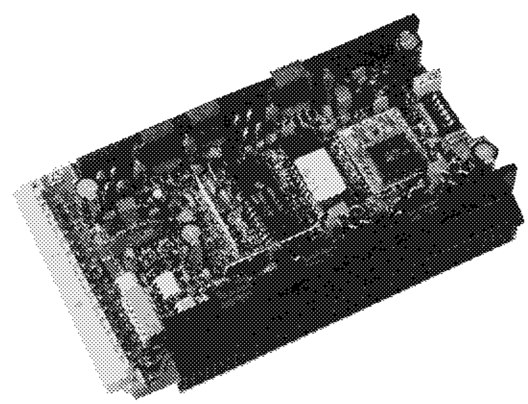
SGS-THOMSON MICROELECTRONICS

GS-D350M

5.6A MICROSTEP DRIVE BOARD FOR STEPPER MOTOR

FEATURES

- 5.6A/phase peak current
- 5, 10, 25, 45, 90, 100, 127 microsteps/step
- Full step operation
- User selectable phase current
- Automatic two quadrant chopping at rest
- Programmable phase current ripple
- 4/8 wires motors drive
- Galvanic isolation
- Full output protection against short circuits
- Thermal, under and overvoltage protection
- Step clock in excess of 140kHz
- Isolated Fault output



DESCRIPTION

The GS-D350M is a member of the SGS-THOMSON family of stepper motor drive modules and boards. It drives the 4/8 wires motor in a microstep mode thus assuring smooth and resonance free operations. On top of that it offers an unusually large number of features that allow a complete control of the electromechanical characteristics of the motion system to obtain optimum performance.
The powermos output stages offer both low conduction and commutation losses for increased efficiency; this, combined with an exclusive protection scheme, results in an extremely rugged unit suitable for harsh environment operation.
The GS-D350M single-Europe board is the simplest and most cost effective solution to any stepper motor drive requirements, thanks to the high number of embedded extra features.

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_S	DC Supply Voltage	42	V
I_{ph}	Output Current per Bridge	3.3	Apk
I_{dis}	Supply Bus Discharge Current	4	A
I_i	Logic Input Current	30	mA
I_o	Logic Output Current	10	mA
V_{is}	Logic to Supply Isolation Voltage	500	V
T_{stg}	Storage Temperature Range	– 20 to +85	°C
T_{hop}	Max Operating Heatsink Temperature*	+85	°C

* Thermal protection intervention @ $T_h > 90°C$

ELECTRICAL CHARACTERISTICS (T_A = 25°C and V_S=24V unless otherwise specified)

Symbol	Parameter		Min	Typ	Max	Unit
V_S	DC Supply Voltage		18		40	V
I_{ph}	Phase Current per Output*		0.5		2.8	A
I_i	Logic Input Current**			10		mA
V_o	Logic Output Voltage (TTL compatible)	Low High	 2		0.8 5	V
fc	Clock pulse frequency				140	kHz

* Output shorts protection phase-to-phase, phase-to-supply and phase-to-ground.
** TTL, 12V, 24V Programmable input voltage level.

Note: The unit requires an input filtering capacitor 4700µF/50V, with low ESR and located as close as possible to the board.

