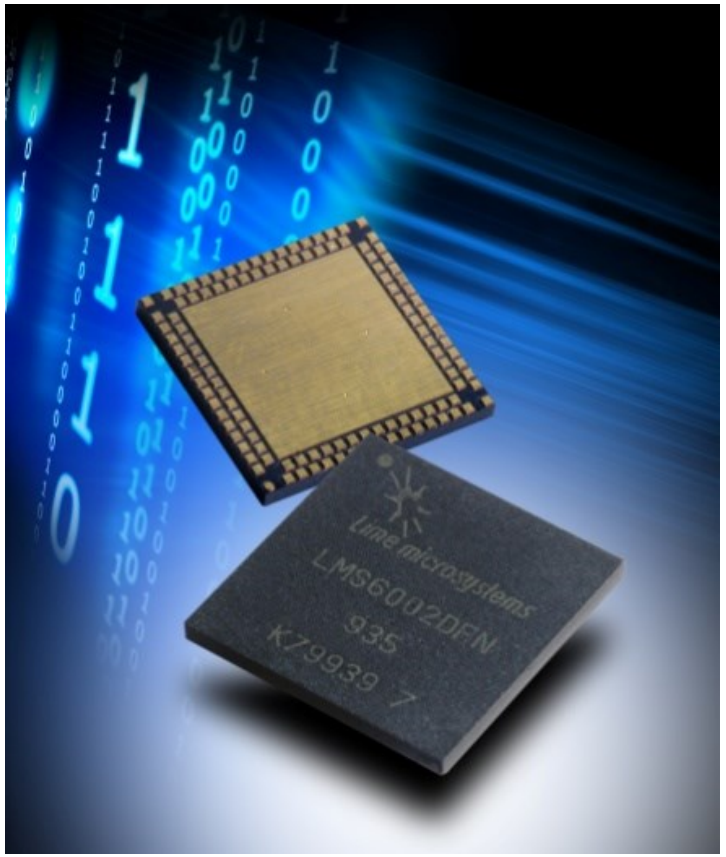
LMS6002 TRX Calibration Using Internal RF Loopback

Measured on UWCT board



Test setup

Conditions of LMS6002D

TxPLL frequency	2140 MHz
TxLPF	5 MHz
TxVGA1	-10 dB
TxVGA2	25 dB
RxPLL frequency	2137 MHz
TxLPF	5 MHz
Active LNA	LNA2
RxVGA2	30 dB
RxVGA1	120

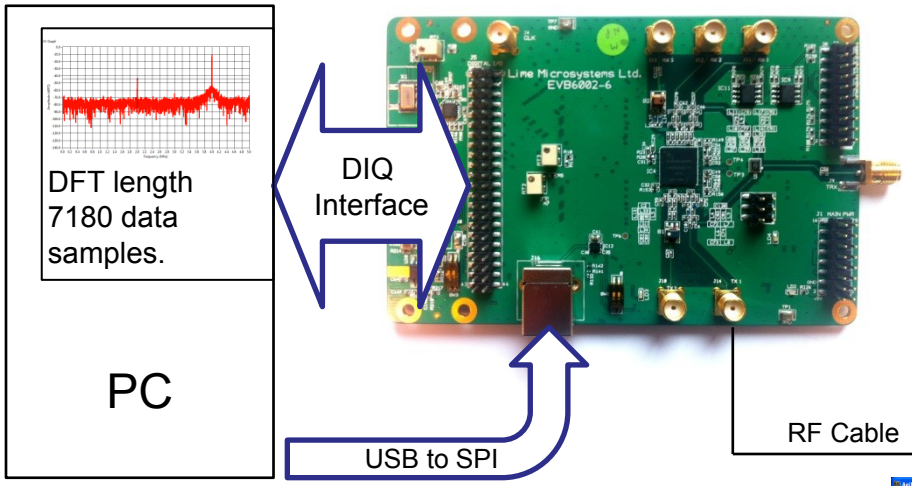
Internal RF Loopback to LNA2 path.

Digital IQ interface running at 30.72 MHz.

