Troubleshooting the Callisto 2nd IF Mixer and Amplifier (down-converter stage)

1. Introduction

Troubleshooting the 2nd mixer/amplifier (down-converter) includes:

- Transistor amplifier T1 and coupling transformer L2 operational test
- Down-converter (mixer IC3, including oscillator quartz resonator Q1, bandpass filter FL1, amplifier T1 and coupling transformer L2) operational test
- Local oscillator operational test
- Local oscillator frequency measurement

Test equipment required:

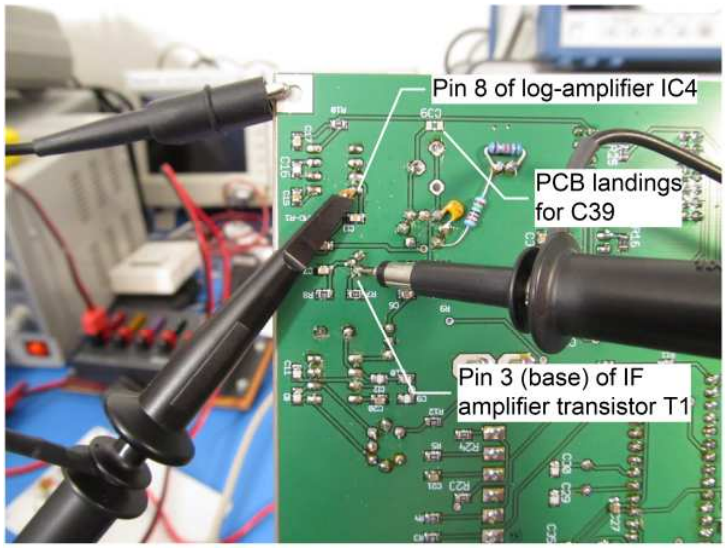
- RF signal generator covering the frequency range 10 to 38 MHz at –20 dBm output level
- Spectrum analyzer covering the frequency range 10 to 38 MHz
- Frequency counter covering the frequency range 10 to 38 MHz with ≥ 1 Mohm input impedance and 30 mV sensitivity or better
- Oscilloscope, 100 MHz bandwidth capability
- 10 Mohm oscilloscope probes (10X) matched to oscilloscope bandwidth (2 required)
- Coaxial cable with ordinary test probes or test clips at one end and coaxial connector at other end to match frequency counter input

