On Site Homework #9

ECEN 2420: Wireless Electronics for Communication

Goals

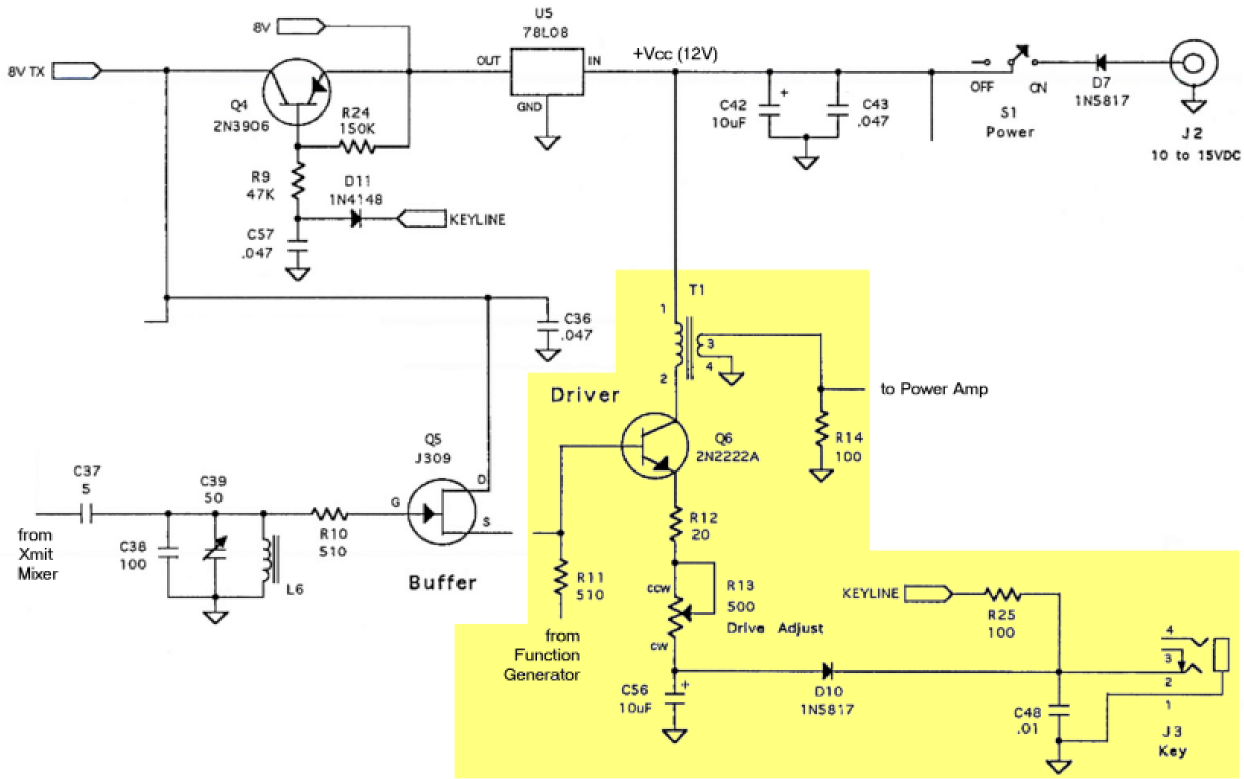
- **Build and Measure the Driver Amplifier of the NorCal 40A transmitter**
- **Build and Measure the Buffer Amplifier of the NorCal 40A transmitter**