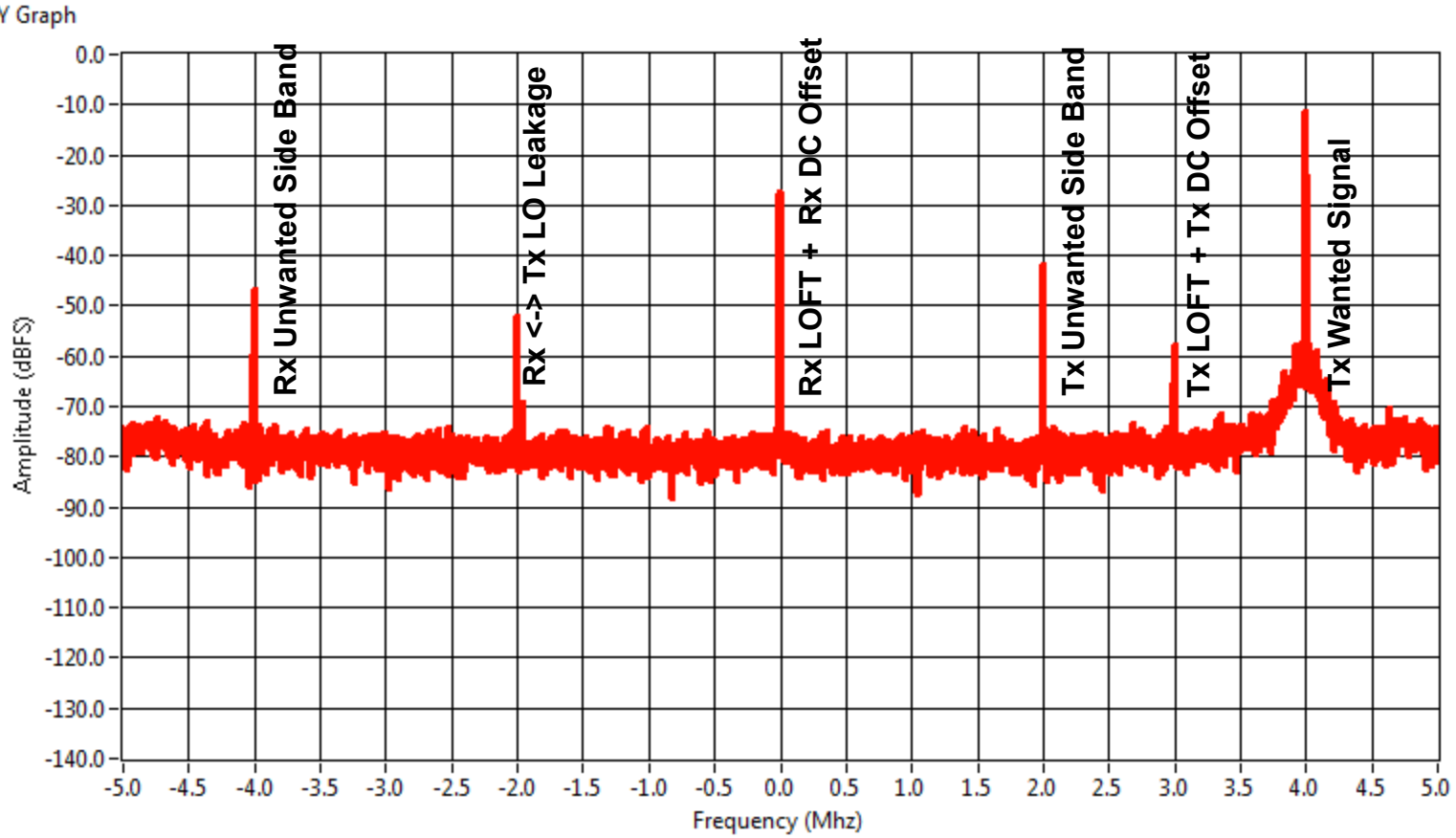
1MHz CW signal is generated by DIO card. Data fed to Tx DAC's.

Tx and Rx I/Q imbalance calibration done from PC via digital interface.

Internal RF Loopback to LNA 2:
Register 0x08 [3-0] = '0010'



Receiver DFT spectrum with RF loopback enabled and no calibration applied

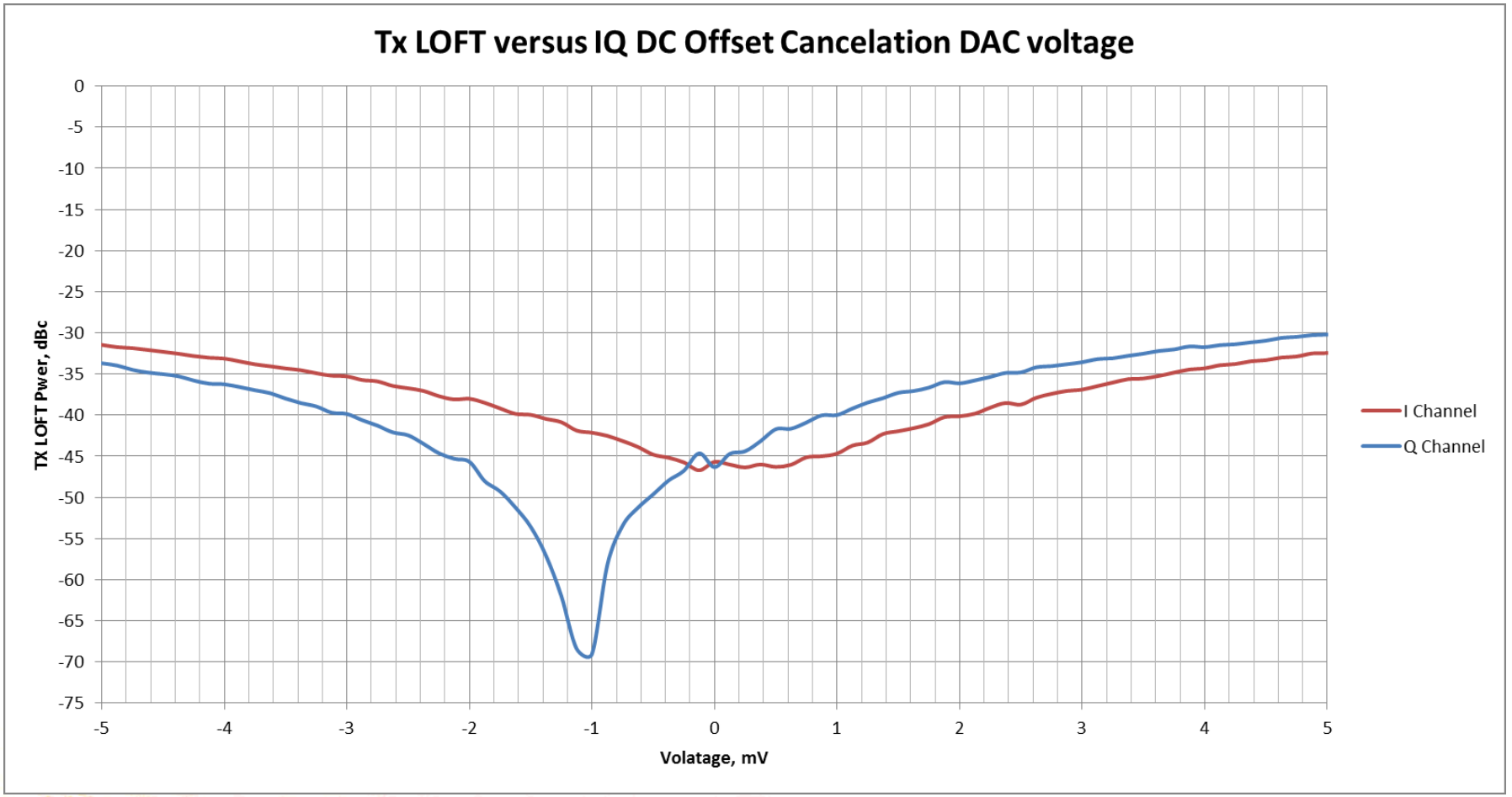


TX <-> LO leakage is because synthesizer frequencies are very close (3MHz) which is not the case in normal operation.

