Lab Notes

Remote control systems

Multi-channel remote control systems have many applications outside the radio control of models. Here, our correspondent illustrates a number of circuits that readers may find useful — all using commonly available components.

Ray Marston

SIMULTANEOUS multi-channel remote control systems, giving either fully proportional or simple on/off action (or a combination of the two) are widely used by the model plane, boat and car fraternities. Figure 1 shows the basic block diagram of an 8-channel version of the type of system in use.

In the transmitter, eight manually actuated pots (in a proportional system) or switches (in an on/off system) are sequentially sampled at a fixed rate by an encoder circuit, which at each sample point generates a pulse with a width proportional to the state of the device being tested. The output of the encoder consists of a repeating series of 'frames' of eight width-controlled pulses followed by a synchronisation pulse, all presented in serial form.

Typically, in an 8-channel proportional system, the width of the controlled pulses may be variable from 0.5 ms to 1.5 ms (depending on the settings of individual control pots), the sync pulse width may be 3 ms, the sample period 2 ms and the frame width 20 ms.

Servo code

The serial output of the encoder is coupled via a suitable 'link' to the input of a decoder circuit that is located in the remote receiver. The link may take the simple form of two wires (or only one if a ground return is used), or the more complex form of a modulated radio, ultrasonic, infrared, or magnetic signal, etc. The decoder circuit detects the sync pulse in each frame, and then counts the individual controlled pulses in the frame and routes each one to its own output terminal. There it may be fed to an electronic switch or a servo-mechanism which will reconstruct the original mechanical control movement that took place at the transmitter.

The 'heart' of the remote control system described above is the encoder and decoder. As already mentioned, the actual 'link' can take any one of a variety of forms. The basic control system is highly versatile and has a vast number of untapped potential applications. The number of channels that can be simultaneously controlled can range from two to dozens (or even hundreds). In on/off applications, the outputs can easily be binary decoded to give non-simultaneous on/off control of a vast number of remote devices: an 8-channel system can, for example, control 256 devices, or a 12-channel system can control 4096.

The system can readily be adapted to give remote operation of lamp dimmers, volume controls, 'combination' locks and garage doors, or independent on/off control of hundreds of household fittings via signals pumped down the mains wiring. You can even, if it takes your fancy, use the system to remote control a full-sized piano from the comfort of an armchair via a hand-held keyboard and an infrared link!

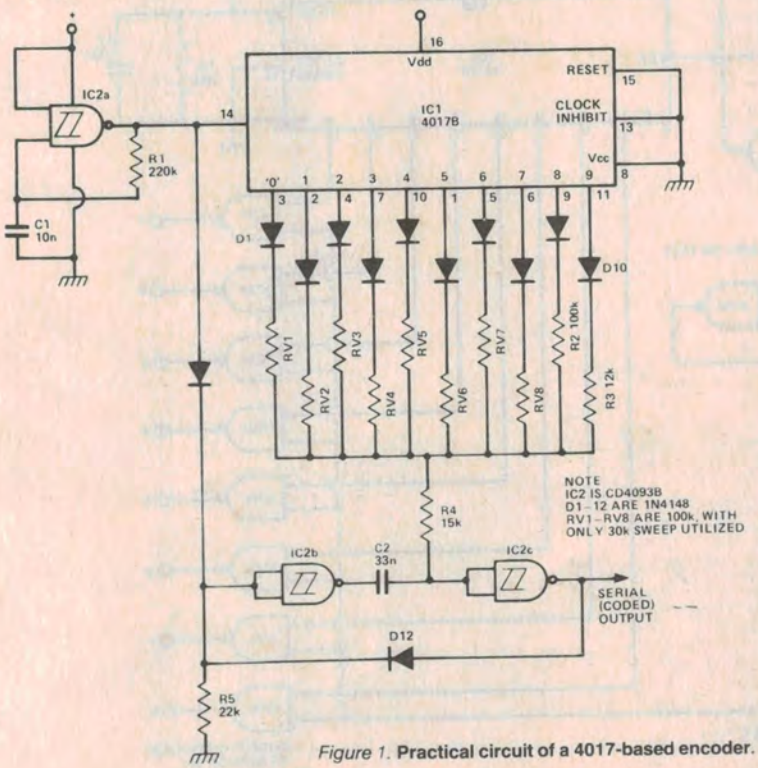

Figure 1. **Practical circuit of a 4017-based encoder.**

An 8-channel proportional control encoder

Figure 1 shows the practical circuit of a 4017-based 8-channel encoder for use in simultaneous control systems. IC2a is a 500 Hz (2 ms) astable multivibrator that simultaneously feeds clock signals ▶

