Programme: DT080

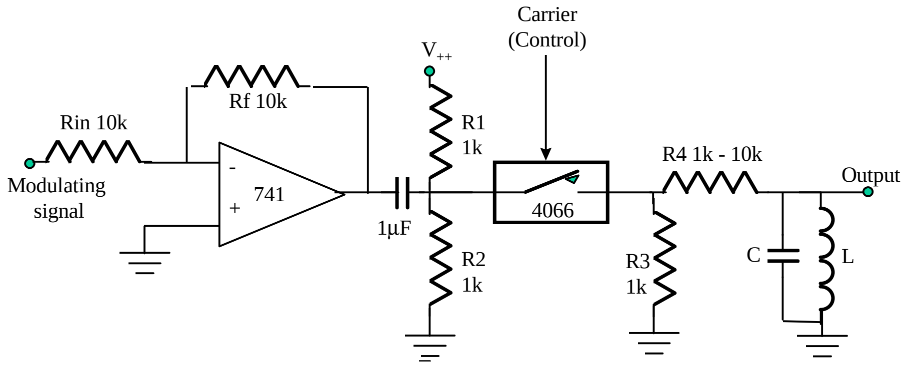
Subject: Analogue & Digital Comms

Laboratory Exercise: Switching Modulator

Purpose: Produce an AM/DSB-SC modulator using switching techniques

Equipment: 4066 quad switch, op-amp, oscilloscope, signal generators, **or** PSpice.

Procedure:



1. The circuit to produce an AM modulator is shown. **Build** this circuit, but leaving out the op-amp at this stage - you can add it in when the rest of the circuit is working correctly.
   Draw the completed circuit
2. **Select and record** a carrier frequency - choose one that is easily handled e.g. around 100to 200 kHz. **Calculate** a value for C and L (a band pass filter) so that f_r (= $1/2\pi\sqrt{LC}$), the resonant frequency matches the selected carrier frequency.
3. Quickly **measure and record** the actual resonant frequency.
   R4, L and C make up a band pass filter. Sweep through a range of frequencies (use sinusoidal signal) into R4 and find, using the oscilloscope, the frequency which gives maximum Output.
   Set the carrier frequency to be the same as the actual resonant frequency.

Double Side Band - Suppressed Carrier

1. Build the circuit, but without R1. Note that the 4066 circuit requires a balanced power supply (+V and -V).
2. Set the modulating signal (baseband signal) to be in the audio frequency range (e.g. in the range 1 to 2kHz) and with an amplitude of a couple of volts.
3. Set the carrier to be a square wave with the frequency as found above.
   Start with a low amplitude carrier and gradually increase to the maximum of the generator output. For each carrier level **note** the signal at the output of the 4066. When the carrier amplitude is sufficient to control the 4066 a switched version of the baseband signal should be seen. It is switched at high frequency and therefore contains harmonics of the switching carrier.
   Record the output waveform from the 4066.
   Using the TiePie software **record** the spectrum of this signal.
   Increasing the level of the carrier has virtually no further effect on the waveform of the 4066 output. **Determine** that this is true.
4. **Record** the final (band pass filtered) output signal, when the 4066 is switching.
   Record the spectrum of this signal. It should contain only those frequencies close to the

carrier frequency. All other frequency components in the switched signal should have been removed - **if** the tuned circuit is resonant at the carrier frequency.

5. **Compare** the baseband signal with the modulated output - **display** both on the oscilloscope. How does the envelope of the latter compare with the baseband signal? Is it what one would expect from a DSB-SC signal.
6. **Examine and record** the spectra of (i) the modulating signal, (ii) the carrier and of (iii) the modulated output.

Full Wave Amplitude Modulation

1. Connect R2 to V_{++} which is a variable DC supply. (Alternatively a fixed DC supply may be used, and a variable potentiometer may be used in place of R1 and R2.) The aim is to add a variable DC offset on to the signal at the input to the 4066.
2. Starting with $V_{++} = 0$ **note** that the final output is that obtained above.
3. As V_{++} is increased **record** the transition from DSB-SC through over-modulated to full wave AM. This last stage is reached when the DC offset exceeds the amplitude of the modulating signal. **Note** the distortion of the envelope when there is over-modulation.
4. At each stage **record** the signals on both the FFT/spectrum analyser and on the oscilloscope i.e. in the **time domain** and in the **frequency domain**.

When everything is working, insert the op-amp at the input stage. Use either the 741 as shown, or use a better amplifier - there are lots of others in the lab. The purpose of the op-amp is to provide buffering between the signal input source (e.g. a microphone) and the modulator/output filter. If you are using a laboratory signal general which can output sufficient current there may be no need for this buffer stage. Check to see if the amp makes any difference to the level of the output signal.