L.J. Technical Systems

DC Motor Control Module

User Manual

L.J. ELECTRONICS

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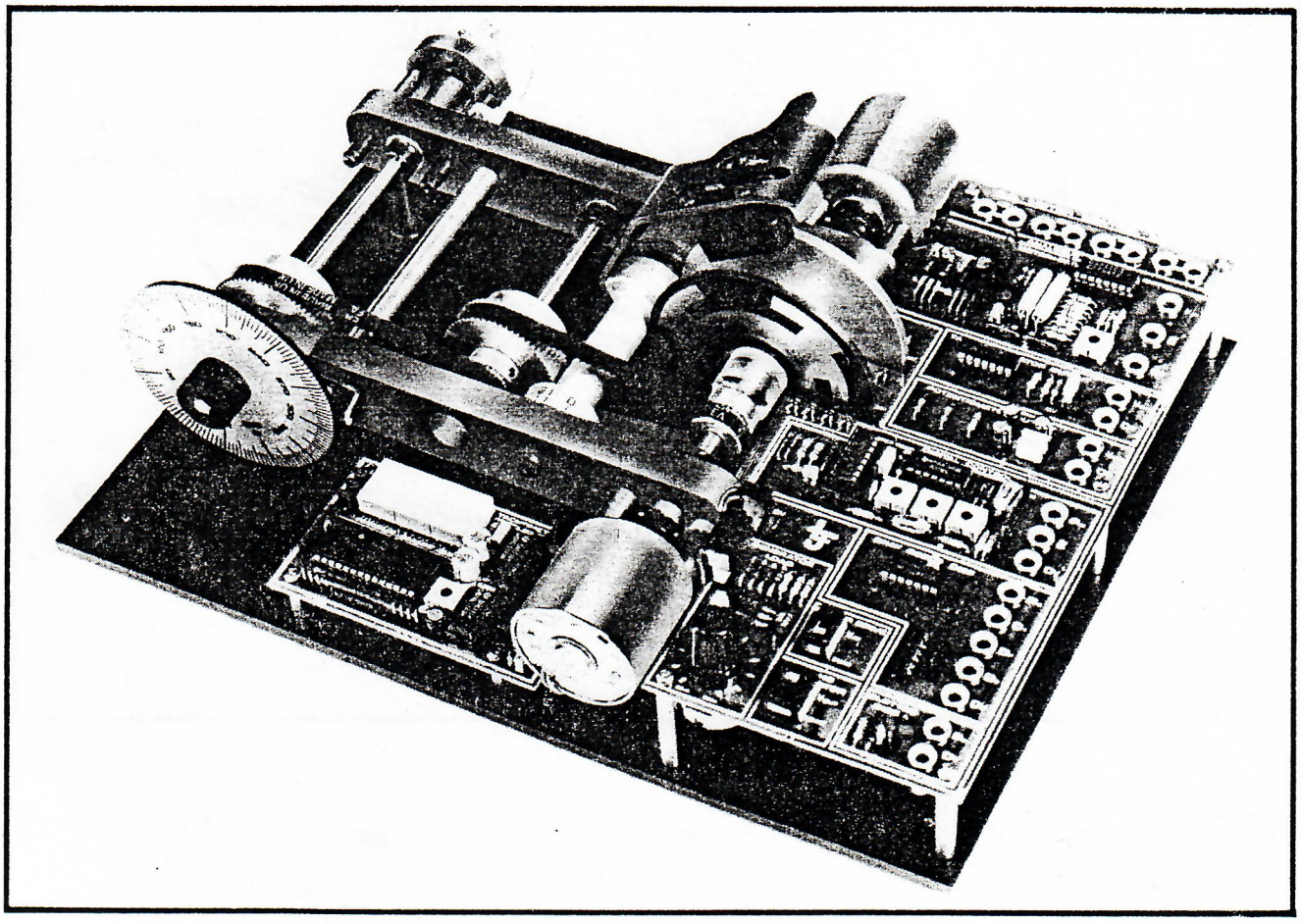
About this Manual

This is the user manual for the LJ MS15 DC Motor Control Module. It is supplied with that unit and contains full technical details on the mechanical and electronic systems found on the MS15 Module.

Complete software details and practical experimentation are contained in separate software manuals. These are available for use with either the LJ EMMA II or MARC Z80 Microcomputer Systems.

For more comprehensive work using this module there are special curriculum texts available for recommended teaching sets CA02, An Introduction to Analog Control and CA04, An Introduction to Direct Digital Control.

Full details on these and other LJ teaching sets are available on request.



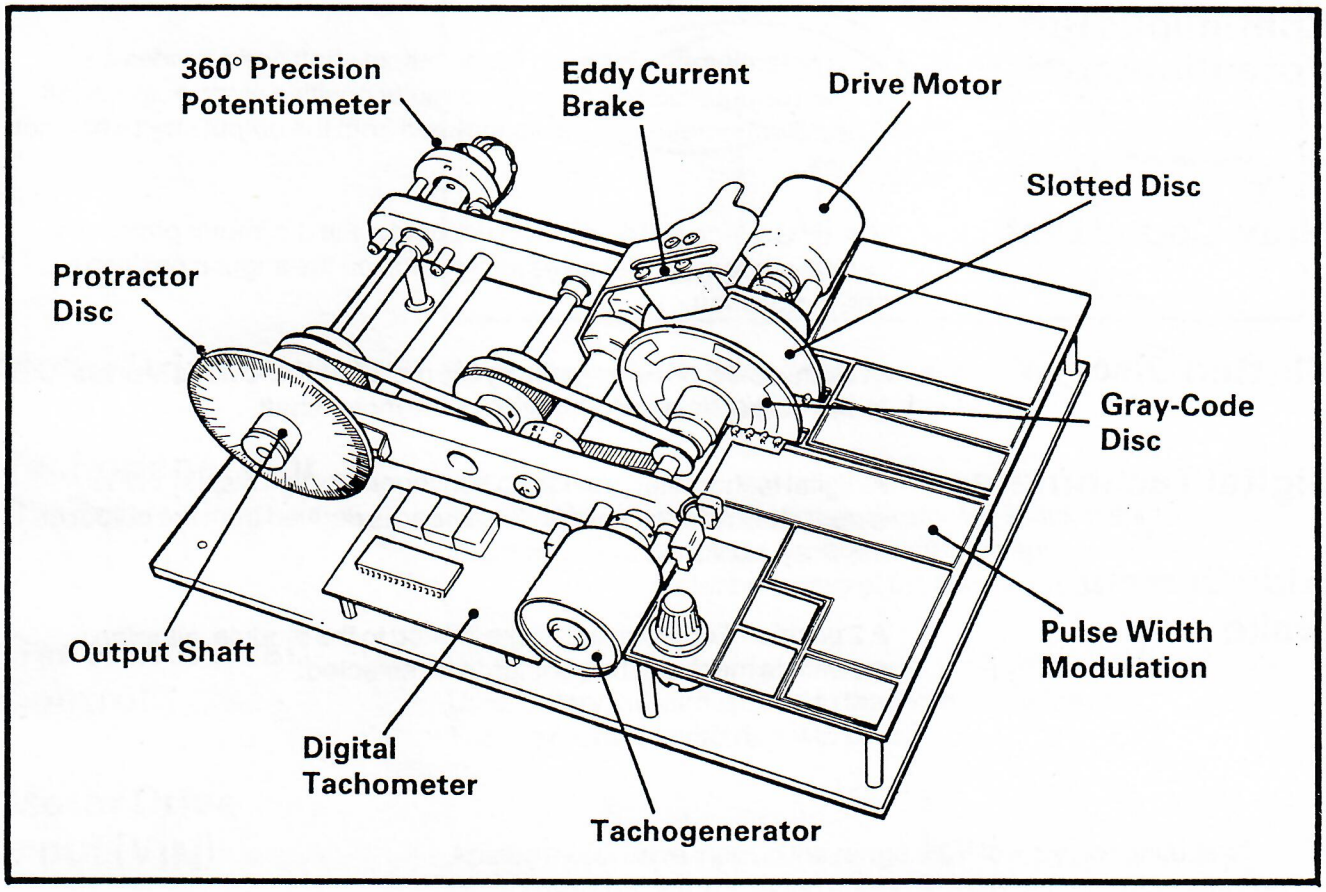
Section 1 Introduction to the MS15 DC Motor Control Module

Introduction

The MS15 DC Motor Module enables the user to perform closed-loop, positional or speed control of a d.c. motor. The speed and direction of rotation of the motor can be controlled by either an analog signal or a pulse width modulated (p.w.m) digital signal.