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to the input of the 4017 and trigger signals to the input of the IC2b-IC2c monostable multivibrator. In any given clock cycle, the period of the monostable is determined by C2-R4 and by the resistance value in series with the relevant 'high' output of the 4017. In clock cycles '0' to '7' the pulse widths are determined by the settings of RV1 to RV8 respectively. In the '8' clock cycle the pulse has a width equal to the clock cycle period (2 ms), and in the '9' clock cycle the pulse is fixed at about 1 ms, thus giving a composite 3 ms sync pulse from the eighth and ninth cycles. The system is designed to give a fixed 20 ms frame width.

Note that, in conformance with normal practice, only one third (or less) of the sweep ranges of RV1 to RV8 are utilised. In practice, component values may have to be altered slightly to give precise ranges of coded output pulse widths.

An 8-channel proportional control decoder

Figure 2 shows the circuit of a decoder for use with the above system. The incoming 'coded' waveform is fed simultaneously to the clock terminal of the 4017 and to the trigger terminal (via C1-R1-D1) of the IC2c-IC2d monostable. IC2c of this monostable produces a negative-going pulse with a period slightly less than the 2 ms clock period (about 1.8 ms), and this negative pulse is ANDed with the positive clock signal by IC2a and IC2b to produce a reset output signal from the 3 ms input sync pulse, but not from the 'control' pulses, which all have periods significantly less than the 1.8 ms reference value.

Note that the value of R3 may have to be adjusted on test to set the correct reference period.

Outputs 1 to 8 of the 4017 are sequentially ANDed with the coded clock input signal once the counter has been reset by the sync pulse, so that each individual code pulse is routed to its own designated output terminal or channel. The individual outputs, which take the form of 0.5 ms to 1.5 ms pulses with repetition periods of 20 ms, can then be fed to suitable servos, etc, to convert the pulses into proportional mechanical movements.

An 8-channel simultaneous on/off encoder

Multi-channel simultaneous on/off coder/decoder systems are technically no easier to implement than full proportional systems. In fact they are often more difficult. Figure 3 shows a practical example of a simultaneous 8-channel on/off control encoder.

Here, astable multivibrator IC2a simultaneously feeds 500 Hz clock signals to the 4017, to the IC3a-IC3b 200 μs monostable multi, and to one input terminal of the IC2b-IC2c AND gate. The other input of the AND gate is sequentially taken from the '0' to '7' outputs of the 4017 via any of the PB0 to PB7 switches that are closed, and directly from the '9' output. The outputs of the AND gate and the 200 μs monostable, plus the direct '8' output of the 4017, are all ORed to produce the final serial coded output across R4.

The final output waveform comprises 200 μs pulses and 1 ms pulses to represent off and on switch states respectively, plus a 3 ms sync pulse spanning the eighth and ninth clock cycles.

