A stepping motor drive

Digital control and position indicator for 2000 revolutions

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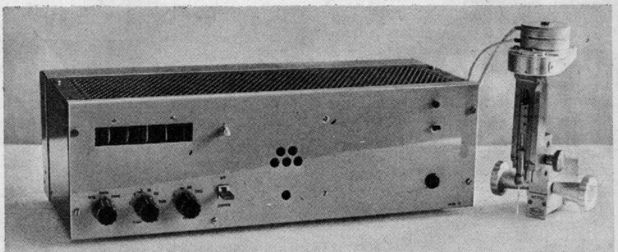
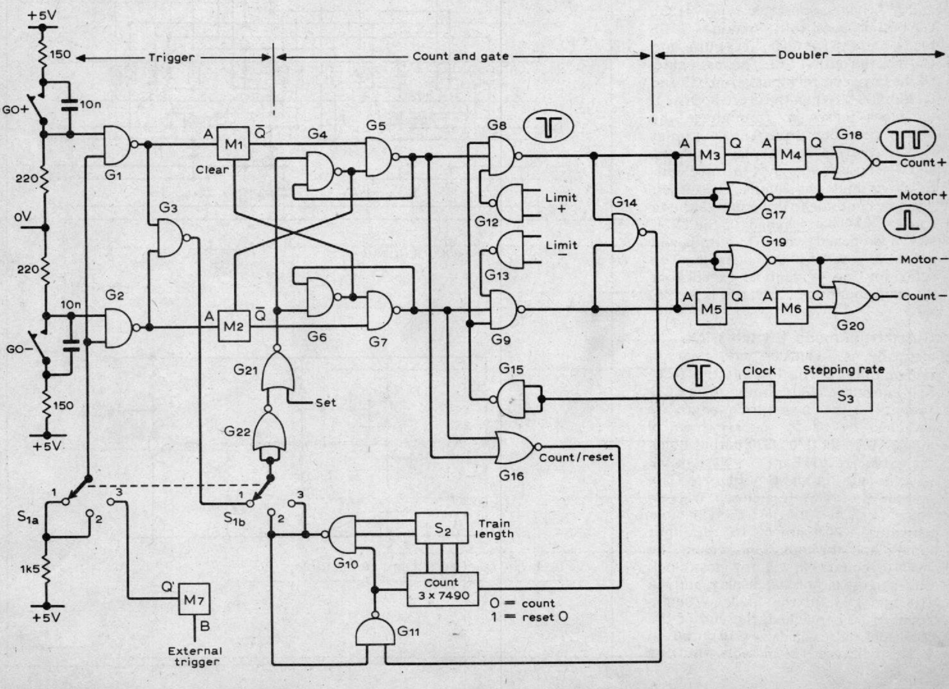
The appearance of the stepping motor has solved a number of problems in the control of both rotational and linear movement, previously the province of the D.C. motor and servo-system.

A typical motor (Impex series ID.07) has four stator coils and twelve pairs of rotor poles, and so can take up 48 distinct positions in one revolution. When the stator coils are energised in the correct sequence, the rotor can be made to move from one stable position to the next (7½° in either direction), at rates of over 1000 steps/s. The ener-



The motor mounted in the drive assembly. This was used for the accurate positioning of micro-electrodes in neurophysiological research.

Fig. 1. The gating circuit



gising waveforms can be provided electronically, or by mechanical switching.

The system described can be used for the general control of such a motor, the five digit readout indicating its position for more than 2000 revolutions. Limits can be chosen so that the motor will not overrun a chosen count in either direction, and the motor can be run continously, or in gated 'trains' of steps from 1 to 999, the stepping rate itself being variable up to 200 steps/second.

Our specific requirement was to drive an electrode along a 25mm track, and know its position to an accuracy of 2μm, and my thanks are due to Mr Lionel Gale for developing the gearbox which achieved this.

The photograph shows the motor mounted on the drive assembly. By driving a micrometer leadscrew of 0.5mm pitch, through a 125:24 anti-backlash gear-train, a movement of 2μm/s along the leadscrew is produced.

Fig. 1 shows the gating circuit. Consider the action for driving forward (Go+). The bistable G4G5, at 'ready', has its two inputs at logical 1, and its output at 0. A '0' pulse on the G5 input will cause the output to go to 1, and hold itself there until a 0 pulse into G4 resets the output to 0.

Continuous mode. Switch 1 position 1.

When the Go+ switch is closed, a 1 → 0 transition is applied to the inputs of G3 and M1 (half monostable type 74123). G3 output goes to 1, making G4G5 ready, and the M1 (200 μs) Q pulse into G5, flips the output to 1. The main gate, G8, has two control inputs, from G5 and G12(limit +). When these are both at 1, the clock pulses go through to the display and motor drive. The limit input is derived from the display counters, and we chose 24,000 since the mechanical drive limit was 25mm. The circuit will now continue to drive until either a count of 24,000 is reached, or the Go+ switch is opened, when G3 output will go to 0, resetting the bistable. The action for Go— is identical, except that the limit, counting backwards, is 99,998.

