Amplitude modulator

In this task, you build an amplitude modulator on a breadboard.

The operation of this amplitude modulator (Figure 1) is based on the 18-MHz *amplifier* that was was build and tested previously. The only significant difference is that there is an extra input, called AF in, audio-frequency input.

1. Build this circuit. Use myDAQ to measure that biasing is ok (that the DC quantities are ok), see the instructions below.
2. In the inclass session you get instructions on how to test the modulator with audio frequency (AF) and carrier (RF) signals. In other words, when testing at home neither AF nor RF signals are fed to the circuit.
3. Try to identify the DC, AF and RF paths when (1) the 15-μH chokes impede only the RF current, (2) the 2.2-nF capacitors impede DC and AF currents, but not RF, and (3) the 100-μF capacitors impede DC, only. The resistors impede currents at all frequencies, equally, according to their resistance. Mark the paths in a reasonable but clear manner to the schematic.

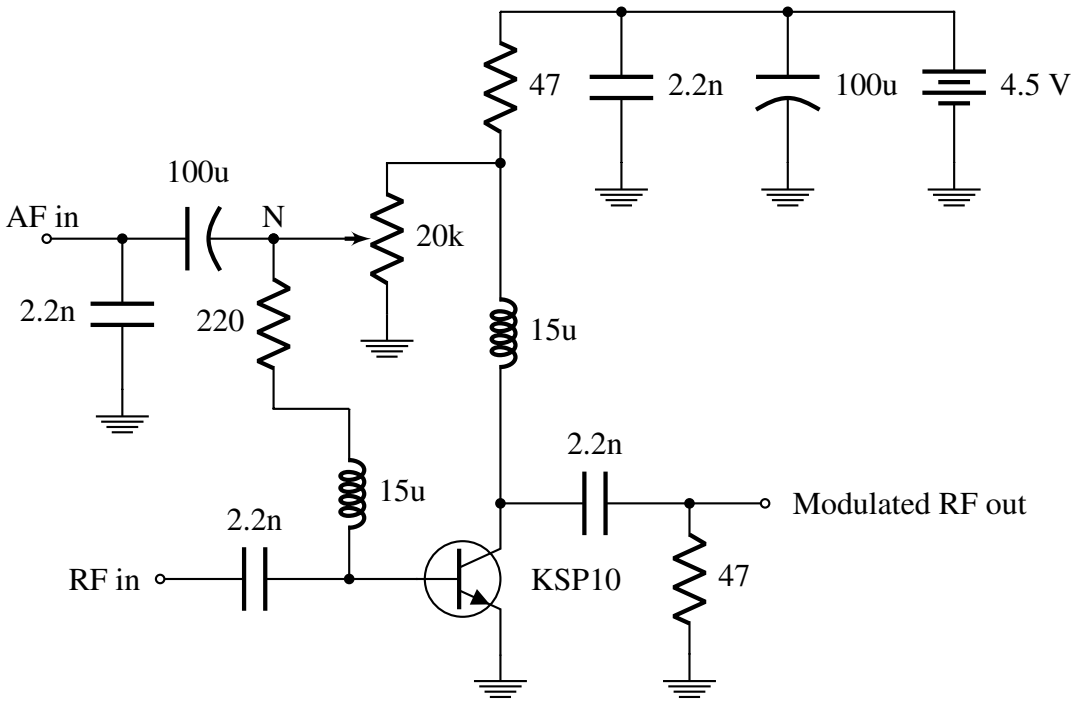

Figure 1: The modulator.

Testing DC operation

You should test at home that DC operation of the modulator is ok.

- Connect +5 V from the myDAQ DC power power supply. Measure the true output voltage that myDAQ produces. It is likely somewhat different from 4.5 V, but close enough for initial DC operation test.

- Check with the multimeter that the transistor gets biased properly: measure the voltage across the upper 47-Ω resistor, and, using Ohm's law, determine the DC current consumption of the modulator. If the DC operation is not satisfactory, see what happens if you turn the potentiometer knob. The current probably changes between zero and about 60 mA. (The transistor will not damage even if the knob is at either extreme, as long as the circuit is correctly constructed.)

- Measure the base-emitter-to voltage V_{be}. Notice how it changes when you adjust the potentiometer from one extreme to the other. The base to emitter voltage probably varies between zero and about 0.9 V.

- Adjust the potentiometer until the DC current consumption is about 4 mA. In case you use a potentiometer with a knob, keep in mind the arrow direction. At this current, the base-to-emitter voltage V_{be} should be close to 0.76 V.

How the modulator works

In the transmitter we generate a *carrier* that is just a sine wave or other periodic signal at 18 MHz. Then we modulate its *amplitude* as we want to vary the amplitude according to an information signal. The instantaneous amplitude or *envelope* of the 18-MHz signal is supposed to be a copy of the information. For more comprehensive discussion, see article Amplitude modulation in Wikipedia.
The potentiometer (Figure 1) allows you to choose the base current I_b and thereby also the collector current I_c, since collector $I_c = \beta I_b$ where β, the DC current gain, is constant; typically $\beta \approx 100 \ldots 120$ for bipolar junction transistors. The voltage gain of the transistor is dependent on the these DC currents. When you turn the potentiometer, you actually adjust the voltage gain. In that sense this circuit is also a "variable-gain amplifier". The gain can be varied by turning the potentiometer knob. In this application you should set the collector current to about 4 mA, because at that current: (1) transistor is operating in active mode (2) the gain is strongly dependent on the current.
The information current that comes form the AF input sums up with the DC current at node N, see Figure 1. The consequence is that both the amplifier gain and the output amplitude will vary according to the information current. Note that the information current is AC. This means that the net current to the transistor base is sinked and sourced at the audio frequency rate, making the gain alternate about the average value.

Table 1: Components needed to construct the modulator

component	value	purpose/description/type	amount
C	2.2 nF	DC block for RF	4
C	100 μF	DC block for AF	2
L	15 μH	RF choke	2
R	47 Ω	for stability	2
R	220 Ω	for stability	1
potentiometer	20 kΩ	for adjusting gain	1
transistor		KSP10	1
connector		SMB	1
breadboard			1
jumper wires			many