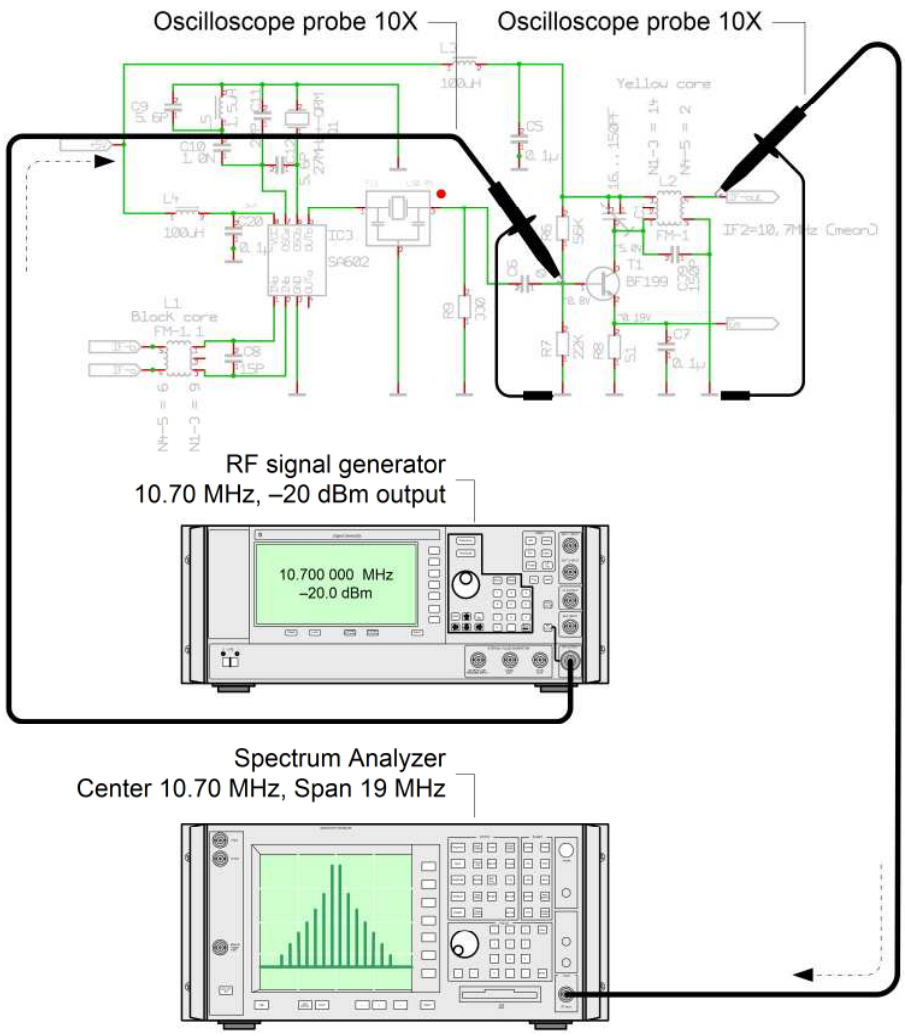
2. Circuit operation

The 36.13 MHz 1st IF output from tuner IC1 is coupled by transformer L1 to 2nd IF mixer IC3 pins 1 and 2. L1 is non-resonant. The mixer produces the 10.7 MHz 2nd IF output on pin 5 by mixing the 1st IF with the 25.43 MHz local oscillator (controlled by quartz resonator Q1) on pins 6 and 7 of IC3. The 2nd IF is filtered by ceramic bandpass filter FL1 and coupled to the base of transistor T1 by capacitor C6. T1 is a common emitter amplifier with a calculated ac voltage gain of about 200. The collector output of T1 is coupled through resonant transformer L2 to the input pin 8 of logarithmic amplifier IC4.

3. Transistor amplifier and transformer operational test

a. Connect an RF signal generator to the base of T1 through a standard 10X oscilloscope probe. Set the output to 10.70 MHz and –20 dBm. Connect the secondary of L2 (log-amplifier input pin 8) through another oscilloscope probe to a spectrum analyzer. Set the analyzer to a center frequency of 10.7 MHz with a span between 1 and 19 MHz. The physical locations and a connection diagram are shown below.