Figure 1. Signals Timing

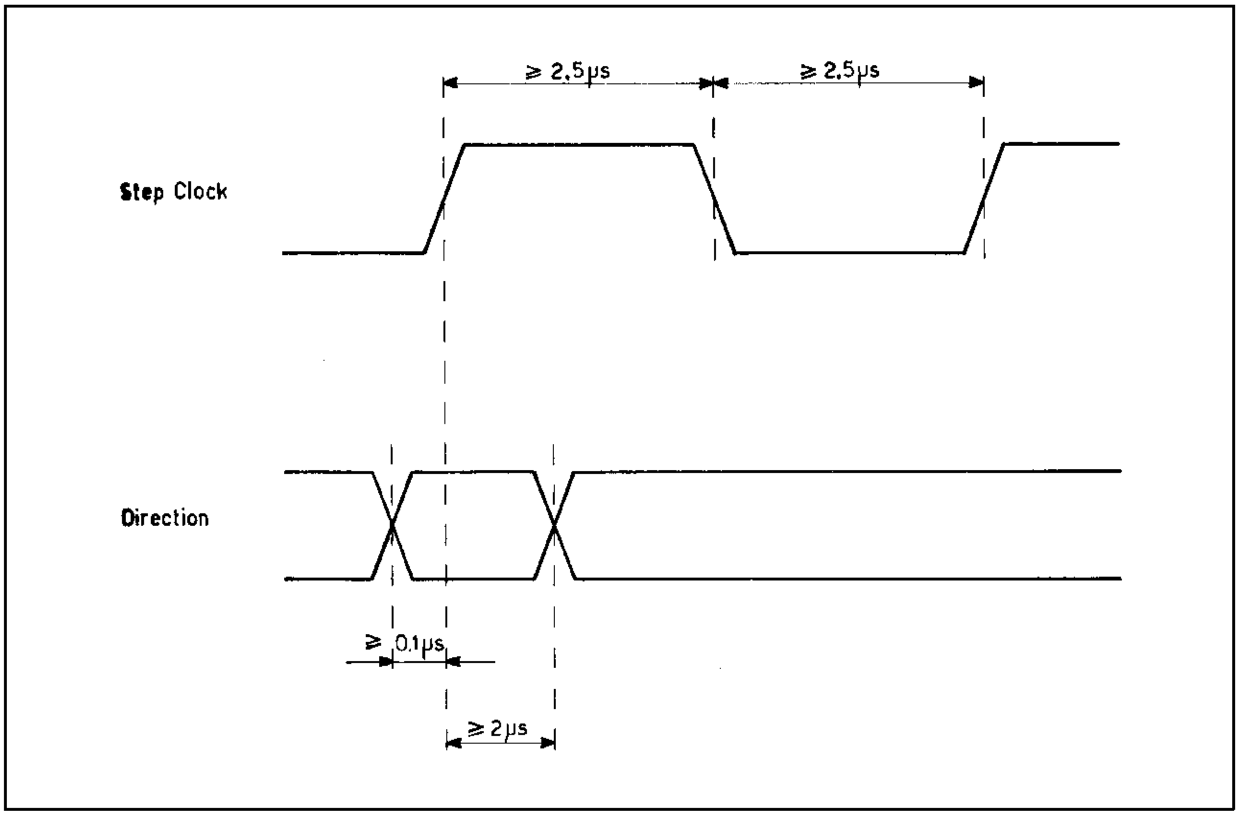
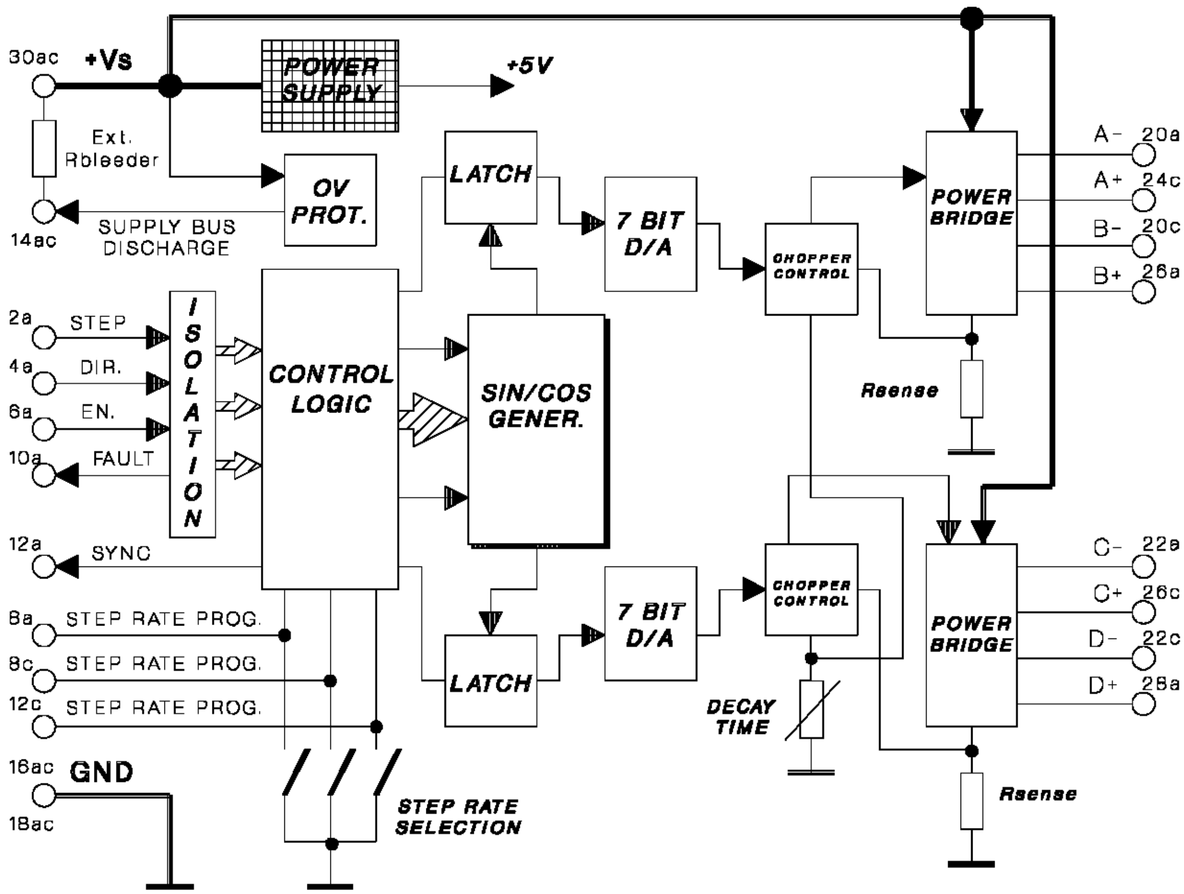
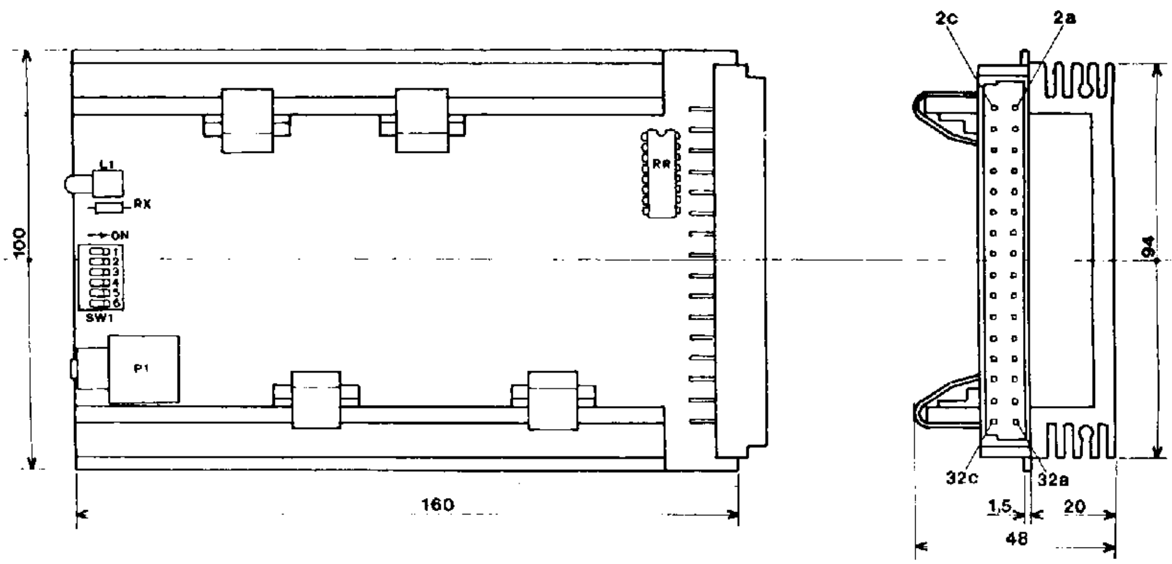