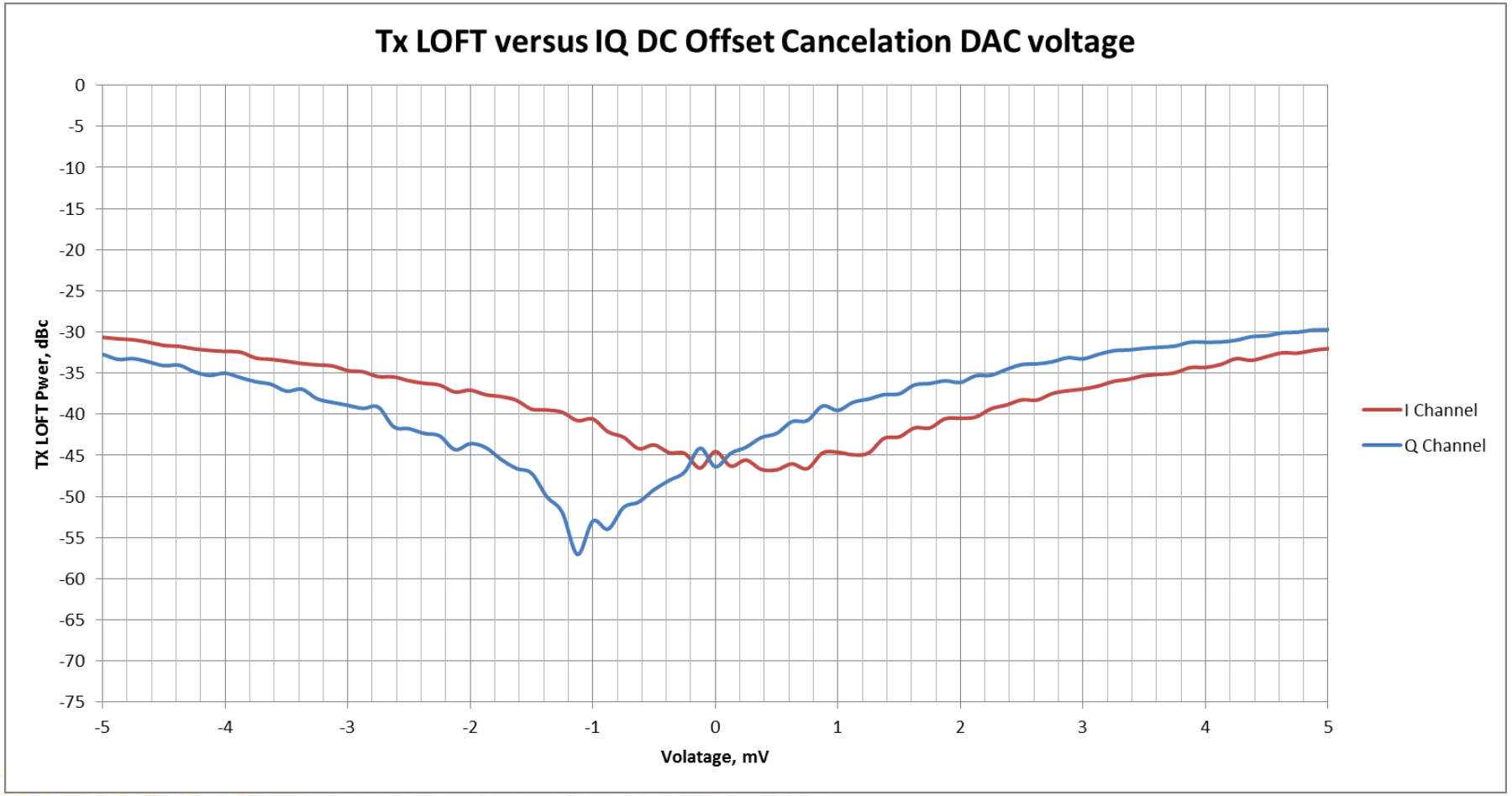
Calibration procedure

1. Reset the transceiver. Enable Tx and Rx path.
2. Set TxLPF and RX LPF to 5 MHz.
3. Set Tx frequency to f MHz (2.14GHz in this example)
4. Set Rx frequency to f - 3 MHz (2.137GHz in this example).
5. Enable loopback mode on LNA #2.
6. Set relevant Tx and Rx VGA gains:
    - TxVGA1 set to -10 dB.
    - TxVGA2 set to 25 dB.
    - RxVGA1 set to 120.
    - RxVGA2 set to 30 dB.
7. Open RXOUT switch.
8. Send 0x000 to DACs.
9. Execute Tx path and RX path auto-calibration sequence to remove DC offset.
10. Apply 1 MHz digital CW tone to DACs.
11. Tune Tx LOFT by minimizing 3 MHz signal in the Rx DFT spectrum.
12. Tune Tx IQ BB phase and gain correction values to minimize TX SSB signal at 2 MHz.
13. Enable the averaging filter in BB to minimize remaining receiver DC offset component.
14. Tune Rx IQ BB phase and gain to minimize RX SSB signal at -4 MHz.
15. Save all calibration values.