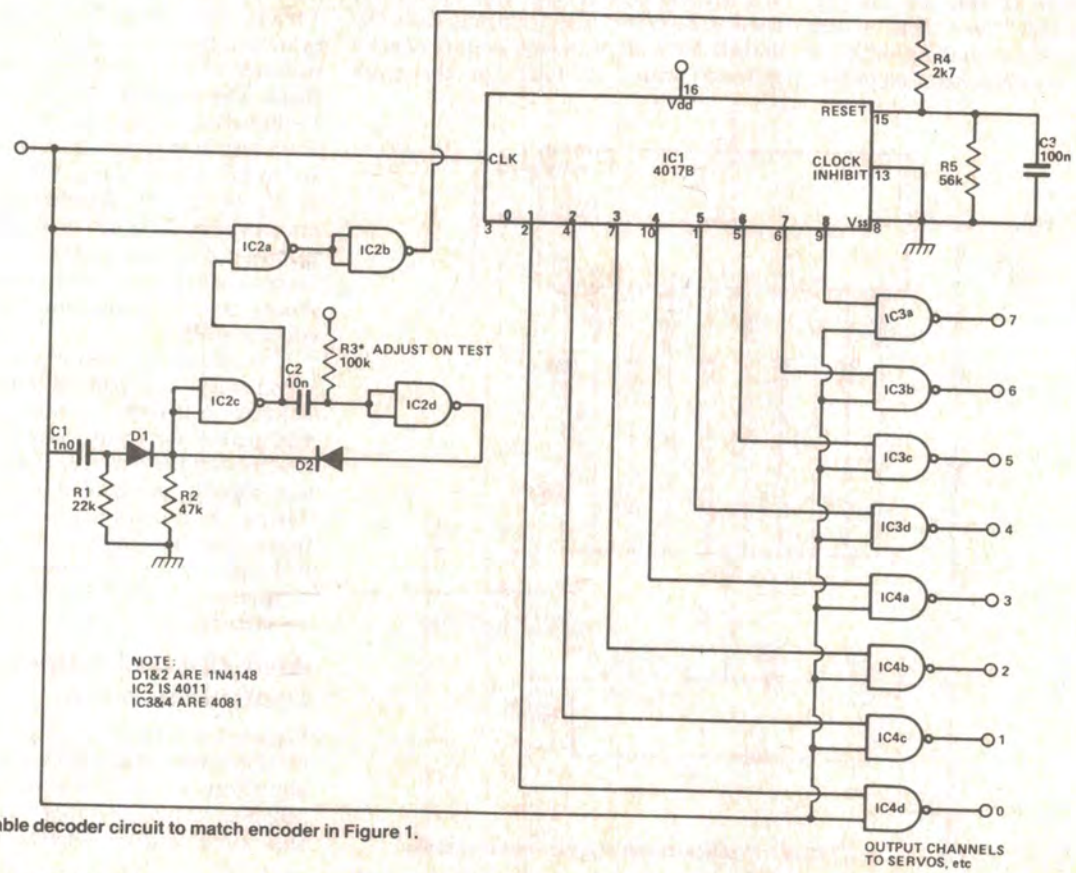

Figure 2. **Suitable decoder circuit to match encoder in Figure 1.**

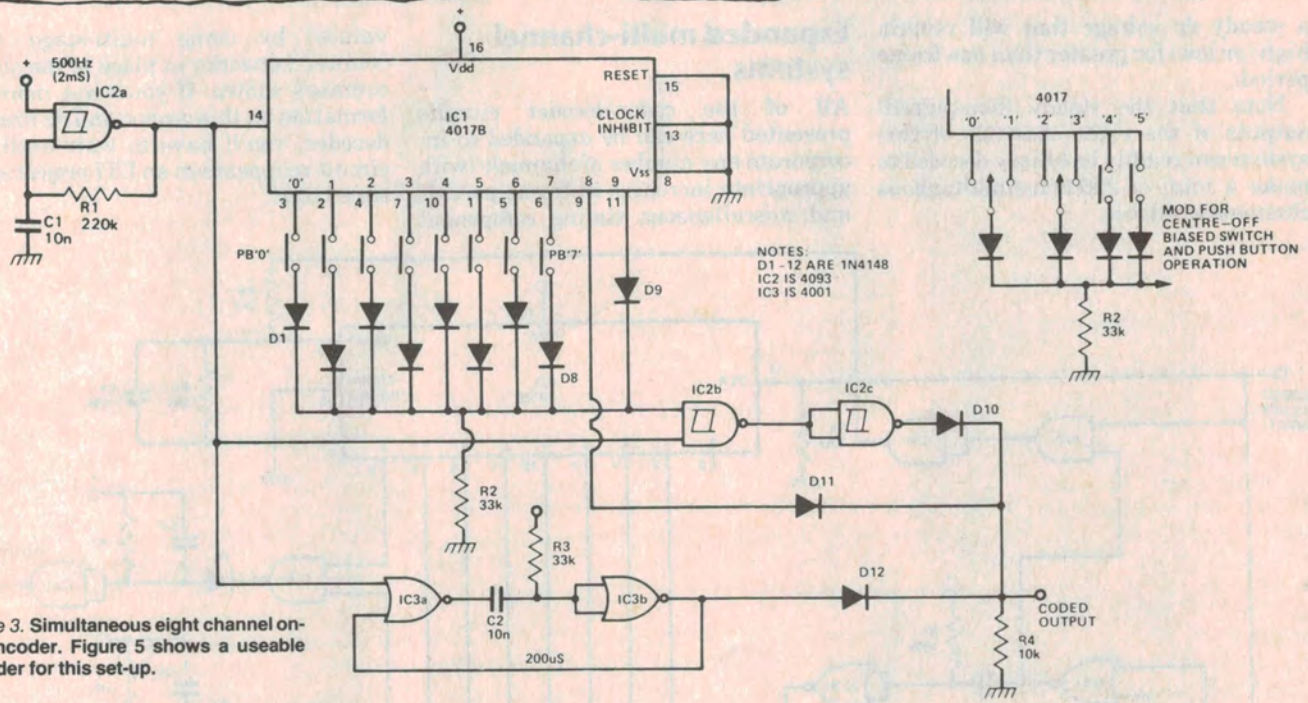

Figure 3. **Simultaneous eight channel on-off encoder. Figure 5 shows a useable decoder for this set-up.**