Figure 2. GS-D350M Block Diagram



CONNECTION DIAGRAM AND MECHANICAL DATA



Dimension in mm

GS-D350M Hardware available commands

SW1, SW2, SW3	Microsteps/step programming
SW4	Step clock transition selection
SW5	Direction polarity selection
SW6	Current ripple reduction at rest
R_X	Maximum peak current setting
P1	Phase current ripple programming
RR	Resistor array for logic level setting

GS-D350M BUS CONNECTOR PINS DESCRIPTION

The GS-D350M uses a 32 pins (16+16) DIN 41612-VG95324 male connector.

Pin	Function
2a	Step clock input: this is a logic input that performs the step function, i.e. on every transition of this input the motor is moved one step in the proper direction. The input is isolated and its logic level can be selected among TTL, 12V and 24V.
2c	Return path for the Step clock input.
4a	Direction input; the logic state applied to this pin decides the rotation direction of the motor shaft. The input is isolated and its logic level can be selected among TTL, 12V and 24V.
4c	Return path for the Direction input.
6a	Enable input; a logic high level applied to this input causes the power driver outputs to float. This condition allows the manual positioning of the system. Care must be used when this input is activated because the detention torque is lost. The input is isolated and its logic level can be selected among TTL, 12V and 24V.
6c	Return path for the Enable input.
8a	Microsteps/step rate remote programming
8c	Microsteps/step rate remote programming
10a	Fault logic output. This isolated output is at a low logic level whenever an anomalous condition is detected. The output is open collector, i.e. a pull-up resistor is required.
10c	Fault output return path. Must be connected to the driven logic ground.
12a	Synchronization signal for Microsteps/step logic programming.
12c	Microsteps/step rate remote programming.
14a-c	Supply bus discharge output; this output is activated when an overvoltage condition is detected. A resistive load connected between this pin and the supply bus can be used to sink power to limit the maximum supply voltage to safe conditions.
16a-c	Power supply ground
18a-c	Power supply ground
20a	Phase A– output.
20c	Phase B– output.
22a	Phase C– output.
22c	Phase D– output.
24c	Phase A+ output.
26a	Phase B+ output.
26c	Phase C+ output.
28a	Phase D+ output.
30a-c	Module supply voltage; hazardous voltages may be present on these pins.

GS-D350M DESCRIPTION

The GS-D350M is a complete subsystem to drive stepper motors either in full step or microstep mode. A very large number of auxiliary functions has been included to allow extreme simplicity and flexibility in use.

Particular care has been devoted to protections, so that the GS-D350M can be safely used in very harsh environments. In addition to the obvious function to drive the motor phases in a chopping mode, the following functions have been implemented:

- Sine/cosine generation
- Selection of seven different microsteps/step rates
- Selection of full step drive
- Programming of peak phase current to optimize the torque
- Automatic phase current ripple reduction at rest
- Full protection against short circuits between phase-to-phase, phase-to-ground and phase-to-supply
- Thermal, undervoltage, overvoltage protection
- Galvanic isolation of input signals and of fault indication output
- On board auxiliary voltages generation.

As a result, the GS-D350M can provide up to 5.6A per phase and, in its simplest application, just three command signals are required: step clock, direction, enable.

SUPPLY VOLTAGE

A single, unregulated supply voltage is requested to operate the board.

THE POWER SUPPLY MUST BE TURNED OFF WHEN PLUGGING OR UNPLUGGING THE BOARD.

The supply pins are: 30a, 30c positive rail
16a, 16c, 18a, 18c ground rail.

The other supply voltages needed by the board are internally generated by a high efficiency step-down switch mode regulator that provides also the subsystem reset at power on. The supply voltage range is between 18V and 42V: it is recommended to operate the board at a maximum voltage of 40V. If an undervoltage condition is detected (Vs < 18V) the GS-D350M is automatically disabled and an LED is activated.

