PHILIPS

Data handbook

PHILIPS Electronic components and materials

Components and materials

Part 6 April 1977

Electric motors and accessories

COMPONENTS AND MATERIALS

Part 6 **April 1977**

DATA HANDBOOK SYSTEM

Our Data Handbook System is a comprehensive source of information on electronic components, subassemblies and materials; it is made up of three series of handbooks each comprising several parts.

ELECTRON TUBES	**BLUE**
SEMICONDUCTORS AND INTEGRATED CIRCUITS	**RED**
COMPONENTS AND MATERIALS	**GREEN**

The several parts contain all pertinent data available at the time of publication, and each is revised and reissued periodically.

Where ratings or specifications differ from those published in the preceding edition they are pointed out by arrows. Where application information is given it is advisory and does not form part of the product specification.

If you need confirmation that the published data about any of our products are the latest available, please contact our representative. He is at your service and will be glad to answer your inquiries.

December 1972

ELECTRON TUBES (BLUE SERIES)

This series consists of the following parts, issued on the dates indicated.

Part 1a	**Transmitting tubes for communication** **Tubes for r.f. heating**	**Types PE05/25 – TBW15/25**	**December 1975**
Part 1b	**Transmitting tubes for communication** **Tubes for r.f. heating** **Amplifier circuit assemblies**		**January 1976**
Part 2	**Microwave products** Communication magnetrons Magnetrons for microwave heating Klystrons Travelling-wave tubes Isolators, Circulators	Diodes Triodes T-R switches Microwave semiconductor devices	**May 1976**
Part 3	**Special Quality tubes** **Miscellaneous devices**		**January 1975**
Part 4	**Receiving tubes**		**March 1975**
Part 5a	**Cathode-ray tubes**		**August 1976**
Part 5b	**Camera tubes** **Image intensifier tubes**		**May 1975**
Part 6	**Products for nuclear technology** Channel electron multipliers Neutron tubes	Geiger-Müller tubes	**January 1977**
Part 7a	**Gas-filled tubes** Thyratrons Industrial rectifying tubes	Ignitrons High-voltage rectifying tubes	**March 1977**
Part 7b	**Gas-filled tubes** Segment indicator tubes Indicator tubes	Switching diodes Dry reed contact units	**March 1977**
Part 8	**TV picture tubes**		**October 1975**
Part 9	**Photomultiplier tubes** **Phototubes (diodes)**		**June 1976**

SEMICONDUCTORS AND INTEGRATED CIRCUITS (RED SERIES)

This series consists of the following parts, issued on the dates indicated.

Part 1a — Rectifier diodes, thyristors, triacs — **March 1976**

Rectifier diodes
Voltage regulator diodes (> 1,5 W)
Transient suppressor diodes
Rectifier stacks
Thyristors
Triacs

Part 1b — Diodes — **October 1975**

Small signal germanium diodes
Small signal silicon diodes
Special diodes
Voltage regulator diodes (< 1,5 W)
Voltage reference diodes
Tuner diodes

Part 2 — Low-frequency transistors — **December 1975**

Part 3 — High-frequency and switching transistors — **April 1976**

Part 4a — Special semiconductors — **June 1976**

Transmitting transistors
Microwave devices
Field-effect transistors
Dual transistors
Microminiature devices for thick- and thin-film circuits

Part 4b — Devices for optoelectronics — **July 1976**

Photosensitive diodes and transistors
Light emitting diodes
Displays
Photocouplers
Infrared sensitive devices
Photoconductive devices

Part 5a — Professional analogue integrated circuits — **November 1976**

Part 5b — Consumer integrated circuits — **March 1977**

Radio - Audio
Television

Part 6 — Digital integrated circuits — **May 1976**

LOCMOS HE family
GZ family

COMPONENTS AND MATERIALS (GREEN SERIES)

This series consists of the following parts, issued on the dates indicated.

Part 1 Functional units, Input/output devices, Peripheral devices — **November 1975**

High noise immunity logic FZ/30-Series
Circuit blocks 40-Series and CSA70
Counter modules 50-Series
NORbits 60-Series, 61-Series
Circuit blocks 90-Series
Input/output devices
Hybrid integrated circuits
Peripheral devices

Part 2a Resistors — **February 1976**

Fixed resistors
Variable resistors
Voltage dependent resistors (VDR)
Light dependent resistors (LDR)
Negative temperature coefficient thermistors (NTC)
Positive temperature coefficient thermistors (PTC)
Test switches

Part 2b Capacitors — **April 1976**

Electrolytic and solid capacitors
Paper capacitors and film capacitors
Ceramic capacitors
Variable capacitors

Part 3 Radio, Audio, Television — **January 1977**

FM tuners
Loudspeakers
Television tuners and aerial input assemblies
Components for black and white television
Components for colour television

Part 4a Soft ferrites — **October 1976**

Ferrites for radio, audio and television
Beads and chokes
Ferroxcube potcores and square cores
Ferroxcube transformer cores

Part 4b Piezoelectric ceramics, Permanent magnet materials — **December 1976**

Part 5 Ferrite core memory products — **July 1975**

Ferroxcube memory cores
Matrix planes and stacks
Core memory systems

Part 6 Electric motors and accessories — **April 1977**

Small synchronous motors
Stepper motors
Miniature direct current motors

Part 7 Circuit blocks — **September 1971**

Circuit blocks 100 kHz-Series
Circuit blocks 1-Series
Circuit blocks 10-Series
Circuit blocks for ferrite core memory drive

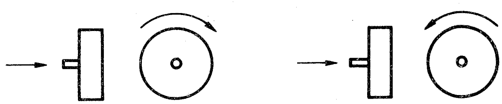
Part 8 Variable mains transformers — **February 1977**

Part 9 Piezoelectric quartz devices — **March 1976**

Part 10 Connectors — **November 1975**

GENERAL REMARKS

- All mechanical drawings have been laid out according to the European (third-angle) projection method.
- The dimensions of the products are given in mm.
- Forces are given in newton (N); 1 N = 100 g = 3,53 ounce (oz).
- Torques are given in millinewtonmetre (mNm); 1 mNm = 10 gcm = 0,139 ounce inch.
- The curves of the performance graphs are derived from measurements made on arbitrary motors.
- The sense of rotation, clockwise (cw) or counter-clockwise (ccw), is that seen when looking towards the spindle, as shown by the arrow.



clockwise (cw) 7Z98289 counter-clockwise (ccw)

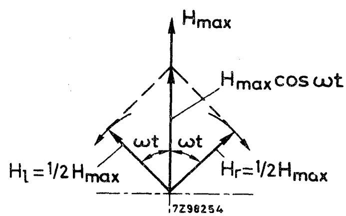
- To order a product please use the relevant catalogue number.
- The information given in this book does not imply a license under any patent.

Small synchronous motors

PRINCIPLES

In a two-pole synchronous motor fitted with a permanent-magnet rotor, a sinusoidally alternating magnetic field is set up in the stator by the sinusoidal exciting current. The alternating field can be assumed to be the resultant of two magnetic fields of equal and constant strength but rotating in opposite directions. The vector diagram at a time t can then be drawn (Fig. below).

The constant fields are here represented by the vectors H_ℓ and H_r. The permanent magnet (the rotor) can now follow either the field rotating counterclockwise or the one rotating clockwise. Fundamentally, therefore, a synchronous motor can rotate in either direction. However, more advanced constructions like our synchronous motors rotate in one direction which is determined electrically as will be explained later on.



During one cycle of the alternating supply current a motor with two poles, that is one pair of poles, will make one revolution. In a motor with p pole pairs the rotor turns through 360/p angular degrees. The speed of the motor is thus determined by the frequency and the number of pole pairs and can be calculated with the formula:

$$n = \frac{60f}{p} \text{ rev/min}$$

where f = frequency and p = number of pole pairs.