Problems

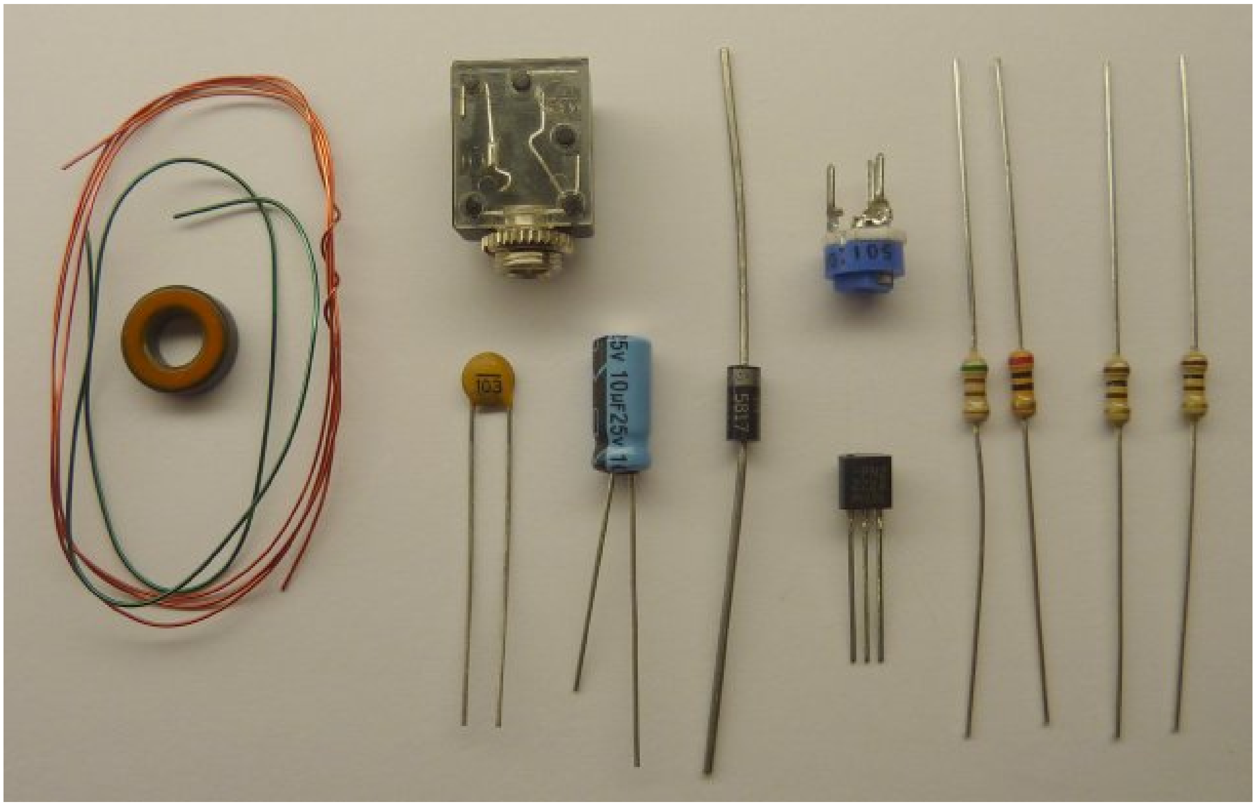
Problem 1

Make sure that your oscilloscope probe is set to 10:1 attenuation to avoid getting wrong results that result from the capacitance of the coaxial cable and the input resistance of the oscilloscope.

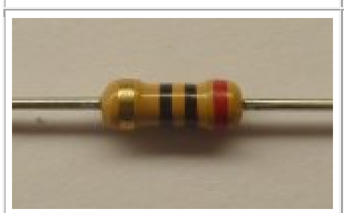
After finishing most of the receive circuitry previously, we now focus our attention on the transmitting part of the NorCal 40A. The first part of the transmit circuit we will install and measure the driver amplifier. The circuit diagram is shown below.



The picture of the parts you need are shown below.



The list of parts are below.

Picture	Reference	Description	Part Number	Quantity
	J3	Jack, 3.5mm, Stereo, PC-MT		1
	R11	Resistor, 510 Ohm, 1/4 W, 5%		1
	R12	Resistor, 20 Ohm, 1/4 W, 5%		1

	R13	Resistor, Trimmer, 500 Ohm		1
	R14, R25	Resistor, 100 Ohm, 1/4 W, 5%		2
	T1	Transformer, Pri: 14T, #26 (10"), Sec: 4T, #26 (4"), 3.5:1	FT37-43 (black, orange mark, 0.37") Ferrite Toroid, A_L=350 mH/1000T	1
	Q6	Transistor	2N2222A	1
	D10	Diode, Schottky	1N5817	1
	C56	10 uF		1
	C48	10 nF		1