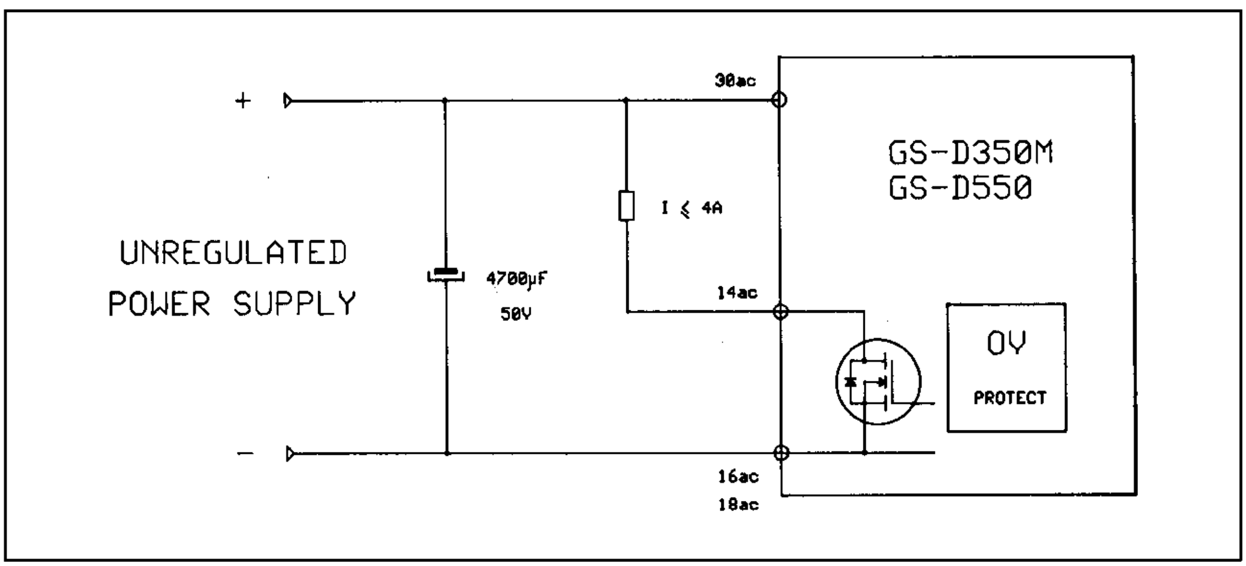
If a voltage above 42V is applied to the board, the following features are activated:

- An LED is turned on.
- An automatic overvoltage active clamping is turned on.

The active clamping system is implemented as shown in fig. 3.
The active overvoltage clamping is mainly intended to clamp transient overvoltages.

In case of permanent overvoltage, excessive power dissipation can occur. Therefore, if the supply voltage is derived from a rectified and filtered secondary winding of a main transformer, this voltage at no load and at maximum main AC voltage must be lower than 42V (50/60 Hz ripple included). Overvoltages may occur during fast deceleration because of transient spikes on the AC main supply during very fast deceleration cycles and when the output bridges are in the fast decay recirculation mode.

Figure 3. Active Overvoltage Clamping



During this mode, the phase current pulses are returned to the supply voltage: if the supply voltage impedance is not adequately low, the current pulse can raise the voltage well above the nominal level.

To avoid that the overvoltage clamping is activated at a chopping mode switching frequency, a 4700µF/50V capacitor must be connected as close as possible to the supply pins.
The ESR of the capacitor at the switching frequency (about 20÷30 kHz) must be very low.

The power rating of the external bleeder resistor can range from 10 to 50W depending on AC main supply condition (overvoltage transients frequency). The resistor must be of a low inductance type to allow fast discharge of the bus voltage.

This value varies according to the operating conditions, but in first approximation it can be calculated according to the following formula:

$$R_{bleeder} \geq \frac{V_S}{4}\ [\Omega]$$

This is the minimum usable value.

MICROSTEP PROGRAMMING

The number of microsteps per step is field programmable. The digitized sine and cosine functions, required by a microstepping control, are stored in a Lock-Up-Table inside the GS-D350M.

Two options are provided for the proper microsteps/step rate selection.

Microstep Programming by Hardware

Three switches (SW1, SW2, SW3) are available on the front edge of the board.

The microsteps/step rate is defined by the following table.

SW1	SW2	SW3	MICROSTEPS/STEP
OFF	OFF	OFF	127
ON	OFF	OFF	100
OFF	ON	OFF	90
ON	ON	OFF	45
OFF	OFF	ON	25
ON	OFF	ON	10
OFF	ON	ON	5
ON	ON	ON	1

The switches are in OFF condition when the knob is pulled versus the board edge. The last condition (ON, ON, ON) defines a full step operation.