Gated train mode. Switch 1/2.

Normally, as G5 and G7 outputs are 0, G16 output is 1. This is fed to the 'reset to 0' line of the 7490 counters. The BCD outputs for the chosen train length are switched by S2 to the G10 control inputs. At 'reset to 0', G10 output holds the bistable ready. For Go+ 50 steps, S2 feeds decade 2 A and C outputs to G10, and the Go+ switch is closed, triggering M1. This toggles the bistable, activating G8 (subject to the limit input), and through G16, setting the 7490s to 'count'. G8 will now pass clock pulses to the motor and display, and via G14 and G11, to the 7490s. When a count of 50 is reached, the end of the 50th clock pulse will drive G10 output to 0. This will reset the bistable, shutting

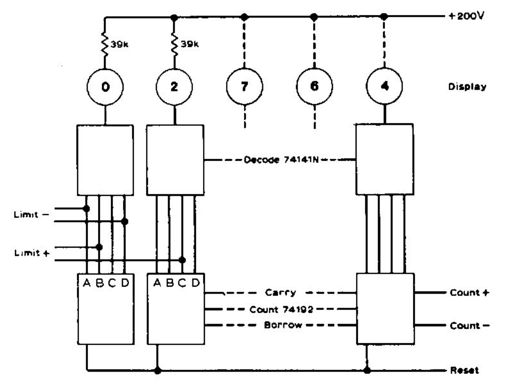


Fig. 2. The count / display unit

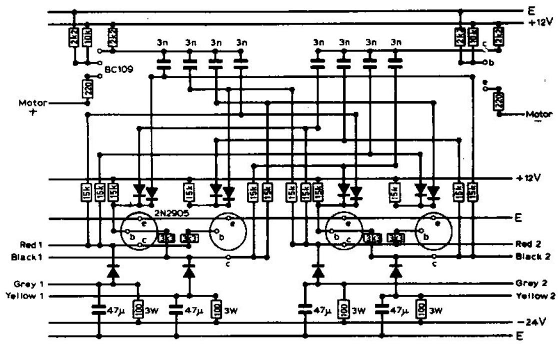


Fig. 3. The Veroboard layout

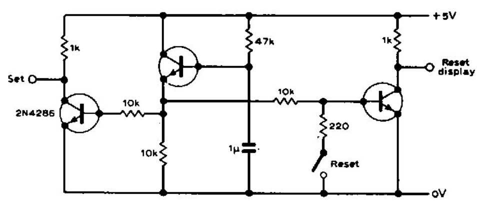


Fig. 4. The reset-zero delay monostable

$\overline{G8}$, G16 goes to 1, resetting the 7490s to 0, G10 to 1, and the bistable to the 'ready' state. During the train of pulses, M1 and M2 are cross-inhibited, disabling the Go + Go- switches.

External trigger mode. Switch 1/3.

In this mode, the gating and counting system is the same, but the trigger is derived from M7. A positive going pulse from an external source, applied to the B input of M7, feeds a Q pulse (200μs) into the common input of G1 and G2. If the Go+ switch is closed, this pulse passes through G1, and triggers M1, initiating a train.

Pulse doubler

M3 M4 and M5 M6 are 74123 monostables, M3 and M5 set to 1ms duration, and M4 and M6 to 200μs. For each input pulse, two output pulses are produced, separated by 800μs. These are fed to the count/display unit, which consists of five decades of up/down counters, decoders and Nixie indicators (Fig. 2). The display progresses by two counts per motor step, and indicates displacement in microns.

Clock generator

A 555 type timer is used in the astable mode, to produce 200μs pulses. The device works reliably on a 5V supply, and S3 switches the rate between 2 and 200 pps.

Motor drive

The motor pulses from the gating unit trigger a conventional drive circuit of two bistables with diode steering to effect forward/reverse rotation of the motor. Fig. 3 shows the vero-board layout for driving the Impex type ID.07. Drive units are available commercially to suit the motor used from Impex Electrical Ltd, Market Road, Richmond, Surrey.

In general

When switching the instrument 'on', it is necessary to reset the display to zero. This is done automatically by a delay monostable (Fig. 4), which produces a 10ms, 5V pulse, when the 5V line is energised. This 'set' pulse is also fed to the 'set' input of G21, to ensure the correct initial state of the bistable G4G5. The reset switch on the front panel also sets the display to zero, and if held on, overrides the electronic limits, enabling the electrode drive to be aligned on its mechanical zero indicator.

The power supplies required are:

5V at 1A for gating and counting.

12V at 50mA and —24V at 300mA for the motor.

200V at 25mA for the display.

By using later types of 5V motor, and also l.v. filament or l.e.d. display, the whole unit can be run off 5V, but this simplification must be weighed against the increased cost involved. How much is your time worth?