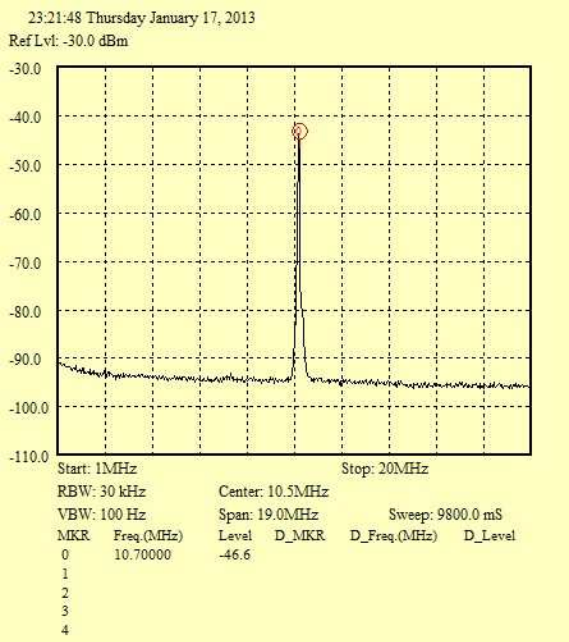


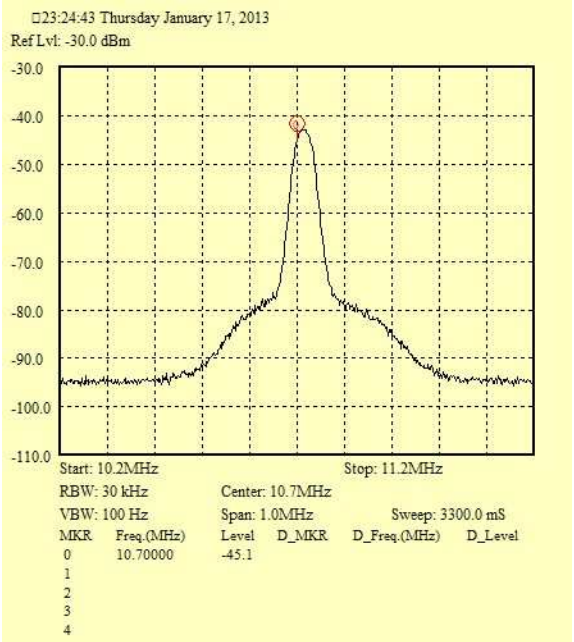
b. Adjust C1 and L2 for maximum amplitude on the spectrum analyzer. A level of –47 ± 3 dBm is fine.

c. Slowly adjust the signal generator frequency upward from 10.7 MHz. If the displayed amplitude increases as frequency is increased, additional capacitance is required. In this case, solder a parallel capacitor ≤ 150 pF to position C39. This capacitor is not necessary if L2 is wound correctly. The additional capacitance indicates that L2 was not wound correctly (probably 13 turns instead of 14).

d. The following spectrum plots are provided for reference. Note The displayed signal width and noise levels are directly affected by the spectrum analyzer resolution and video bandwidth settings in these and the following plots:

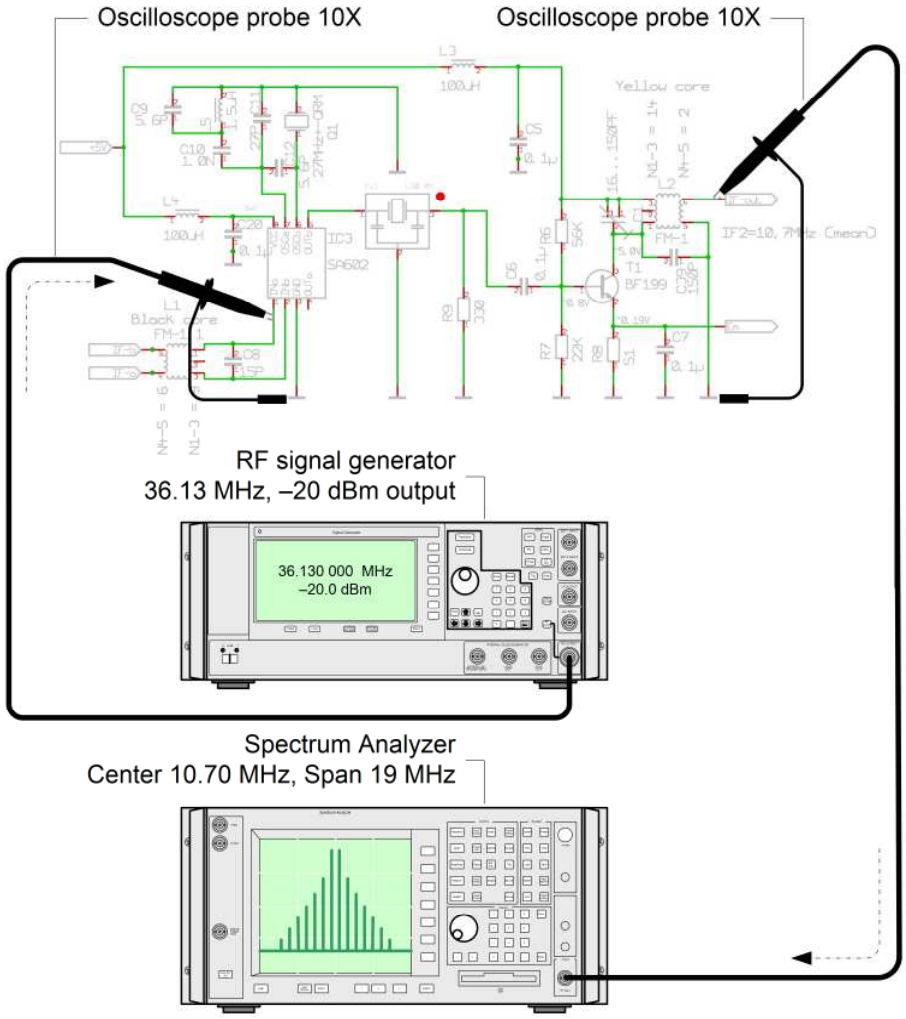
Left: Full span (19 MHz) as described above, measured with spectrum analyzer at log amplifier pin 8 (measured level –46.6 dBm) Right: 10.700 MHz input, 1 MHz span, measured log detector pin 8