An 8-channel simultaneous on/off decoder

Figure 5 shows a decoder circuit that is suitable for use with the above encoder. Here, the IC3a-IC3b-IC2a-IC2b network detects the input sync pulse and then resets the counter, and the IC3c-IC3d-IC2c-IC2d network detects 'wide' (1 ms) or 'on' code pulses and then ANDs the selected output of the 4017 via the IC4-IC7 array to produce a high potential on the appropriate output channel. Note that the purpose of the D-R-C network in each output channel is to convert a detected 'wide' pulse into ▶

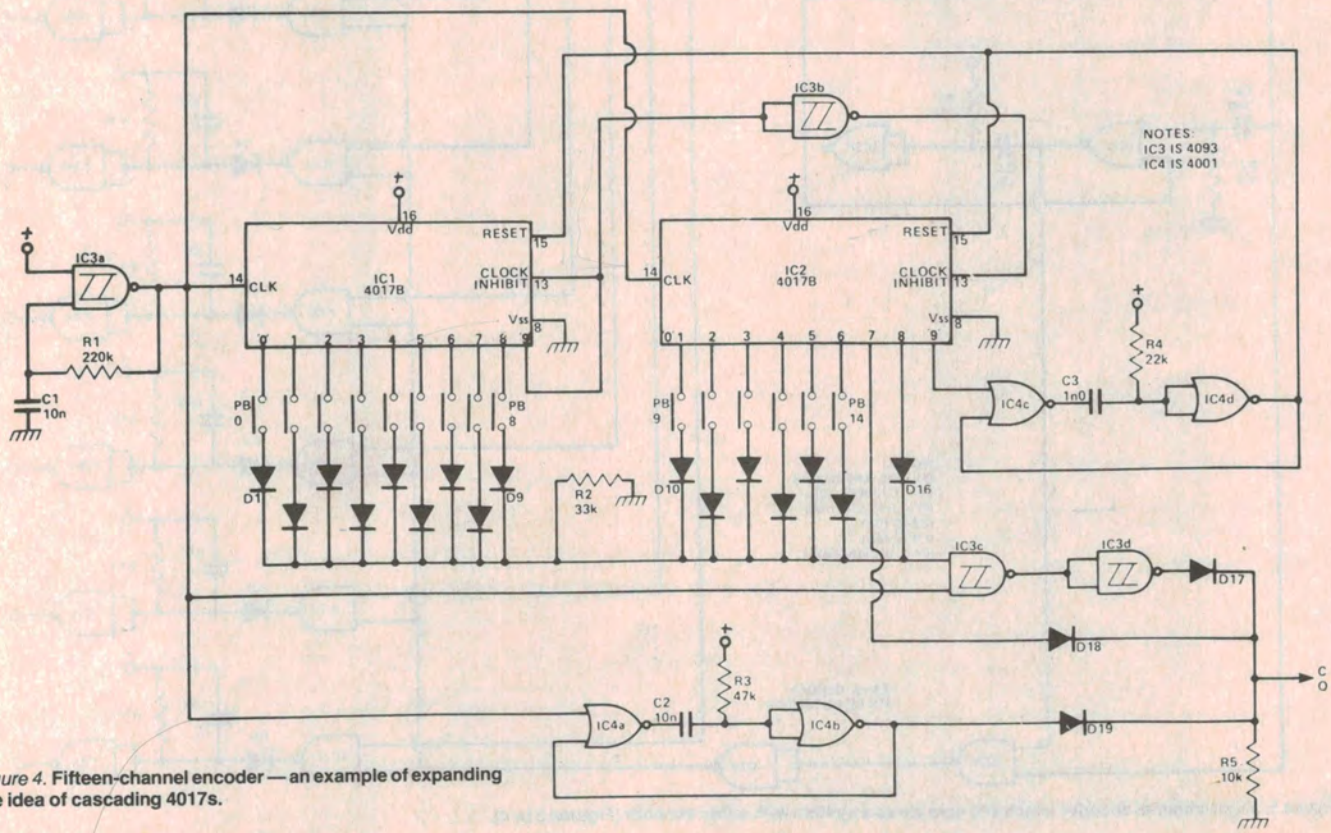

Figure 4. **Fifteen-channel encoder — an example of expanding the idea of cascading 4017s.**

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a steady dc voltage that will remain high (or low) for greater than one frame period.

