SGS-THOMSON MICROELECTRONICS

GS-D050

0.5 A SWITCH MODE BIPOLAR STEPPER MOTOR DRIVER MODULE

- NO EXTERNAL COMPONENT REQUIRED
- INPUTS TTL/CMOS COMPATIBLE
- LOGIC INHIBIT/ENABLE
- CHOPPER REGULATION OF MOTOR BIPOLAR CURRENT
- PROGRAMMABLE MOTOR CURRENT (0.5 A max) (by steps or continuously)
- WIDE VOLTAGE RANGE (10-46 V)
- FULL-STEP, HALF-STEP AND QUARTER-STEP OPERATIONS
- OVERTEMPERATURE PROTECTION

ORDER CODE : GS-D050

DESCRIPTION

The GS-D050 is a driver for bipolar stepper motors that directly interfaces a microprocessor and two phase permanent magnet motors.

The motor current is controlled in a chopping mode up to 0.5 A. The small outline makes the GS-D050 ideal when space is a premium.

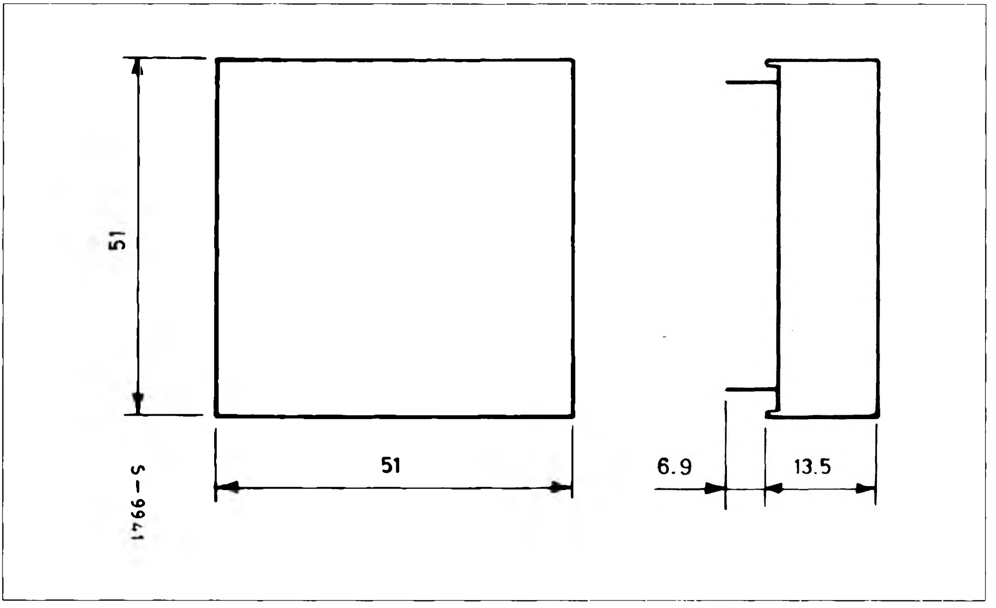
ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_s	Supply Voltage	46	V
V_{ss}	Logic Supply Voltage	7	V
V_i	Logic Input Voltage	6	V
I_o	Peak Output Current	1.2	A
V_{ref}	Reference Input Voltage	5	V
T_{stg}	Storage Temperature Range	– 40 to + 105	°C
T_{cop}	Operating Case Temperature Range	– 20 to + 85	°C

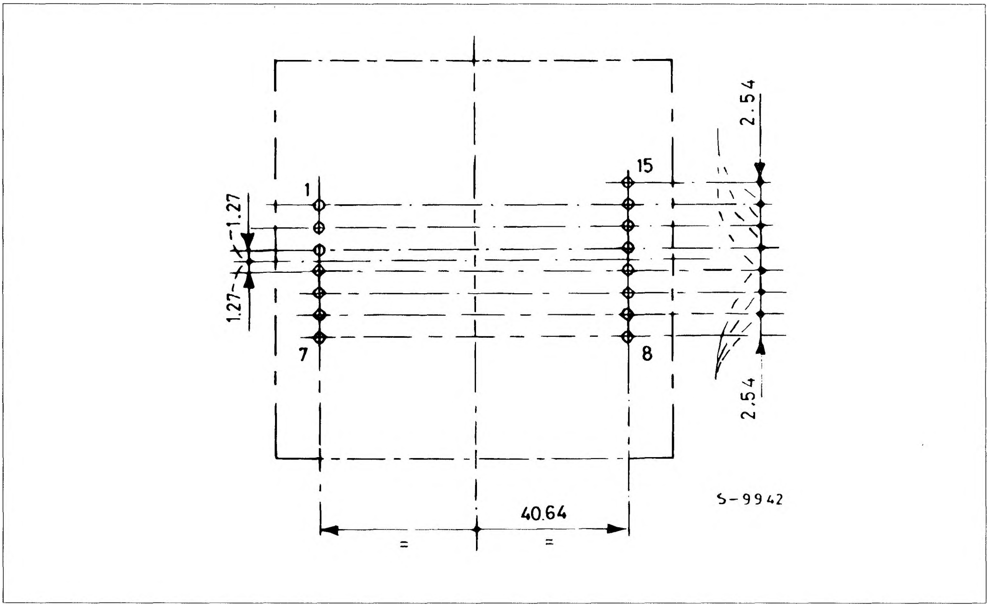
THERMAL DATA

$R_{th\ (c-a)}$	Case-ambient Thermal Resistance	Max	8.0	°C/W

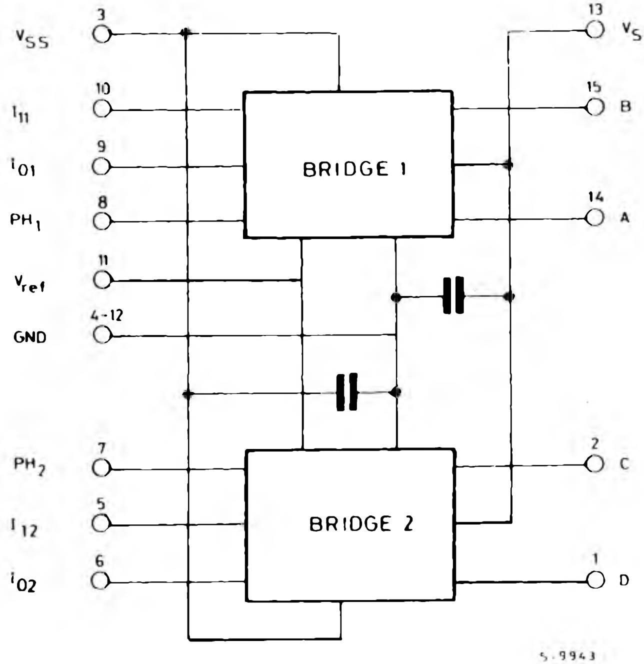
MECHANICAL DATA (dimension in mm)



