UNDERSTANDING PCM FOR MODEL RADIO CONTROL

A Series of articles on the new technology relating to modellers'

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THE PURPOSE of this series of articles is to explain *Pulse Code Modulation* (PCM) in a manner that will be fully understood by most modellers, resulting in a basic understanding of this relatively new technology and its application to our hobby. Some technical authors seem to delight in impressing us with their grasp of the subject rather than imparting information in an easily understood manner. Any reader who loses interest and does not read the whole series, will only prove that I have also joined this misguided band of unfortunates.

There would be no point in explaining PCM until we grasp the basics of our existing proportional system therefore we shall use this as our starting point.

Pulse Width Systems (PWS)

This is the correct terminology for the digital proportional systems that we have learned to love, be it AM or FM (what's AM and FM? – I shall explain that also.)

Lets take the throttle stick on the transmitter and move it from one extreme position to the other ie from low throttle to high throttle. We notice that the throttle servo output arm moves in sympathy with the throttle stick from one end of its travel to the other and ceased moving when the throttle stick became stationary. They would have burnt you at the stake for that in the middle ages and it would also have been considered magical by modellers 35 years ago.

It can be seen from fig 1 that the throttle stick is attached to a potentiometer or variable resistor and when we move the stick we alter the value of its resistance to the Pulse Generator connected to it. The purpose of the Pulse Generator (as its name implies) is to produce square waves who's width is varied by the potentiometer when we move the stick.

The width of the square wave is measured in thosandths of a second and are called milliseconds abbreviated to mS. When the stick was at maximum throttle the pulse generator produced a square wave of 2mS. At minimum throttle it was 1mS, so obviously it was 1.5mS at mid-throttle. This pulse was sent via the transmitter and receiver to the servo.

The servo has its own pulse generator and it compares the incoming pulse to its own to produce an error signal.

If the incoming pulse was wider it would move clockwise until the error signal was cancelled. Similarly if it was smaller it would move anticlockwise for cancellation. If by chance the incoming pulse was exactly the same as the servo's pulse then the servo would remain stationary.

How is the error signal cancelled? – simple, there is a small potentiometer inside the servo connected to the servo pulse generator with its wiper attached to the gear train and output arm. When the servo moves, the wiper on the potentiometer moves, changing the width of the pulse generator until it is the same as the incoming signal, when this point is reached no signal error is produced and the servo stops. When the transmitter stick is moved again, a new error signal is produced and the whole process is repeated.

When we have more than one pulse, in this case four, the pulses from the stick units must be directed to the right servo ie the throttle stick operates the throttle servo only etc.

When, in this particular example the fourth pulse has been produced it is necessary to reset both the transmitter and receiver so that the system remains synchronised. This is achieved by transmitting a long reset pulse or pause after the fourth pulse.

The above criteria is achieved by using a counter, analogue gates and a multiplexer. Referring to fig 2 let the output from stage 1 of the counter be positive and all the other outputs 2-7 be at zero. The positive voltage will open the analogue switch A1 allowing the signal from the pulse generator PG1 to pass through to the multiplexer to the RF module to be transmitted.

When the next clock pulse arrives the output of stage 2 will go positive and all the other outputs 1, 3-7 will go or remain at zero. Analogue switch A1, A3 and A4 will be closed and A2 opened allowing the output from PG2 to pass through to the RF module. This procedure repeats to open A3 then A4 allowing all the pulses to pass through in succession (serially).

In order to produce a large reset pulse stages 5, 6 and 7 are then triggered. During this period A1-A4 are closed and therefore no signals reach the RF module, producing a large pause or reset pulse. After stage 7 the whole cycle is repeated to produce a string of four separate pulses whose individual widths are determined by the value of their respective potentiometers (attached to their associated stick units) followed by a long reset pulse.

The purpose of the multiplexer is to give electrical isolation between the analogue gates.

One single integrated circuit, for example the NE5044 could contain the necessary logic to perform the switching functions just described.

The RF module could be of an AM or FM type depending on which form of modulation was required.

If you wished to communicate with somebody alongside you, you would naturally talk to that person. If the distance between you increased it would be necessary to raise your voice until eventually you were shouting. At this stage you might notice that a sharp whistle carried a further distance than your shout. The whistle being at a higher frequency than speech apparently travelled a greater distance. Taking this line of argument, if we used much higher frequencies to carry our voices we could communicate farther and this is precisely what is done in radio transmission.

With model radio control in the UK the pulses of information for the servos are mixed (modulated) with a 27MHz or 35MHz frequency in order to transmit these signals to the receiver.

At present we can use two techniques *Amplitude Modulation (AM)* or *Frequency Modulation (FM)*. In AM we use the 35MHz to carry the pulses of information from the transmitter to the receiver. You will notice in fig 3 the presence of the carrier frequency where there are pulses and the absence of the carrier when there are no pulses.

In FM we transmit a frequency all the time, except that the frequency transmitted for the duration of the pulses is slightly different to the frequency transmitted indicating their absence. For example the frequency could be 35.100MHz (CH70) during the pulses and 35.098MHz with no pulses giving a frequency shift between the two of (35.100-35.096) = 0.004MHz or 4.0KHz. The receiver detects the difference between these frequencies and the required pulse information is decoded as previously described and then passed to the servos.

To be continued in Issue 4.

Fig 1

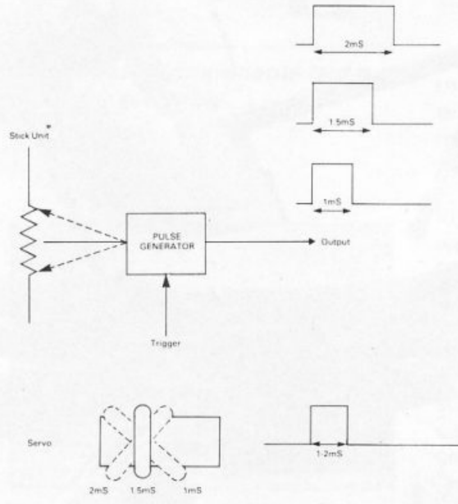

Fig 2

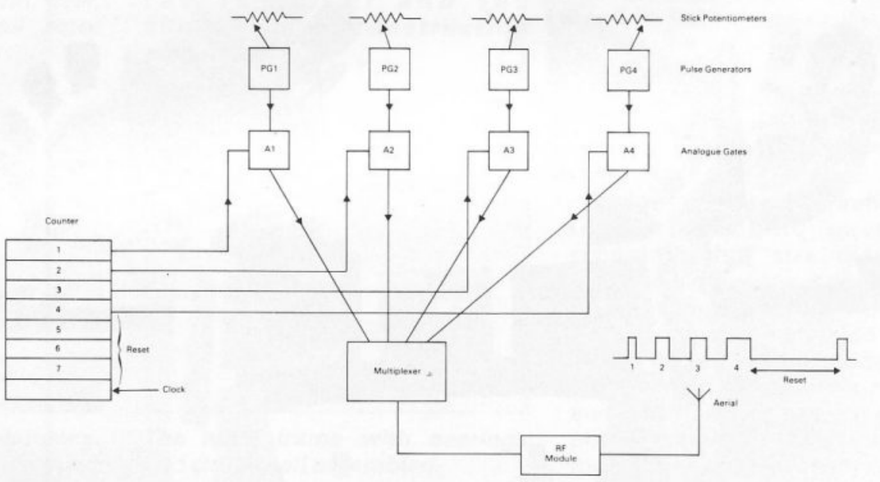

Fig 3