Literature Received

Microwave test instruments and a range of attenuators and components made by Weinschel Engineering are described in two catalogues, obtainable from the UK distributors, Marconi Instruments Ltd — Sanders Division, Gunnels Wood Road, Stevenage, Herts SG1 2AU WW401

Test equipment for use in the servicing of two-way radio is the subject of a short-form catalogue from Motorola. Equipment described includes p.s.us, meters, signal generators, counters and test sets, together with the new Motorola oscilloscope and power meter. Motorola Inc., Communications Group, 1313E. Algonquin Road, Schaumburg, Illinois, 60196, USA . WW402

Further leaflets in the BBC series 'Engineering Design Information,' in which mention is made of BBC designs available for commercial development, are now published. They are as follows: a low-noise (<7dB) 15dB video amplifier (AM5/526), u.h.f. test equipment for transmitters (EP14M/507), an i.t.s. generator and inserter (GE4M/556), a Band II f.m. monitor receiver (RC1/12), video amplitude measuring unit (UN1/715) and pulse delay unit (UN14L/532). Copies are obtainable from the Liaison Engineer, Designs Department, BBC, Broadcasting House, London W1A 1AA WW403

"Electronic Measuring Instruments" is the title of Wayne Kerr's new catalogue which briefly describes, in English, French and German, most of their range of test gear, including the new B424 component bridge. A section is devoted to the Dimeq capacitive contactless gauging system. Wayne Kerr Sales, Wilmot Breeden Electronics Ltd, 442 Bath Road, Slough LS1 6BB WW404

A short-form catalogue of equipment for stripping, marking, sleeving, identifying and trunking cables is produced by Hellermann Electric, Gatwick Road, Crawley, West Sussex, RH10 2RZ. WW405

Four ranges of pliers, cutters and nippers in the Lindstrom range are fully described in catalogue No. 99-74, from Wm A. Meyer Ltd, 9 Gleneldon Road, London S.W.16 . WW406

Slewing rates of 50V/μs and 240V/μs are provided in a high-voltage power supply series CPS 7000, which is intended for the control of the beam-penetration type of colour tube. A leaflet describing the series can be had from CPS, Inc., 722E. Evelyn Avenue, Sunnyvale, California 94086, U.S.A. WW409

We have received a copy of the technical standard for v.h.f./u.h.f. television and radio domestic receiving aerials from the British Aerial Standards Council, dealing with terminology, specifiable parameters, measurement and mechanical parameters. Copies can be obtained from Jack Hum, Secretary BASC, 27 Ingarsby Lane, Houghton on the Hill, Leicester LE7 9JJ at £1.25 by post or £5.00 for five copies.

The applications of Marconi's TF2370 spectrum analyser in an impedance measuring and matching role is described in a booklet (No. 18) in the Measuretest series. The booklet has been written by A. V. Griffiths of AWA and B. R. Webster of Marconi Instruments and is obtainable from the Publicity Dept, Marconi Instruments Ltd, Longacres, St. Albans, Herts AL4 0JN WW408

Sixty Years Ago

The measurement of frequency was not, in 1917, anywhere near as easy and precise as it was to become a few years later. In our October, 1917 issue, "D.J." wrote describing one of the first heterodyne wavemeters, using a valve and designed for frequencies between 500kHz and 200kHz. It consisted of a feedback valve oscillator and detector and relied for its accuracy, in part at least, on the fact that the frequency couldn't be more than 10kHz out, since a higher note was inaudible.

"A wavemeter with the connections given above may be used for a variety of purposes. As it generates continuous waves of a frequency varying with the value of the condenser, it can be used as a sending wavemeter as well as a receiving wavemeter without making the slightest alteration whatever to the circuits.

Let us, however, for the time being, consider only its use as a measurer of the length of continuous waves. Suppose the instrument is brought up to a set which is sending out waves of, say, 800 metres length. These waves will have an interference effect on the oscillations already taking place in the wavemeter. If the wavemeter is set to, say, 750 metres, the system will be oscillating at a frequency of 400,000. When the wavemeter receives the 800 metre continuous waves, oscillations of 375,000 frequency are set up in addition. These two sets of oscillations, superimposed upon each other, will produce a resultant oscillating current, with beats when the two sets of oscillations are momentarily assisting one another. The frequency of these beats will be equal to the difference of the two separate frequencies, and will in the present case be 25,000.

The valve is also acting as a detector in addition to generating oscillations. The beats, therefore, are rectified, and will produce in the telephone receivers a note having a frequency equal to the beat frequency. This note, to be audible to the human ear, must be below a frequency of about 14,000. It is obvious then that if the wavemeter be set to 750 metres nothing whatever will be heard in the 'phones. Only when the wavemeter condenser is turned round till 770 metres is reached will anything at all be heard in the ear pieces, and then only an exceptionally high note. As the wavemeter is turned nearer to 800 metres — i.e. as the two frequencies approach each other — the note in the telephones gradually gets lower and lower till at 800 metres nothing whatever is heard. The two frequencies, local and superimposed, are now identical, and, whether in phase or not, produce resultant oscillations of constant amplitude, and which therefore are unable to affect the telephone even when rectified."