Speed of rotation and positional feedback information are available in both analog and digital forms, thus the module can be controlled by either an analog or digital system.

A full set of layout and circuit diagrams of the module are given in Appendix 1, page 13.



The module consists of the following elements.

d.c. Motor

The motor is capable of being driven at speeds of up to 2,500 rpm in either direction. The motor output is geared down by a ratio of 9:1 to drive the output shaft which has a calibrated indicator disc to show angular shaft rotation. Input circuitry is provided to allow the motor to be driven from either the analog input, V_{IN} or the digital p.w.m. input P_W.

Tachogenerator

A second d.c. motor driven directly by the first motor provides an analog voltage feedback proportional to the speed and direction of rotation. A variable load can be applied to the d.c. motor by switching the **Generator Load** circuit across the tachogenerator output. In this case the tachogenerator output, V_{OUT}, is not available.

Continuous Rotation Potentiometer

This potentiometer is driven by the output shaft and provides an analog ouput proportional to the angular position of the output shaft. The potentiometer can be disengaged from the output shaft when not in use.

Gray-Coded Disc

A 4-bit Gray-coded disc driven directly by the d.c. motor provides a 4-bit digital output that gives information on the angular position of the motor shaft.

Slotted Disc

A slotted disc, driven directly by the motor shaft provides a single pulse output for each revolution of the motor shaft.

Digital Tachometer

A digital tachometer provides a continuous 3-digit display of the output shaft rotation speed. This speed is derived from the output of the Gray-coded disc.

Eddy Current Brake

A 2 position Eddy Current brake is fitted to the module, allowing repeatible mechanism loadings to be selected.

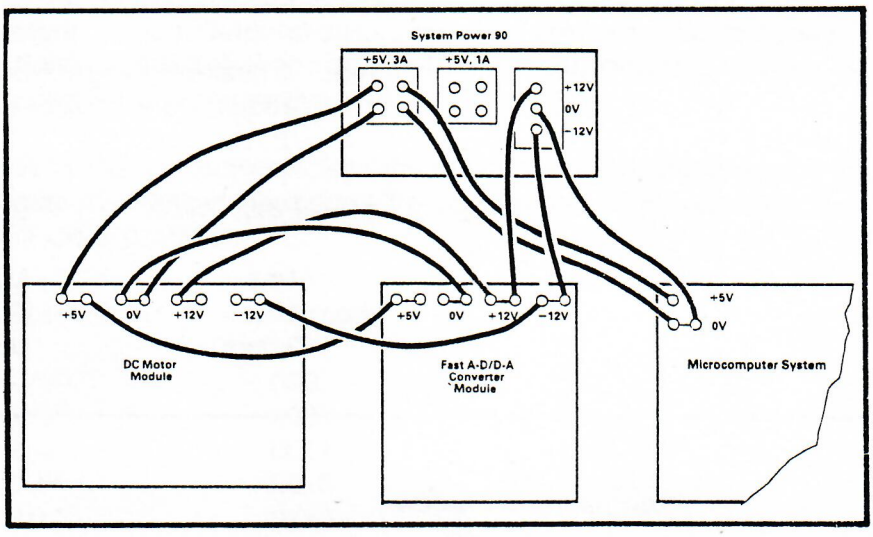
Section 2 User Information

Power Supplies

Power requirements for the module are:

+5V at approx. 400mA
+12V at approx. 0.5 to 0.9A (1.5A with motor stalled)
−12V at approx. 0.5 to 0.9A (1.5A with motor stalled)

Ensure that supplies have a common 0V rail.



Motor Drive Switch

Position V_{IN}: selects analog motor drive input V_{IN}
Position PWM: selects digital p.w.m. input P_W

Tachogenerator Switch

Position V_{OUT}: enables tachogenerator feedback output.
Position LOAD: enables a variable load to be applied to the d.c. motor by means of the **Generator Load** control.

Generator Load Control

Used to vary the load applied to the d.c. motor when the Tachogenerator switch is set to **Load.**

Motor Drive Input (V_{IN})

Analog motor drive input in the range +5V to −5V; magnitude of voltage determines the speed and polarity determines the direction of rotation.

Voltage	Speed and Direction
+5V	Maximum speed counter clockwise
0V	Stationary
−5V	Maximum speed clockwise

Enable input ($\overline{E}$)

Logic '0' enables selected input, V_{IN} or P_W, to control the motor.

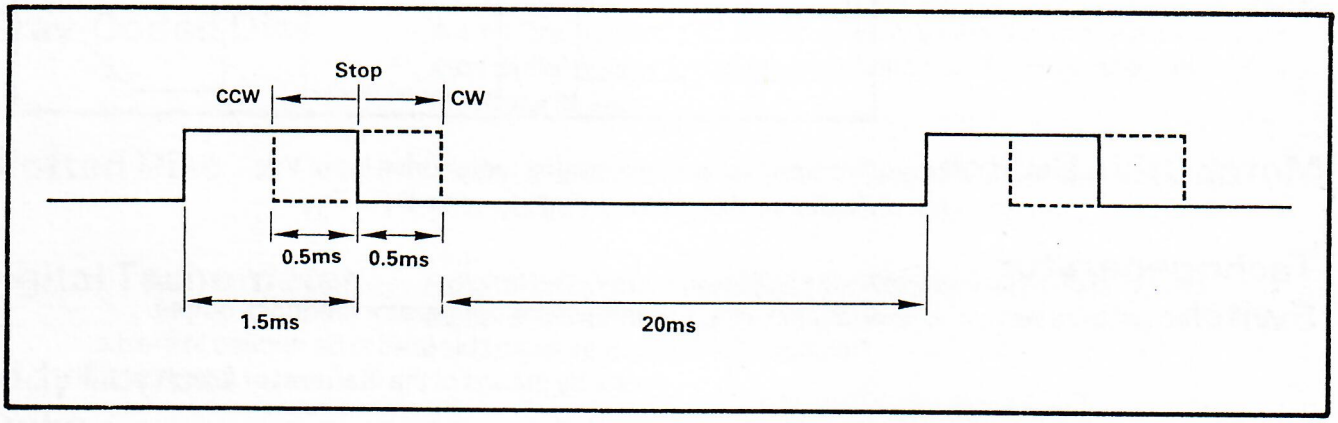
When using the LJ Electronics MS14 Fast A-D/D-A Converter connect $\overline{E}$ to an I/O port and write to logic '0' during program execution. This prevents the motor from rotating due to random data when the system is reset.

PWM Input (PW)

Pulse width modulated digital input to control motor speed and direction.

Format: a positive-going t.t.l. pulse of duration 1-2 ms duration is required and must be repeated approximately every 20 ms.

Pulse Width	Speed and Direction
1ms	Maximum speed counter clockwise
1.5ms	Stationary
2.0ms	Maximum speed clockwise



Tachogenerator

Analog output in the range +5V to −5V indicating the speed and direction of rotation of the motor as follows:

Speed and Direction	Output Voltage (unloaded)
Maximum speed clockwise	−5V approx
Stationary	0V
Maximum speed counter clockwise	+5V approx.

Potentiometer Output (V_{OUT})

Analog voltage varying between +5V and −5V for one complete revolution of the output shaft. Note that this output is held artificially at +5V for approximately 20° where the potentiometer is discontinuous.

Gray-Coded Disc Output (D0 to D3)

A 4-bit t.t.l. compatible Gray-code output dependent on the motor shaft position. Output shaft gearing of 9:1 gives a resolution of one Gray-coded bit change per 2.5° of output shaft rotation. Thus the code will be repeated every 40° of rotation.

