CONSTRUCTION

DIGITAL CONTROL OF A MACHINE

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In case of accurate mechanical processes such as deep hole drilling and surface grinding, high accuracy of the process (1 thou to 2 thou) cannot be maintained by purely mechanical or electrical techniques. In such cases digital electronics plays a crucial role to control the processes. By the method described below, it is possible to achieve a high degree of accuracy with the minimum cost.

The block diagram of the system is shown in Fig. 1.

A photo-detector with wheel and light arrangement which is coupled to the lead screw of the machine gives electrical pulses when the screw rotates. These pulses are counted after the limit switch is pressed, i.e. starting point of the process. When the count is equal to the number set in the thumbwheel switch, the rotation stops and the counter resets automatically. The number of thumbwheel switches, counter ICs and holes in the wheel correspond to the accuracy needed. Here only two thumbwheel switches are used.

The photo-detector system (Fig. 2) comprises a wheel with some holes, a lens and a bulb whose light is detected by a 10k LDR. A 2. 2W, 12V bulb may be used with the lens as a source of light.

Care must be taken to ensure that the bulb's light focussed by the lens falls exactly on the centre of LDR through a hole in the wheel. When the wheel rotates, the LDR should thus be able to receive light pulses through all the holes in the wheel, one by one.

The next stage consists of a timer IC whose main function is to give electrical pulses when light pulses fall on the LDR (see Fig. 3). The output voltage is limited to 5.1V by zener D2 to protect the following ICs.

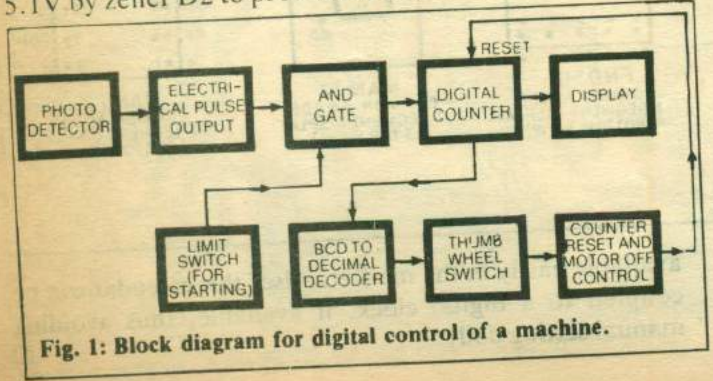


Fig. 1: Block diagram for digital control of a machine.

The wheel must be attached to the lead screw of the machine. The number of holes and diameter of the wheel should be large for better accuracy. Thus each rotation of the lead screw is converted to a number of electrical pulses that is equal to the number of holes in the wheel.

The electrical pulses generated by rotation of the wheel should be counted only from the instant the process (drilling etc) has actually started. As shown in Fig. 4, originally the drill bit may be at position 'a'. It starts drilling only when it comes to the position 'd' just touching the job. The lead screw movement during this portion (i.e. a to d) should not be counted. For this, an AND gate is provided. The AND gate gets one input from the limit switch and another in the form of electrical pulses from the wheel. So only when the limit switch S2 is pressed these pulses will be counted. The limit switch can be positioned in such a manner that touching of drill with the job and pressing of limit switch takes place at the same time.

Before giving the output of limit switch to AND gate a contact debouncer (using 7404 invertor) is used to avoid false counting. The circuit is shown in Fig. 5.

The output from the AND gate is given to the digital counter. The number of counter ICs used is two (7490).

The circuit in Fig. 6 is a 2-digit decade counter. Normally pin 2 will be at zero potential for 7490 to be in counting mode. When the pulses are equal to the number set in the thumb wheel switch, a high level voltage goes to pin 2 to reset the counter.

The BCD output from these ICs are given to BCD-to-seven segment decoder and BCD-to-decimal decoder, as shown in Fig. 7.

7441 is a BCD-to-decimal decoder and one of 10 pins gets ground potential according to the BCD input.

Let us suppose that the thumbwheel switch is set at 34. As 7447 is BCD-to-7 segment decoder, the number is displayed when the wheel rotates. When the BCD output is equal to 34, i.e. A2B2C2D2 is 0011 and A1B1C1D1 is 0100, the output of 7441 at pin 9 (IC5) and pin 13 of IC8 get ground potential. So at this position we get the output at 'COM' point of both thumbwheel switches as ground potential and at all other counts for this setting, we get a high impedence the 'COM.' point.

