

BPSK - MODULATION

modules

basic: MULTIPLIER, SEQUENCE GENERATOR

optional basic: TUNEABLE LPF

optional advanced: LINE-CODE ENCODER, 100kHz CHANNEL FILTERS

preparation

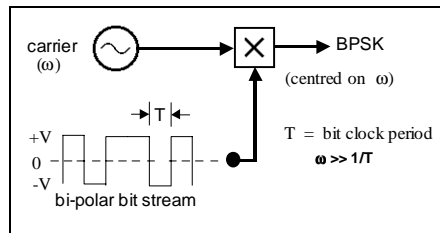


Figure 1: generation of BPSK

Consider a sinusoidal carrier. If it is modulated by a bi-polar bit stream according to the scheme illustrated in Figure 1, its polarity will be reversed every time the bit stream changes polarity.

This, for a sinewave, is equivalent to a phase reversal (shift). The multiplier output is a BPSK¹ signal.

The information about the bit stream is contained in the changes of phase of the transmitted signal. A synchronous demodulator would be sensitive to these phase reversals.

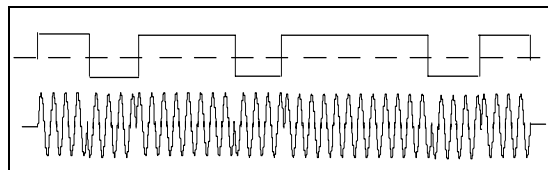


Figure 2: a BPSK signal

A snap-shot of a BPSK signal in the time domain is shown in Figure 2 (lower trace).

The upper trace is the binary message sequence.

There is something special about the waveform of Figure 2.

The wave shape is 'symmetrical' at each phase transition. This is because the bit rate is a sub-multiple of the carrier frequency $\omega/(2\pi)$. In addition, the message transitions have been timed to occur at a zero-crossing of the carrier.

Whilst this is referred to as 'special', it is not uncommon in practice. It offers the advantage of simplifying the bit clock recovery from a received signal. Once the carrier has been acquired then the bit clock can be derived by division.

But what does it do to the bandwidth ?

bandlimiting

The basic BPSK generated by the simplified arrangement illustrated in Figure 1 will have a bandwidth in excess of that considered acceptable for efficient communications. Bandlimiting can be performed either at baseband or at carrier frequency.

¹ also sometimes called PRK - phase reversal keying.

demodulation

Demodulation of this signal is possible with a demodulator of the synchronous, product-type. But there will be a phase ambiguity between the sent and received signals. One way of overcoming this is to use a digital line code which is impervious to phase ambiguity - this is *differential* phase shift keying (DPSK).

These effects are examined in the Lab Sheet entitled *BPSK - demodulation*.

experiment

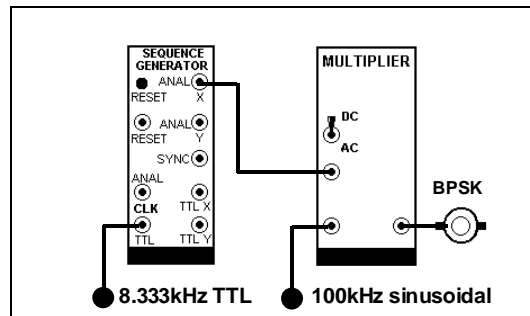


Figure 3: model of Figure 1

To overcome the phase ambiguity at the receiver line coding can be instituted. This is shown modelled in Figure 4.

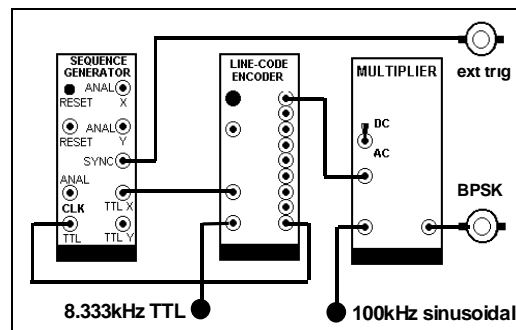


Figure 4: BPSK generator with line coding

Figure 3 shows a model of the block diagram of Figure 1.

The bit clock is here a sub-multiple of the carrier (1/12), so the phase reversals should be clearly visible when the BPSK is viewed in the time domain.

A lower (synchronous) bit rate is possible by clocking the SEQUENCE GENERATOR with the '2 kHz' message from MASTER SIGNALS.

This should be implemented at the transmitter when attempting to demodulate with the demodulator examined in the Lab Sheet entitled *BPSK - demodulation*. Select different line codes to determine which is insensitive to phase reversals.

Note that the bit rate is a sub-multiple (1/48) of the carrier frequency. The 8.333 kHz 'master clock' has been divided by four by the LINE-CODE ENCODER before being used to clock the SEQUENCE GENERATOR.

bandwidth

Use the PICO SPECTRUM ANALYSER to measure the bandwidth of the BPSK signal, and compare it with that of the message sequence alone. Where could band limiting be introduced? Do the different line codes have different bandwidths?

Band limiting can be implemented with a TUNEABLE LPF at baseband, or a 100 kHz CHANNEL FILTERS module at carrier frequency.