Note that the steady (non-pulsed) outputs of the eight channels of this system can readily be binary decoded to make a total of 256 non-simultaneous channels available.

Expanded multi-channel systems

All of the coder/decoder circuits presented here can be expanded to incorporate any number of channels (with appropriate increases in frame periods and miscellaneous timing component values) by using multi-stage 4017 counter networks in place of the single counters shown. If you want more information on this circuit and its brother decoder, you'll have to wait until the circuit reappears in an ETI project some time later!

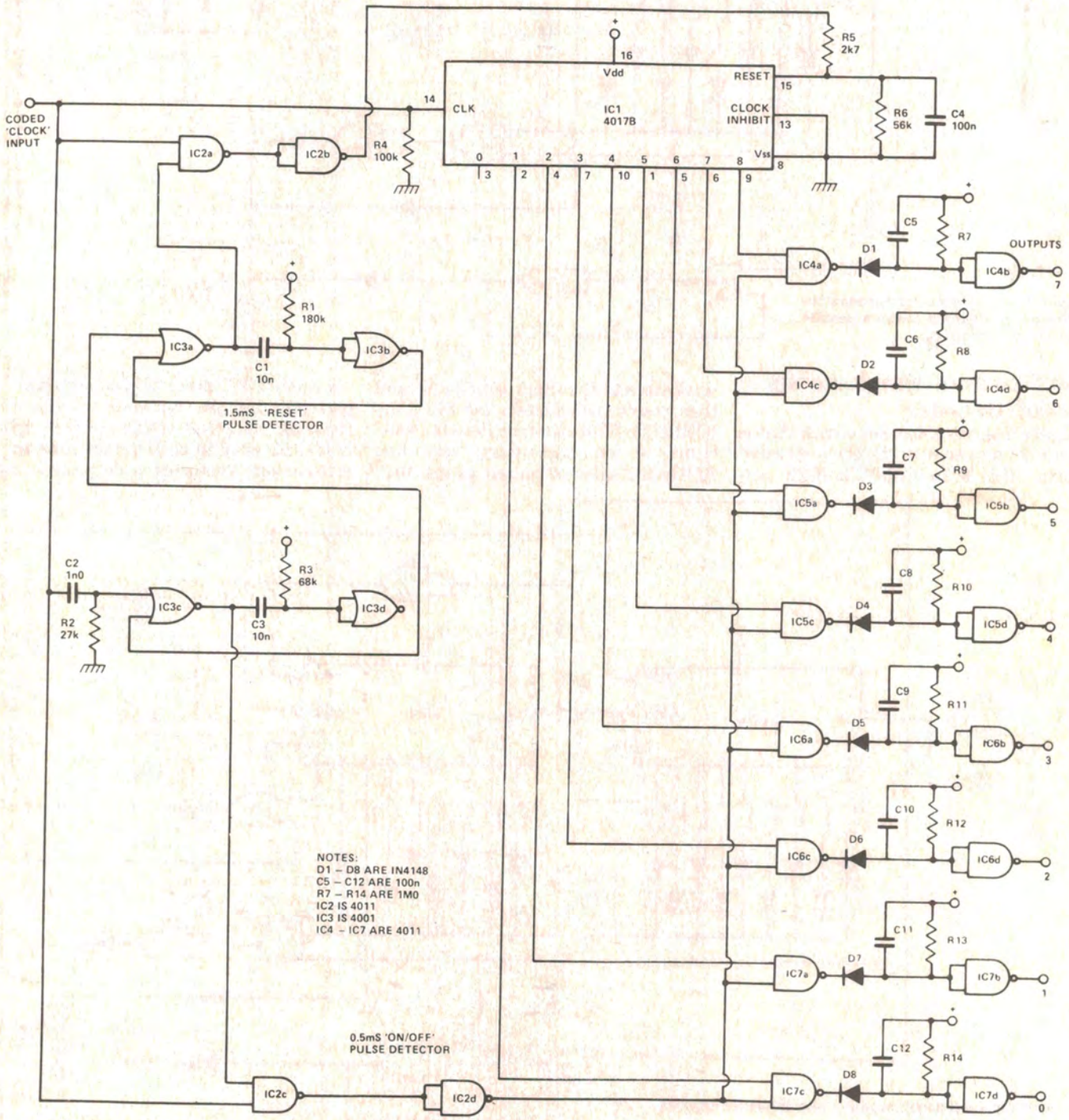

Figure 5. **Eight-channel decoder which will operate as a system with either encoder (Figures 3 or 4).**