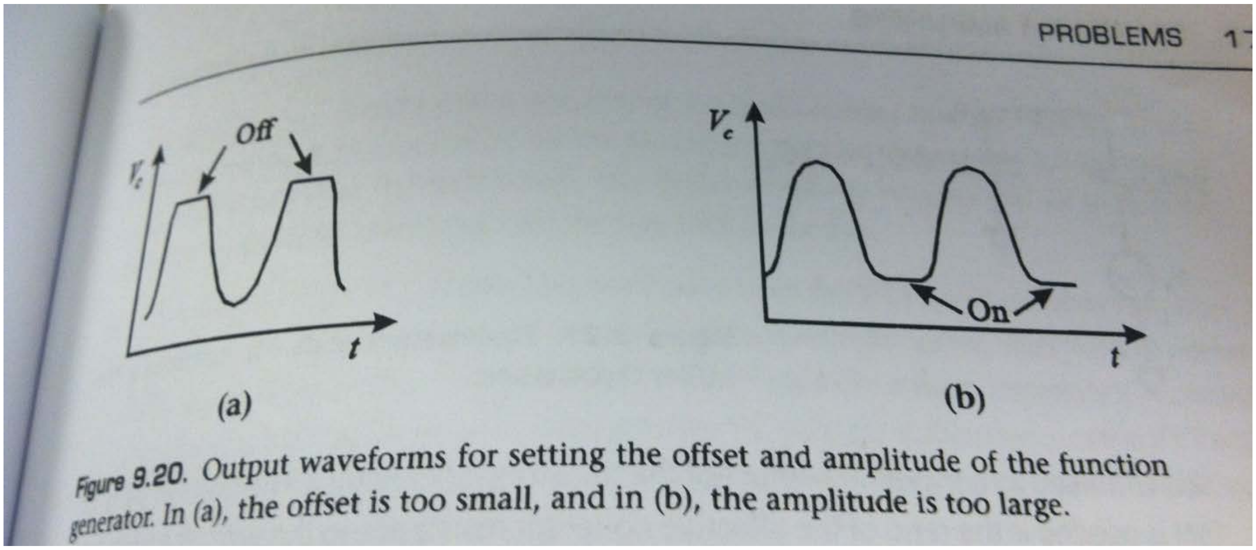
You should have transformer T1 constructed from on site homework #2.

Do not solder R11 fully to the board, only solder the connection to the gate of the transistor!

Go ahead and solder all other components into the board. Make that you put resistors in the right places!

In this configuration, R13 controls the gain of the driver amplifier. **Adjust R13 so that it is fully clockwise, leaving it at its lowest resistance**.

Plug in the power supply and connect the function generator to the free end of R11. Attach the oscilloscope across R14. For this problem you will need to provide a DC offset with the function generator. Set the function generator to 7.04 MHz, 2 Vpp, with an offset of 0.5 V. If the offset is too small, the output will clip because the transistor will turn off during part of the cycle. However, be careful when increasing the offset, as the current will grow quickly and reduce the efficiency. If the amplitude is too high, the waveform will bottom out when the transistor saturates. See the figure below for example waveforms.



The following questions come from problems 21 and 22 from the book. It is recommended to have the book for reference.

- Measure the output voltage using the scope, and calculate the output power.
- We will now calculate the power delivered by the power supply. Record the DC voltage across R12, and use that to calculate the emitter current. Now measure the input voltage V_{cc}, and use this to calculate the supply power.
- Use the supply power and output power calculations to calculate the efficiency of the system.
- What is the gain of the amplifier when R13 is fully clockwise? What is the gain when R13 if fully counter-clockwise?