PERMANENT-MAGNETIC ROTOR

As described above, the speed of the motor is governed by the number of pole pairs. How many pole pairs can be provided on a magnet ring depends on the space available along the periphery of the ring, and on the properties of the magnetic material. The magnetic material is characterized by a high coercive force so that a great number of poles can be accommodated in a small space. Moreover, the residual flux will not be attenuated by the alternating field. In our synchronous motors as many as 24 poles can be made along the periphery of the magnet ring. Thus, the speed of these motors operating from 50 Hz mains is:

$$n = \frac{60 \times 50}{12} = 250 \text{ rev/min}$$

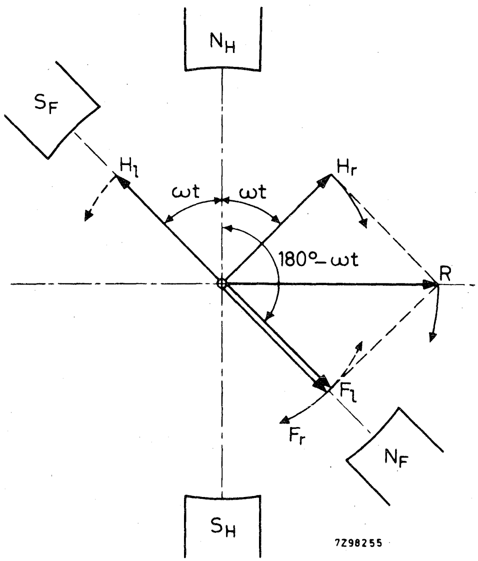
and with 60 Hz mains:

$$n = \frac{60 \times 60}{12} = 300 \text{ rev/min}$$

The low motor speed means that for most applications the gearing-down ratio can be very small. This results in gearboxes of simple design which show very little wear in the bearings.

SYNCHRONOUS MOTORS WITH A SINGLE CONSTANT ROTATING FIELD

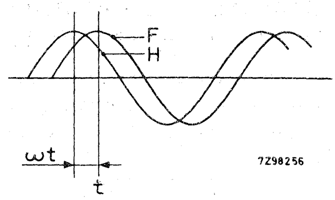
The figure below shows the situation at a time t in a synchronous motor with an auxiliary field added. Both the main field and the auxiliary one are again represented as being the resultant of two magnetic fields of equal and constant strength but rotating in opposite directions.



The main field, which changes sinusoidally, is represented by the vectors H_l and H_r. The poles of the main field are indicated by N_H and S_H.
If the rotor is driven by, for example, H_r (clockwise), then H_l (counterclockwise) will give rise to a vibration at double the frequency of the main field. To control the rotation of the motor and, as in this example, make it run clockwise only, and to eliminate the vibration at the same time, H_l must be eliminated. This can be achieved by the compensating or auxiliary field F (with its component fields F_l and F_r, identical and rotating in opposite directions), between poles N_F and S_F. We see that F_l, rotating counterclockwise, will always oppose H_l (also counterclockwise), and even eliminate it when fields H and F are of equal strength. We also see that F_r and H_r combine to the resulting rotating field R. The rotor will rotate in the direction of R because it is the only remaining field. Evidently R can also be chosen such that the motor can only run counterclockwise.

Finally, we see that in the figures the auxiliary field F lags behind the main field H by an angle (phase shift) ωt.

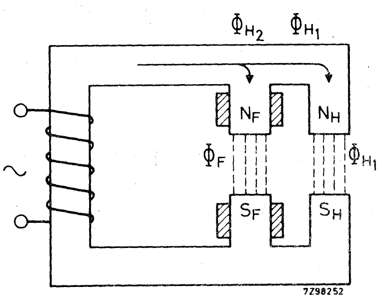
The above explanation applies to a two-pole motor; in motors with more poles the auxiliary poles must be uniformly distributed between them.

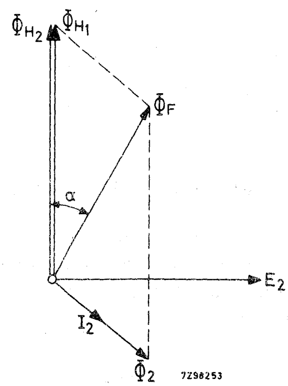


Two methods are available for obtaining a single constant rotating magnetic field:
- an auxiliary lagging field is derived from the main field; our unidirectional motors operate on this principle (see below)
- two stators are used yielding alternating fields with a certain phase shift between them, as in our reversible types of motors (see the next page).

SYNCHRONOUS MOTORS WITH ONE DIRECTION OF ROTATION (catalogue numbers 9904 110 .....)

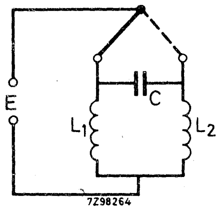
All these motors are provided with a copper ring around each of the auxiliary poles. The effect is that an induction current is produced through the rings, lagging behind the voltage E_2 (induced by the field ϕ_{H_2}). The induced magnetic flux ϕ_2 forms with the main flux ϕ_{H_2} the desired auxiliary flux ϕ_F, which lags behind the main flux, ϕ_{H_2}, by the angle α. The construction is such that the auxiliary field, though weaker than the main field, ensures unidirectional operation of the motor.

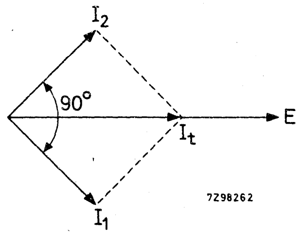




SYNCHRONOUS MOTORS WITH AN ELECTRICALLY REVERSIBLE DIRECTION OF ROTATION (catalogue numbers 9904 111 .....)

As mentioned on the preceding page, the rotation of a synchronous motor can be made stable by incorporating two stators in one casing. The required phase shift is obtained by means of a capacitor which can be connected in series with either stator coil.

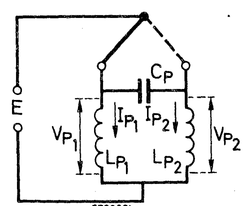




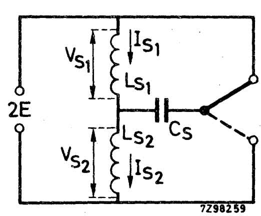
Current I_1 in coil L_1 will lag behind voltage E by 45^o. With the aid of a capacitor, current I_2 in coil L_2 can be made to lead the voltage by 45^o, giving a phase angle between I_1 and I_2 of 90^o. The total current I_t will then be approximately in phase with the voltage so that the maximum torque, and hence a high efficiency, is attained at a very low power consumption. From the above explanation it follows that the poles of the two stators must be an angle of $180\text{-}90^o$ apart.
With L_1 and L_2 in parallel, as above, either the intersection of L_1 and the capacitor, or of L_2 and the capacitor, can be connected to the supply. Switching over will, however, reverse the rotation of the motor.
An arrangement with the two stator coils connected in series is also possible; this point is dealt with in some detail in the next subsection.

PARALLEL AND SERIES CONNECTION OF THE STATOR COILS IN REVERSIBLE MOTORS

The reversible synchronous motors can be made to produce a higher torque by connecting the stator coils in series, with the exception of the type 9904 111 06... which is available only with parallel-connected coils.
The figures below show the circuit diagrams.



Parallel-connected stator coils

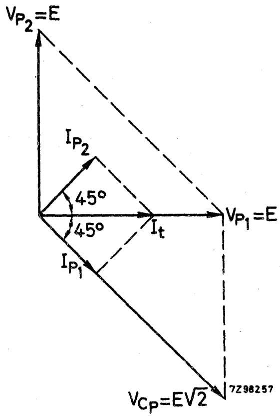


Series-connected stator coils

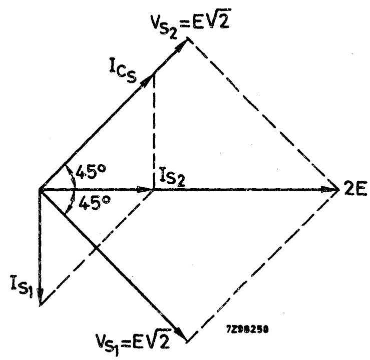
With series-connected coils the motors require about double the supply voltage.