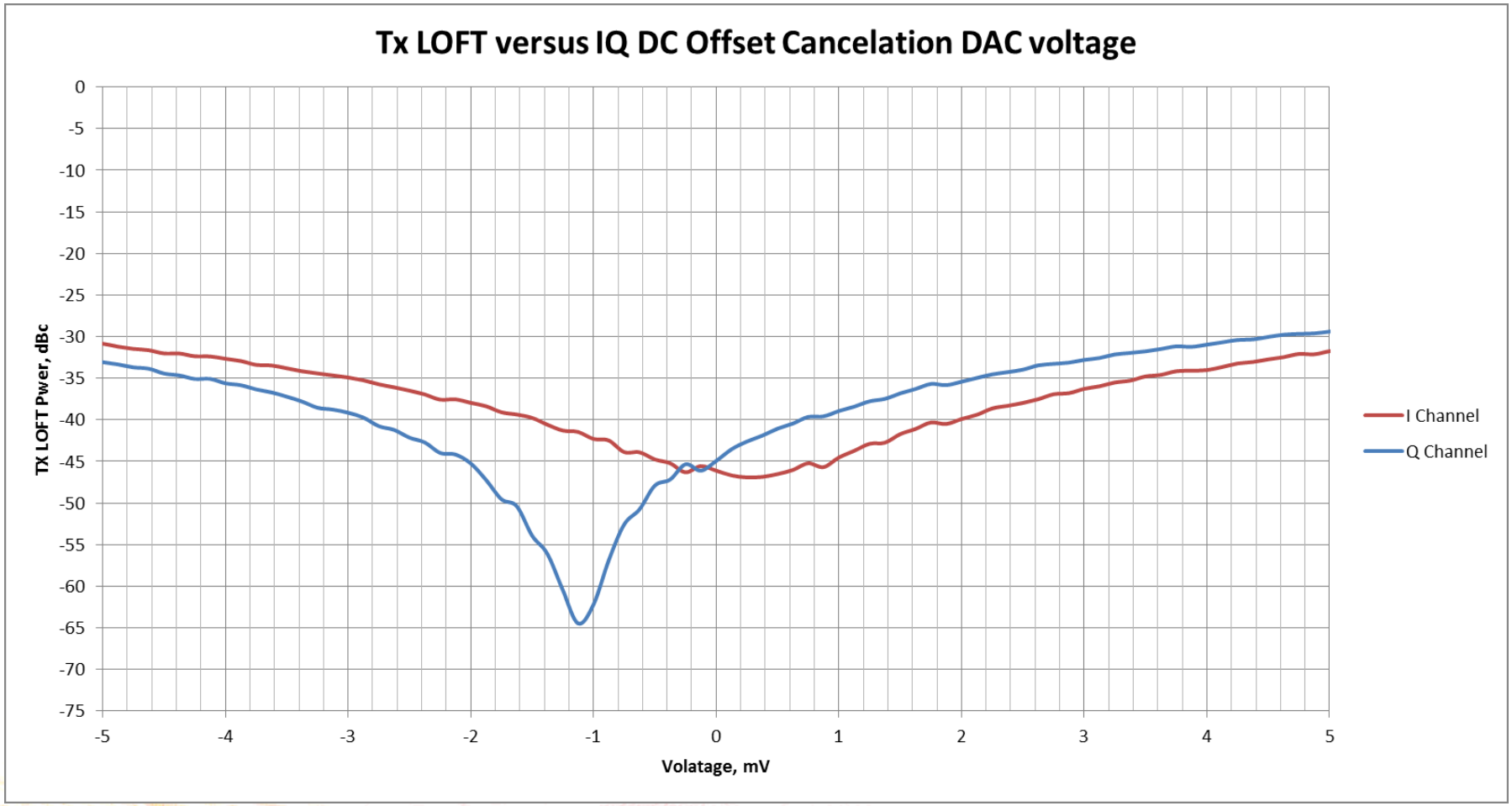
TX LOFT level variation over DC offset cancelation voltage, measured with spectrum analyzer



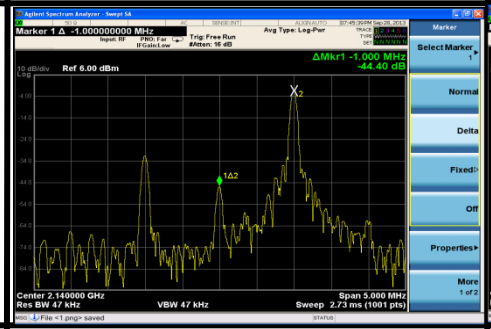
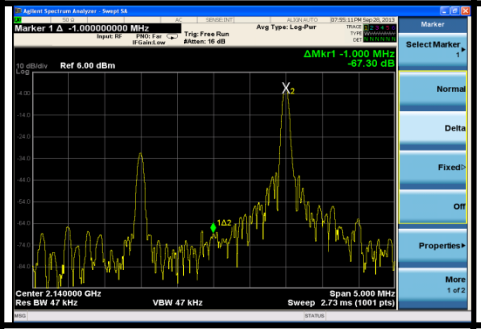
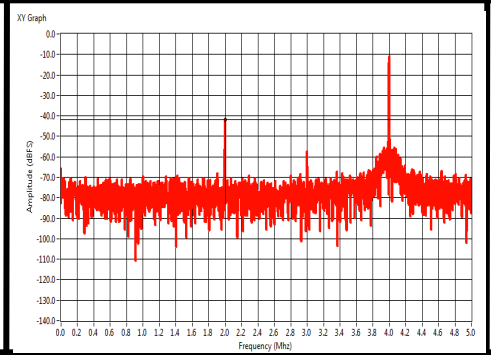
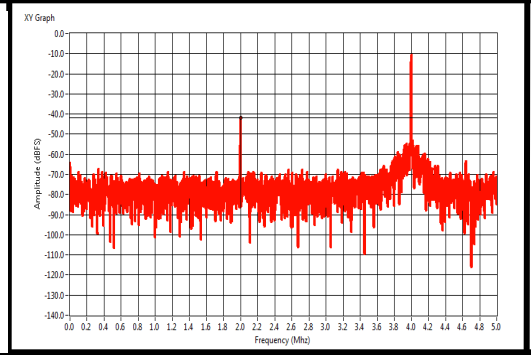
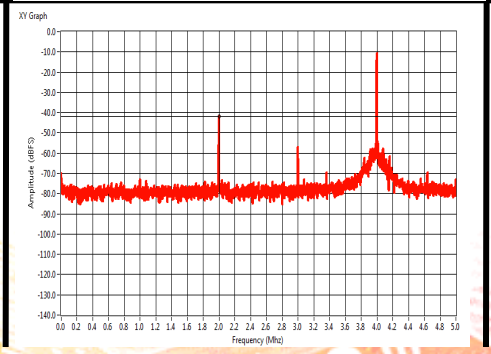
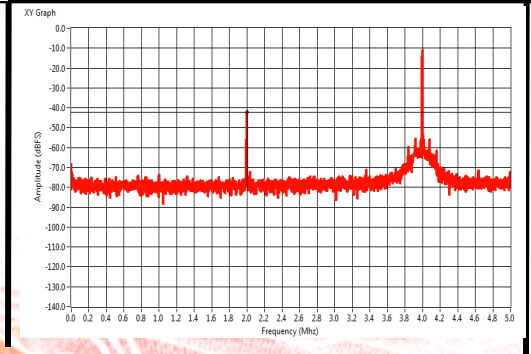
TX LOFT level variation over DC offset cancelation voltage, measured using DFT, internal RF loopback enabled