Microstep Programming by Host Computer

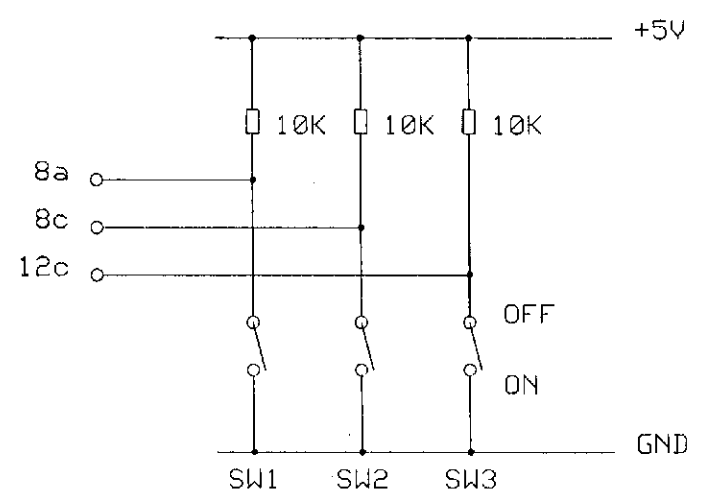
The microsteps/step rate can also be changed on-the-fly by using the three logic inputs available on the bus connector (8a, 8c, 12c) that correspond, respectively, to SW1, SW2, SW3.

This mode of operation may be requested during the motor operation to obtain, as an example, smooth start up and maximum top speed to reduce the time-to-move.

The interaction between logic signals and hardware switches is shown in fig. 4.

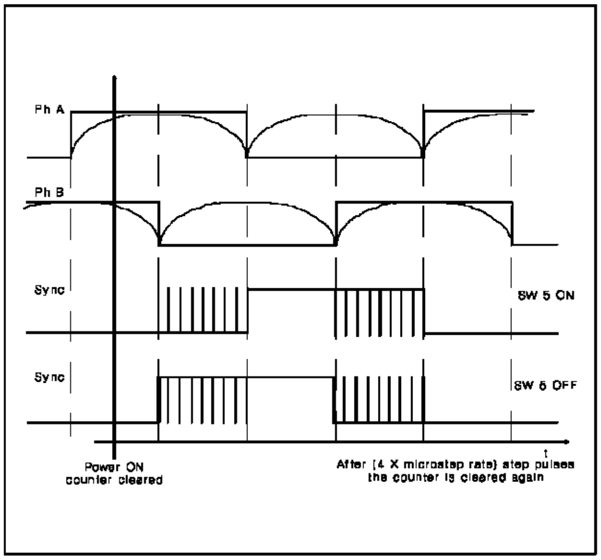
To operate the logic pins of the bus, the three internal switches must be in the OFF state (state 1).

Figure 4. Remote Microstepping Programming



The remote programming of the microsteps/step rate cannot be implemented asynchronously: it must be made only when the phase currents are at 45 electrical degrees.

That corresponds to have the internal microstep counter to zero. This counter is zeroed at power on and then cleared again at every (4 x microstep rate) step pulses.



To change the pulses ratio:

- The system controlling GS-D350M must take in count the pulses
- Every 4 x microstep rate pulses respect to the power on it can change the microstep rate
- The changing must take place more than 5 microseconds after the active edge of the clock pulse and before the next step pulse.

SETTING OF THE ACTIVE EDGE OF THE STEP CLOCK

The step clock active edge (i.e. the edge that advances the motor by one step) can be the rising or the falling edge depending on the position of the switch SW4.
The following table allows the proper setting:

SW4	ACTIVE TRANSITION
ON	Low-to-high
OFF	High-to-low

SETTING OF THE DIRECTION POLARITY

The rotation direction signal must be applied between pin 4a and 4c.
The direction (CW or CCW) depends on the status of the direction signal and of the position of the switch SW5 as shown in the following table:

DIR SIGNAL	SW5	ROTATION
HIGH	ON	CCW
HIGH	OFF	CW
LOW	ON	CW
LOW	OFF	CCW

PHASE CURRENT PROGRAMMING

The GS-D350M can be used to drive both four-wires and eight-wires motors.
Particular care must be paid to connect the wires with the correct polarity.

The GS-D350M uses four powerfet H-bridges (PHA, PHB, PHC, PHD outputs respectively)
PHA and PHB are energized in parallel as well PHC and PHD.

The possible connections of a motor are shown in fig. 5 and fig. 6.

Figure 5. Four Wires Motor Connection

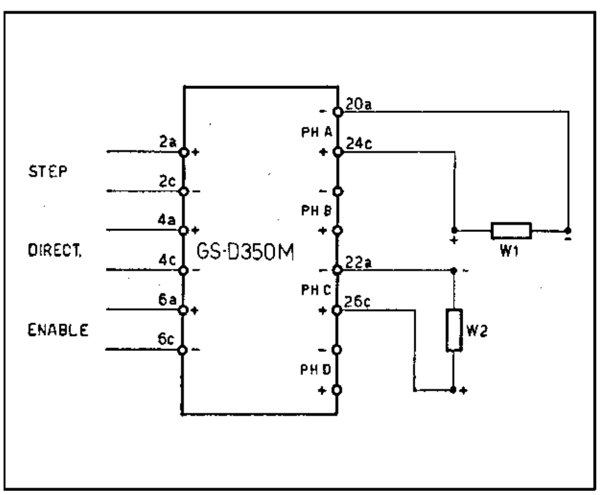
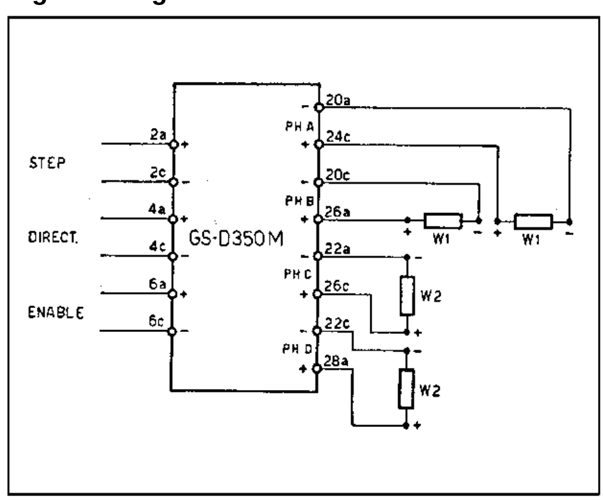


Figure 6. Eight Wires Motor Connection



In case of a four-wires motor, PHA and PHC only must be used.