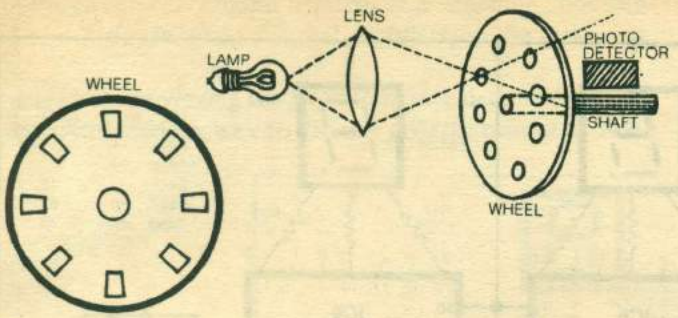


Fig. 2: Photo-detector system with wheel and lamp.

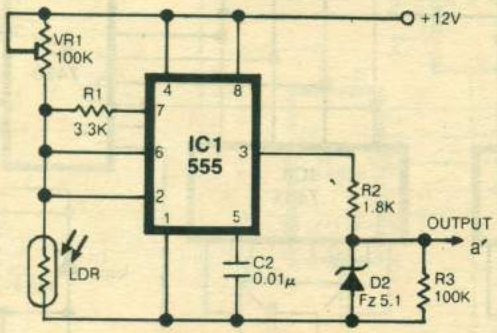


Fig. 3: Arrangement for coverting light pulses to electrical pulses.

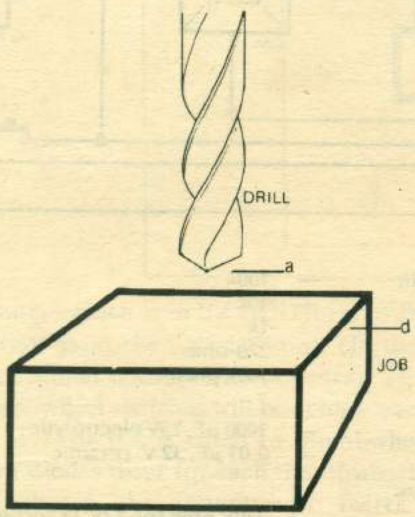


Fig. 4: Touching of the drill bit with job before drilling and pressing of the limit switch should be synchronised. See text.

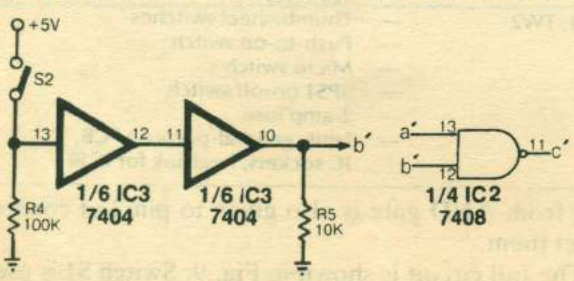


Fig. 5: Contact debouncer circuit used to avoid false counting.

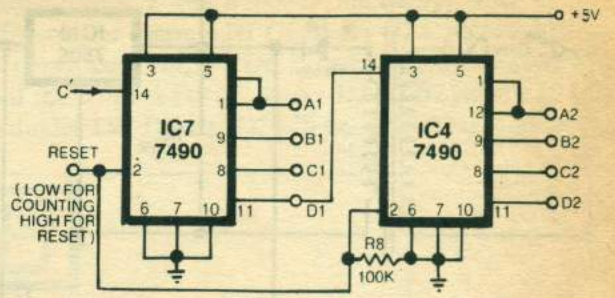


Fig. 6: 2-digit decade counter.