Evidently a motor suitable for operation from a 24-volt source with parallel-connected coils may be operated from a 48-volt source when the coils are connected in series. In this way we get:

parallel-connection	series-connection
24 V	48 V
48 V	110 V
110 V	220 V
220 V	380 V



Vector diagram for parallel-connected stator coils



Vector diagram for series-connected stator coils

The vector diagrams show that the voltage across each coil in the series arrangement is $\sqrt{2}$ times that in the parallel arrangement. The same is true of the current through each coil. Therefore the maximum torque produced by a motor with series-connected coils is considerably higher than that of a motor with parallel-connected coils.

However, not only the torque but the power consumption as well increases in the case of series connection. This is accompanied by a rise in the temperature of the stator coils (ΔT). As most of the materials used in the motors cannot withstand a temperature exceeding 110 °C, users of reversible motors with series-connected coils will have to make sure that the sum of the ambient temperature and ΔT never exceeds 110 °C, when the motors are in continuous operation.

STARTING CHARACTERISTICS

Among the factors determining how fast synchronous motors using permanent magnets will start and whether the direction of rotation is correct, the following two deserve attention:
- the loading conditions
- the relative positions of stator and rotor upon starting.

Loading may be as follows:
1. No load is present.
2. The torques are equal in both directions of rotation but they are below the maximum available motor torque.
3. The clockwise torque is equal to the maximum available motor torque but the counter-clockwise torque is much lower.
4. The counter-clockwise torque is infinitely high (that is: a mechanical stop is applied) but the clockwise torque equals the maximum available motor torque.
5. A torque is placed on the motor even when it is not energized (the load takes the form of a spring) but it does not exceed the motor's stalling torque.
6. The load has a high moment of inertia.

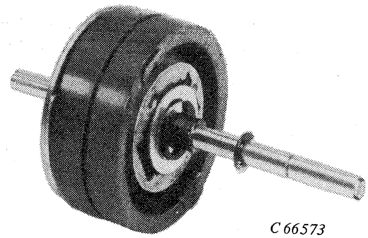
These loads can be applied directly to the motor spindle or via gears. In the latter case there will normally exist some backlash between the gearwheels which is sufficient to enable the motor to start in the unloaded mode and there will be no difficulty in handling the loads except in case 5. This is a special case because one can never be sure that a smooth start in the desired direction is made. To understand this we must realize that before the motor is excited the load torque equals a holding torque produced by the motor's magnetic circuit, otherwise the rotor would turn round. When the supply voltage is switched on, the holding torque may be reduced which will result in the motor being driven in the wrong direction by the load torque. The field operating in the wrong direction will have to be suppressed first.

The above phenomenon is most pronounced in unidirectional motors with the auxiliary field derived from the main one; the constant rotating field motors with two stator coils are less sensitive to it. In extreme cases it will be necessary to introduce a mechanical stop to neutralize the effect.

In case 6 the high inertia moment, when placed direct on the spindle, may cause the load not to be accelerated enough to reach synchronous speed; the rotor may then oscillate. Given sufficient amplitude, these oscillations may after a longer or shorter time - depending on the nature and magnitude of the load, and on the motor excitation - develop into a steady rotation. The sense of rotation is determined by the direction of the oscillation which is the first to attain the necessary maximum. Hence it may well happen that the motor starts running in the wrong direction. It will continue to do so when the load in this direction is small enough. To avoid this effect one must make sure that the inertia moment of the load does not surpass a certain maximum.

Stronger motors are hampered by the inertia moment of the rotor which is so high that not much is left for the load. For this reason the motors 9904 111 06... have been equipped with a so-called resonance rotor, with a flexible connection between rotor and spindle. The rotation of this rotor upon switching-on is first an oscillating one but here too the oscillations develop into the steady rotation. Thanks to this rotor construction this type of motor starts rapidly, practically noiseless and without vibrations.

Laboratory measurements have demonstrated that unidirectional motors when starting under adverse loads need a starting time of about 250 ms. However, in most cases the starting time is considerably shorter. Twin-stator types of electrically reversible motors need, under adverse conditions, a starting time of about 80 ms.



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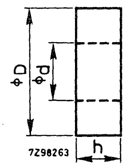
Resonance rotor

Note

The mass inertia moment of the pinion can be calculated with the formula

$$J = \frac{\pi}{32} \times \gamma \times h \times (D^4 - d^4)$$

for an annular object (see the sketch alongside) with



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outer diameter	(D)	in cm
inner diameter	(d)	in cm
height	(h)	in cm
mass density	(γ)	in g/cm^3

In the case of a pinion we may have:

D = 4 mm (outer diameter over the teeth; this simplifies the calculation and provides a safety margin)

d = 1,6 mm (spindle diameter)

h = 4,5 mm

mass density = 7,6 g/cm^3

Its mass inertia moment may then work out to be 0,0086 gcm^2.

Any pinion with an outer diameter smaller than that of the centring rim on the motor will, as a rule, have a sufficiently small inertia moment.

SOME NOTES ON THE STRAY FIELD

For the major part our synchronous motors are provided with a steel casing which minimizes the stray field. Exceptions are the types 9904 111 06... and 9904 111 27....

The strength of a stray field decreases as a function of the distance from the motor. It can be determined by measuring the e.m.f. induced in a coil placed in the stray field, and using the formula:

$$H_{eff} = C \times e_{eff}$$

where H_{eff} = effective value of the field strength at the location of the measuring coil;

C = a constant representing the size and the number of turns of the coil (can be found by calculation or calibration);

e_{eff} = value read from the tube voltmeter.

Example: In the case of the 9904 111 06211 motor the following values were determined:
at the motor casing: 5680 A/m;
at 1 cm distance : 992 A/m;
at 2 cm distance : 376 A/m.

SOME MECHANICAL NOTES

Braking torque

In all the types of synchronous motor a considerable braking torque is produced when the current is interrupted due to the strong rotor magnet poles moving close to the stator poles. The rotor is strongly braked, so that the motor stops almost immediately.
The angle through which the rotor can still turn after switching off depends on the magnitude and moments of inertia of the load. In normal use it will not be more than 20^{o}. For most applications additional mechanical brakes are, therefore, not required.

Bearings

It has been found that the following materials were best suitable for manufacturing bearings of sound construction and meeting the wide variety of demands imposed on the motors.

1. Plastic slide bearings
   A polyamide of a high quality with a very finely graded emulsion of molybdenum disulphide (MoS_2) which gives self-lubricating properties, is used in the motors
   → 9904 110 02... and 9904 110 05....
   Water absorption: negligible (<1, 5%).
   Coefficient of friction: low (<0, 15), so the losses due to friction are very small.
   Chemical resistance: very high; it is resistant to the normal organic solvents, esters, ketones, lubricating oil, petrol, paraffin, and solutions of organic salts.
2. Sintered-metal slide bearings
   a. Sintered-bronze self-aligning slide bearings are used in the motors 9904 110 06..., → 9904 110 09..., 9904 111 04..., 9904 111 07... and in the rear assembly of the motors 9904 111 27....
   b. Sintered-iron is used in the type 9904 111 06... motors.
3. → Ball bearings.
   These bearings are used in the front assembly of the motors 9904 111 27....

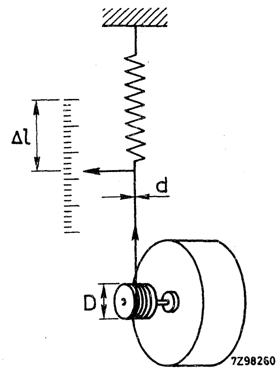
MEASURING THE MOTOR TORQUE

The adjoining sketch illustrates the set-up for measuring the maximum motor torque. A pulley with diameter D is placed on the spindle, and a string is fastened at one end around the pulley and at the other to a helical spring with diameter d.