With 0° on the indicator disc aligned with the marker the Gray-coded output is 0000 and the code will change as follows with counter clockwise rotation:

Disc marker	Gray code
0/360°	0000
2.5°	0001
5.0°	0011
7.5°	0010
10.0°	0110
12.5°	0111
15.0°	0101
17.5°	0100
20.0°	1100
22.5°	1101
25.0°	1111
27.5°	1110
30.0°	1010
32.5°	1011
35.0°	1001
37.5°	1000
40.0°	0000

Clockwise rotation will reverse the output code sequence as follows:

0000
1000
1001
etc.

Slotted Disc Output (P_0)

Normally at logic '1' with a single t.t.l. compatible logic '0' pulse generated for each 360° rotation of the motor drive shaft.

Section 3 Control of a DC Motor

The MS15 DC Motor Control Module features both analog and digital control inputs and outputs.

This allows the user to directly control the system using either an analog or a digital system. By using an A-D/D-A converter it is possible to utilize both types of control inputs and outputs for direct digital control of speed and direction.

Analog Control

The LJ AS1 Operational Amplifier Patching System can be used to construct various analog control systems based on operational amplfiers. The curriculum CA02, An Introduction to Analog Control covers this area of work and is an ideal means of exploring introductory analog control techniques.

Direct Digital Control

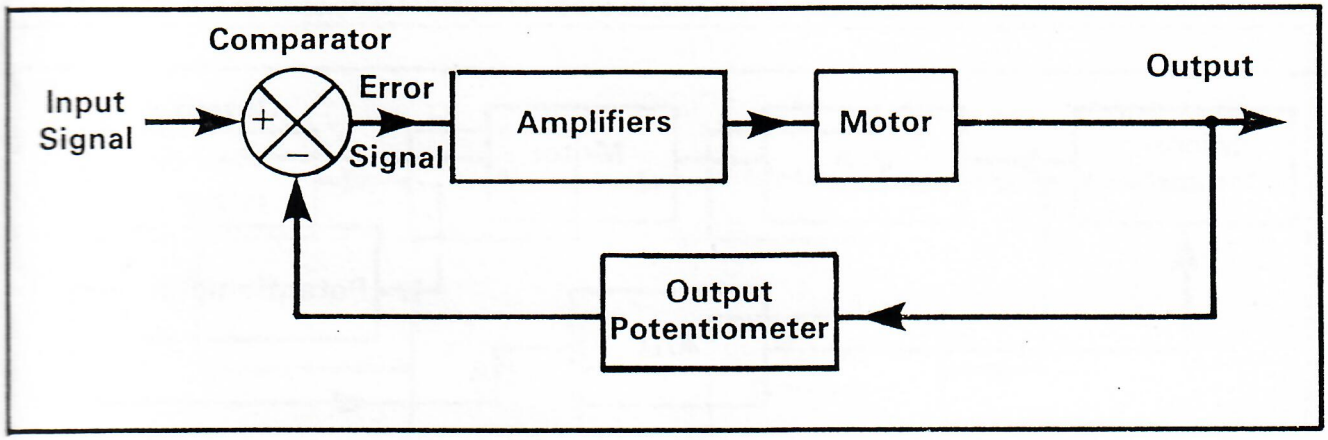
Using any of the LJ microcomputer systems, the user can directly control the DC Motor module using pulse width modulation. Digital feedback from the gray coded disc can also be used to form a closed loop system.

By incorporating an LJ MS14 fast A-D/D-A converter module in the system the user has access to the analog feedback outputs. This allows them to create sophisticated direct digital control systems. This work is covered in the curriculum CA04, An Introduction to Digital Control.

Section 4 Analog Control

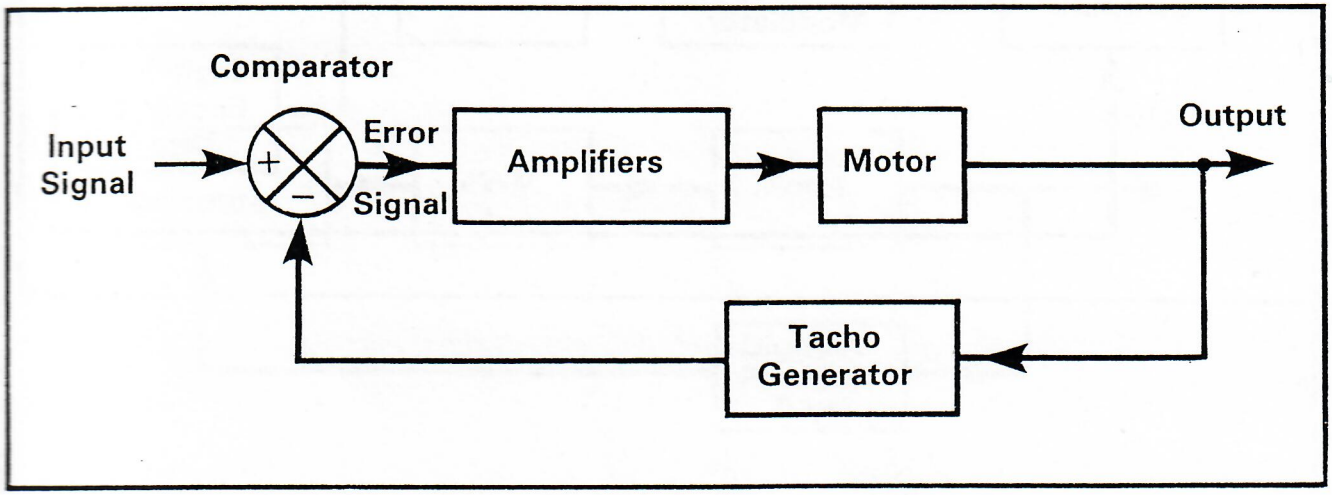
Analog Control

The position and speed of a d.c. motor can be controlled by the use of analog control. The block diagram of a simple positional control system is shown below.



The output potentiometer sends a feedback signal to the comparator and an error signal is generated. This error signal results in a motor movement, causing change in the output potentiometer voltage feedback, giving a reduction in the magnitude of the error signal. Ideally, the system stops when the potentiometer feedback reduces the error signal to zero.

Speed control of a motor can be obtained using the system below:

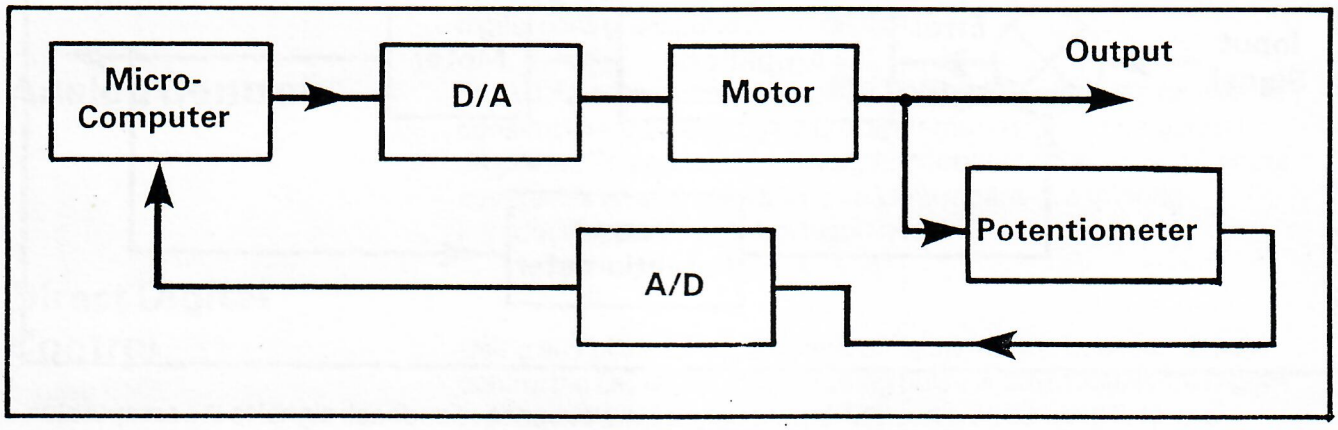


A given input signal will result in a certain motor speed, this speed will reduce as the motor is loaded, reducing the tachogenerator feedback. This results in an increase in error signal magnitude, causing an increase in motor speed. Ideally, the system should maintain a constant speed for various applied loads.