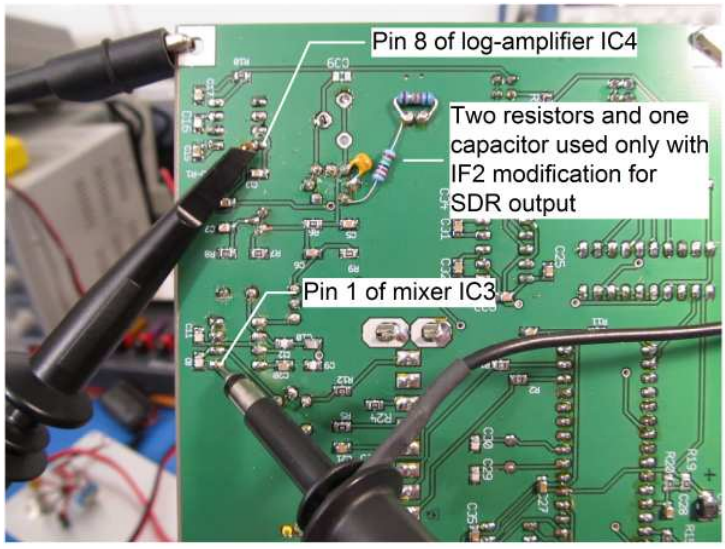




4. Down-converter operational test

a. Using the same scope probe from the RF signal generator as shown below, inject a 36.13 MHz, –20 dBm signal into pin 1 of mixer IC3. In older non-North American versions, use a frequency of 37.7 MHz. Use the same spectrum analyzer connections and setting as before.



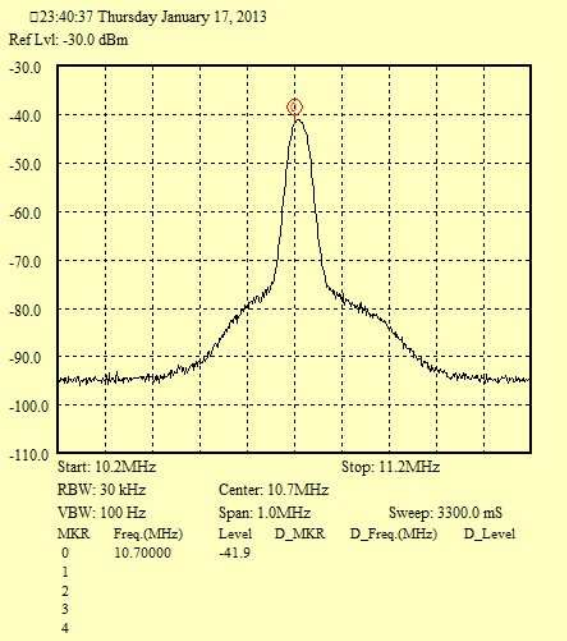


b. For this test the expected amplitude is on the order of (subject to change) –44 dBm ± 3 dBm. The scope probes are not matched to circuit impedances, so this method cannot be used to measure total gain. It is only recommended to adjust and check the amplifier response.