Each H-bridge can deliver up to 2.8 Apk that is also the maximum current for a winding.

Therefore a four-wires motor can have a maximum phase current of 2.8 A.

In the case of an eight-wires motor the maximum phase current is 2 x 2.8 = 5.6 Apk.

The output peak current level can be programmed by a single resistor Rx that acts on all the four H-bridges.

The value of Rx for a given I_{pk} is

$$R_X = [\frac{3.2}{I_{pk}} - 1]\ k\Omega$$

The maximum value of I_{pk} is 2.8 Apk and the minimum value of Rx is 143 Ω.

The factory setting is for 1.6 Apk current for each output.

The user can modify the peak current by a proper substitution of Rx.

PHASE CURRENT RIPPLE PROGRAMMING

The phase current level control is performed by a chopping method with fixed off-time (about 32 µs) i.e. by Frequency Modulation technique.

By definition, a chopping control imposes a certain ripple on the average current. Being the off-time fixed, the amount of the current decay during the off-time, i.e. the current ripple, depends on many variables such as:

- Supply voltage
- Motor winding inductance L and resistance R
- Maximum step rate
- Microsteps/step rate.

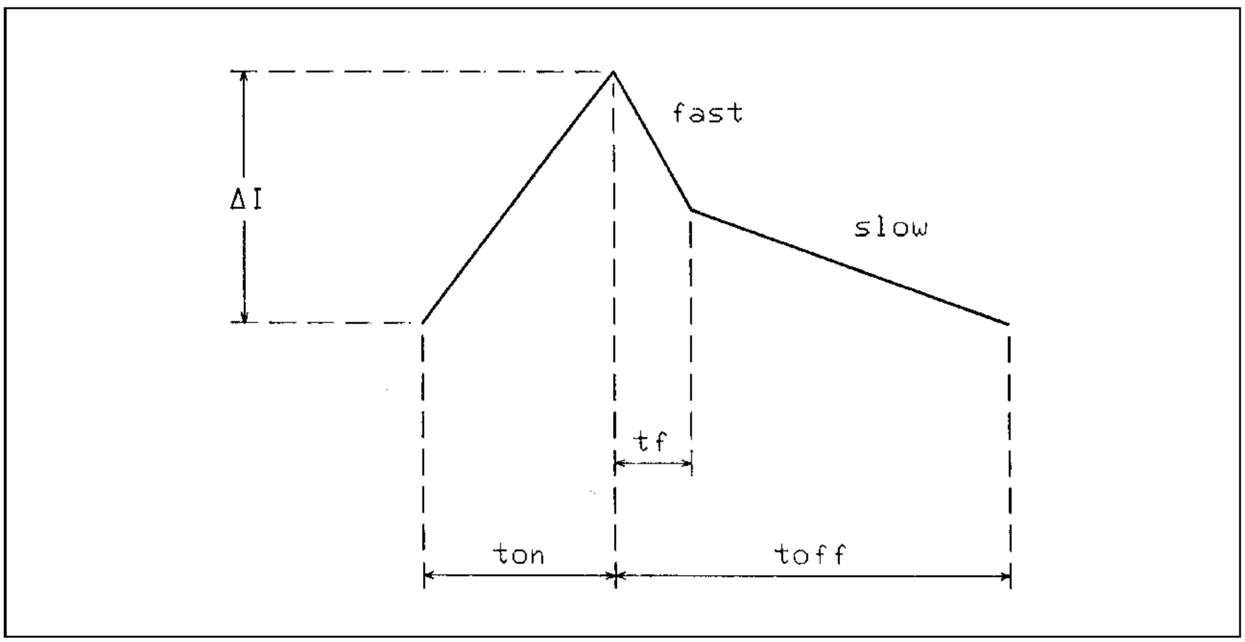
It depends also on the method used to recirculate the phase curent during the off-time (slow decay i.e. two quadrants operation or fast decay i.e. four quadrants operation).

The amplitude of the phase current ripple is a very important parameter for every microstepping drive mode because it contributes to the electromechanical performance of the system.

A low current ripple offers noiseless operation and reduced power dissipation in the motor.

The GS-D350M uses a mixed recirculating method: fast and slow decay as shown qualitatively in fig. 7.

Figure 7. Mixed Decay Method



During the time t_f, a fast decay (four quadrants operation) is imposed. The off-time is then completed in a slow decay (two quadrants operation). The current ripple is, therefore, a function of t_f too. The fast decay time t_f can be continuously adjusted by acting on potentiometer P1 (R36) provided on the front edge of the board.

The proper setting of P1 (R36) can be made by monitoring the phase current under the worst case operation and by adjusting P1 (R36) until a sinusoidal current waveform is reached.