Next the motor is started, and it will wind the string around the pulley thereby stretching the spring. This goes on until the force exerted by the spring equals the maximum motor torque. The motor then stops and Δl, that is the total displacement of a needle fixed to the spring, is measured.

The motor torque can be calculated with the aid of the formula: $M = (\frac{1}{2}D + \frac{1}{2}d) \times C \times \Delta l$, where C is a constant characteristic for the spring and Δl is the displacement of the needle.

It is also possible to mark the scale in such a way that the motor torque can be read directly from it. Attention should be paid to the fact that the mass of the pulley should be as small as possible for accurate results.



QUALITY CONTROL

Quality control is the prime concern from the moment a development is started until the product has been series-produced.
Thus, checks are carried out:
- during the development by testing the most important properties;
- at the end of development by approval tests on hand-made samples to make sure that the motor conforms to specifications; there is a standard programme of checks and tests subdivided into five groups (see below);
- during the first trial run in the factory, when the same programme of tests is carried out;
- during manufacture where, in the scope of quality assurance, systematic checks are made on motor components, sub-assemblies and finished motors.

The finished product is examined by an independent testing organization making random tests thus checking whether the manufacturer's quality control is up to standard. Any complaints on the part of customers are also investigated by the quality department of the factory and by the independent testing organization.

There is a great difference between the tests carried out before full production starts and those performed during production, as becomes clear from the schedules given below.

QUALITY CONTROL BEFORE MANUFACTURING STARTS

The following approval or qualification tests are made.

1. Check on initial quality:
   - visual inspection;
   - dimensional check on conformity with drawings;
   - check of mechanical and electrical characteristics on conformity with the specification.

2. Check on safety according to the specification:
   - insulation resistance measurement;
   - dielectric strength test.

3. Mechanical tests on robustness:
   - simulated transport tests on packed motors (drop and bounce test);
   - vibration test on motors mounted on a frame;
   - shock test on motors mounted on a frame.

4. Climatic tests:
   - functional test at $-20\ ^{o}C$ unless otherwise specified;
   - temperature cycle test, -40 to $+85\ ^{o}C$, 5 cycles (total duration 30 h);
   - damp heat cycle test (duration 6 days);
   - dry heat storage test at maximum specified storage temperature (duration 96 h).

5. Endurance tests:
   - accelerated life test for 2000 h under extreme conditions of load and temperature;
   - continuous tests under normal conditions of load and temperature, to gather statistical data over the total functional life of the motor.

QUALITY CONTROL DURING PRODUCTION

The following tests are performed during production.

1. Random checks on motor components.
2. Random checks on sub-assemblies for the motor.
3. Either sample or 100% inspection of finished motors on characteristics, such as :
   - critical dimensions;
   - directional stability of rotation;
   - current;
   - torque;
   - spindle deviation;
   - noise due to friction;
   - insulation resistance;
   - dielectric strength.

Each production lot is submitted, on a statistical basis, to lot acceptance tests by the Quality Control Department. Sampling procedures are according to MIL-STD-105D. Unless otherwise specified inspection level I and an AQL value of 1% for major defects are applied.

RELIABILITY

→ Synchronous motors are mostly used in control and indication systems where they are required to operate for a long time. It is often overlooked that the synchronous motor is the determinant reliability factor of these systems.
The combination of our approval and endurance tests are based upon practical experience from the field and assure that our synchronous motors are fit for continuous service for many years.
The well-considered design, and the stringent quality procedures, account for the high degree of reliability of our synchronous motors.

APPLICATIONS

The synchronous motors can be used in a wide range of applications.

Industrial

Different types of clocks:

- control clocks
- master clocks
- secondary clocks
- signal clocks
- rate change clocks
- switch clocks

Different types of time devices:

- delay relays
- time printers and stamps
- time checking devices
- time recorders
- time switches

Signal apparatus for air traffic control and waterway traffic control
Recording instruments
Electric stage control stands
Control equipment for the processing industry, and for heating and air-conditioning installations
Remote control units
Programme switches

Entertainment

Record players
Slide projectors
Television selector units
Tape recorders
Toy drivers
Television sets

Domestic

Timers and programme switches for:

- defroster sections in refrigerators and deep-freezers
- washing machines
- dish washers
- cooking ranges and ovens
- ultraviolet lamps
- automatic vending machines.

REMARKS ON THE TECHNICAL DATA

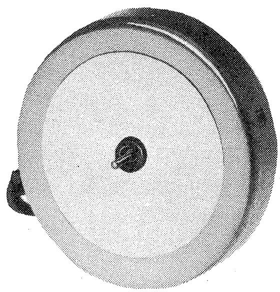
- The current, power and temperature increase values are guidance values and are measured at 20 °C, in free circulating air and at nominal voltage.
- The torque values are minimum ones, for the values at nominal voltage see the performance graph.
- Derating of torque is given in a percentage per °C above the ambient temperature of 20 °C.
- The curves of the performance graphs are measured on arbitrary motors of basic types.
- At the lower end of the ambient temperature range the moment in which the motors reach their synchronous speed will be delayed.

UNIDIRECTIONAL SYNCHRONOUS MOTORS

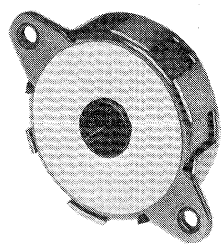
SURVEY

The range of unidirectional synchronous motors comprises the following types:
- industrial type, for general purpose : 9904 110 02... ;
- instrument type, for small equipment : 9904 110 05... ;
- instrument type, for low noise requirements : 9904 110 06... ;
- miniature type, for clock mechanisms : 9904 110 09....

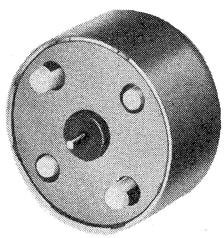
A mounting bracket for motors 9904 110 02... is given in the chapter "Accessories".



Industrial type for general purpose 9904 110 02...



Instrument type for small equipment 9904 110 05... and for low noise requirements 9904 110 06...



Miniature type for clock mechanisms 9904 110 09...

UNIDIRECTIONAL SYNCHRONOUS MOTORS

industrial type for general purpose

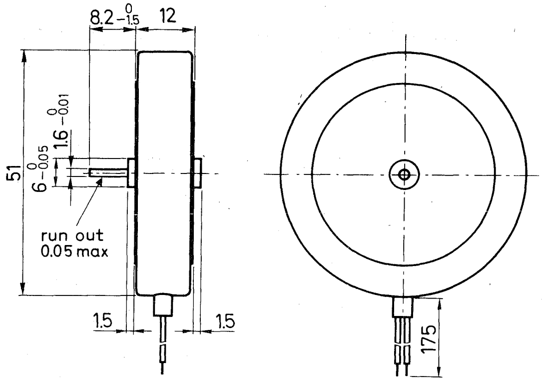
QUICK REFERENCE DATA		
Nominal voltage	220 V	110 V
Frequency	50 Hz	50 Hz
Speed	250 rev/min	250 rev/min
Input power	1,6 W	1,6 W
Torque	3 mNm	3 mNm

APPLICATION

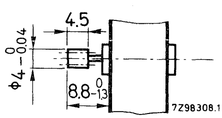
These motors have been designed to provide an accurate and reliable time-base for a variety of industrial applications.
They are ideally suitable for use in delay relays, time switches, time printers, signal clocks and master clocks.