MOTHER BOARD LAYOUT (top view)



EQUIVALENT BLOCK DIAGRAM OF GS-D050



PIN FUNCTIONS

Pin	Function
1 – D	Bridge Output D. This output has a phase opposite to the driving signal PH2.
2 – C	Bridge Output C. This output has the same phase of the driving signal PH2.
3 – V_{SS}	Logic Supply Voltage. Maximum applicable voltage is 7 V.
4 – GND	See Pin 12
5 – I_{12}	Input pin for current level and operating mode selection (see I_{11} description).
6 – I_{02}	Input pin for current level and operating mode selection (see I_{11} description).
7 – PH2	Phase 2 Logic Input
8 – PH1	Phase 1 Logic Input
9 – I_{01}	Input pin for current level selection (see I_{11} description)
10 – I_{11}	Input pin used, together with I_{01}, to select the current level according to the following table. I_{11}/I_{12} — I_{01}/I_{02} — Phase Current 0 — 0 — I_{ph} = 100 % I_{set} 0 — 1 — I_{ph} = 60 % I_{set} 1 — 0 — I_{ph} = 19 % I_{set} 1 — 1 — No Current
11 – V_{ref}	Reference Input Voltage for the Chopper Comparators. The voltage applied to this pin settles the phase current to the desired value. A 5 V ref sets a 0.5 A phase current when full-step drive is selected.
12 – GND	Ground Connection. Motor and logic supply voltage must be referenced, as well as the logic signals, to this pin.
13 – V_S	Motor Unregulated Supply Voltage. Maximum Applicable Voltage is 46 V.
14 – A	Bridge Output A. This output has the same phase of the driving signal PH1.
15 – B	Bridge Output B. This output has a phase opposite to the driving PH1.

ELECTRICAL CHARACTERISTICS (T_{amb} = 25 °C unless otherwise specifed)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_S	Supply Voltage	Pin 13	10		46	V
V_{SS}	Supply Voltage	Pin 3	4.75	5	5.25	V
I_S	Quiescent Supply Current	Pin 13 V_S = 35 V I_{out} = 0		15	30	mA
I_{SS}	Quiescent Supply Current	Pin 3. All Input High I_{out} = 0 V_{SS} = 5 V		15		mA
V_i	Input Voltage	Pin 5, 6, 7, 8, 9, 10 Low High	 2.0		0.8 V_{SS}	V V
I_i	Input Current	Pin 5, 6, 7, 8, 9, 10 Low High			0.4 10	mA µA
V_{sat}	Source Saturat. Voltage	Pin 1, 2, 14, 15 I_o = 0.5 A Conduction Period			2.1	V
V_{sat}	Source Saturat. Voltage	Pin 1, 2, 14, 15 I_o = 0.5 A Recirculation Period			1.4	V
V_{sat}	Sink Saturat. Voltage	Pin 1, 2, 14, 15 I_O = 0.5 A			1.4	V

MODULE OPERATION

The module consists of two identical sections each of them driving one winding of a bipolar permanent magnet stepper motor.

A brief description is given for one section.

An H bridge output stage (fig. 1) drives the winding of the motor by a constant current up to 0.5 A. The direction of the current depends on which diagonal of the H bridge is activated.

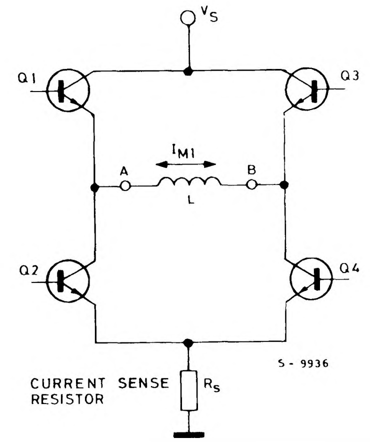
The input signal PH1 selects the diagonal. (See block diagram). When PH1 is high the two transistors Q_1 and Q_4 are switched ON and the current is sourced by the A pin and sinked by the B pin. When PH1 is low, Q_3 and Q_2 are switched ON. At switch ON the current through the winding increases almost linearly according to the equation :

$$\frac{dI_{M1}}{dt} = \frac{V_S}{L}$$

being L the inductance of the winding.

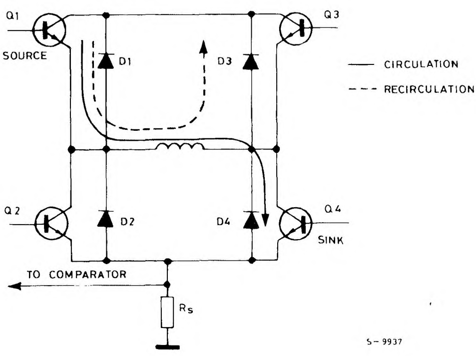
This current is sensed by a current sense resistor R_S and the voltage drop is compared to a reference voltage.

Figure 1 : Output Bridge Circuit.



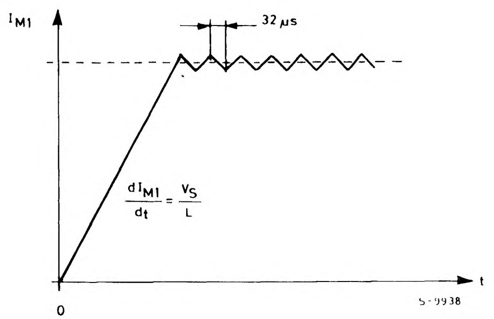
When the voltage drop is higher than reference the sink transistor (for example Q_4) is switched off and the current decays through the source transistor and the recirculating diode D3 (fig. 2).

Figure 2 : Current Paths During Current Level Control.