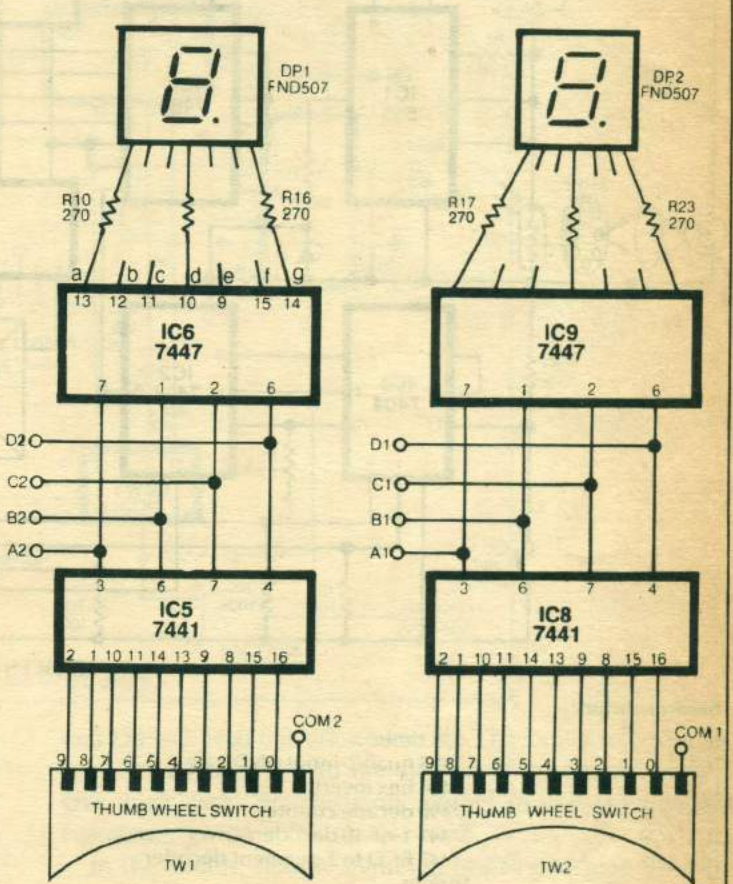


Fig. 7: BCD-to-7 segment and BCD-to-decimal decoder.

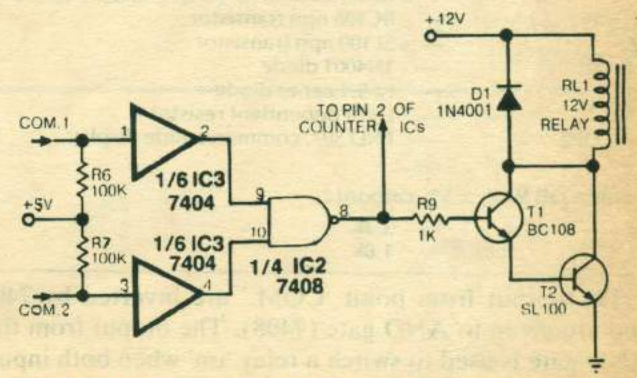
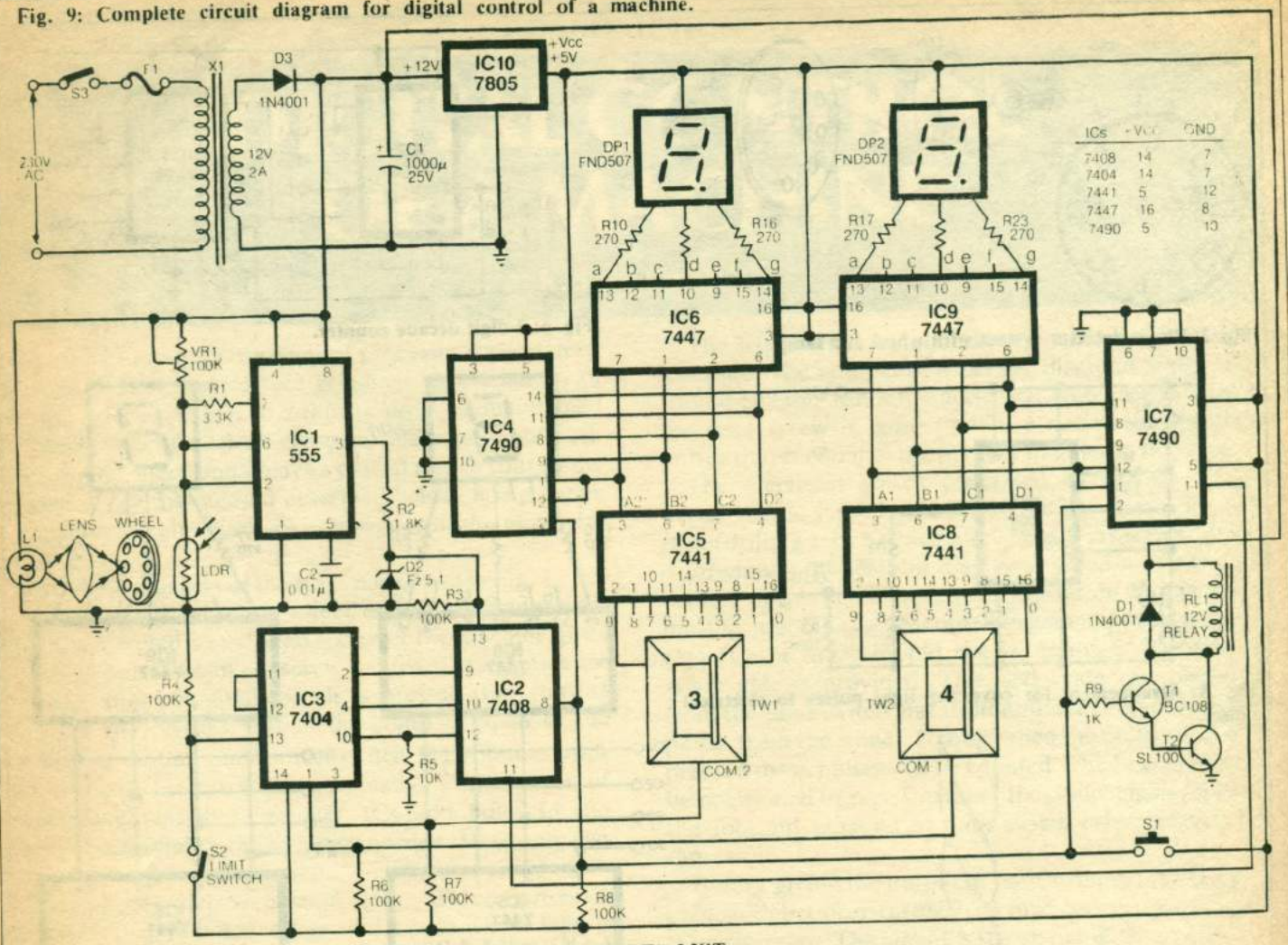