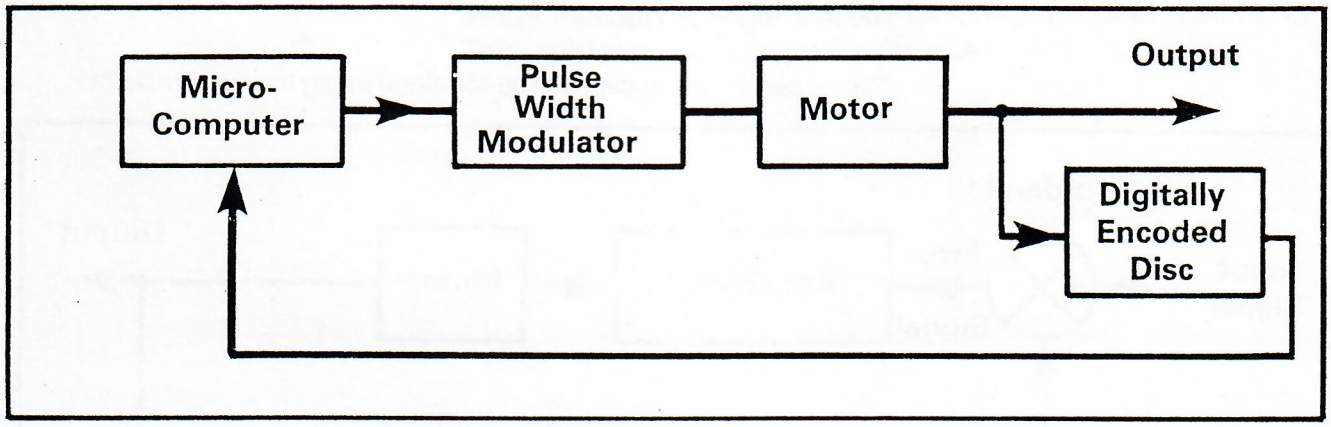
Section 5 Digital Control

Digital Control

The basic principle of a positional control system is that the error signal applied to the controller (sometimes a computer) is related to the difference between the input signal to the system and the output signal from the system. The output shaft of the motor is driven to a position that reduces the error signal to zero and the system stops.

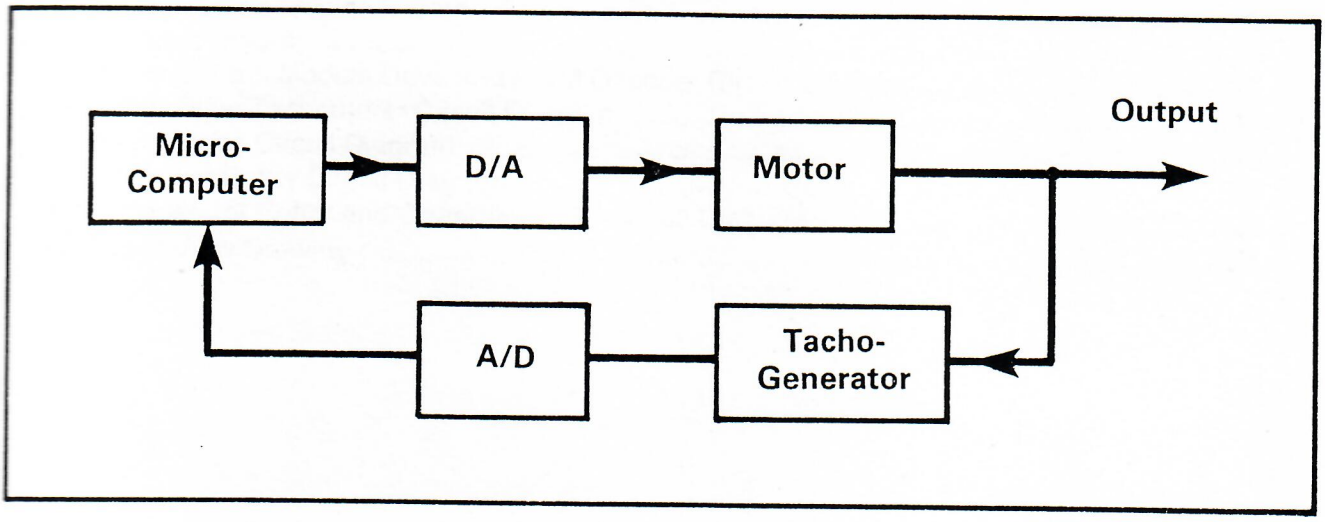


A positional control system is shown above. If digital drive circuitry and digital feedback signals are used, the D/A and A/D converters are no longer required. The system now becomes:-

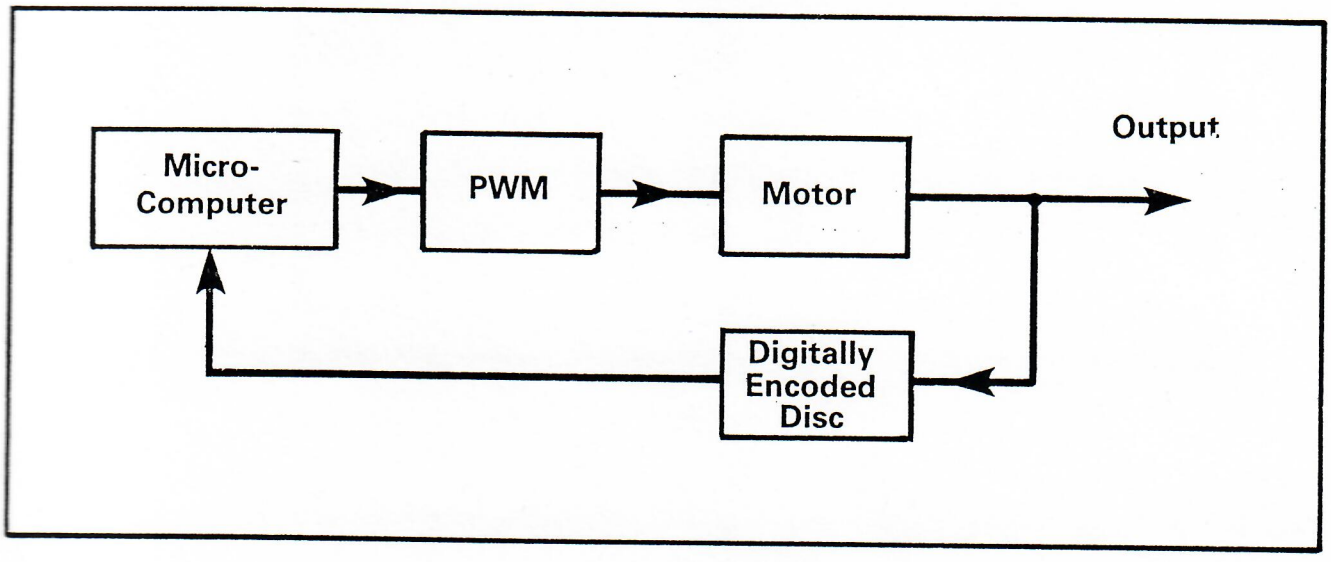


Speed Control of a d.c. Motor

The basic principle of a speed control system is that the controller attempts to keep speed constant by comparing the feedback signal with the command signal to compensate for changes which will occur when there are variations in load.