TX LOFT level variation over DC offset cancelation voltage, measured using DFT (***average (10 times) function enabled***), internal RF loopback enabled



TX LOFT calibration results

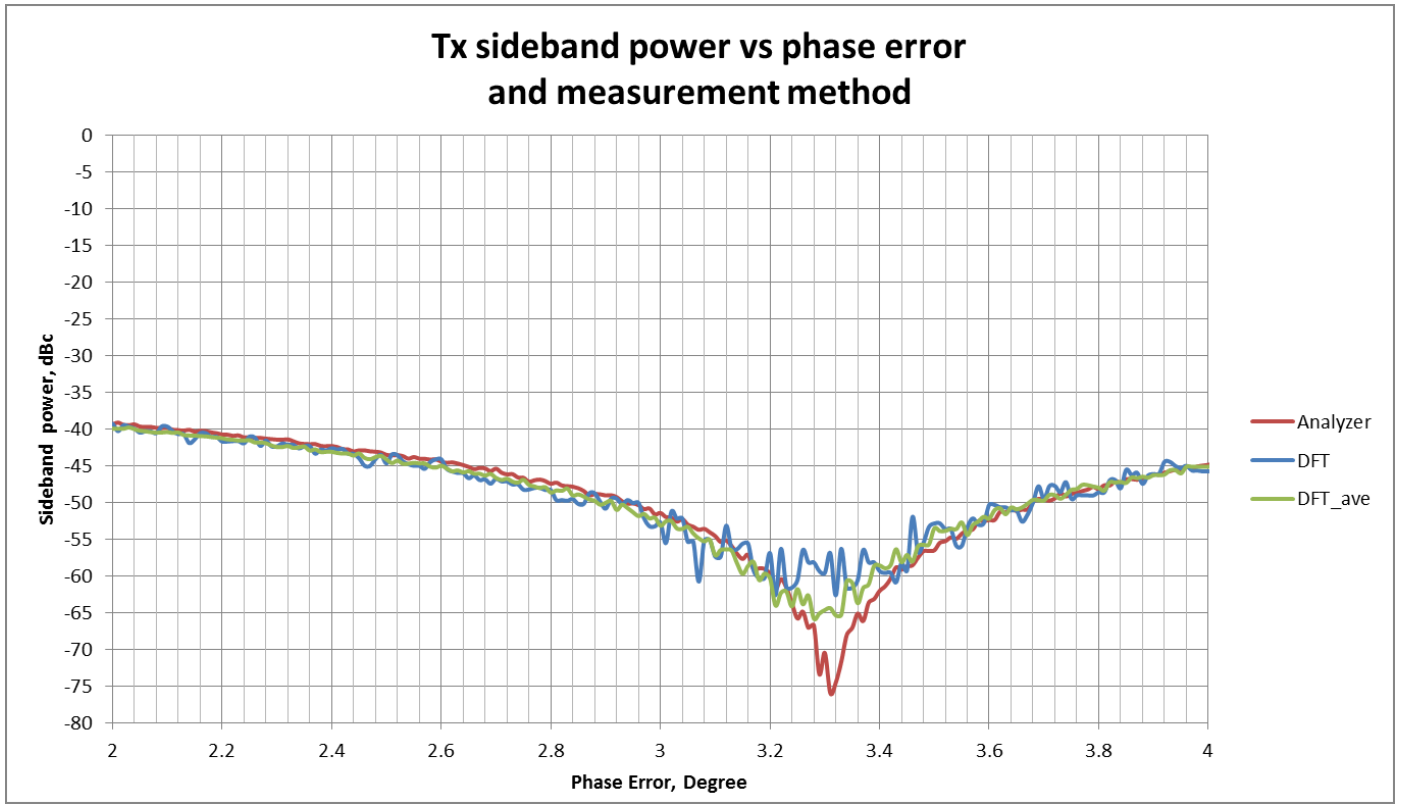
	Before Calibration	After Calibration	Spectrum Picture	
Calibrated using Analyzer				LOFT Level -67 dBc
Calibrated using DFT				LOFT Level -59 dBc
Calibrated using DFT Average enabled				LOFT Level -64 dBc

Measured Tx SSB level over phase error

Red Curve
Measured SSB with analyzer. Best SSB level achieved below -70 dBc

Blue Curve
Measured SSB via digital interface. Samples are collected with DIO card on PC. DFT length is **7180** samples. Best SSB level achieved below -55 dBc.