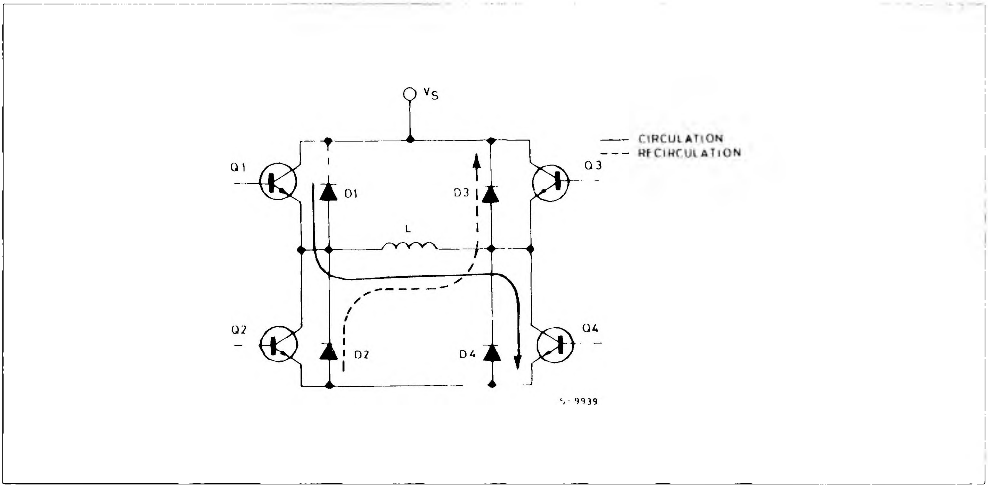
The module contains a monostable circuit that keeps OFF Q_4 for a fixed period of time (t_{OFF} = 32 µS). After t_{OFF}, Q_4 is switched on again and the cycle is repeated as long as PH1 signal is high fig 3).

Figure 3 : Output Current Waveforms.



When the signal PH1 changes state (from high to low), both Q_1 and Q_4 are switched OFF and Q_2 and Q_3 are switched ON. The current recirculates through D2 and D3 until it decays to zero and then it reverses the direction (fig. 4).

Figure 4 : Current Path During Phase Reversal.

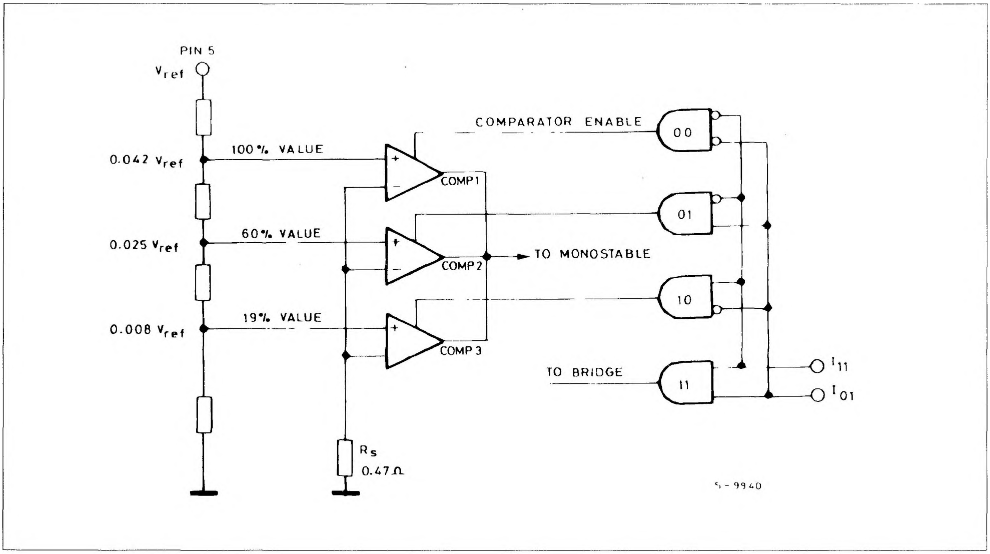


The current phase reversal is therefore obtained by a four quadrant operation while the current level control is by a two quadrant operation. The current decay by a four quadrant is faster being the total voltage applied to the winding almost equal to supply voltage.

The decay time during chopping control of the current level is internally fixed (t_{OFF}), the applied voltage to the inductance is also fixed (about 3 V) and, therefore, the amplitude of current decay or the current ripple depends exclusively on the value of L.

The level of the maximum current is fixed and controlled by a set of voltage dividers and comparators. Four current levels can be digitally selected according to the status of I_{11} and I_{01} (See block diagram and fig. 5).

Figure 5 : Current Level Setting.



When $I_{11} = I_{01} = 1$ the H bridge is disactivated and no current can circulate.

For $I_{11} = 0$; $I_{01} = 0$ the comparator 1 is enabled. The maximum current is allowed to flow through the bridge and the value of the current is given by

$$I_M = \frac{0{,}042\ V_{ref}}{R_S} = 100\ \%$$

$R_S = 0.47\ \Omega$ is internally fixed. For $V_{ref} = 5$ V the maximum allowed current is 0.45 A.

For $I_{11} = 0$; $I_{01} = 1$ the comparator 2 is enabled and the current is reduced to 60 % of the maximum value.

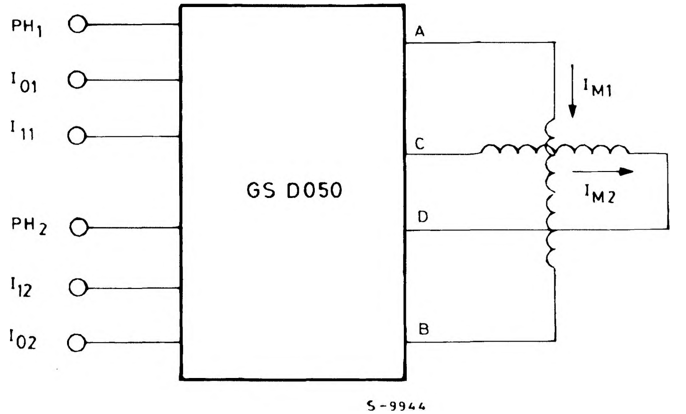
For $I_{11} = 1$; $I_{01} = 0$ the comparator 3 is enabled and the current is reduced to 19 %.

When in Wave or Half Step mode, the signals I_{11} and I_{01} are used also for the correct timing.

The following paragraphs show the mode operation of the GS-D050 making reference to the schematic of fig. 6.

The current is considered positive when flowing from A to B or from C to D.

Figure 6 : Basic GS-D050 Inputs and Outputs.



ONE PHASE ON OR WAVE DRIVE

Only one winding is energized at any given time according to the sequence (for FWD direction)

AB ; CD ; BA ; DC ;

(BA means a negative current flowing from B to A).