TECHNICAL DATA

Dimensions in mm

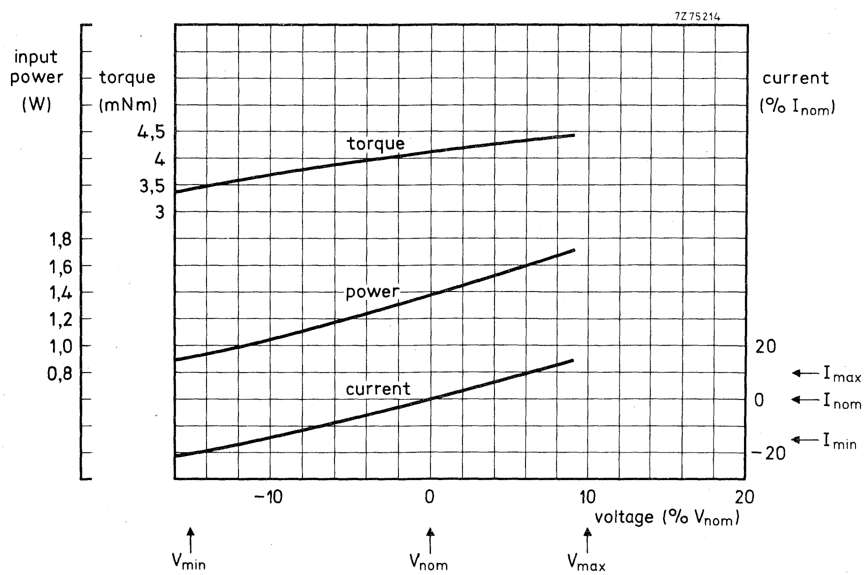


Note: - Motors with different voltage ratings, or provided with a pinion (see figure below), are available on request only in minimum order quantities, and involve longer delivery times.



version with pinion
number of teeth = 10
module = 0, 3
addendum modification = +0, 2

	catalogue number	
clockwise rotation	9904 110 02101	9904 110 02301
counter-clockwise rotation	9904 110 02111	9904 110 02311
Nominal voltage (V)	220	110
Frequency (Hz)	50	50
Speed (rev/min)	250	250
Current (mA)	7,5	17
Input power (W)	1,6	
Starting torque (mNm)	2,5	
Working torque (mNm)	3	
Torque derating (%)	0,6	
Temperature increase of the motor (°C)	30	
Ambient temperature range (°C)	−20 to +70	
Permissible voltage fluctuations (%)	−15 to +10	
Insulation according to CEE10	class 2	
Insulation test voltage (V)	2500	
Bearings	slide bearings	
Maximum radial force (N)	0,9	
Maximum axial force (N)	0,5	
Maximum inertial load (gcm^2)	0,15	
Housing	zinc plated	
Mass (g)	90	



Typical curves.

UNIDIRECTIONAL SYNCHRONOUS MOTORS

instrument type for small equipment

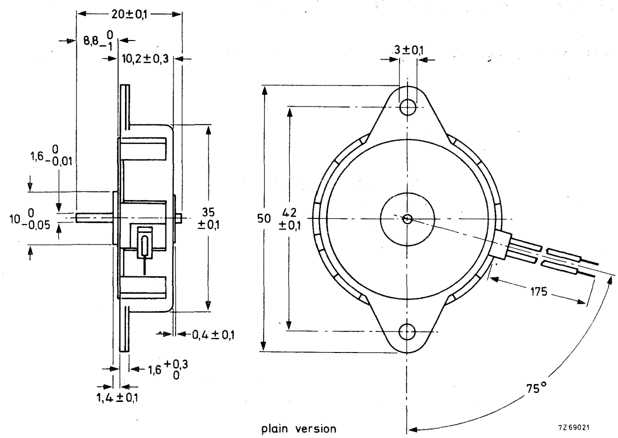
QUICK REFERENCE DATA		
Nominal voltage	220 V	110 V
Frequency	50 Hz	50 Hz
Speed	250 rev/min	250 rev/min
Input power	1, 8 W	0, 5 W
Torque	0, 5 mNm	0, 5 mNm

APPLICATION

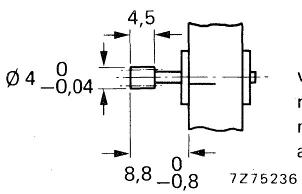
These motors have been designed for optimum performance in equipment where the available space is limited and a high torque is required.
The 220 V version operates via a series resistor to keep the dimensions of the motor as small as possible. The motors find their application in a variety of small timing devices.

TECHNICAL DATA

Dimensions in mm



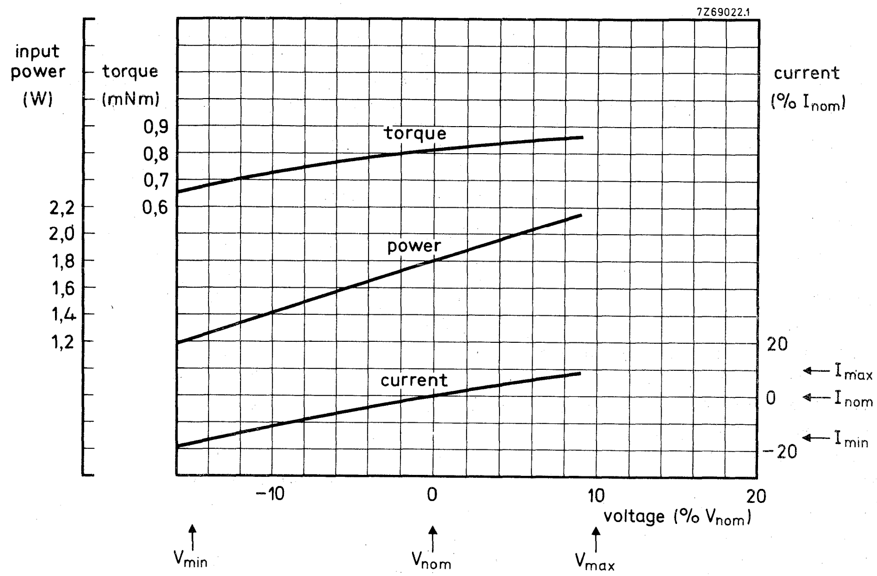
Note: - Motors with different voltage ratings, or provided with a pinion (see figure below), are available on request only in minimum order quantities, and involve longer delivery times.



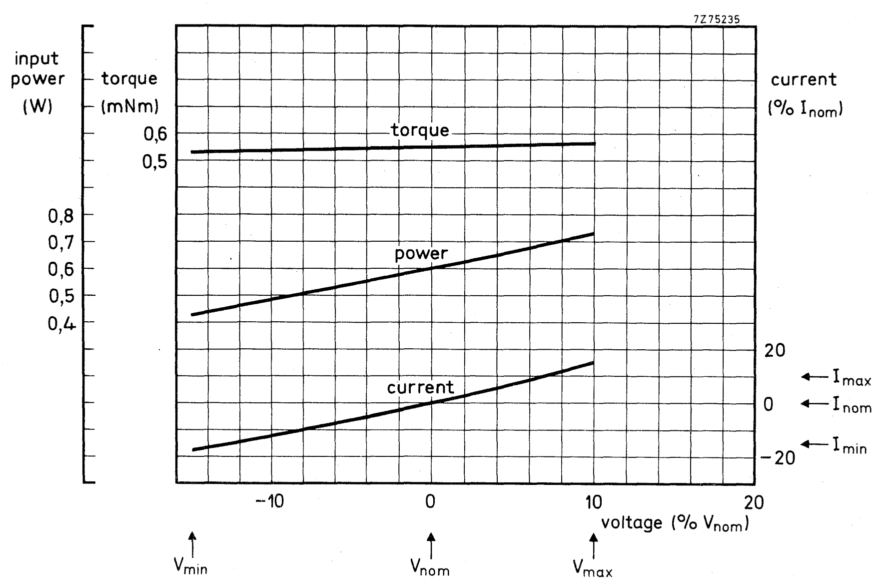
version with pinion
number of teeth =10
module = 0,3
addendum modification = +0,2

		catalogue number	
clockwise rotation counter-clockwise rotation		9904 110 05102 [1]) 9904 110 05112 [1])	9904 110 05301 9904 110 05311
Nominal voltage	(V)	220	110
Frequency	(Hz)	50	50
Speed	(rev/min)	250	250
Current	(mA)	8	5
Input power	(W)	1, 8	0, 5
Starting torque	(mNm)	0, 5	
Working torque	(mNm)	0, 5	
Torque derating	(%)	0, 6	
Temperature increase of the motor	(°C)	20	
Ambient temperature range	(°C)	−20 to +70	
Permissible voltage fluctuations	(%)	−15 to +10	
Insulation according to CEE10		class 1	
Insulation test voltage	(V)	2500	
Bearings		slide bearings	
Maximum radial force	(N)	0, 3	
Maximum axial force	(N)	0, 1	
Maximum inertial load	(gcm^2)	0, 05	
Housing		zinc plated	
Mass	(g)	40	

[1]) This motor has to be used with a series resistor (20 kΩ, 2 W), which can be supplied on request.