Fig. 8: The output circuit for switching the relay.

Fig. 9: Complete circuit diagram for digital control of a machine.



PARTS LIST

Semiconductors:

IC1	—	555 timer
IC2	—	7408 quad 2-input AND gate
IC3	—	7404 hex inverter
IC4, IC7	—	7490 decade counter
IC5, IC8	—	7441 1-of-10 decoder/driver
IC6, IC9	—	7447 BCD to 7-segment decoder driver
IC10	—	7805, 5-volt voltage regulator with heatsink
T1	—	BC108 npn transistor
T2	—	SL100 npn transistor
D1, D3	—	1N4001 diode
D2	—	Fz 5.1 zener diode
LDR	—	Light dependent resistor
DP1, DP2	—	FND 507, common anode display

Resistors (all ¼W, ± 5% carbon):

R1	—	3.3k
R2	—	1.8k
R3, R4, R6-R8	—	100k
R5	—	10k
R9	—	1k
R10-R23	—	270-ohm
VR1	—	100k preset

Capacitors:

C1	—	1000 μF, 25V electrolytic
C2	—	0.01 μF, 32 V ceramic

Miscellaneous:

X1	—	230V primary, 12V 2A secondary transformer
L1	—	2.2W, 12V lamp
RL1	—	12V relay
TW1, TW2	—	Thumbwheel switches
S1	—	Push-to-on switch
S2	—	Micro switch
S3	—	SPST on-off switch
F1	—	2-amp fuse
	—	Lens, general-purpose PCB, IC sockets, heatsink for IC10

The output from point 'COM.' are inverted by 7404 and are given to AND gate (7408). The output from this AND gate is used to switch a relay 'on' when both inputs to the AND gate are 1, i.e. after exact count is obtained according to the setting of thumbwheel switches. The output from AND gate is also given to pin 2 of counters to reset them.