Fig. 7 and 8 show the timing of the input signals and of the output currents.

Figure 7 : Wave Drive FWD Direction.

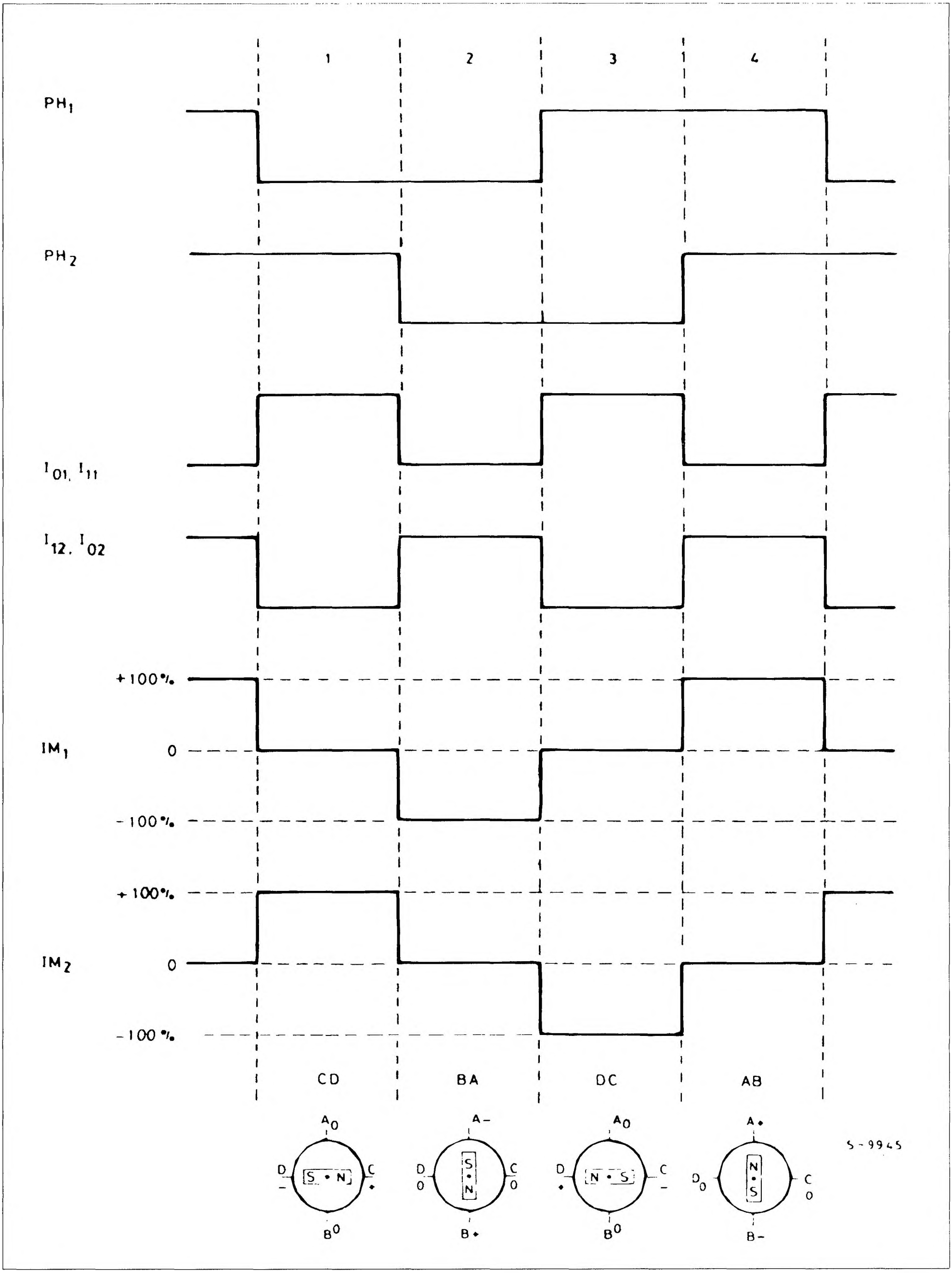
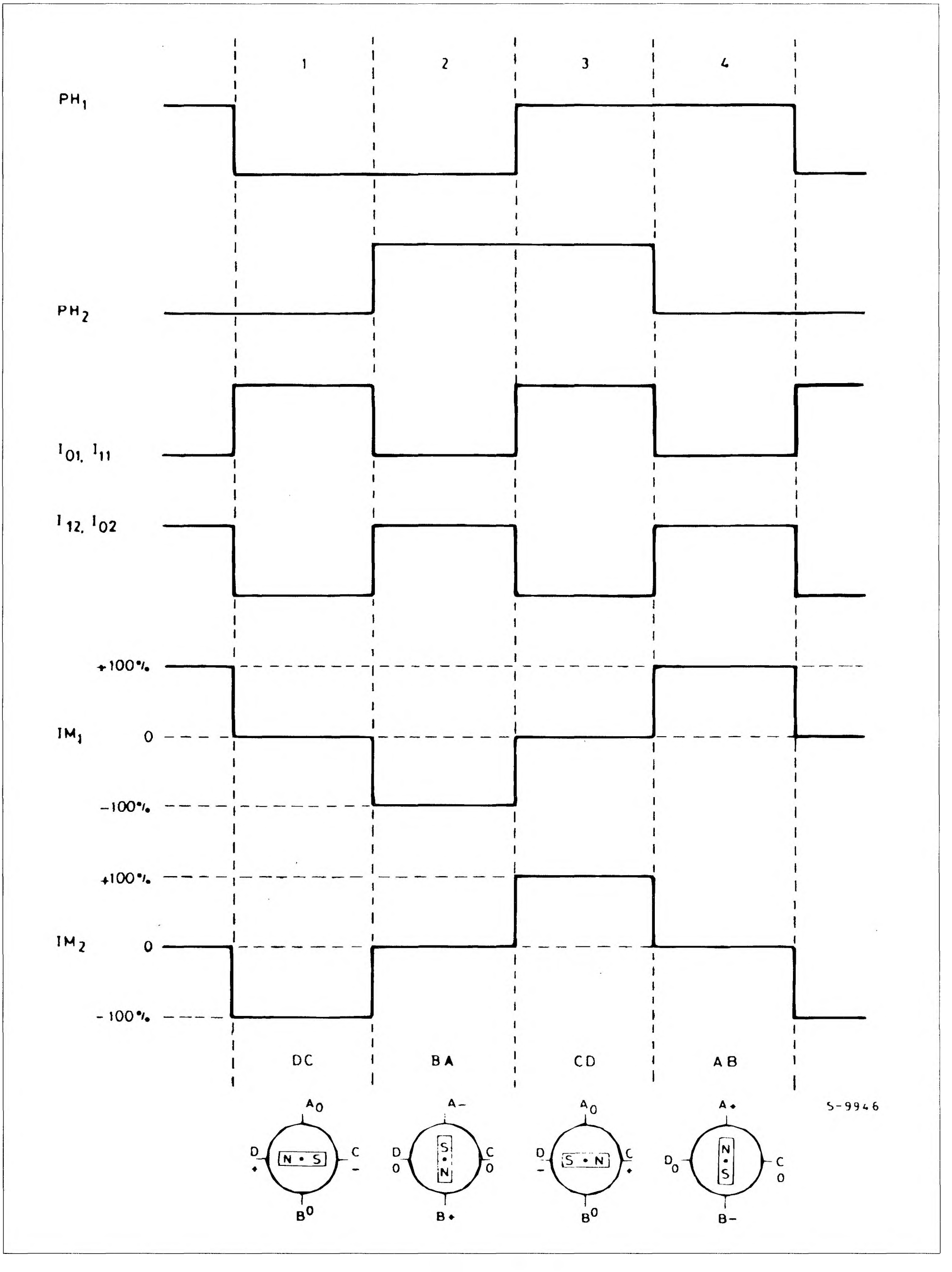


