4-phase Unipolar stepper motors

7.5° Step angle

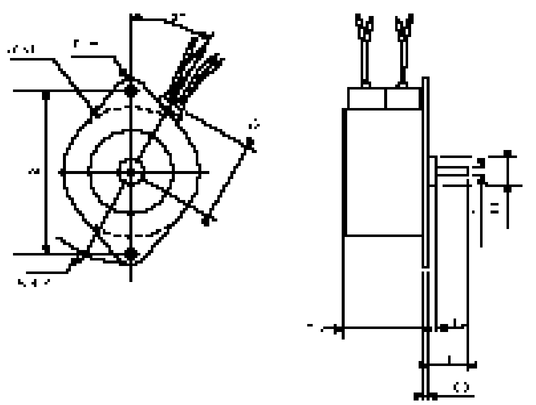
Holding torque (mNm)	**RS** stock no.
20mNm	440-262
57mNm	440-284
155mNm	440-290
240mNm	440-307

15° Step angle

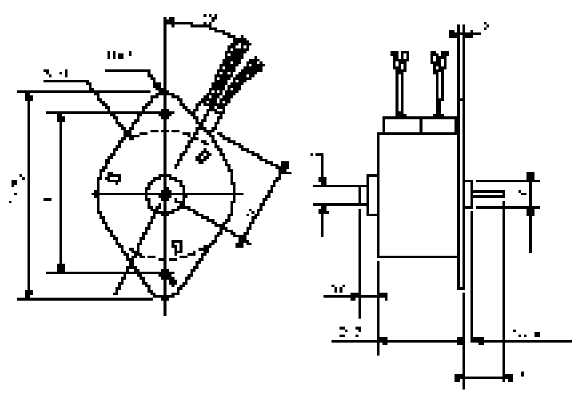
Holding torque (mNm)	**RS** stock no.
14.5mNm	199-863