Green Curve
Measured SSB via digital interface. Samples are collected with DIO card on PC. DFT length is 7180 samples. The average function is enabled (10 times). Best SSB level achieved below -65 dBc.

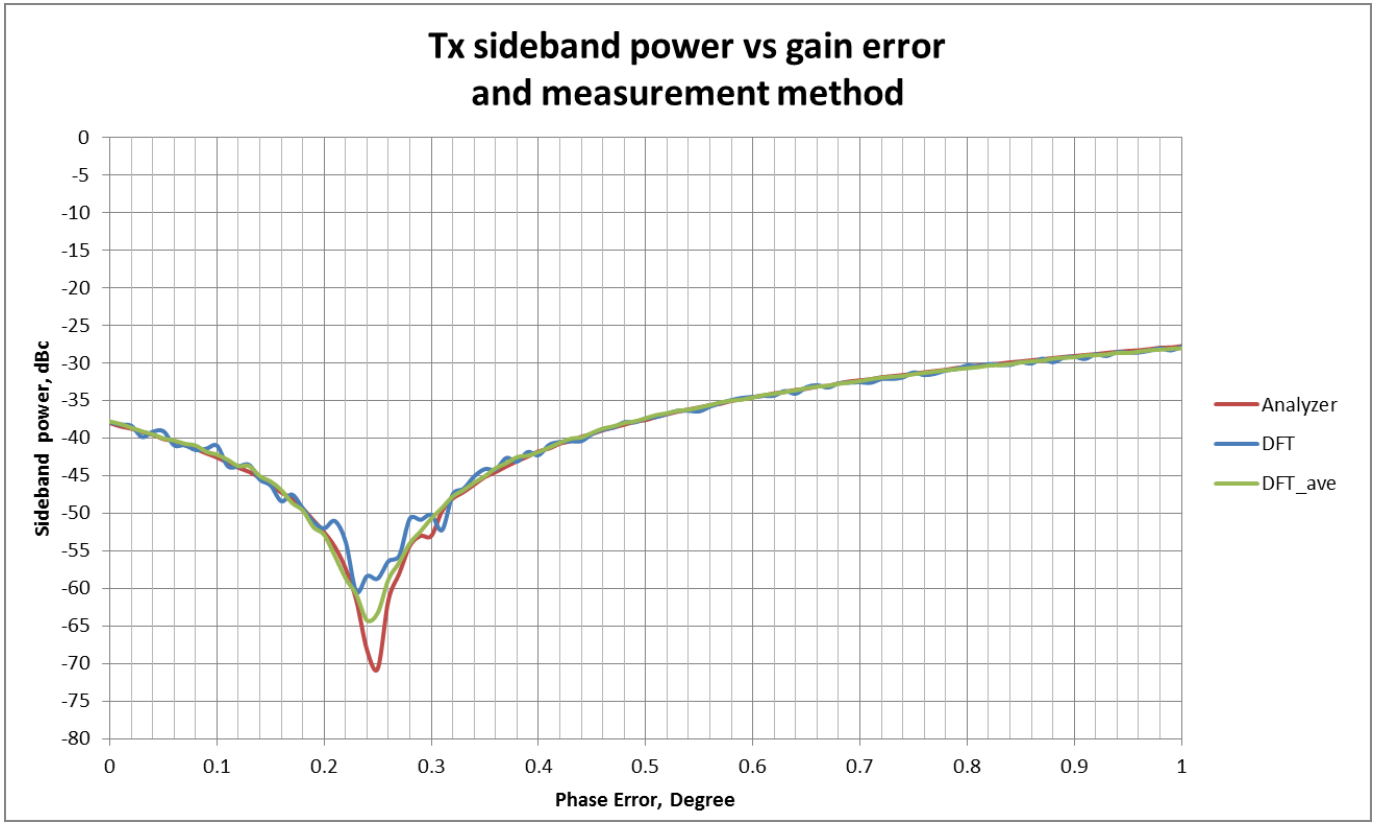


Measured Tx SSB level over gain error

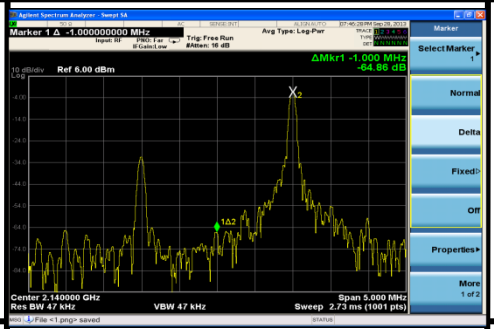
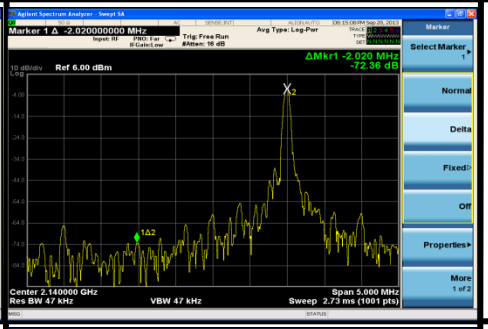
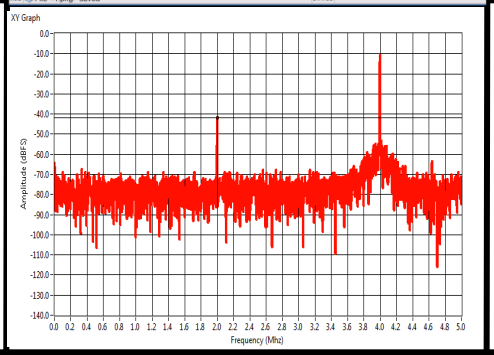
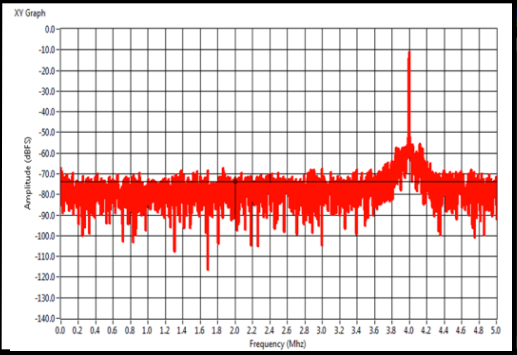
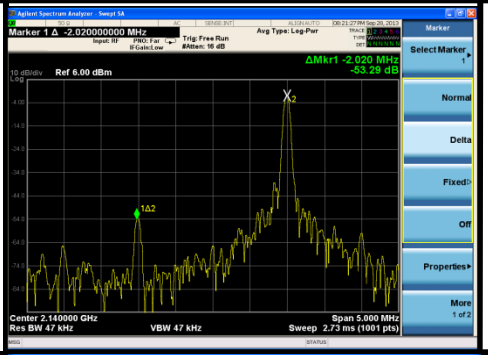
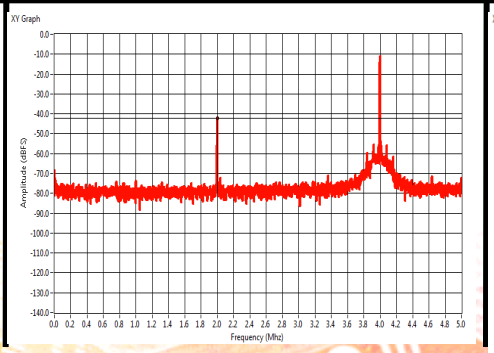
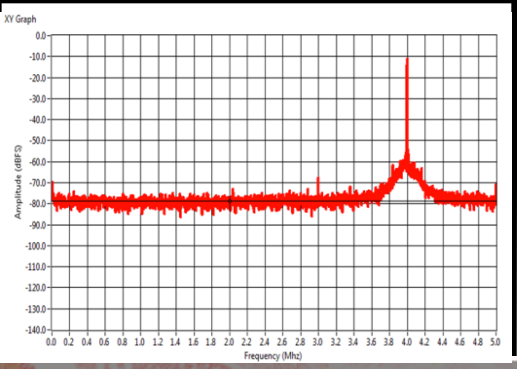
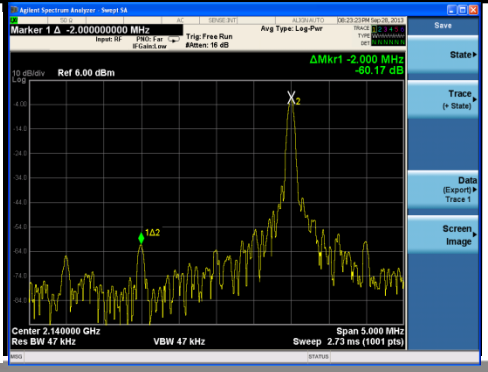
Red Curve
Measured SSB with analyzer. Best SSB level achieved below -70 dBc

Blue Curve