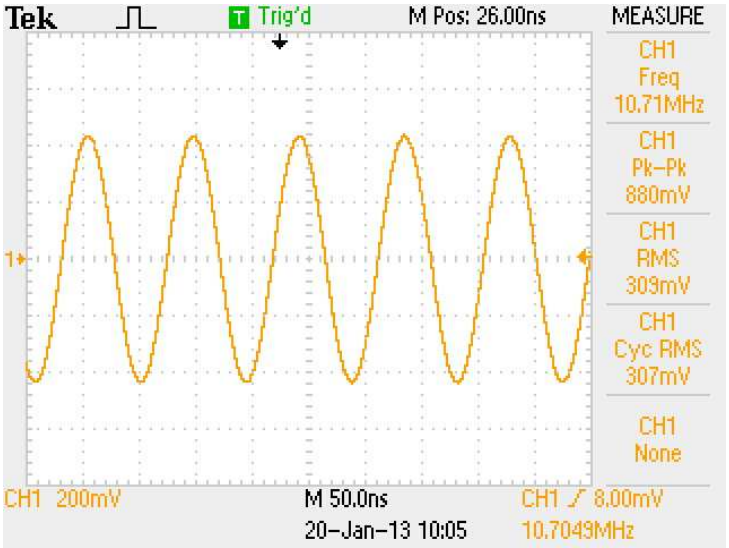
c. An oscilloscope may be connected to the collector of T1 to observe the 10.7 MHz waveform.

d. The following spectrum plot and oscilloscope screen are provided for reference

36.13 MHz, –20 dBm input at mixer input pin 1, 1 MHz span, measured with spectrum analyzer at log amplifier pin 8 (measured level –41.9 dBm).



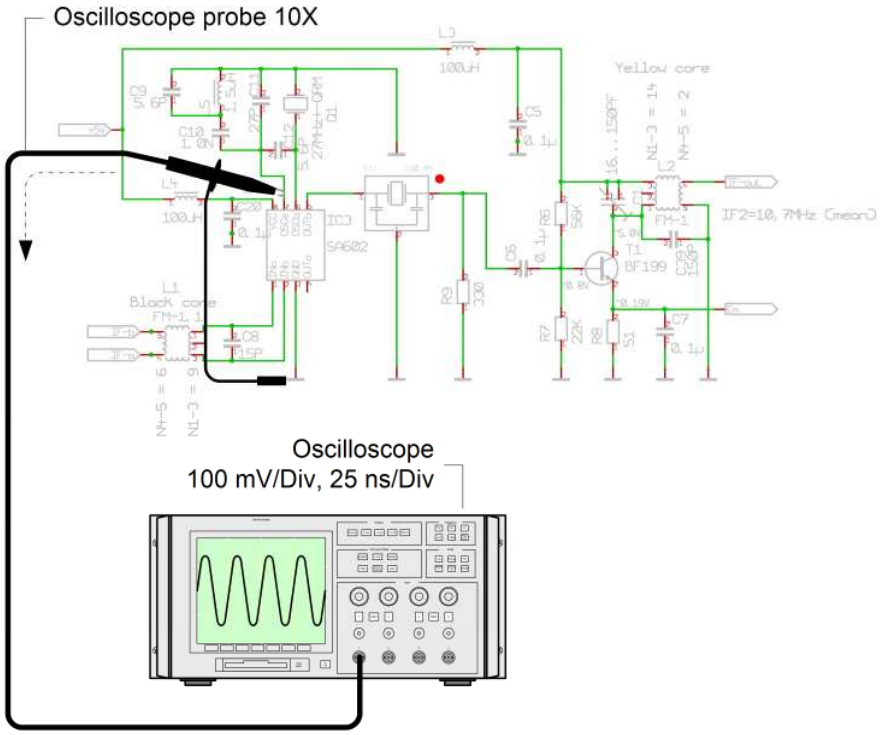
36.13 MHz, –20 dBm input at mixer input pin 1, measured with oscilloscope at transistor T1 collector (measured amplitude 309 mVrms).