Motor dimensions

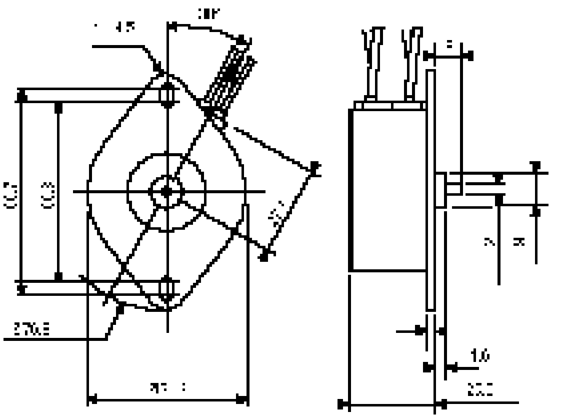
RS stock no. 440-262



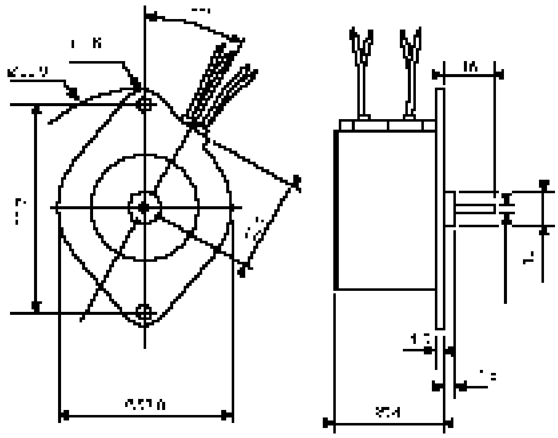
RS stock no. 199-863



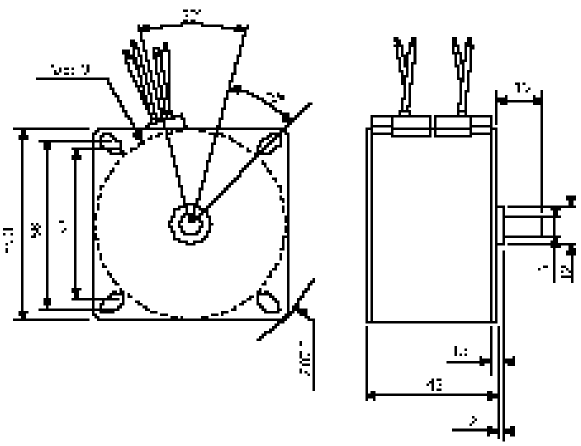
RS stock no. 440-284



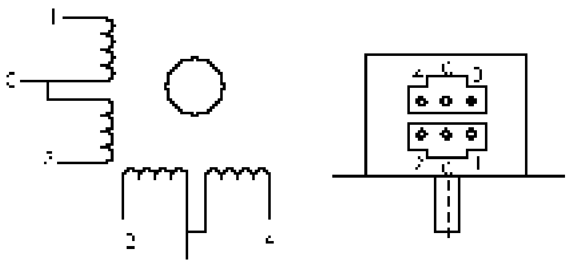
RS stock no. 440-290



RS stock no. 440-307



Motor’s connection diagram



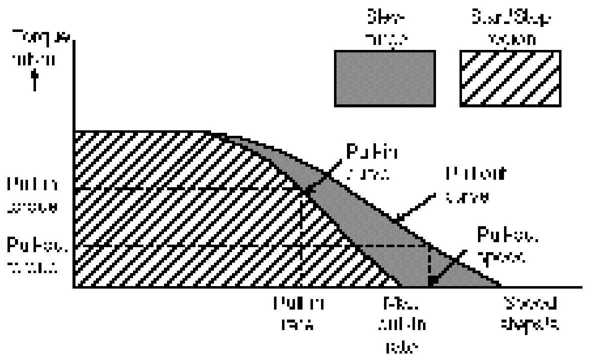
Technical specification

RS stock no.	440-262	199-863	440-284	440-290	440-307
Power consumption (w)	5	5	7.5	10	12.5
Step angle (deg.)	7.5	15	7.5	7.5	7.5
Holding torque (mNm)	20	20.0	57	155	240
Max. detent torque (mNm)	3	5.0	6	12	16
Nominal voltage (v)	12.7	13.0	12.9	12.5	12.7
Length of leads (mm)	250	250	250	250	250
Max. motor temp. (°C)	120	120	120	120	120
Resistance/Phase (Ω)	66	70	46	32	26.7
Inductance/Phase (mH)	28	32	48	47	40
Current/Phase (A)	0.19	0.19	0.28	0.39	0.48
Weight	90	90	90	210	250

Characteristics and terminology

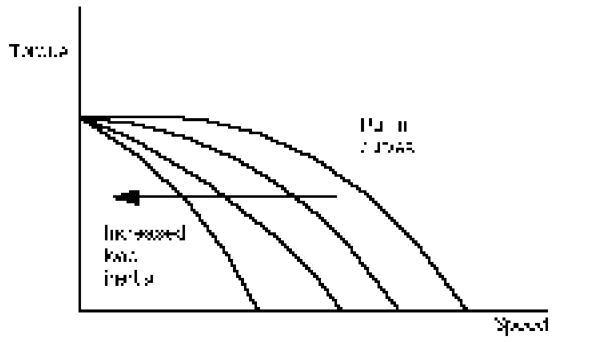
Torque-speed characteristic for a stepper motor may be represented as in Figure 1.

Figure 1 **Torque-speed characteristics**



The pull-in curve describes the maximum constant start/stop rate that a frictionally loaded motor can achieve without loss of step. This curve is dependent on the method of driving the motor and the load inertia. The effect of the latter is shown in Figure 2.

Figure 2 **Effect of load inertia on pull-in curve**



The pull-out curve describes the maximum stepping rate which a frictionally loaded motor can follow without losing steps, assuming sufficient time is allowed to accelerate the motor by ramping the frequency of the command drive circuit. Within the start/stop region the motor can be started, stopped or forced to change direction of rotation following a sudden command change from the drive circuit. However, within the slew range the motor can be accelerated or decelerated to the required speed and it cannot suddenly change direction.

Stepper motor terminology

Detent torque: The maximum torque that can be applied to the spindle of an unexcited motor without causing continuous rotation.

Holding torque: The maximum steady torque that can be externally applied to the spindle of an excited motor without causing continuous rotation.

Maximum working torque: The maximum torque that can be obtained from the motor.

Pull-in torque: The maximum torque that can be applied to a motor spindle when starting at the pull-in rate.

Pull-in rate (speed): The maximum switching rate (speed) at which a frictionally loaded motor can start without losing steps.

Maximum pull-in rate (speed): The maximum switching rate (speed) at which an unloaded motor can start without losing steps.

Pull-out rate (speed): The maximum switching rate (speed) which a frictionally loaded motor can follow without losing steps.

Pull-out torque: The maximum torque that can be applied to a motor spindle when running at the pull-out rate.

Step angle: The nominal angle that the motor spindle must turn through between adjacent step positions.

Stepping rate: The number of step positions passed by a fixed point on the rotor per second.

Positional accuracy

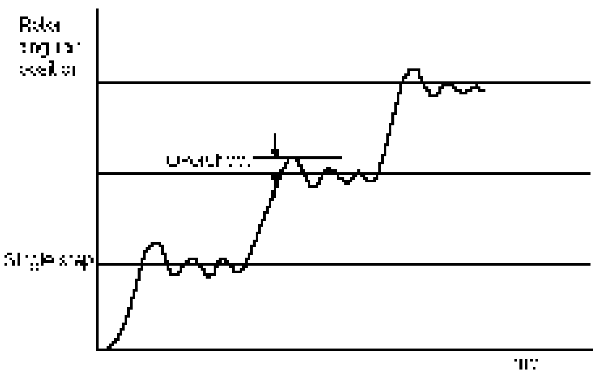
This represents the tolerance of each angular step movement. Typically within 5-10% of one step angle this error is non-cumulative ie. remains constant regardless of the number of steps advanced.

For a 4-phase motor this error averages to zero in 4 steps (corresponding to a full drive cycle). For this reason when accurate positioning is desired it is recommended, whenever possible, that the movement is divided into multiples of 4 steps.