Figure 8 : Wave Drive REV Direction.



TWO PHASE ON OR NORMAL DRIVE

Two windings are energized at any given time according to the sequence (FWD direction).

AB & CD ; CD & BA ; BA & DC ; DC & AB

In this case I_{01}, I_{11} signals are used just for current level set.

Fig. 9 and 10 show the timing or various signals.

Figure 9 : Two Phase on -FWD Direction.

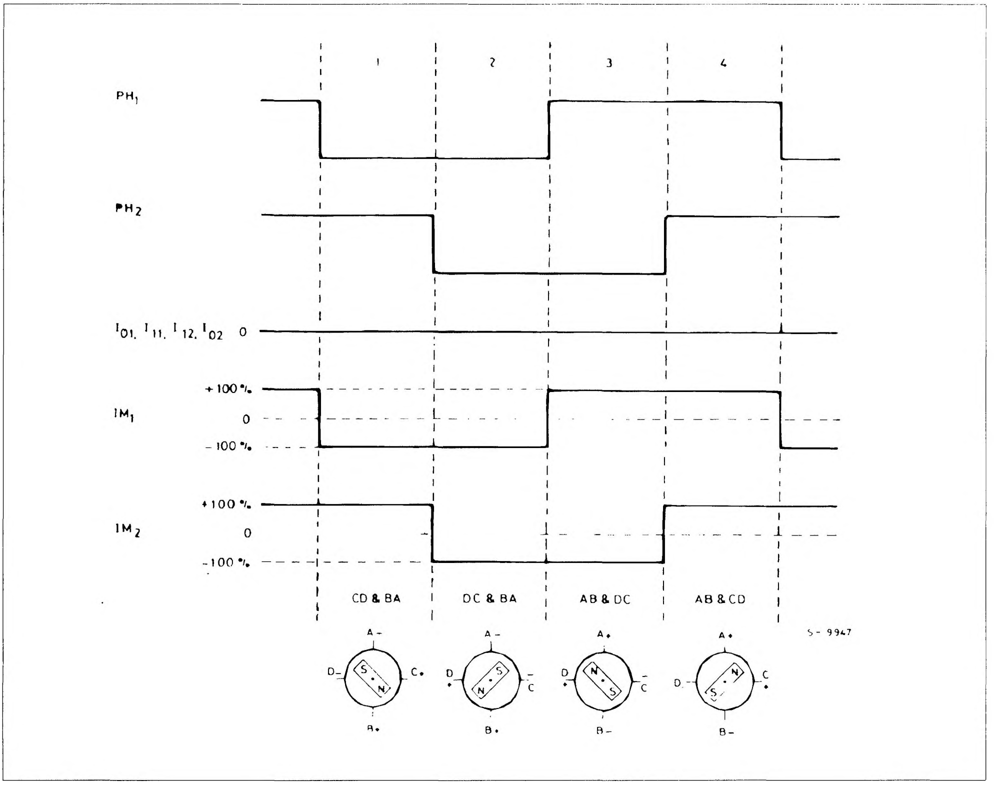
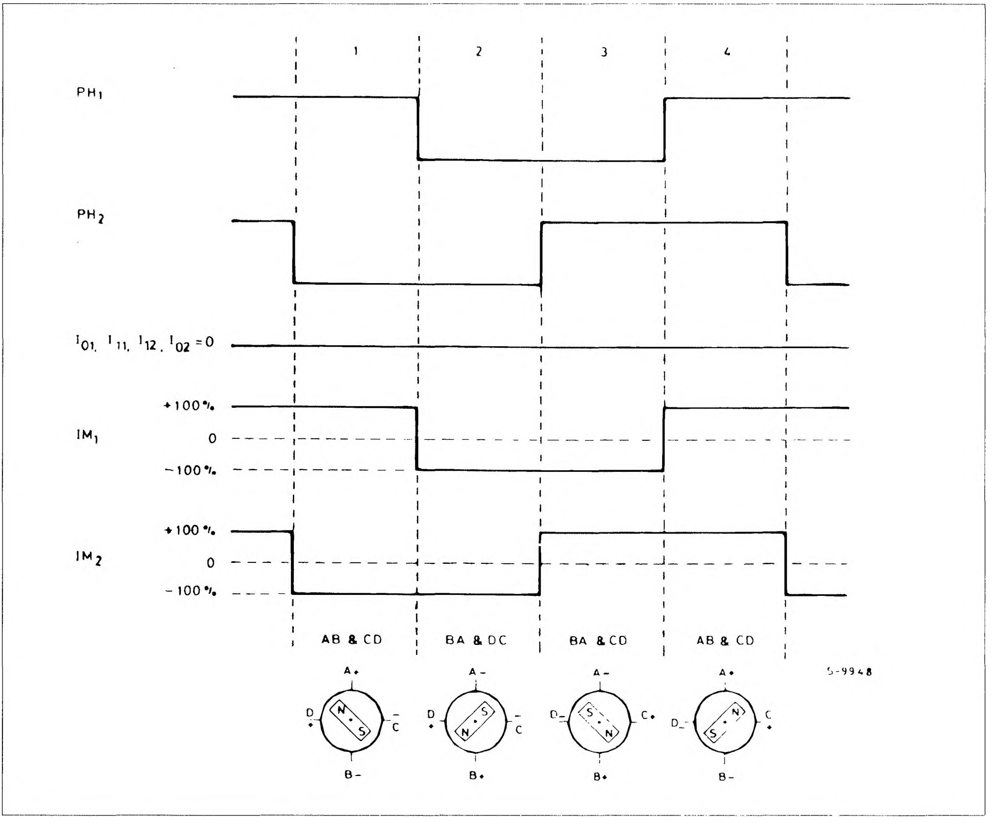


Figure 10 : Two Phase on -REV Direction.