When the motor is at rest, no back EMF is generated and the current ripple might increase.
To prevent this phenomenon, the automatic ripple reduction feature at rest has been implemented in the GS-D350M.

By putting the switch SW6 in the ON position, the phase current recirculates in a slow decay for all the off-time ($t_f = 0$), so giving the minimum possible ripple current determined, only, by the supply voltage and the L/R constant of the motor.

The user could eventually reduce the external supply voltage at rest to further reduce the current ripple. If the SW6 is in the OFF position there is no ripple reduction at rest.

INPUT COMMANDS

In its most straightforward application, the GS-D350M requires just three input commands as shown in fig. 5 (STEP CLOCK, DIRECTION, ENABLE).

The module is disabled when pin 6a is at high logic level versus pin 6c.

These three signals are galvanically isolated by internal optocouplers. (Isolation voltage: 500V).

The level of the input signal is field programmable. The factory setting is for TTL signals.

In case the signals level is 12V or 24V, a DIL resistor array must be changed as shown in fig. 8.

THERMAL PROTECTION

The GS-D350M board has an integral heatsink that allows continuous operation up to 50°C ambient temperature if the phase current is limited to 4 Apk.

At higher ambient temperature and/or higher phase current levels additional cooling must be provided by forced ventilation or by additional heatsink.

The maximum allowable winding current for an eight-wires motor versus the ambient temperature is shown in fig. 9 while fig. 10 shows maximum current level at rest.

To protect the system against unforeseen odd events, a thermal protection is activated whenever the heatsink temperature reaches about 90°C.
The thermal protection disables the module and the condition is signaled by the FAULT signal.

OUTPUT OVERLOAD AND SHORT CIRCUIT PROTECTION

To prevent permanent damage to the GS-D350M, three protections have been implemented against overload and short circuits between:

– output to supply voltage
– output to output
– output to ground.

When one of these adverse conditions occurs, the drive of the output H-bridges in disabled and the condition is signaled by the FAULT signal.

FAULT SIGNAL

The FAULT signal is available at pin 10a and 10c. When a fault is present, pin 10a goes low versus pin 10c.

This output is a galvanically isolated TTL signal.
Whenever the FAULT signal is activated, the LED provided in the front edge of the module is switched ON.

Figure 8. Input Signal Level Programming

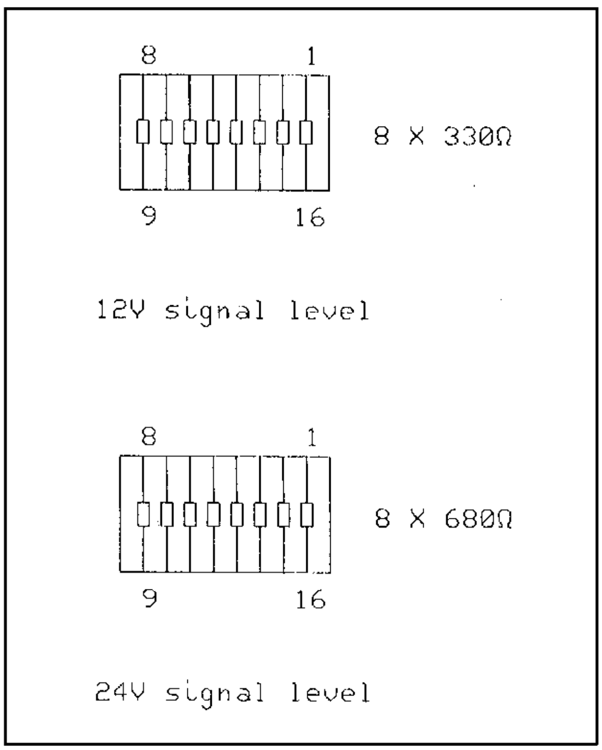


Figure 9. Thermal behaviour when stepped

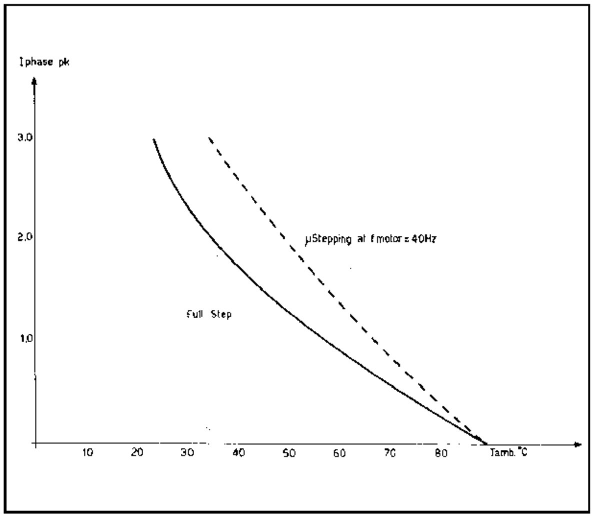
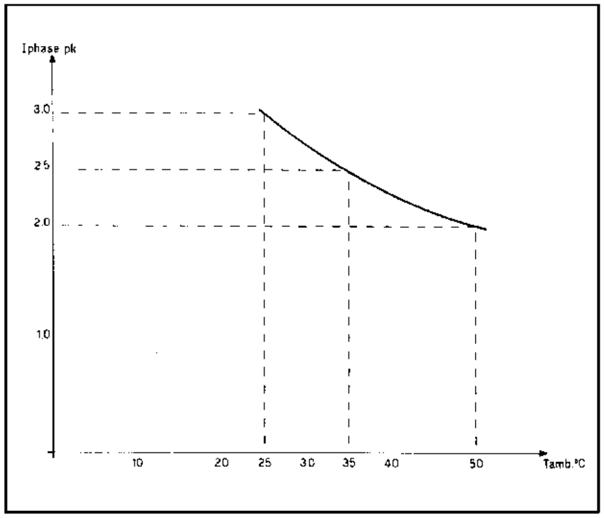