5. Local oscillator operational test

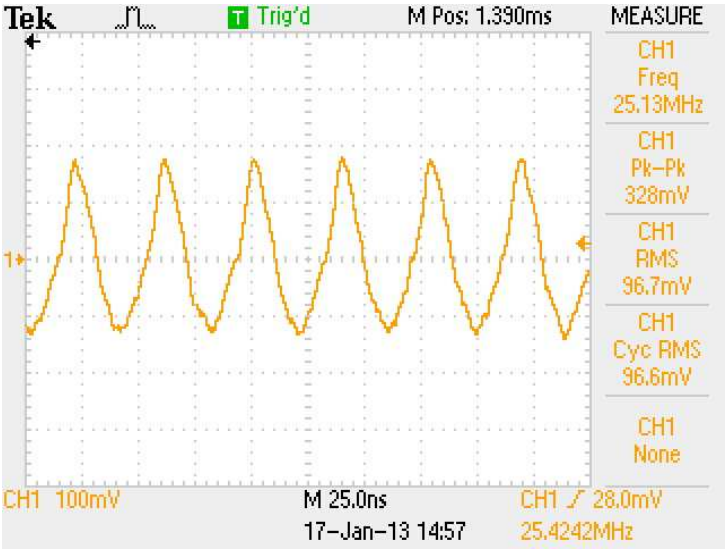
a. If the local oscillator does not appear to be working correctly, it may have an incorrect or defective quartz resonator, incorrect capacitors or inductor or incorrect or defective mixer IC3.

b. For a quick check connect an oscilloscope (at least 50 MHz bandwidth) through a standard high-impedance scope probe to terminal 7 of mixer IC3 as shown below. The expected signal is a distorted sinewave (see scope screen below). The amplitude should be on the order of 250~350 mVp-p with a period/frequency of about 39.3 ns/25.43 MHz (older versions will have a period/frequency of about 37.04 ns/27.0 MHz). Note: These tests provide only an operational check and do not accurately measure the local oscillator frequency.

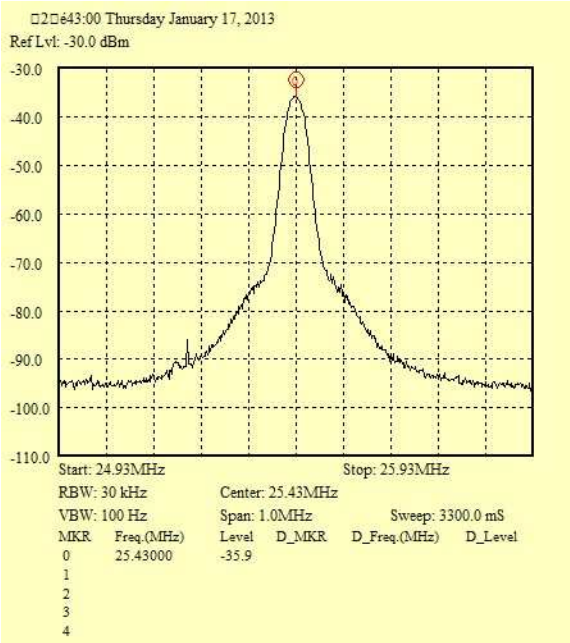


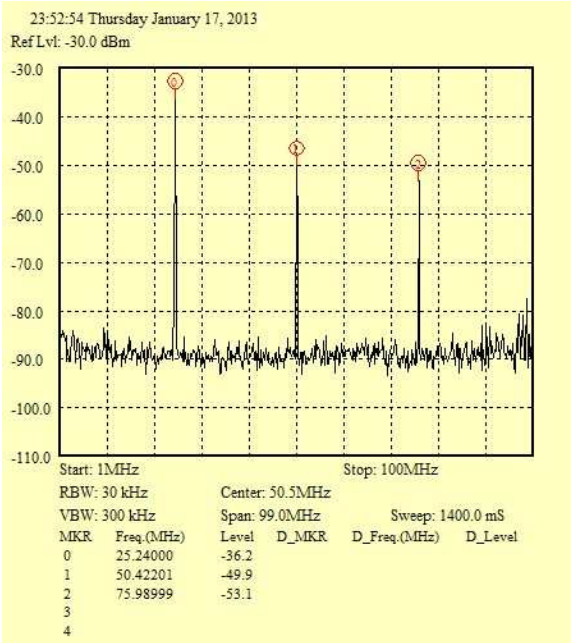
c. The following oscilloscope screen and spectrum plots are provided for reference