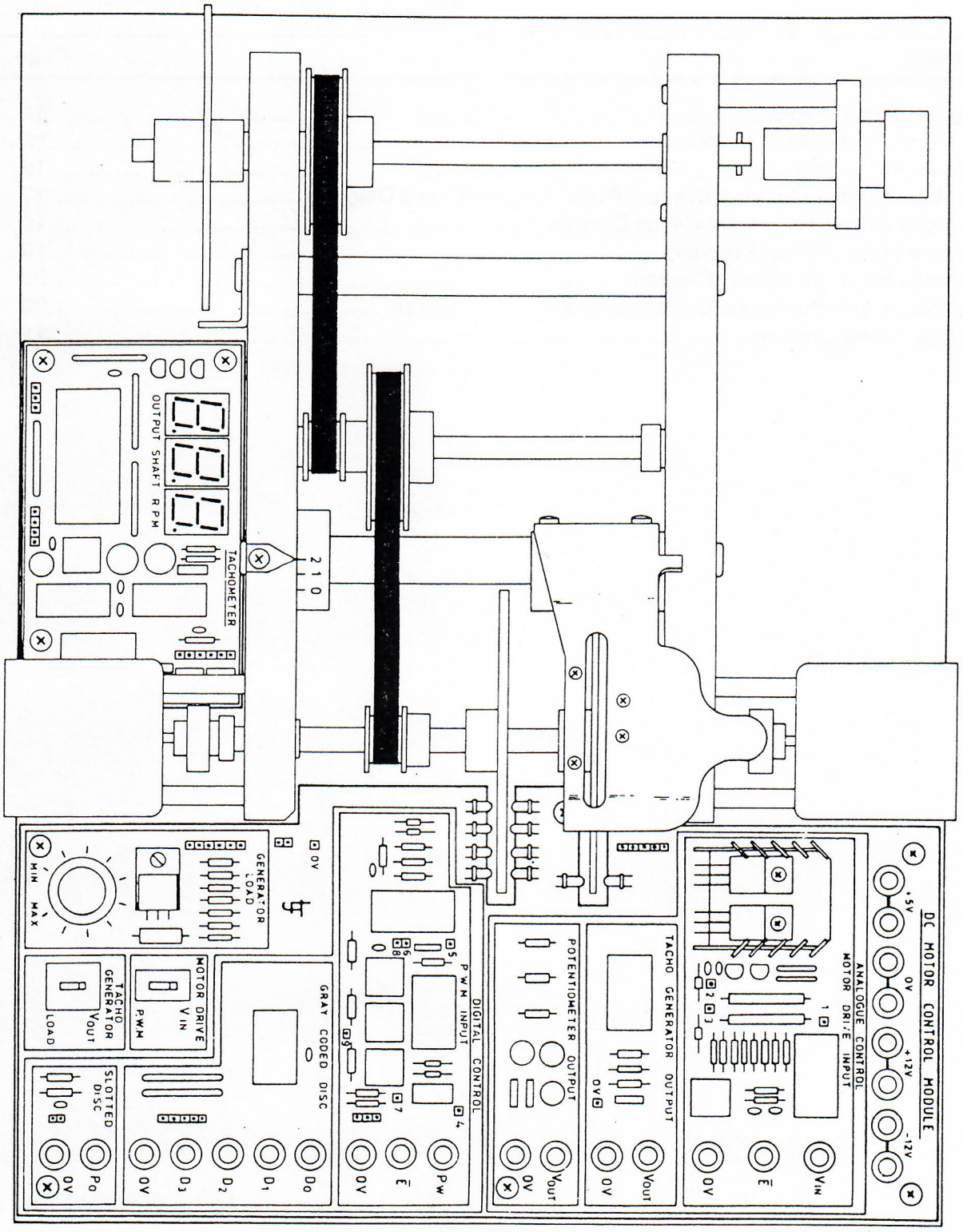
A speed control system is shown above. As with the positional control system, the necessity for using D/A and A/D converters is eliminated by implementing a Pulse Width Modulator. The system now becomes:-