Overshoot

When making a single step the rotor tends to overshoot and oscillate about its new position. The response depends on the drive method and load inertia. The greater the torque to inertia ratio, the less is the overshoot. In addition friction damping reduces the amount of overshoot.

Figure 3 **Overshoot**



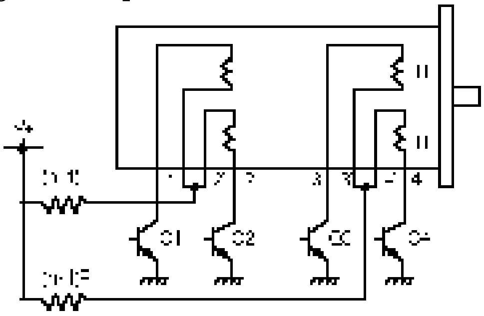
Resonance

Certain operating frequencies cause resonance and the motor loses track of the drive input. Audible vibration may accompany resonance conditions. These frequencies should be avoided if possible. Driving the motor on the half step mode greatly reduces the effect of resonance. Alternatively extra load inertia and external damping may be added to shift resonance regions away from the operating frequency.

Motor drive methods

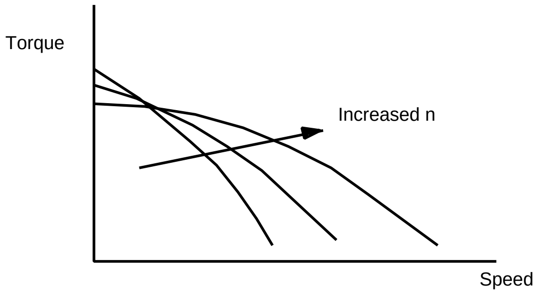
The normal way of driving a 4-phase stepper motor is shown in Figure 5.

Figure 5 **Unipolar drive**



This is commonly known as the 'Unipolar L/nR drive'. Here the current in each winding, when energised, flows in one direction only. 'n', value is ≥1 (but not necessarily an integer) and nR is the sum of the external resistance plus the winding resistance (R). By selecting a higher value for n (ie. larger external resistance) and using a higher dc supply to maintain the rated voltage and current for each winding, improved torque speed characteristics can be obtained (see Figure 6). Thus a 6V, 6Ω motor (1A per phase) can be driven from a 6Vdc supply without any series resistor, in the L/R mode. Alternatively it can be driven from a 24Vdc supply using 18Ω series resistance in the L/4R mode with much improved performance.

Figure 6 **Effect on motor performance of higher supply voltages and larger series limiting resistance**



To step a motor in a particular direction a specific switching sequence for the drive transistors Q1-Q4 needs to be followed. If this sequence is as in Table 1 (known as the unipolar full step mode) it results in the rotor advancing through one complete step at a time.

Alternatively the motor can be driven in the half step mode by a mixed single/dual phase switching as shown in Table 2. This results in the rotor advancing through half the step angle at a time. This mode stabilises the motor operation and allows faster stepping rates (refer to stepper motor drives).

Table 1 **Full step mode**

	Step No.	Q1	Q2	Q3	Q4
Start position (arbitrary)		ON	OFF	OFF	ON
	1	ON	OFF	ON	OFF
(arbitrary)	2	OFF	ON	ON	OFF
	3	OFF	ON	OFF	ON
	4	ON	OFF	OFF	ON
Above sequence repeating	5	ON	OFF	ON	OFF

↑ Anti-clockwise ↓ Clockwise

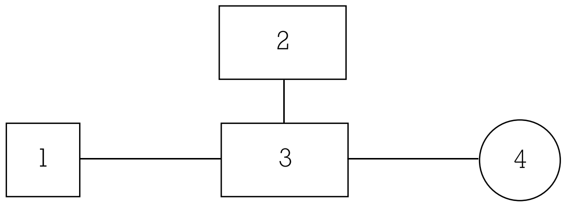
Table 2 **Half step mode**

	Step No.	Q1	Q2	Q3	Q4
		ON	OFF	ON	OFF
Start position	1	ON	OFF	OFF	OFF
	2	ON	OFF	OFF	ON
	3	OFF	OFF	OFF	ON
	4	OFF	ON	OFF	ON
	5	OFF	ON	OFF	OFF
	6	OFF	ON	ON	OFF
	7	OFF	OFF	ON	OFF
Above sequence repeating	8	ON	OFF	ON	OFF
	9				

↑ Anti-clockwise ↓ Clockwise

Typical stepper motor control system

The operation of a stepper motor requires the presence of the following elements:



1. **A control unit**. Usually a microprocessor based unit which gives step and direction signals to the drive card. **RS** stepper motor control board (**RS** stock no. 440-098) is ideally suited for this function.
2. **Power supply**. Giving the required voltage and current for the drive card.
3. **Drive card**. This converts the signals from the control unit in to the required stepper motor sequence. **RS** stock nos. 217-3611 and 255-9069 are designed for the function.
4. **Motor**.