Typical curves of 220 V motors.



Typical curves of 110 V motors.

UNIDIRECTIONAL SYNCHRONOUS MOTORS

instrument type for low noise requirement

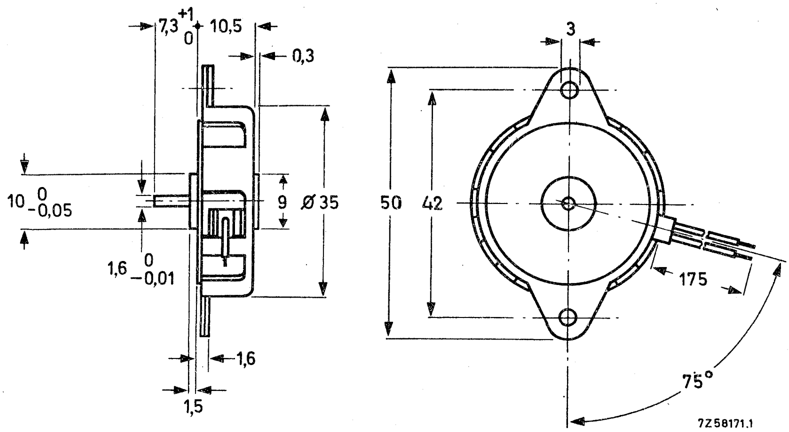
QUICK REFERENCE DATA		
Nominal voltage	220 V	110 V
Frequency	50 Hz	50 Hz
Speed	250 rev/min	250 rev/min
Input power	2, 6 W	1 W
Torque	0, 25 mNm	0, 25 mNm

APPLICATION

These motors have been designed specifically for timing devices which need small motor dimensions and a very low running noise.
The design is similar to that of the 9904 110 05... series but the accent has been placed on low running noise characteristics.
The motors are ideally suited for small equipment such as 24-hour timing devices which operate in environments where noise should be kept to a minimum.
Clock mechanisms in hospitals, living rooms and offices are typical application areas for these motors.
The 220 V version operates via a series resistor to keep the dimensions of the motor as small as possible.

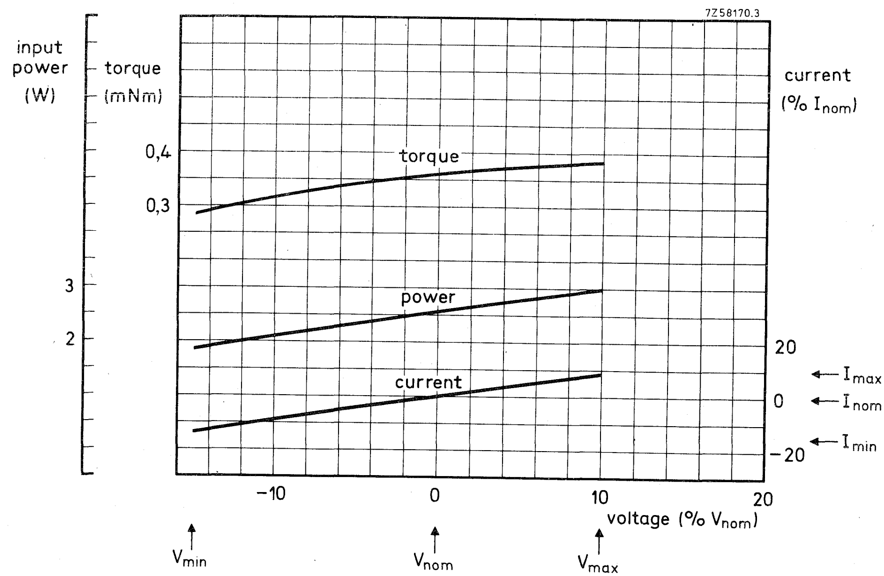
TECHNICAL DATA

Dimensions in mm

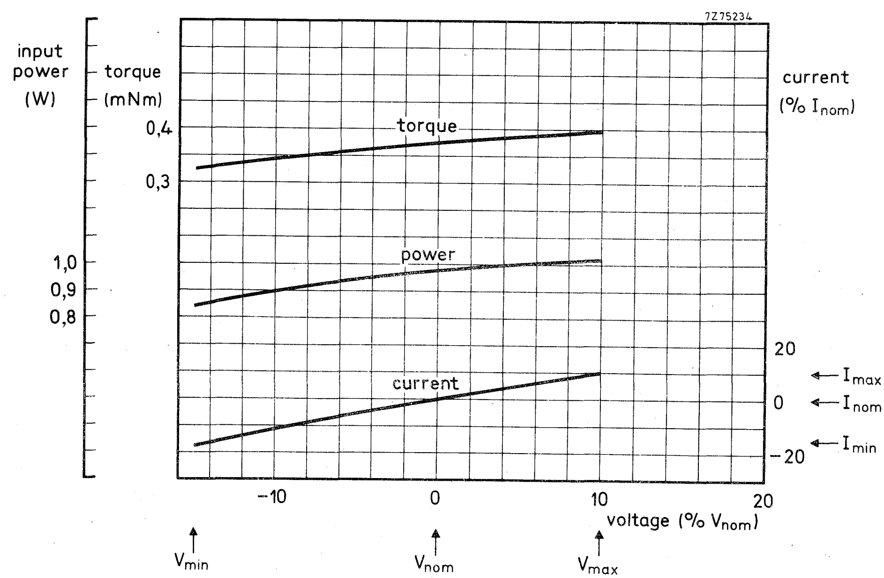


		catalogue number	
clockwise rotation		9904 110 06102 [1])	9904 110 06301
counter-clockwise rotation		9904 110 06112 [1])	9904 110 06311
Nominal voltage	(V)	220	110
Frequency	(Hz)	50	50
Speed	(rev/min)	250	250
Current	(mA)	12	10
Input power	(W)	2, 6	1
Starting torque	(mNm)	0, 25	
Working torque	(mNm)	0, 25	
Torque derating	(%)	0, 4	
Temperature increase of the motor	(^{o}C)	40	
Ambient temperature range	(^{o}C)	−5 to +50	
Permissible voltage fluctuations	(%)	−15 to +10	
Insulation according to CEE10		class 1	
Insulation test voltage	(V)	2500	
Bearing		sintered bronze slide bearing	
Maximum radial force	(N)	0, 2	
Maximum axial force	(N)	0, 15	
Maximum inertial load	(gcm^2)	0, 02	
Housing		passivated zinc plating	
Mass	(g)	40	

[1]) This motor has to be used with a series resistor (12 kΩ, ±5%, 2 W).



Typical curves of 220 V motors.



Typical curves of 110 V motors.

