Keywords: VCO output, VCO output swing, MAX2607 output swing

APPLICATION NOTE 3633

Tuning the MAX2607 EV Kit for High Differential Voltage

Sep 23, 2005

Abstract: The differential output voltage on the MAX2607 EV Kit can be measured using a differential probe. But due to board parasitics and the input capacitance of the probe, using passive pullups, the swing was only 320mV$_{P-P}$. The solution is to use inductive pullups that resonate out those capacitances. This new application delivers 2400mV$_{P-P}$ differential V_{OUT} when measured with a differential probe on a spectrum analyzer. The modifications made to the board as well as some theory behind the calculations are detailed.

Equipment Used

Spectrum analyzer—Agilent Technologies 8562EC
Differential probe—Tektronix® P6248
Probe power supply—Tektronix 1103
Power supply
MAX2607 EV Kit

Click here for an overview of the wireless components used in a typical radio transceiver.

Setup and Test Conditions

The setup for the above tests is shown in **Figure 1**. The two differential outputs of the MAX2607 (OUT+ and OUT-) are connected to the two input pins of the differential probe, the other end of which is connected to the probe power supply, which provides external power to the probe. The output from the probe power supply is then connected to the spectrum analyzer. The test conditions are as follows:

V_{CC} = 3V
Frequency out = 197MHz
V_{TUNE} = 0.4-2.4V (In this case, the external inductance, LF, has been chosen so that V_{TUNE} is approximately in the middle of its tuning range)
The differential probe is set to 1:1 attenuation

Spectrum Analyzer Settings

Amplitude units: volts
Center frequency: 197MHz
Span: 1MHz
Resolution bandwidth: 10kHz

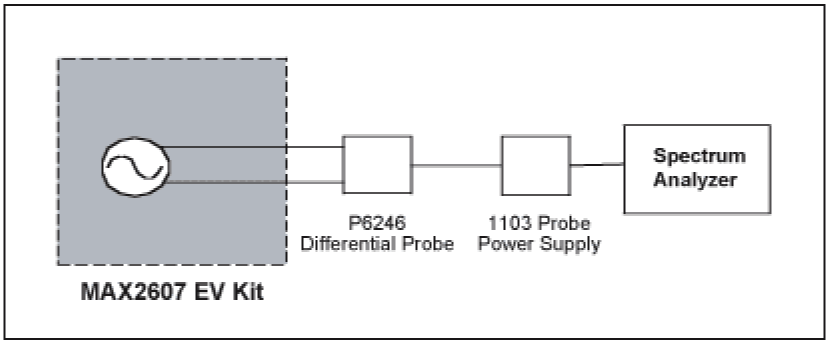

Figure 1. Test setup.

Input and Output Matching Networks and Respective Measurements

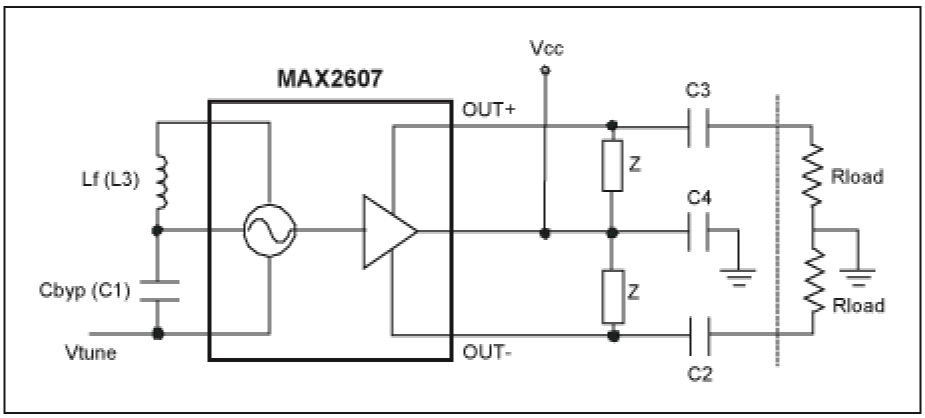

Figure 2. Typical operating circuit.