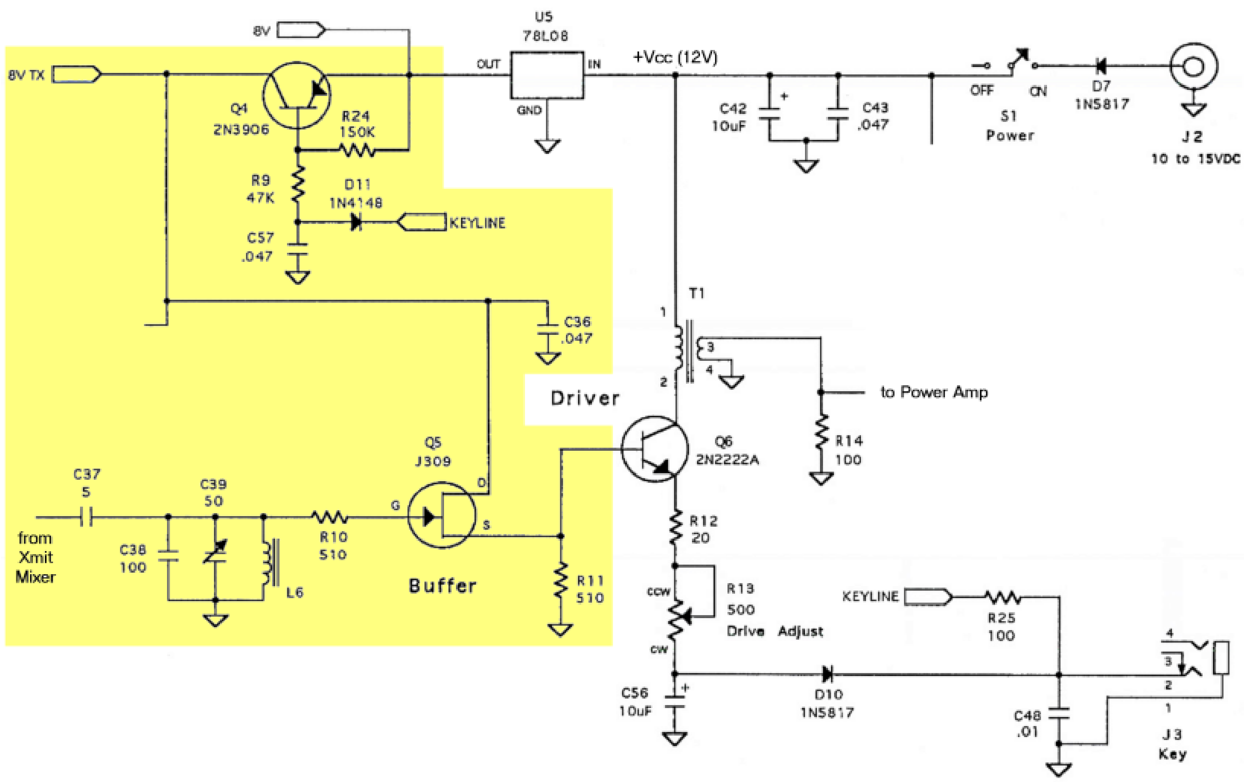
- Using the voltage gain you calculated at the maximum setting to calculate the Miller capacitance. Use the diagram shown below to do this. We will assume that the input impedance of the amplifier is dominated by the Miller capacitance and ignore the rest. Using figure 9.21, what is C_m?

  When you are finished, solder in the other end of R11.