HALF STEP DRIVE

By this mode one winding or two windings are alternatively energized. Eight steps are required for a complete revolution of the rotor.

For FWD direction the sequence is :

AB ; AB & CD ; CD & BA ; BA ; BA & DC ; DC ; DC & AB

Fig. 11 and 12 show the timing of various signals.

Figure 11 : Half Step -FWD Direction.

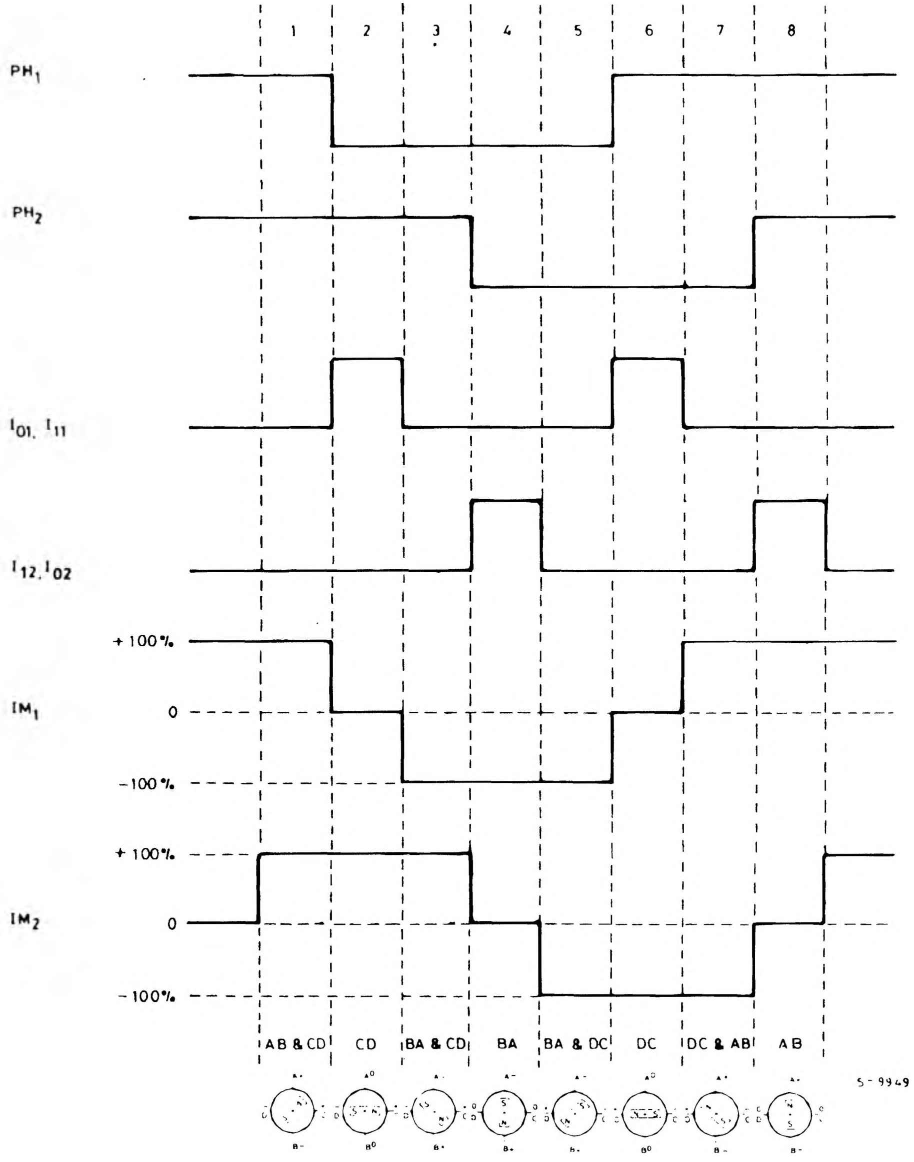


Figure 12 : Half Step -REV Direction.