25.43 MHz oscillator, measured with oscilloscope at mixer pin 7 (measured amplitude 328 mVp-p and 36.7 mVrms).



Left: 25.43 MHz oscillator, measured with spectrum analyzer set for 1 MHz span, measured at mixer pin 7 (measured level –35.9 dBm). Right: 25.43 MHz oscillator measured with spectrum analyzer set to 100 MHz span showing 2nd and 3rd harmonics, measured at mixer pin 7 (fundamental –36.2 dBm; harmonics –49.9 and –53.1 dBm)



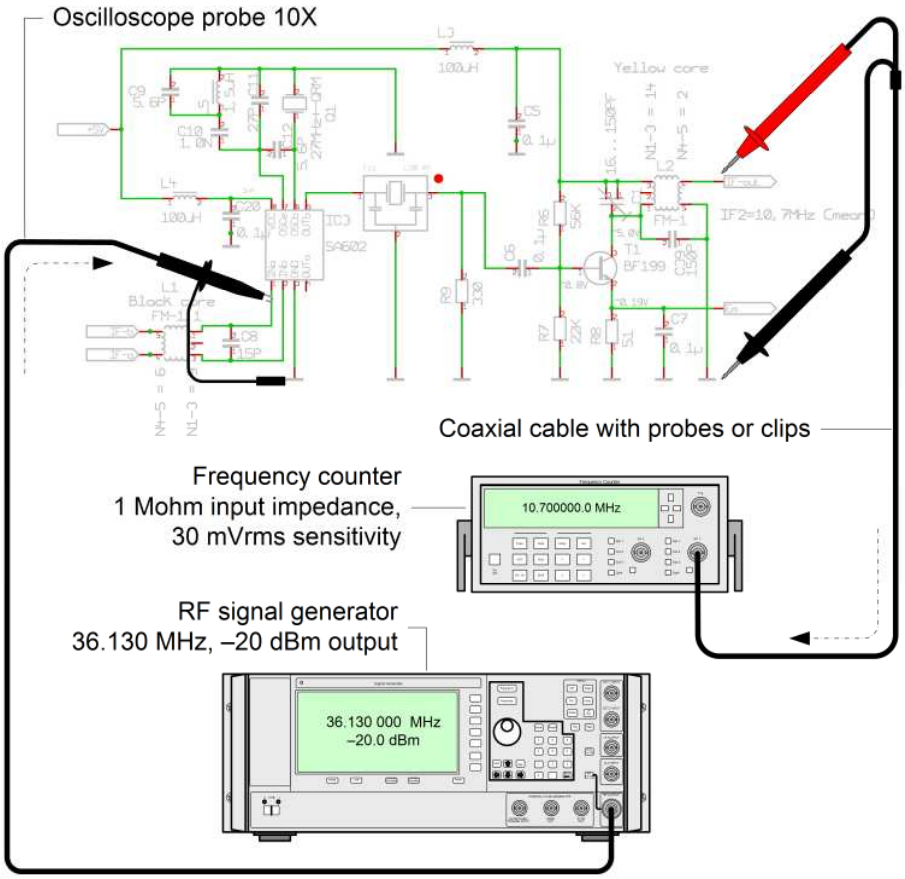


6. Local oscillator frequency measurement

a. The setup described here injects an RF carrier at 36.13 MHz into the 2nd mixer and then measures the IF2 output frequency, providing an indirect measure of the local oscillator frequency.

b. Accurately set the signal generator frequency to 36.13 MHz at –20 dBm and connect its output to mixer IC3 input pin 1 using a 10X scope probe as shown below. Connect a frequency counter with 1 Mohm input, 30 mV sensitivity and 1 Hz resolution to the log-amplifier IC4 input pin 8 using an ordinary coaxial cable with clips or probes.

c. The measured IF2 frequency should be 10.7 ± 0.015 MHz.



Document information:

Author: Whitham D. Reeve

Issue: 0.0 (Draft started 18 Jan 2013)
0.1 (Released for review, 20 Jan 2013)
1.0 (Minor edit and issued for distribution, 21 Jan 2013)
1.1 (Reformatted, 01 Jun 2016)