UNIDIRECTIONAL SYNCHRONOUS MOTORS
miniature type for clock mechanisms

QUICK REFERENCE DATA				
Nominal voltage	12 V, 50 Hz	24 V, 50 Hz	24 V, 50 Hz[1])	110 V/220 V, 50 Hz
Speed	375 rev/min	375 rev/min	375 rev/min	375 rev/min
Input power	0,2 W	0,2 W	0,12 W	0,75 W/1,5 W
Torque	0,08 mNm	0,08 mNm	0,03 mNm	0,08 mNm

APPLICATION

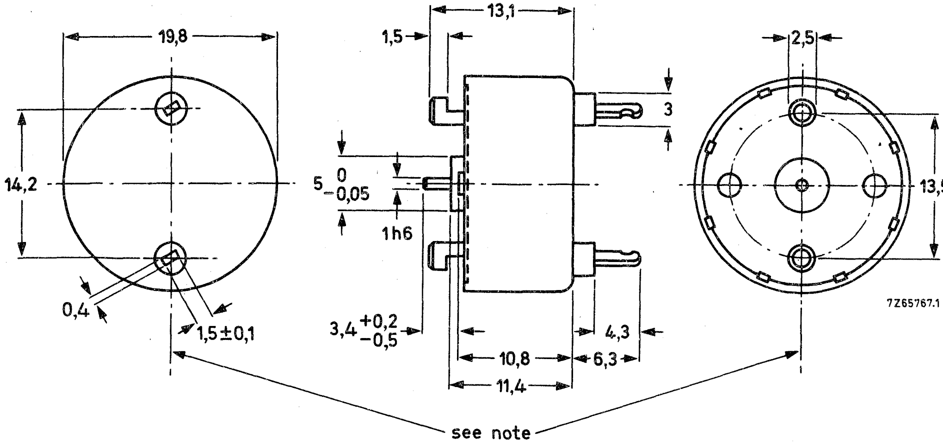
These miniature timing motors are designed to drive small clock mechanisms specifically where low power consumption (thus low temperature rise) is required and where small dimensions are preferred.

Versions are available for 12 V, 24 V, or 110 V/220 V operation at 50 Hz. The low power consumption of the 12 V and 24 V types allows battery operation (via d.c./a.c. converter). For applications which normally use hysteresis motors, with their unfavourable volume-to-output ratio, a much better proposition is the silent 24 V version. The 12 V and 24 V versions can operate from the mains but, to obtain optimum results, it is preferable to use the 110 V/220 V version (in each case the appropriate resistor or capacitor is required in series with the motor coil).
Typical applications are:
- electronic car clocks;
- rate change clocks in electricity meters;
- central heating control clocks;
- miniature time switches;
- miniature elapsed-time indicators.

[1]) Silent version.

TECHNICAL DATA

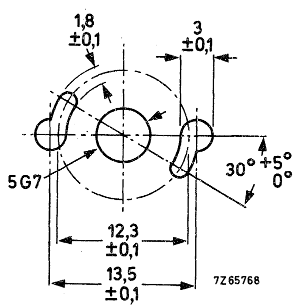
Dimensions in mm



Note – The angle between the axial plane through the centres of the mounting pins and the axial plane through the centres of the solder tags is maximum 2° 30'.

Mounting

Two plastic twist-lock mounting pins are provided, but can be cut off if desired. Maximum thickness of mounting plate is 0,8 mm.



12 V version

		catalogue number		
clockwise rotation		9904 110 09701		
counter-clockwise rotation		9904 110 09711		
Nominal voltage	(V)	12	6	1)
Frequency	(Hz)	50	50	1)
Speed	(rev/min)	375	375	1)
Current	(mA)	18	9	1)
Input power	(W)	0,2	0,05	1)
Starting torque 2)	(mNm)	0,08	0,02	1)
Working torque 3)	(mNm)	0,08	0,02	1)
Torque derating	(%)	0,6	0,6	1)
Temperature increase of the motor	(^{o}C)	16	4	1)
Ambient temperature range				
operating	(^{o}C)	−30 to + 85	−10 to + 85	1)
storage	(^{o}C)	−40 to +100	−40 to +100	1)
Permissible voltage fluctuations	(%)	−15 to + 10	0 to +110	
Insulation according to CEE 10		class 3		
Insulation test voltage	(V)	500		
Bearings		sintered bronze		
Maximum radial force	(N)	0,05		
Maximum axial force	(N)	0,05		
Maximum inertial load	(gcm^2)	0,002		
Housing		steel, zinc plated		
Mass	(g)	14		

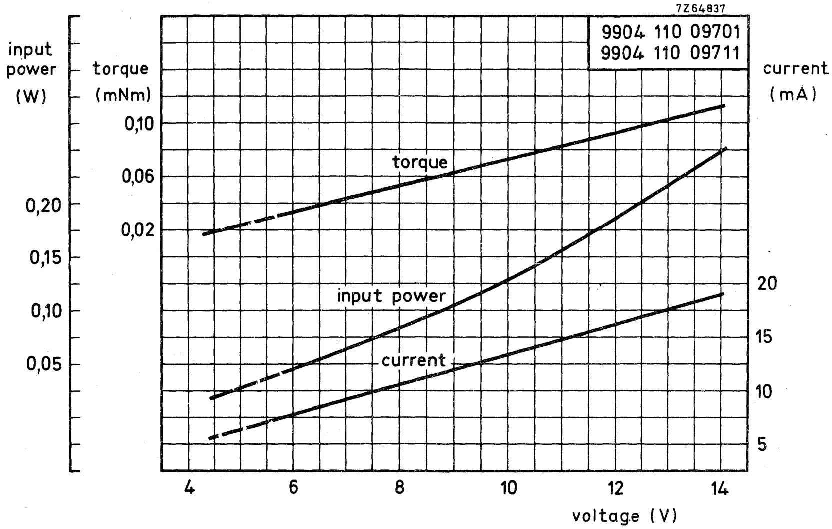
For typical curves, see next page.

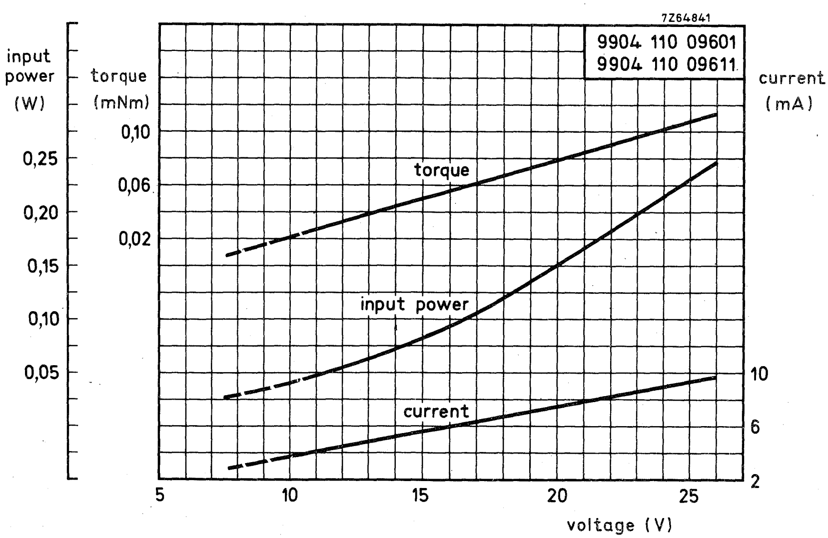
This version can also be used for operation from 110 V/220 V, 50 Hz supply, provided that the appropriate resistor or capacitor is in series with the motor coil see "Additional information".

1) These figures for 6 V operation are for guidance only; they are not guaranteed but in practice ensured.

2) If allowed for sufficient free movement of the motor spindle at the initial stage of starting (e.g. a gearbox).

3) At 1 rev/min the working torque is 30 mNm (guidance value 7,5 mNm), without taking into account the efficiency of the gearbox.