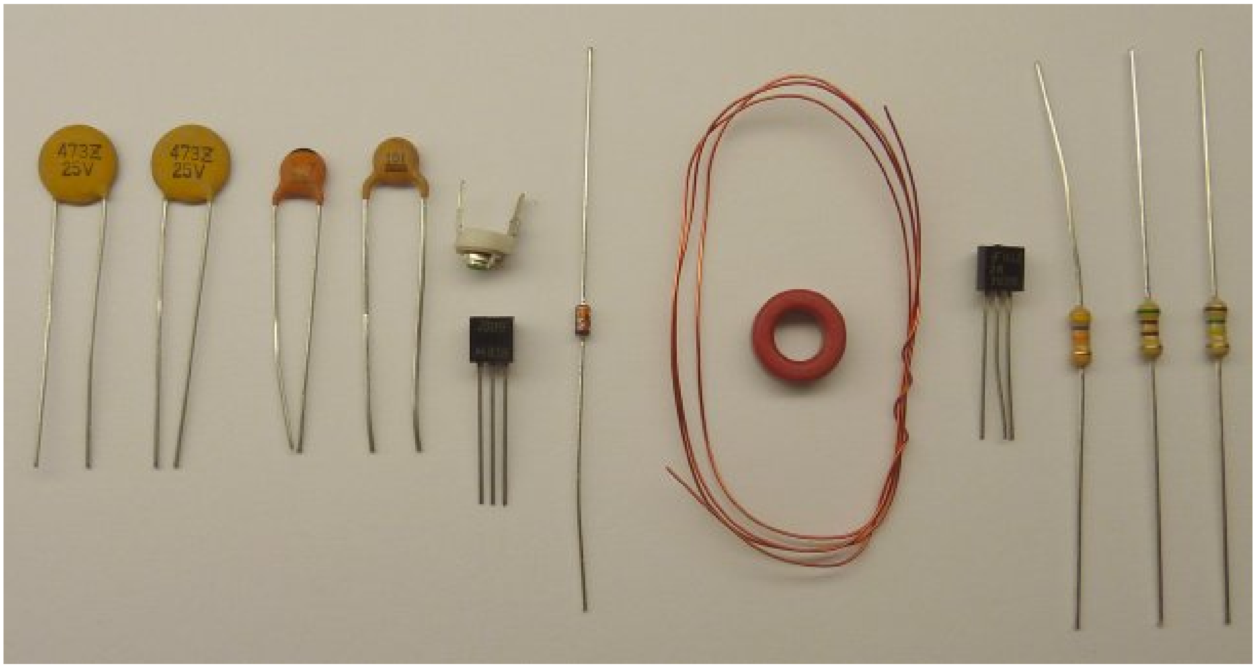
Problem 2

The Driver amp has an input impedance that is dominated by Miller capacitance. In the transmitter, the input for the Driver Amp comes from the Transmit Mixer, after passing through the Transmit Filter. A large change in load capacitance would upset the filter resonance if we put the filter output into the Driver amplifier directly. In order to isolate the filter from changes in the driver amplifier, the transceiver has a JFET Buffer Amplifier. The buffer Amplifier is a source-follower circuit, which has a high input impedance but no voltage gain.

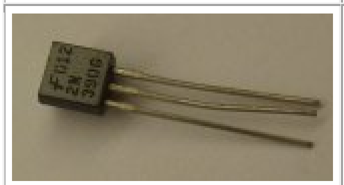
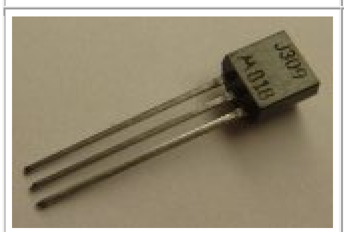
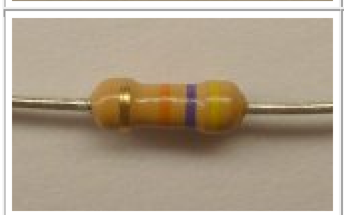
Below is the circuit diagram of the Buffer Amplifier.

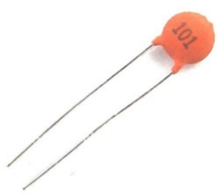
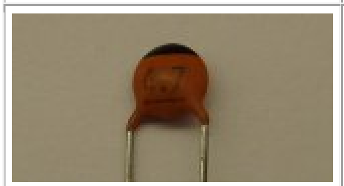
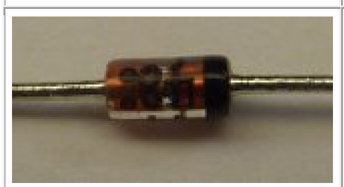


The parts needed for the Buffer Amplifier are shown below.