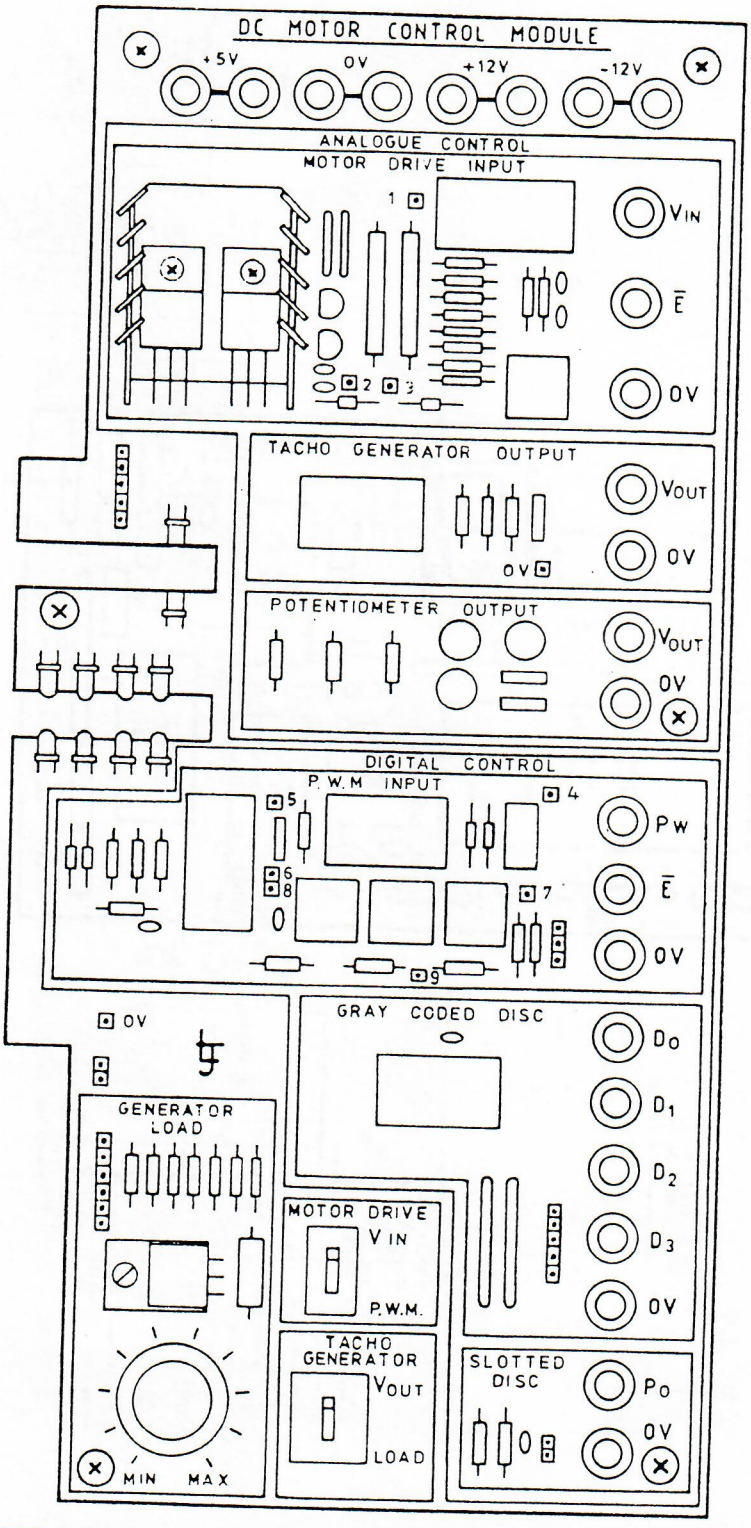
Appendix 1 Layout and Circuit Diagrams

Drawing	Page

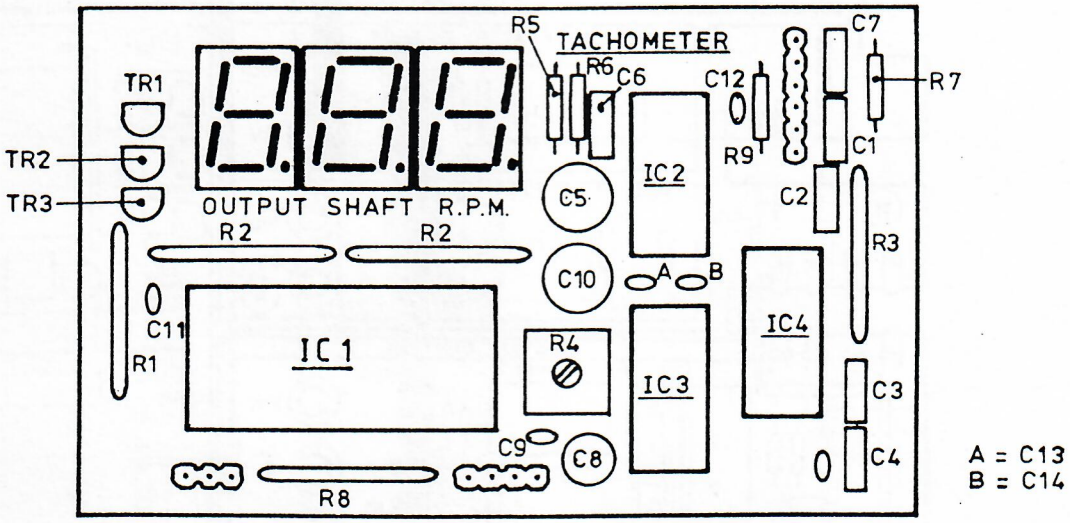
Module Layout Diagram



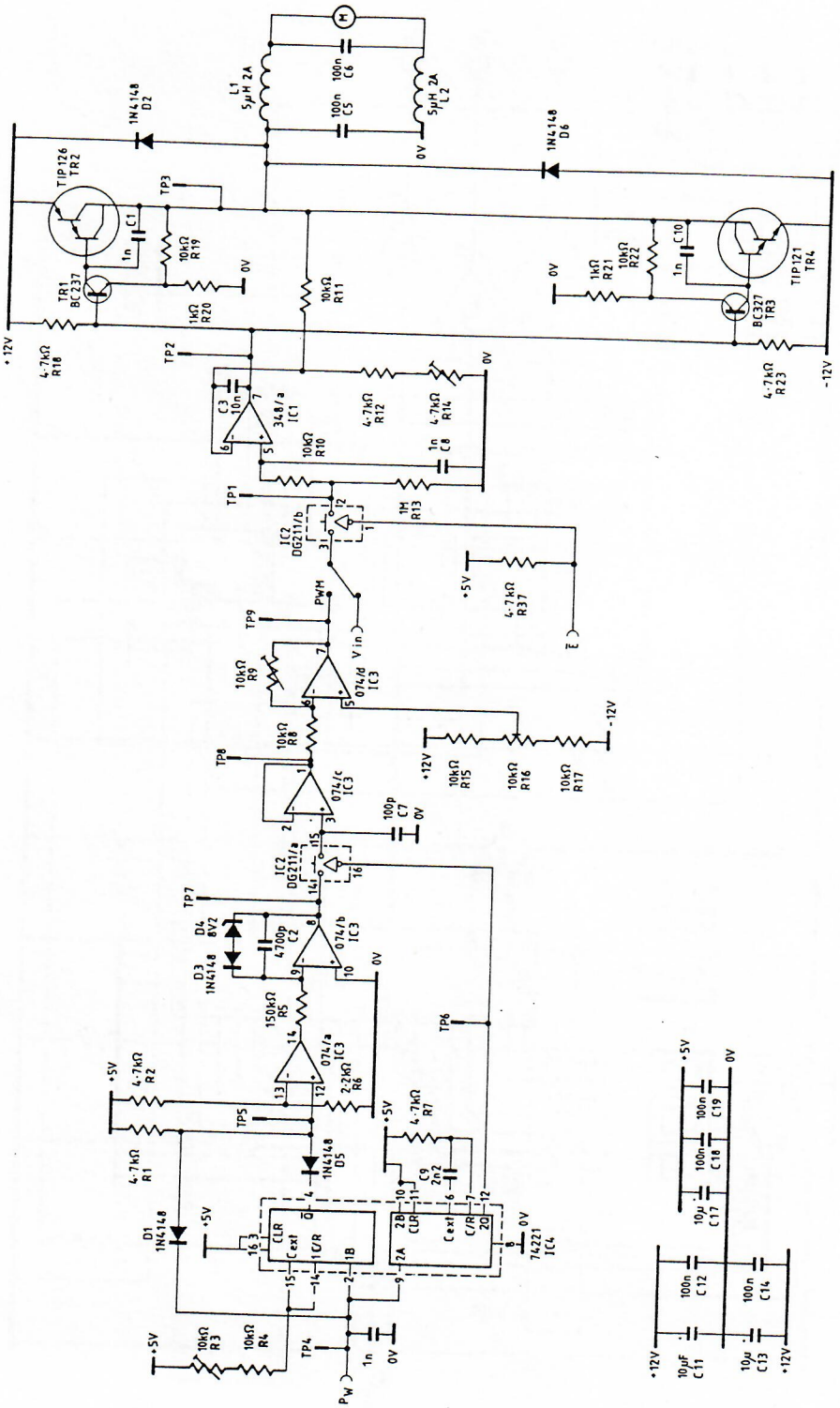
Motor Control Board Layout