Figure 10. Thermal behaviour at rest

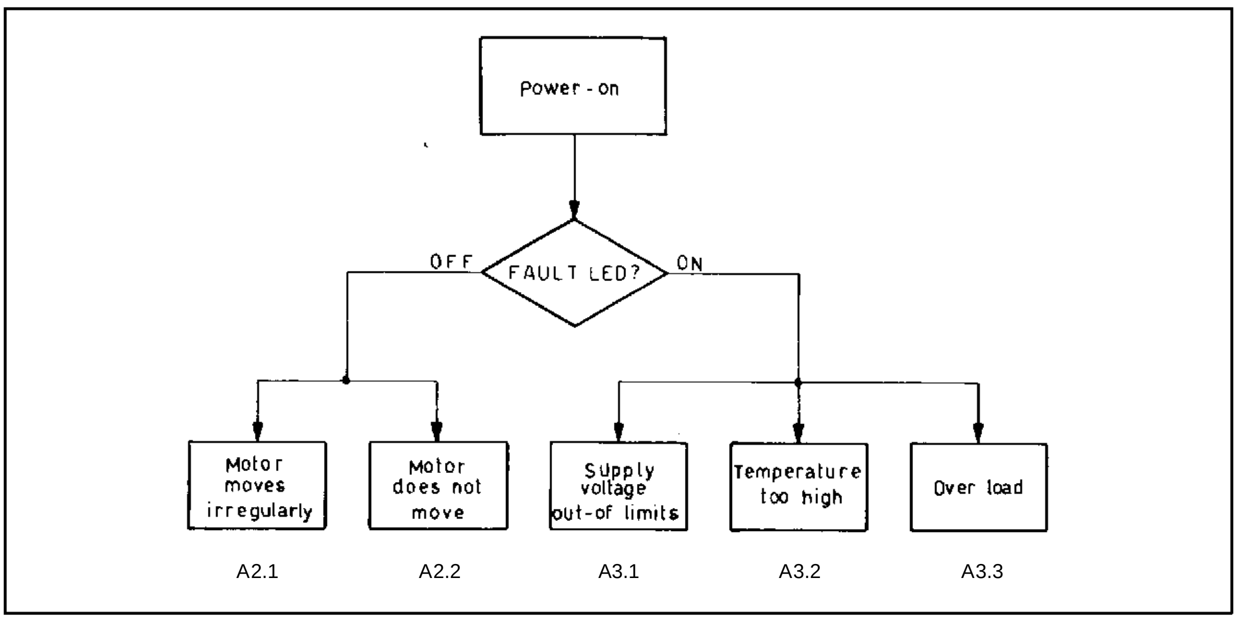


The FAULT signal is active (low) when:

– the supply voltage is lower than 18V
– the supply voltage is higher than 42V
– the heatsink temperature is higher than 90°C
– an output overload is present.

A - TROUBLE SHOOTING

A1 - Troubleshooting Sequence



A2 - FAULT SIGNAL INACTIVE

A2.1 - The motor moves irregularly if:

a) there is an error in the motor connection;

b) the step rate is close to the resonance frequency or too high;

c) the load plus friction torque is close to motor torque;

d) the motor is defective.

The corrective actions are:

a) check and correct the motor connections;

b) change the step rate;

c) increase the phase current or decrease the step rate;

d) substitute the motor.

A2.2 - The motor doesn't move if:

a) there is an error in the motor connection;

b) the Step-clock signal is not present, wrongly connected or badly timed;

c) the load plus friction torque is too high;

d) the motor is defective.

The corrective actions are:

a) check and correct the motor connections;

b) verify the step-clock connection and the timing;

c) increase the phase current or use a larger motor;

d) substitute the motor.

A3 - FAULT SIGNAL ACTIVE

The fault output is active when:

a) the supply voltage is lower than 18V;

b) the supply voltage is higher than 42V;

c) the heatsink temperature is higher than 90°C;

d) there is an output overload condition.

A3.1 - An anomalous supply voltage condition occurs if:

a) the power supply is incorrectly set or a power supply fault has occurred;

b) the motor is used as a generator;

c) very fast deceleration is used.

The corrective actions are:

a) check and correct the power supply setting;

b) use the bus discharge circuit and limit the motor speed to safe values;

c) use the bus discharge circuit and longer deceleration times.

A3.2 - The heatsink temperature is higher than 90°C if:

a) the ambient temperature (around the board) is too high.

The corrective actions are:

a) provide an adequate heatsink, space and ventilation to the board.

A3.3 - An output overload condition is detected if:

a) an accidental short circuit phase-to-phase, phase-to-ground or phase-to-supply has occurred;

b) the motor has an internal short circuit.

The corrective actions are:

a) check the integrity of the connections between the board and the motor;

b) substitute the motor.