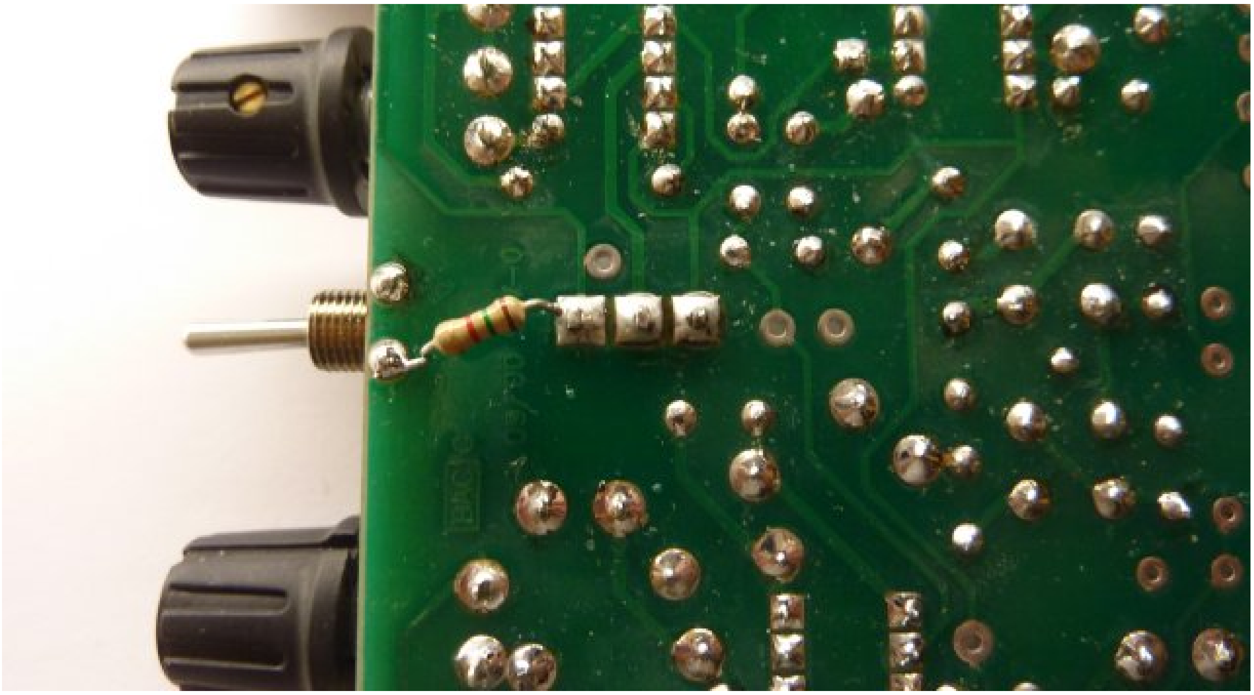


Here is a list of the individual components. Note that you should already have L6.

Picture	Reference	Description	Part Number	Quantity
	L6	Inductor, 3.1 uH, 28T #28 (16")	T37-2 (red, 0.37"=9.4mm) Iron Powder Toroid, A_L=40 uH/100T	1
	Q4	Transistor, PNP, TO-92	2N3906	1
	Q5	Transistor, JFET, TO-92	J309	1
	R9	Resistor, 47 kOhm, 1/4 W, 5%		1

	R10	Resistor, 510 Ohm, 1/4 W, 5%		1
	R24	Resistor, 150 kOhm, 1/4 W, 5%		1
	C36, C57	Cap. Disc or Mono, 0.047 uF, 20%, 25 V		2
	C38	100 pF		1
	C39	Cap., Var., 8-50 pF, Mica		1
	C37	4.7 pF		1
	D11	Diode, Switching	1N914 or 1N4148	1

To start, solder in the parts needed for the Buffer Amplifier (C36, C38, C39, L6, Q5, R10, R11) and the 8 Volt transistor switch (C57, D11, Q4, R9, R24) onto the board. You may also now remove the 1.5 kOhm resistor shown in the picture below.



Only solder in C37 partway into the board, connected to the transmit filter. Put a 1.5 kOhm resistor on the unsoldered end of C37 for measurements.

Solder all components to the board, except for the free end of C37. Connect your function generator to the C37 and 1.5 kOhm combination. Use a frequency of 7.04 MHz and amplitude of 1 Vpp.

- Measuring at the start of R10, or the filter input of R10, adjust C39 for maximum probe voltage. Use a plastic screwdriver as you have done previously to adjust the device. What is this maximum voltage that you measure?
- Now move the probe to R11 to measure the output voltage. You may need to adjust C39 again, as the probe capacitance may have affected your previous tuning. What is the voltage gain that you measure? (dB)
- Using the fact that you are using a 1.5 kOhm resistor at the input and 510 Ohm at the load, what is the power gain? (dB)