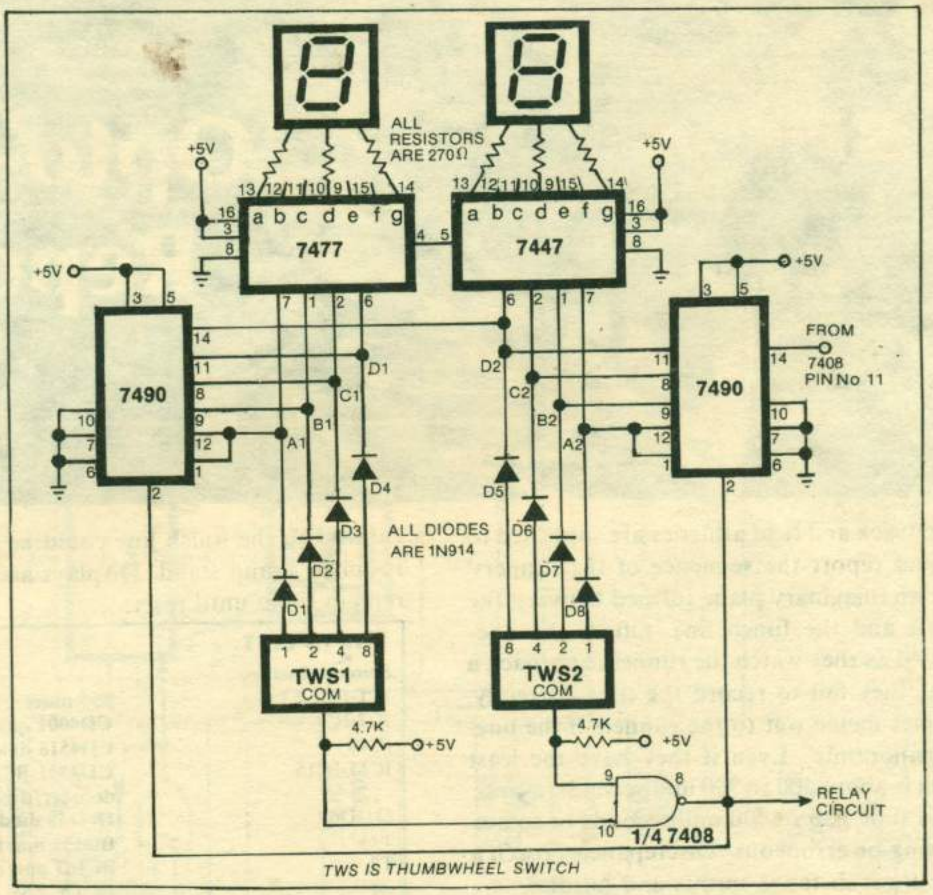
The full circuit is shown in Fig. 9. Switch S1 is used for initial resetting of counters. □

READER'S COMMENTS:

In the circuit for 'Digital Control of a Machine', one can save two 7441 (BCD to decimal decoders) in the following way.

Instead of converting the BCD data into decimal form by using 7441 decoders, we can directly give the output of 7490 (decade counter) which is in the BCD form to BCD thumbwheel switches, as in the figure shown. (In the article the author uses decimal thumbwheel switches). The 'common' point of thumbwheel switches will be at high level only when the output of 7490 ICs is equal to thumbwheel switches' setting. Eight diodes (four for each thumbwheel switch) are connected between the thumbwheel switch and 7490 outputs.

Let us suppose that the setting is 37, i.e. TWS1 'common' is connected to 1 and 2 points, and TWS2 'common' is connected to 1, 2 and 4 points internally. Now, say, the decade counter outputs D1 C1 B1 A1 D2 C2 B2 A2=0 0 0 0 0 0 0 0, then diodes D3, D4, D6, D7 and D8 will be conducting. And if the outputs D1 C1 B1 A1 D2 C2 B2 A2=0 0 1 0 1 0 0 1 then diodes D4, D6 and D7 will be conducting, and D3, D5 and D8 will be at cut-off, and so on. The moment the decade counters come to 37, all the diodes will be cut-off and will give high level at 'common' points of the thumbwheel switches.



In the circuit, remote blanking is also provided by using remote blanking input (RBI pin 4) and remote blanking output (RBO pin 5) of the 7447 ICs.

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