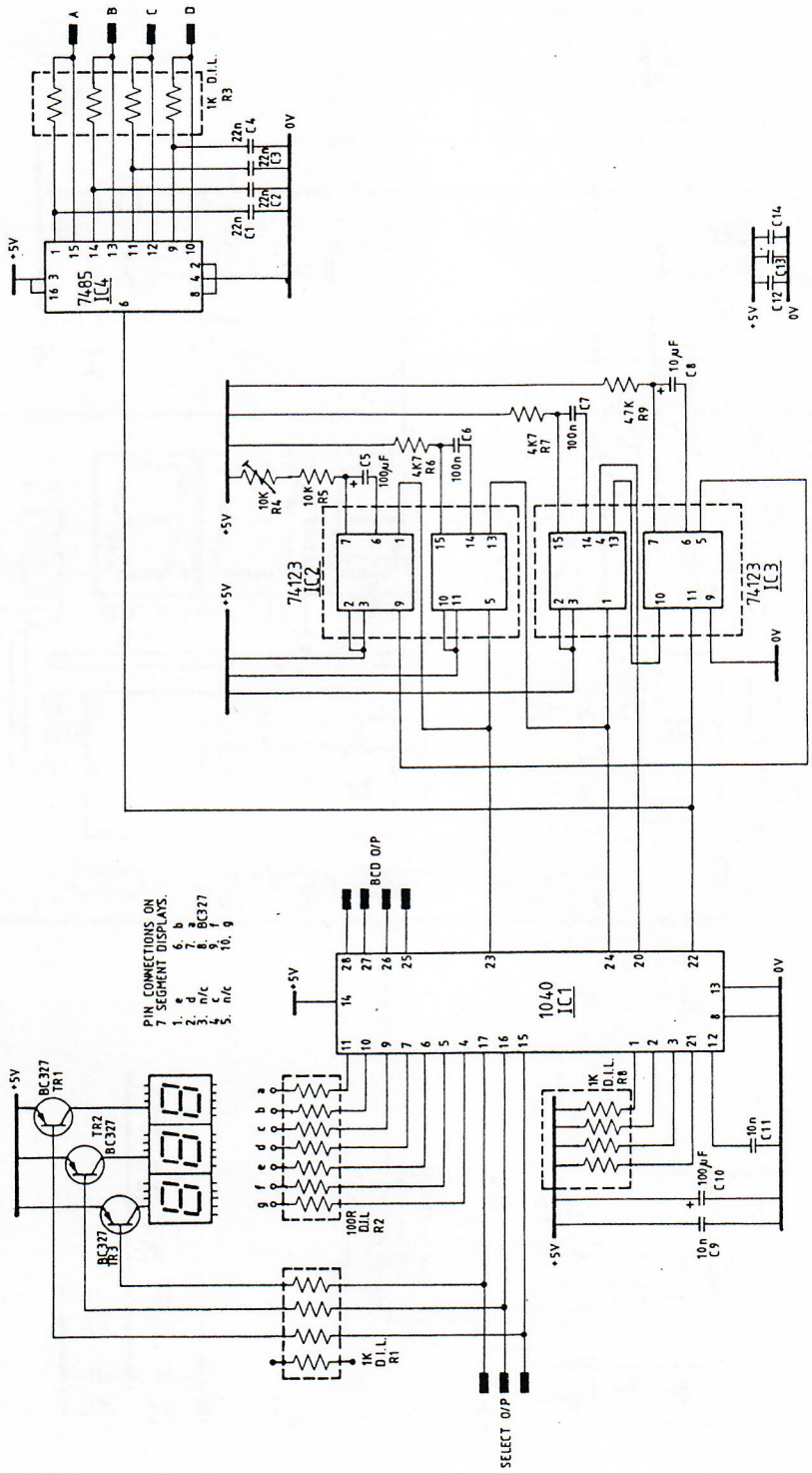
Tachometer Layout



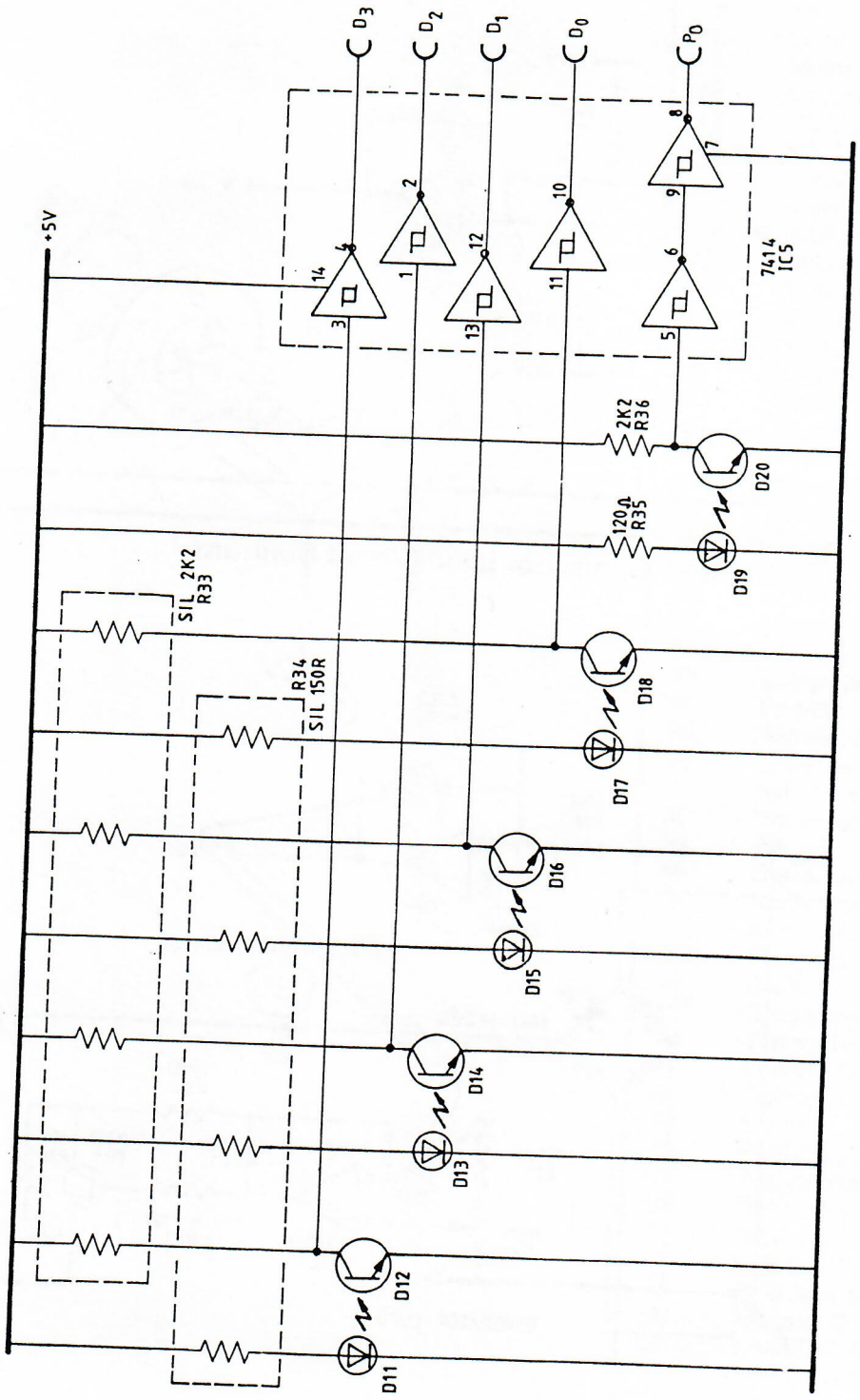
DC Motor Control Module Drive and PWM Decoder Circuit Diagram



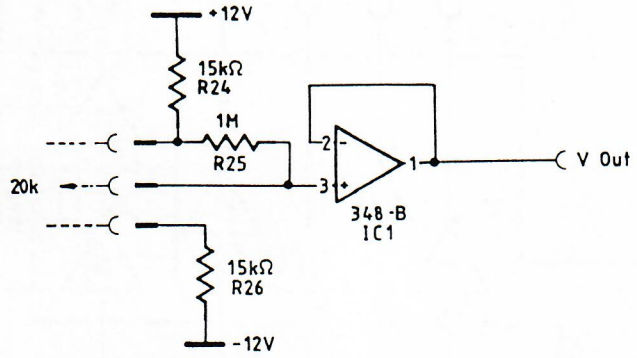
DC Motor Drive Tachometer Circuit Diagram



