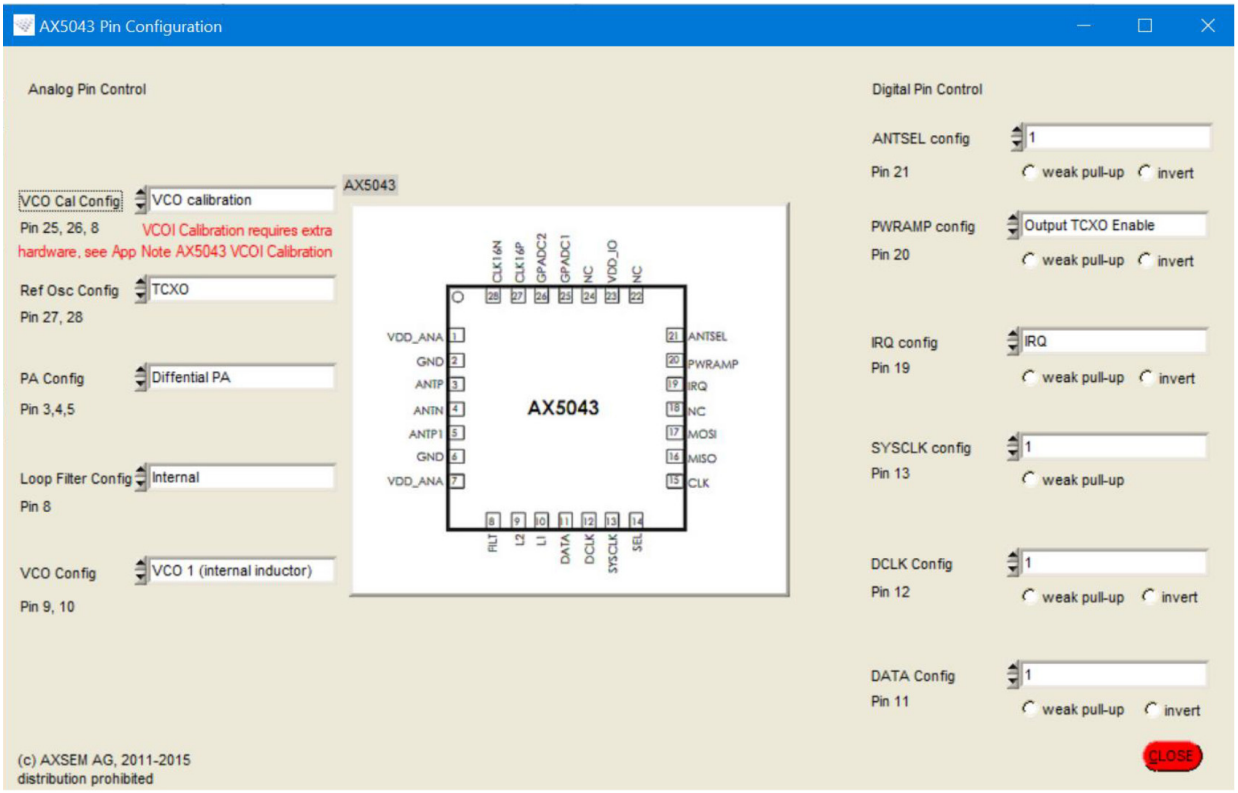

Figure 6.

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