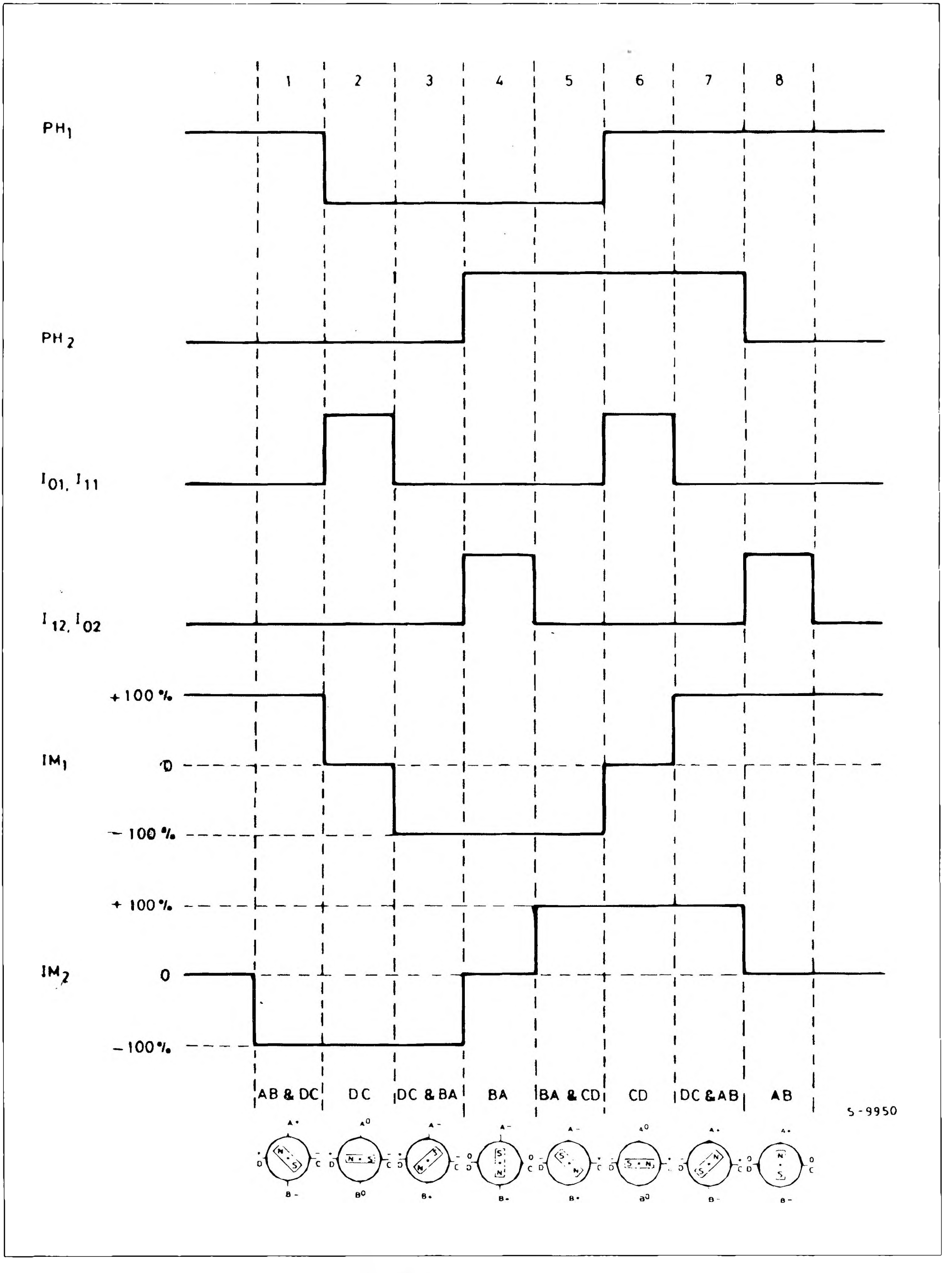


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Figure 13 : Quarter Step-FWD Direction.

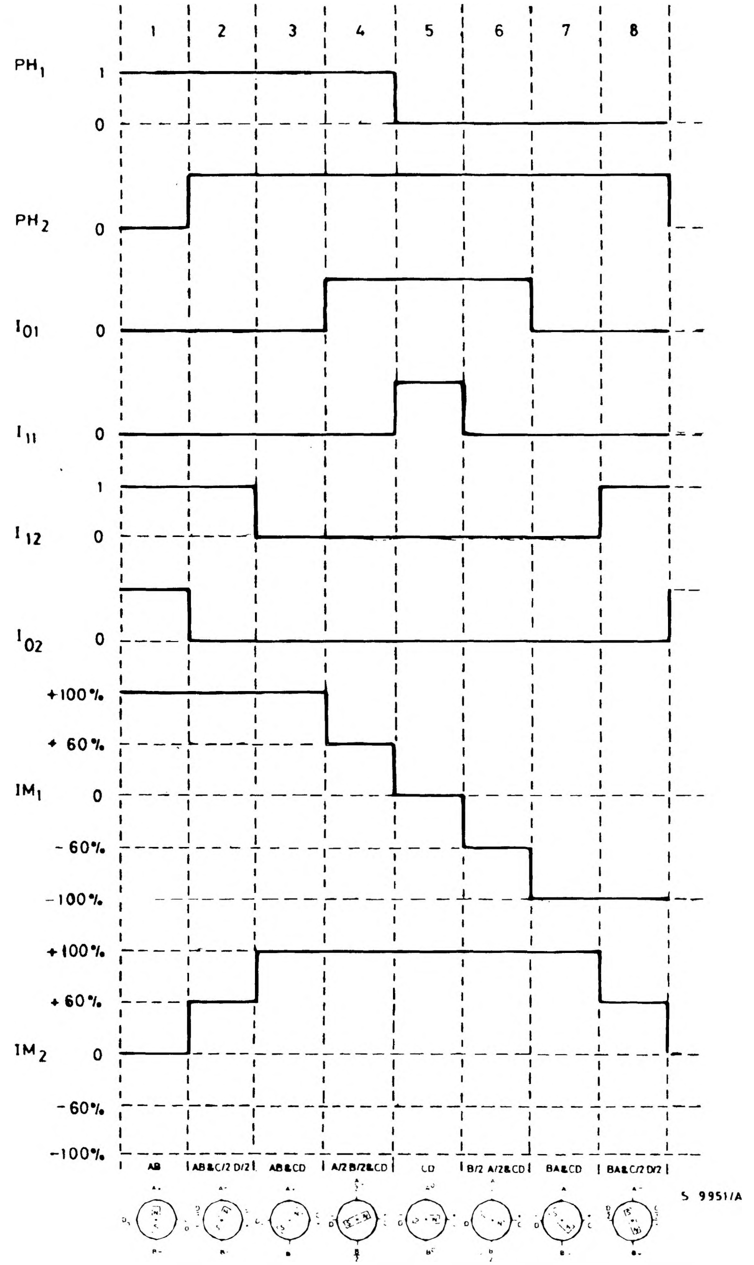
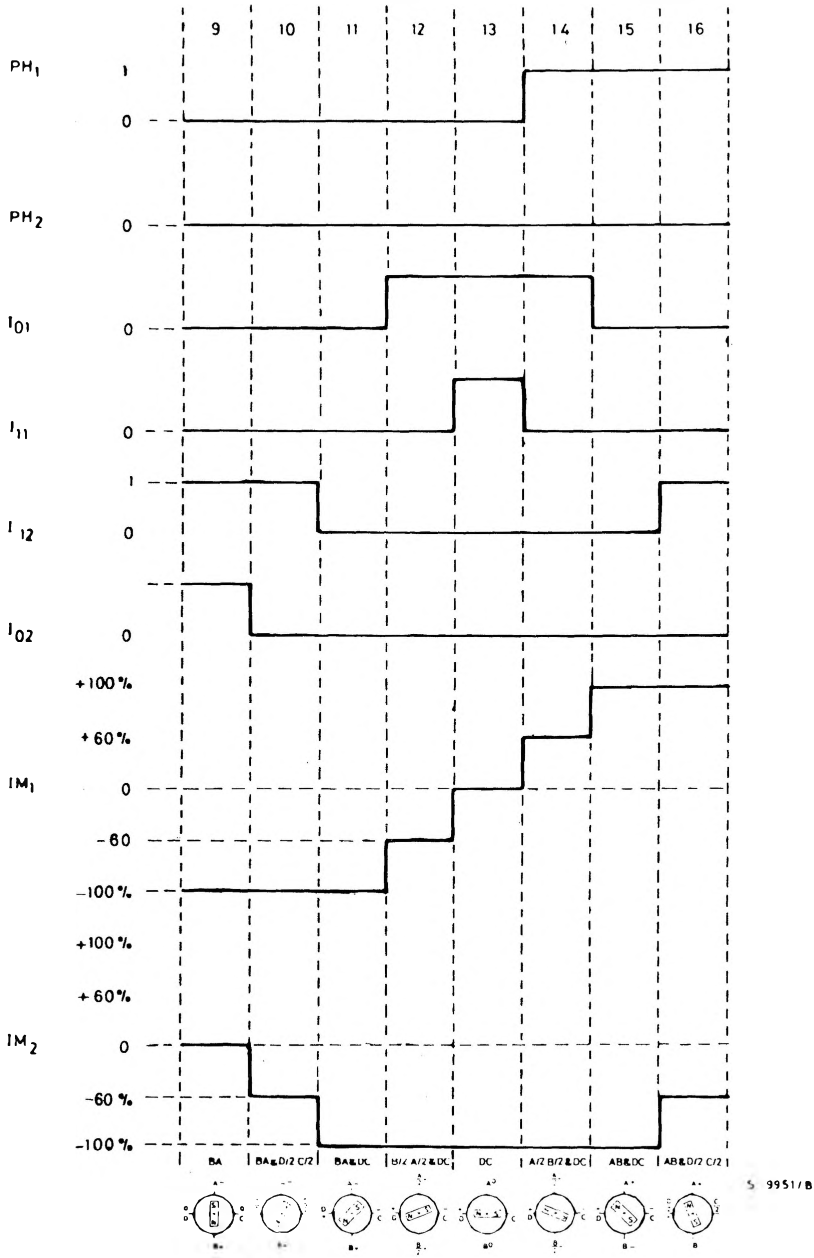