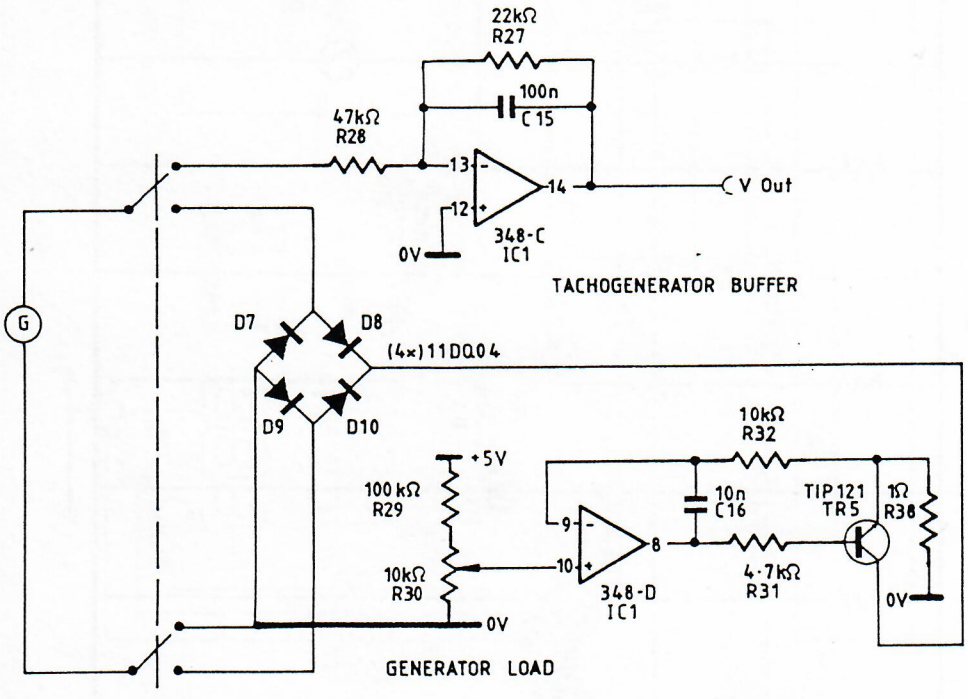
Optoelectronics Circuit Diagram



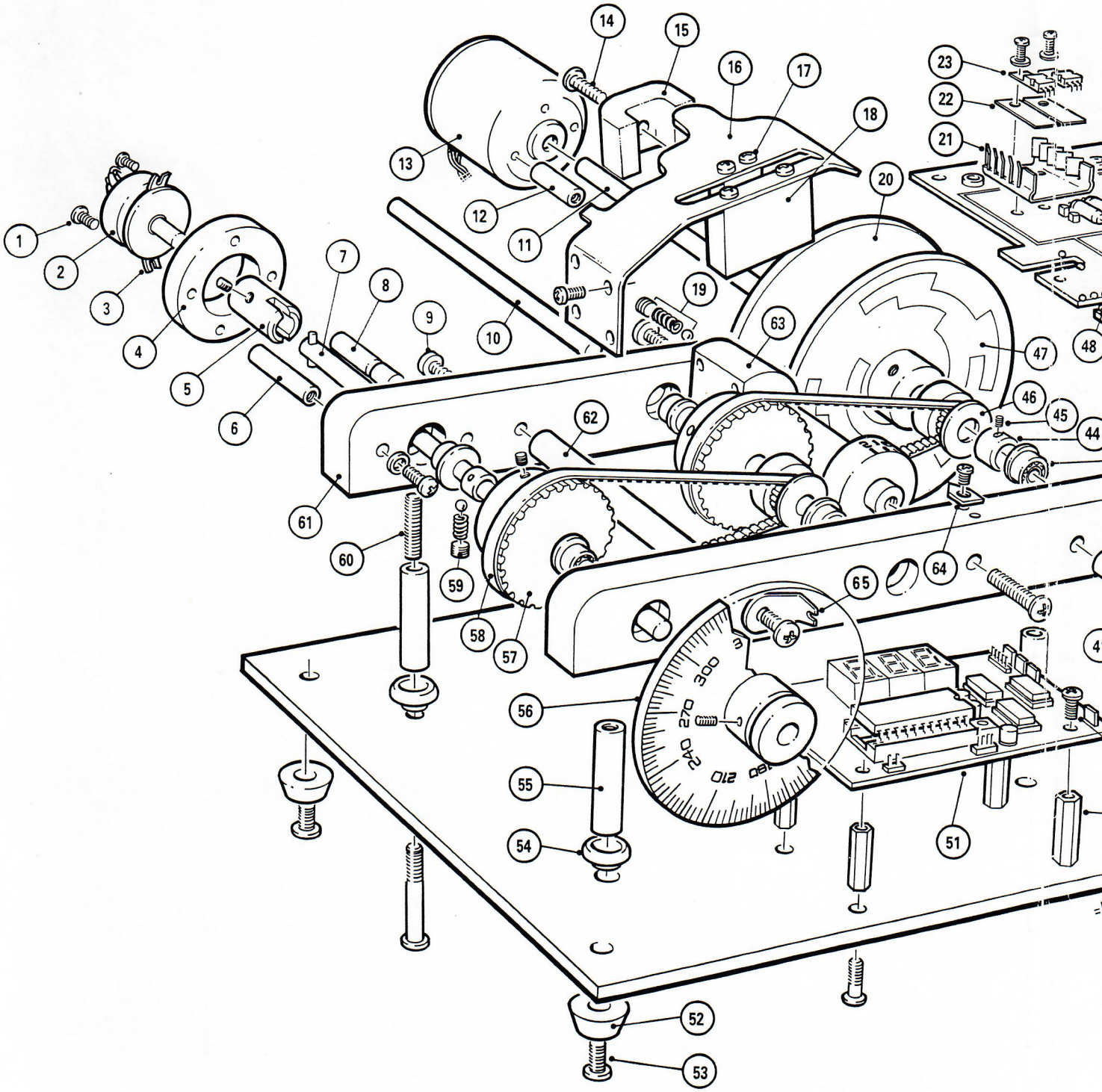
Precision Pot Buffer Circuit Diagram



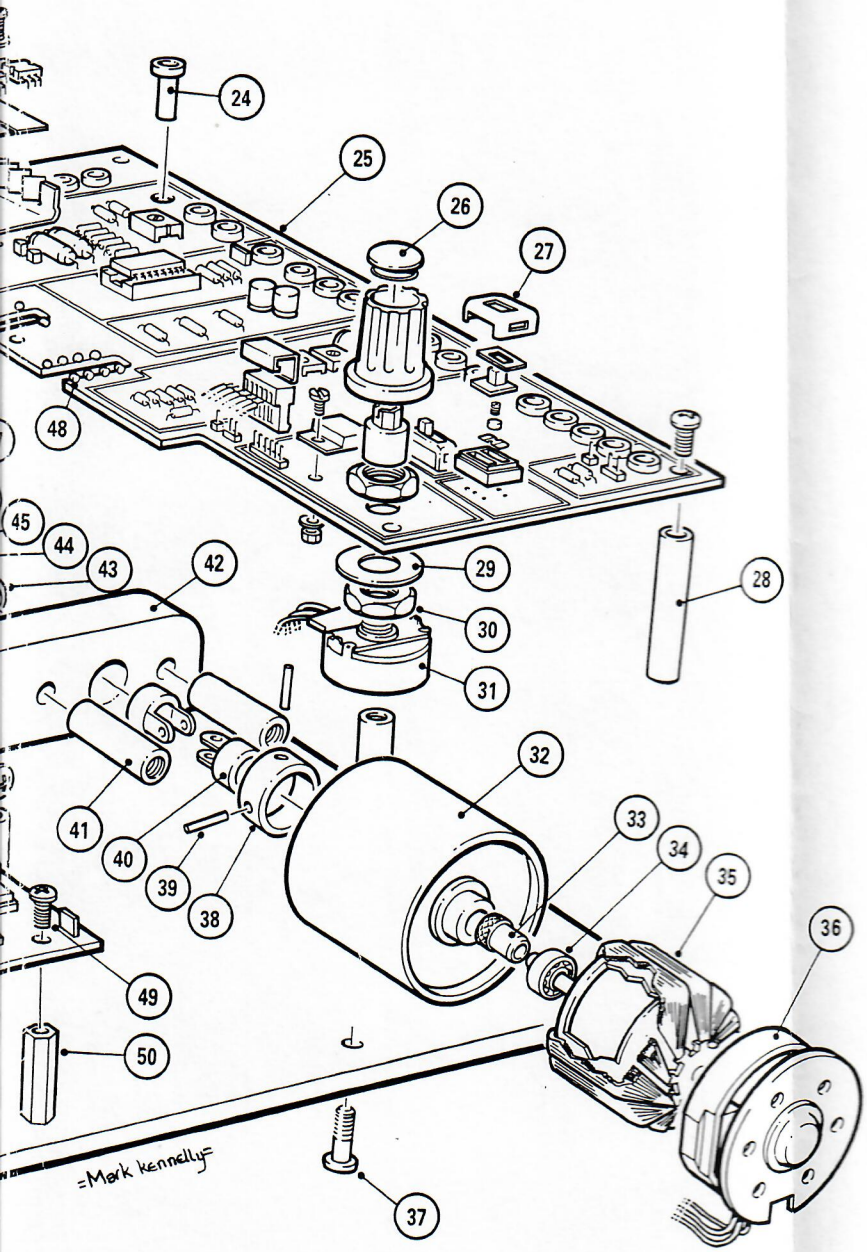
Tachogenerator Buffer and Generator Load Circuit Diagram



MS15 DC Motor Control Module Explode



ed View Drawing



Key	
1	M3 Pan Head
2	Potentiometer
3	Clamp
4	Potentiometer Holder
5	Potentiometer Coupling
6	Pot Support Pin
7	Disc/Pot Support
8	Pot Locking Pin
9	M4 Cap Head
10	Gear Shaft
11	Motor Drive Shaft
12	Motor Mounting Shaft
13	DC Motor
14	M5 Cap Head
15	Horseshoe Magnet
16	Brake Mechanism Carrier
17	M3 Pan Head
18	Field Intensifier Plate
19	Release Catch Assembly
20	Slotted Disc
21	Heatsink
22	Insulator
23	Transistor
24	Socket
25	PCB
26	Rotary Pot Switch Assembly
27	Linear Switch Assembly
28	PCB Spacer
29	Washer
30	Locking Nut
31	Rotary Pot
32	DC Motor Casing
33	Stator Retaining Bush
34	Bearing
35	Windings
36	Cover Assembly
37	M3 Pan Head
38	Universal Coupling Holder
39	Pin
40	Universal Coupling
41	Motor Mounting Pillar
42	Indicator Disc Side Rail
43	Flanged Bearing
44	Bush
45	Grub Screw
46	Timing Belt Pulley
47	Encoder Disc
48	Opto Electronics
49	Screw
50	PCB Support Pillar
51	Tachometer PCB
52	Rubber Foot
53	M3 Pan Head
54	Isolating Bush
55	PCB Spacer
56	Indicator Disc
57	Timing Pulley
58	Timing Belt
59	Tensioner Assembly
60	Stud
61	Potentiometer Side Rail
62	Rail Spacer
63	Bracket Fulcrum Block
64	Pointer
65	Disc Indicator