QPSK - GENERATION

modules

basic: ADDER, 2 x MULTIPLIER, SEQUENCE GENERATOR

optional advanced: 100kHz CHANNEL FILTERS

preparation

Consider the block diagram of Figure 1. It is a modulator.

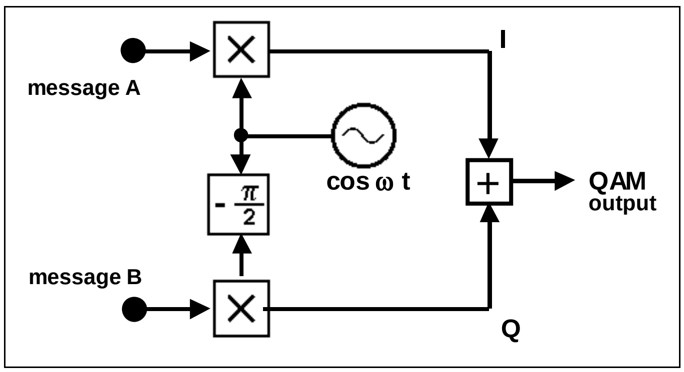

Figure 1: a quadrature modulator

There are two messages, A and B. Whilst these are typically independent when they are analog, it is common practice for them to be intimately related for the case of digital messages. In the former case the modulator is often called a quadrature amplitude modulator (QAM), whereas in the latter it is generally called a quadrature phase shift keyed (QPSK) modulator.

This Lab Sheet investigates a digital application of the modulator.

Whilst the two messages are typically intimately related, having come from a single data stream which has been split into two, *for the purpose of demonstration* (of both generation, and later demodulation) these two messages can be independent. In this experiment *they will be* independent.

See other Lab Sheets for more realistic realizations.

experiment

Figure 2 shows a model of the block diagram of Figure 1. The quadrature carriers come from the MASTER SIGNALS module. Note that these do not need to be in *precise* quadrature relationship; errors of a few degrees make negligible difference to the performance of the system as a whole - transmitter, channel, and receiver. It is at the demodulator that precision is required - here it is necessary that the local carriers match *exactly* the phase difference at the transmitter. This required phase exactitude can be automated, or, as in the Lab Sheet entitled ***QPSK - demodulation***, is adjusted manually.

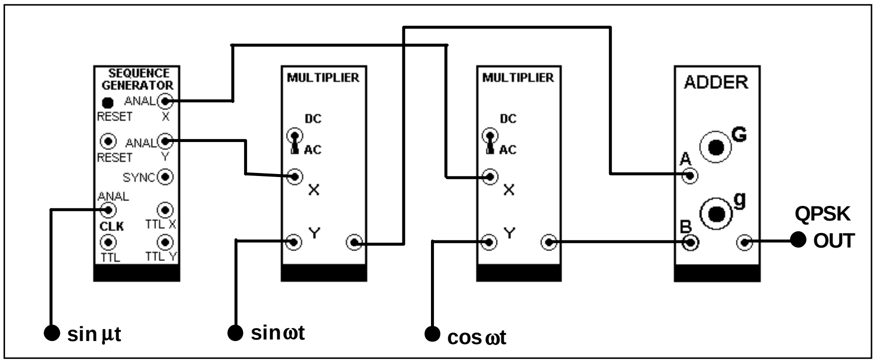

Figure 2: QPSK generation - the model of Figure 1

The two independent binary message sequences (PRBS) X and Y, sharing a common bit clock (2.083 kHz), are available from a *single* SEQUENCE GENERATOR module. Select *short* sequences (both toggles of the on-board switch SW2 UP). Note that the bi-polar outputs are taken from the SEQUENCE GENERATOR modules; these are of an amplitude suitable for the analog MULTIPLIER modules. It is the fact that these are bi-polar that results in each of the MULTIPLIER outputs being phase shift keyed (PSK) signals.

Once the model is patched up the only adjustment is that of ensuring that the 'I' and 'Q' signals appear in equal proportions at the output of the ADDER. This is done by connecting them separately to their respective inputs to the ADDER, and adjusting to a common output amplitude. The sum amplitude should be at the TIMS ANALOG REFERENCE LEVEL of 4 volt peak-to-peak, to suit other analog modules which will follow in later experiments.

Knowing the amplitude of each output separately, what will their sum be?

What does the QPSK signal look like in the time domain? To what signal will the oscilloscope be triggered? It will help to use short sequences (at least initially). Think about it in advance.

To give yourself confidence in the model, once aligned, it is instructive to replace both sequences from the SEQUENCE GENERATOR with the 2kHz message from MASTER SIGNALS. This is no longer a QPSK generator, but it does display some familiar waveforms.

Lowpass filter bandlimiting and pulse shaping of each sequence is not a subject of enquiry in this experiment. To restrict the bandwidth of the QPSK signal a single bandpass filter at the ADDER (summer) output will suffice. A 100 kHz CHANNEL FILTERS module (filter #3) would be suitable.

signal constellation

Set the oscilloscope into its X-Y mode and connect the two sequences X and Y to the X and Y oscilloscope inputs. With equal gains in each oscilloscope channel there will be a display of four points. This is referred to as a *signal constellation.* See your text book, as well as the Lab Sheet entitled ***Signal constellations***.

comment

The single data stream from which the X and Y sequences are considered to have been derived would have been at a rate of twice the SEQUENCE GENERATOR clock - namely 4.167 kHz. Put another way, the two data streams obtained by splitting the input data stream are at *half* the original data rate. This is significant !