Measured SSB via digital interface. Samples are collected with DIO card on PC. DFT length is **7180** samples. Best SSB level achieved below -60 dBc.

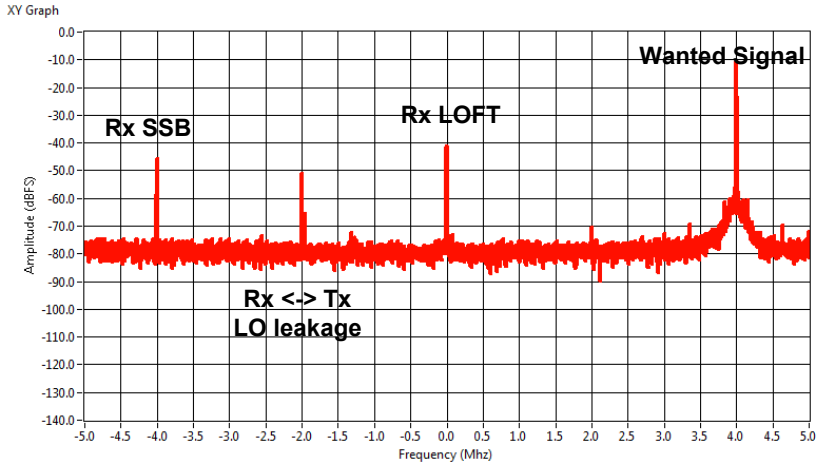
Green Curve
Measured SSB via digital interface. Samples are collected with DIO card on PC. DFT length is 7180 samples. The average function is enabled (10 times). Best SSB level achieved below -65 dBc.



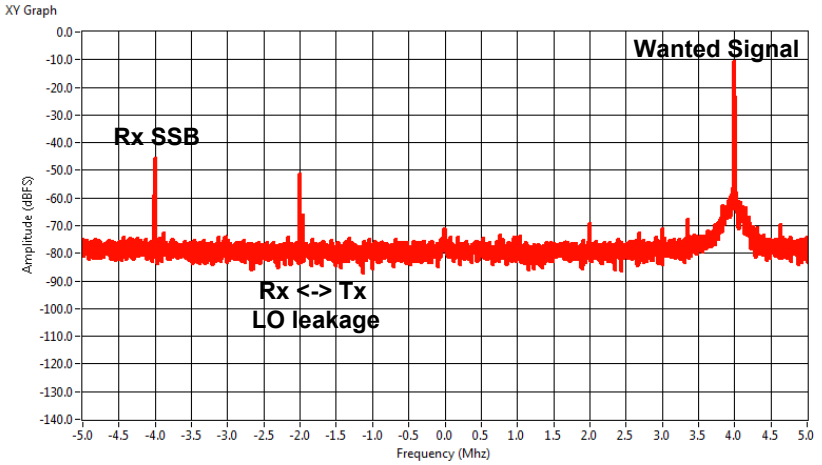
Tx SSB calibration results

	Before Calibration	After Calibration	Spectrum Picture	
Calibrated using Analyzer				SSB Level -72 dBc
Calibrated using DIO card				SSB Level -53 dBc
Calibrated using DIO wit Average enabled				SSB Level -61 dBc

RX LOFT calibration enabling averaging filter in BB.