Figure 13 : Quarter Step-FWD Direction (continued).



For Wave, normal, half step, the driving can be made at any current level : for simplicity the previous diagrams refer to a condition where 100 % of the motor current is used, as set by the equation.

$$I_H = \frac{0.042\ V_{ref}}{R_S}$$

In half step mode it is advisable to reduce the current level to 60 % of the maximum when two windings are energized and to use the maximum value when one winding is energized : this allows a less irregular torque.

This operation can be simply performed by selecting the proper status of I_{01} and I_{02}.

QUARTER STEP DRIVE

It is preferable to perform the quarter step drive at full power to have a more regular torque.

The extra quarter steps are added to the half step sequence by putting one winding at half current according to the sequence.

AB ; AB & $\frac{CD}{2}$; AB & CD ; $\frac{AB}{2}$ & CD ; CD ;

CD & $\frac{BA}{2}$; CD & BA ; $\frac{CD}{2}$ & BA ; BA ;

BA & $\frac{DC}{2}$; BA & DC ; $\frac{BA}{2}$ & DC ; DC ;

DC & $\frac{AB}{2}$; DC & AB ; $\frac{DC}{2}$ & AB.

The timing for forward direction is shown on fig. 13. 16 steps are required for one complete revolution.

APPLICATION CIRCUIT

A typical application is shown on fig. 14 for a maximum winding current of about 0.5 A.

As shown, no external component is needed to drive the motor.

Signals I_{01}, I_{11}, I_{02}, I_{12} may be used to inhibit the module when they are permanently kept at high level. If they are left open, the GS-D050 treats them as at high logic level.

The case of the GS-D050 is electrically connected to ground : radiated EMI caused by chopping operation is therefore shielded by the case itself.

To reduce further EMI a low pass filter can be inserted across the outputs of the GS-D050 as shown on fig. 15.

L, C, components should be selected according to

$$L \approx \frac{L_M}{10} \qquad C = \frac{4 \cdot 10^{-10}}{L}$$

The module is protected against thermal overload.

If by any reasons (very high ambient temperature or high power dissipation or both) the junction temperatures of active components inside the GS-D050 reach 150 C the module automatically reduces the output power and the power dissipation.

Even if the module controls the maximum output current, a short circuit of the outputs can damage the device.

Figure 14 : GS-D050 Basic Application Circuit.

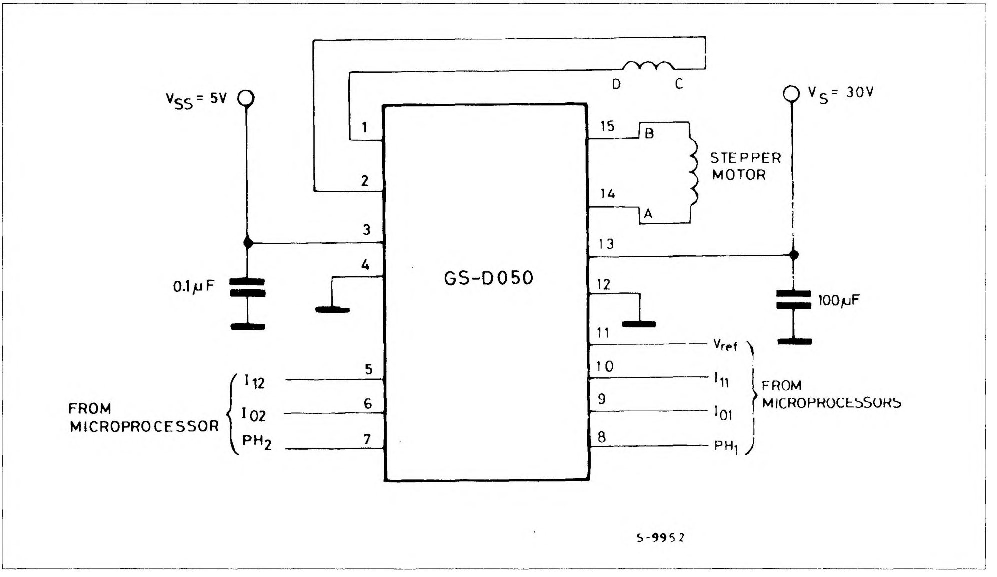


Figure 15 : Circuit for EMI Reduction.