FM - DEMODULATION BY ZX COUNTING

modules:

basic: ***for demodulation*** TWIN PULSE GENERATOR, UTILITIES

basic: ***for generation*** VCO

optional basic: AUDIO OSCILLATOR

preparation

There are several methods of FM demodulation. One method, examined in this experiment, is to derive a train of fixed width rectangular pulses for each positive going excursion through zero amplitude of the FM signal. If this pulse train is integrated, then the output will vary according to the separation in time of the individual pulses. This effectively counts the number of zero crossings ('ZX') per unit time. You will confirm this in the experiment, and show that in fact the integrator output will be a copy of the message.

Figure 1 is a block diagram showing the principle of the arrangement.

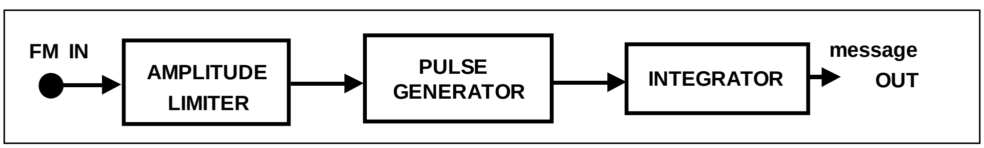

Figure 1: the zero crossing detector

Figure 2 shows an FM signal (upper) and the train of fixed width, rectangular pulses (lower) which would appear at the output of the pulse generator of Figure 1

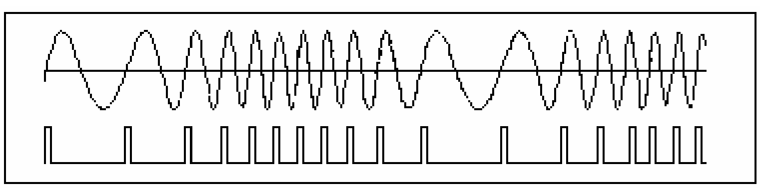

Figure 2: an FM waveform and a related pulse train

The arrangement of Figure 1 will be modelled with a COMPARATOR to detect the positive-going zero crossings of the FM signal. The COMPARATOR output, a TTL signal, is used to clock a TWIN PULSE GENERATOR module, which produces a train of *constant width* output pulses (one for each positive or negative going edge of the TTL signal, depending on how the COMPARATOR is set up). These pulses are integrated by the lowpass filter, to produce the output message.

Other methods of FM demodulation include a phase locked loop (PLL) demodulator, and various arrangements using tuned circuits (once popular, but no longer in these days of miniature, integrated circuit implementations). The PLL is examined in the Lab Sheet entitled ***FM - demodulation by PLL***.

experiment

Test the demodulator by using the output from the generator described in the Lab Sheet entitled ***FM - generation by VCO***. Set up the generator as described there, with a carrier in the vicinity of 100 kHz, and a frequency deviation of 10 kHz. Use the 2 kHz MESSAGE from MASTER SIGNALS, or alternatively the output from an AUDIO OSCILLATOR.

Patch up the demodulator as shown modelled in Figure 3.

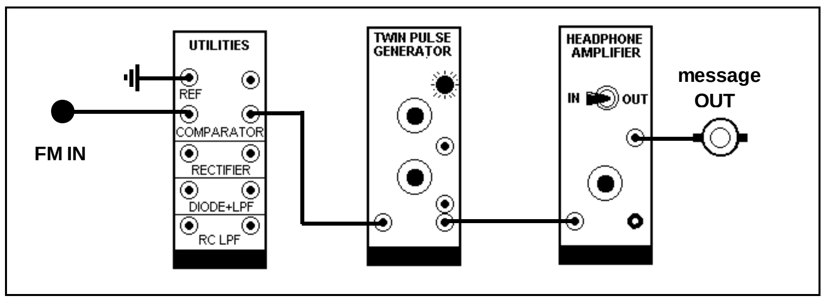

Figure 3: demodulator model

Before plugging in the TWIN PULSE GENERATOR, set the on-board MODE switch SW1 to SINGLE.

Initially use a 100 kHz sinewave as the input to the demodulator. Use this signal to synchronize the oscilloscope. Observe the pulse train at the output of the COMPARATOR, confirming it is a TTL format.

On the second channel of the oscilloscope observe the output from the TWIN PULSE GENERATOR. Set the pulse width to be less than the period of the 100 kHz signal. How much less ?

Look at the output from the LPF of the HEADPHONE AMPLIFIER. This will be a DC voltage. Confirm that its magnitude is proportional to the width of the pulses. Is the output dependent upon the filter bandwidth ? Explain.

Now replace the 100kHz sinewave with the output of the FM generator.

The highest frequency in the message will be determined by the bandwidth of the LPF in the HEADPHONE AMPLIFIER, which is 3 kHz.

Confirm that there is an output from the LPF which matches the frequency and waveform of the message.

Measure the sensitivity of your demodulator - that is, the relationship between the demodulator message output amplitude and the frequency deviation at the transmitter.

From a knowledge of the parameters of your demodulator, and the those of the input FM signal, calculate the expected sensitivity, and compare with measurements.