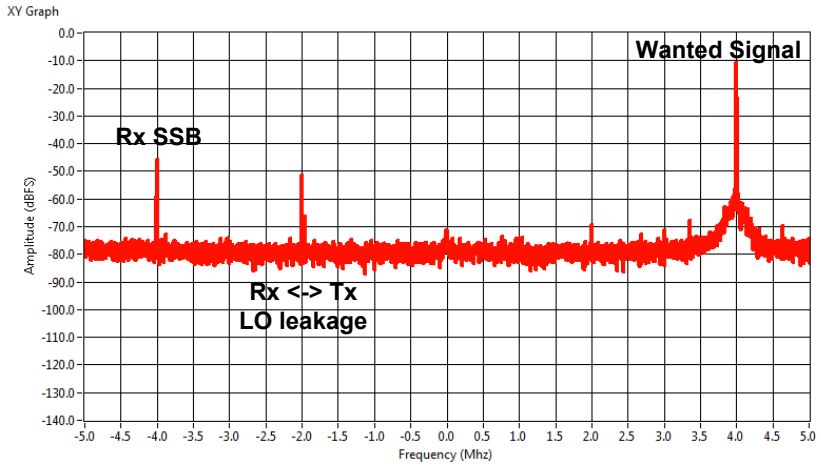


Before Calibration

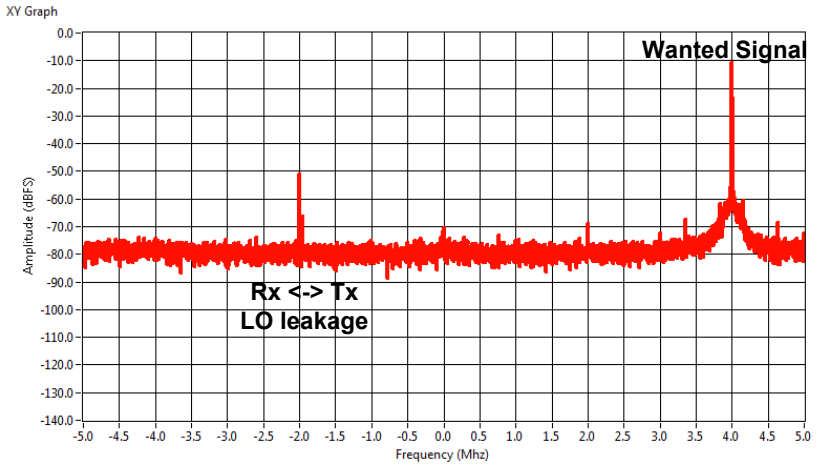


After Calibration

RX SSB calibration using calibration routines in BB.



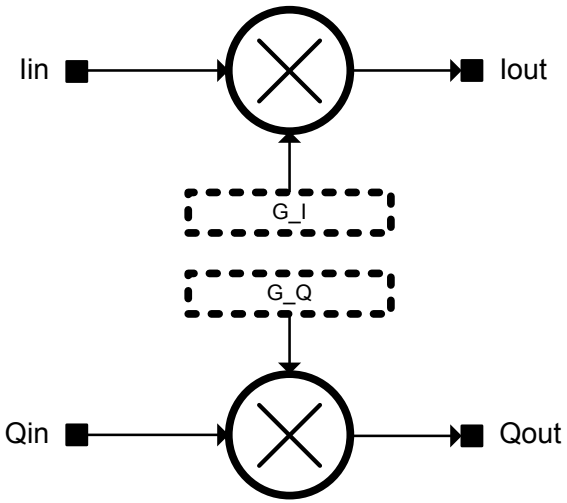
Before Calibration



After Calibration

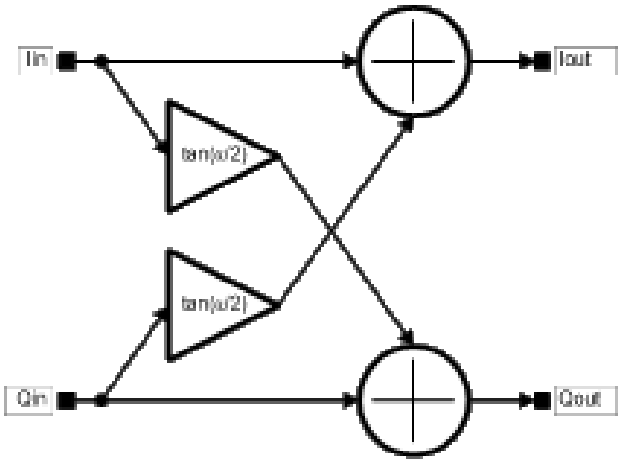
Gain error correction block

Software in baseband initially applies course gain variation on the I or Q channel and measures the loop back signal via the LMS6002D receiver to measure the optimum value. The example block for gain correction is shown below:



Phase error correction block

The baseband S/W applies a course phase multiplier on the I or Q channel and measures the loop back signal via the LMS6002D receiver to measure the optimum value. The process is then repeated using a finer control step to ascertain the optimum phase and gain offset value to be applied. The example block for gain correction is shown below:



Conclusion

Using averaged DFT improves LMS6002 calibration procedures