Initial component values (Refer to **Figure 2** above):

L3 was tuned to get an output frequency of 197MHz with V_{TUNE} close to the center of its tuning range. This value was found to be 100nH.
C1 = C4 = 1000pF
C2 = C3 = 330pF
Z = R2 = R3 = 1100kΩ

The differential outputs are fed into the input pins of the differential probe, which has an input impedance of 400kΩ in parallel with a 1pF capacitance. This can be represented single-endedly as 2pF capacitance. Thus, R_{LOAD} in this case can be considered to be a 2pF capacitance (C_{LOAD}) which has a reactance of -j400. In addition, there is some parasitic capacitance to ground due to the circuit. Using the circuit in Figure 2, the differential voltage was measured to be $320mV_{P-P}$. So single-endedly, this would equate to $160mV_{P-P}$ across the 2pF capacitance. This gives us a current I_{LOAD} of 0.4mA flowing through the load as shown in **Figure 3**.

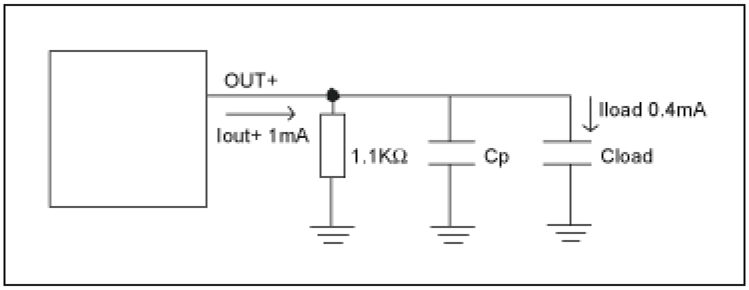

Figure 3. Output resonant circuit.

Using the above results, the parasitic capacitance C_P can be approximated to be around 2.87pF. The parallel combination of this capacitance with the 1kΩ has a magnitude of about 270Ω.

Therefore, using current division:

$$I_{load} = I_{out} * \left(\frac{267}{(267 + 400)}\right) = 0.4mA$$

Thus, the calculation for C_P is correct.

From this analysis it was concluded that in order to increase the differential V_{OUT} we would have to use a pullup inductor to resonate out the parallel combination of C_P and C_{LOAD}. The calculations for the value of this inductor are:

$$(1/jwL) + (jwC_p) + (jwC_{load}) = 0 \qquad (1)$$

where $C_p = 2.87pF$
$C_{load} = 2pF$

$$(1/jwL) = -j*2pi*F_{out}\,[C_p+C_{load}]$$
$$= -j0.00612$$

Therefore, *L* = 130nH. The closest standard value is 120nH.

Final Circuit and Results

Referring to Figure 1:

L3 was tuned to get an output frequency of 197MHz with V_{TUNE} close to the center of its tuning range. This value was found to be 100nH.
C1 = C4 = 1000pF
C2 = C3 = 330pF
Z = L4 = L5 =120nH
R3 = R4 = open

Results

V_{CC} = 3V, I_{dc} = 2mA, V_{TUNE} = 1.4V

Output frequency = 197MHz
Differential output voltage = $860mV_{RMS}$ = $2400mV_{P-P}$

Note: If another application is using a differential probe that is different from the one mentioned above, then even the value for *L* that produces resonance will be different. Replace C_{LOAD}, in Equation 1 above, with the value for the input capacitance of the differential probe being used, and re-calculate *L*. Similarly, for the case when the MAX2607 is going to be used to drive an LVDS buffer, C_{LOAD} will have to be replaced with the input capacitance of the buffer, and *L* will have to be re-calculated.

Conclusion

The MAX2607 EV Kit was modified to increase the amplitude of differential output voltage. Inductive pullups were used instead of passive pullups to resonate out the board parasitics and the probe input capacitance. This new application delivers $2400mV_{P-P}$ differential V_{OUT} when measured with a differential probe on a spectrum analyzer.

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Related Parts		
MAX2605	45MHz to 650MHz, Integrated IF VCOs with Differential Output	Free Samples
MAX2606	45MHz to 650MHz, Integrated IF VCOs with Differential Output	Free Samples
MAX2607	45MHz to 650MHz, Integrated IF VCOs with Differential Output	Free Samples
MAX2608	45MHz to 650MHz, Integrated IF VCOs with Differential Output	Free Samples
MAX2609	45MHz to 650MHz, Integrated IF VCOs with Differential Output	

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