7Z64837
9904 110 09701
9904 110 09711
input power (W)
torque (mNm)
current (mA)
0,10
0,06
0,02
0,20
0,15
0,10
0,05
torque
input power
current
20
15
10
5
4
6
8
10
12
14
voltage (V)


7Z64841
9904 110 09601
9904 110 09611
input power (W)
torque (mNm)
current (mA)
0,10
0,06
0,02
0,25
0,20
0,15
0,10
0,05
torque
input power
current
10
6
2
5
10
15
20
25
voltage (V)

24 V version

	catalogue number	
clockwise rotation	9904 110 09601	
counter-clockwise rotation	9904 110 09611	
Nominal voltage (V)	24	12
Frequency (Hz)	50	50 [1]
Speed (rev/min)	375	375 [1]
Current (mA)	9	4,5 [1]
Input power (W)	0,2	0,05 [1]
Starting torque [2] (mNm)	0,08	0,02 [1]
Working torque [3] (mNm)	0,08	0,02 [1]
Torque derating (%)	0,6	0,6 [1]
Temperature increase of the motor (°C)	16	4 [1]
Ambient temperature range		
operating (°C)	-30 to +85	-10 to +85 [1]
storage (°C)	-40 to +100	-40 to +100 [1]
Permissible voltage fluctuations (%)	-15 to +10	0 to +110
Insulation according to CEE10	class 3	
Insulation test voltage (V)	500	
Bearings	sintered bronze	
Maximum radial force (N)	0,05	
Maximum axial force (N)	0,05	
Maximum inertial load (gcm^2)	0,002	
Housing	steel, zinc plated	
Mass (g)	14	

For typical curves, see preceding page.

This version can also be used for operation from 110 V/220V, 50 Hz supply provided that the appropriate resistor or capacitor is in series with the motor coil, see "Additional information".

[1] These figures for 12 V operation are for guidance only; they are not guaranteed but in practice ensured.

[2] If allowed for sufficient free movement of the motor spindle at the initial stage of starting (e.g. a gearbox).

[3] At 1 rev/min the working torque is 30 mNm (guidance value 7,5 mNm), without taking into account the efficiency of the gearbox.

Versions for mains operation

		catalogue number			
clockwise rotation counter-clockwise rotation		9904 110 09101 9904 110 09111			
Mains voltage	(V)	110		220	
		low torque mode 1)	high torque mode	low torque mode 1)	high torque mode
Required series resistor, ± 5%	(kΩ)	22	12	47	30
Maximum power dissipation	(W)	0, 5	0, 7	1, 1	1, 6
Frequency	(Hz)	50	50	50	50
Speed	(rev/min)	375	375	375	375
Current	(mA)	4	7	4	7
Input power	(W)	0, 47	0, 75	0, 94	1, 5
Starting torque 2)	(mNm)	0, 02	0, 08	0, 02	0, 08
Working torque 3)	(mNm)	0, 02	0, 08	0, 02	0, 08
Torque derating	(%)	0, 6	0, 6	0, 6	0, 6
Temperature increase of the motor	(°C)	5	17	5	17
Ambient temperature range					
operating	(°C)	−15 to +85			
storage	(°C)	−40 to +100			
Permissible voltage fluctuations	(%)	−15 to +10			
Insulation according to CEE10		class 3			
Insulation test voltage	(V)	500			
Bearings		sintered bronze			
Maximum radial force	(N)	0, 05			
Maximum axial force	(N)	0, 05			
Maximum inertial load	(gcm^2)	0, 002			
Housing		steel, zinc plated			
Mass	(g)	14			

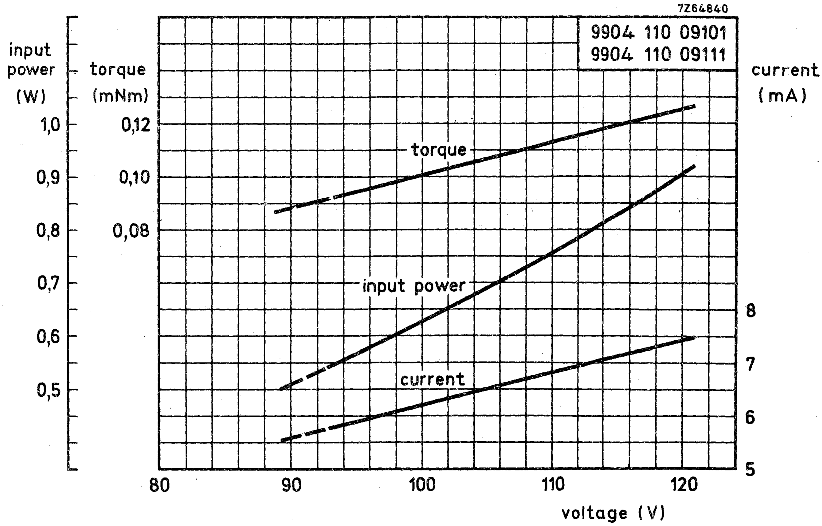
For typical curves, see next pages.

For use of a series capacitor instead of a series resistor, see "Additional information".

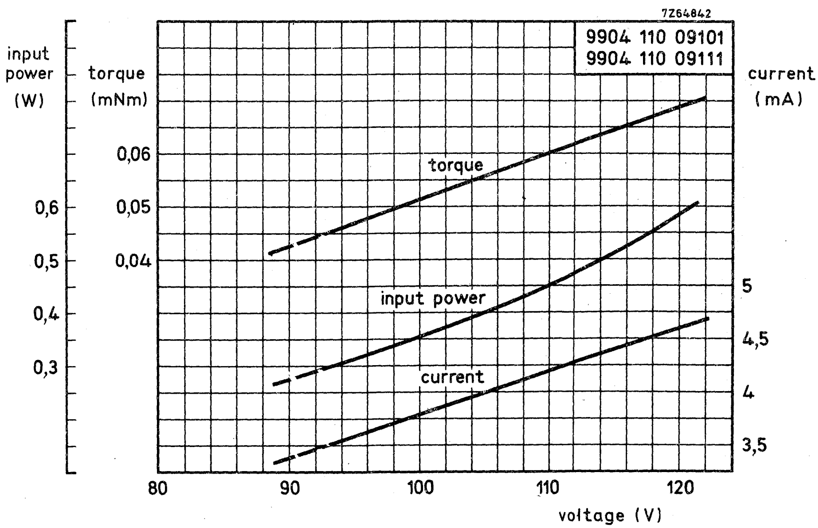
1) If used in low torque mode, the motor noise is reduced at minimum.

2) If allowed for sufficient free movement of the motor spindle at the initial stage of starting.

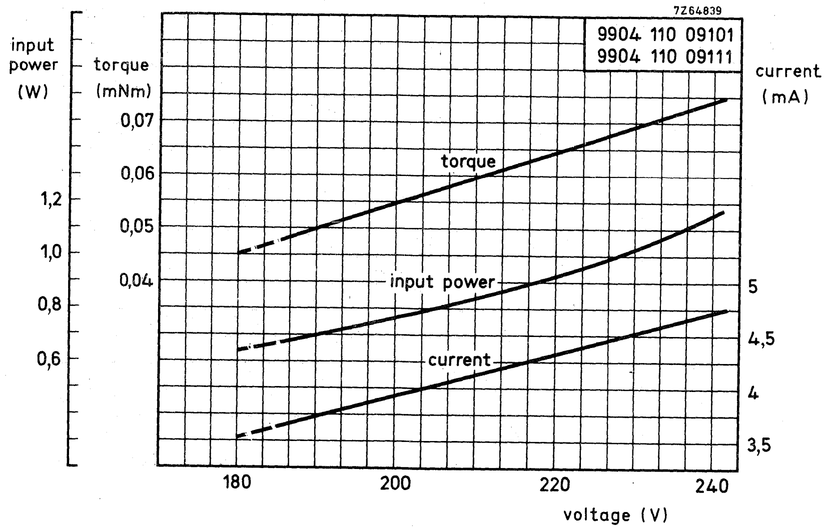
3) At 1 rev/min the working torque is 7, 5 mNm if used in low torque mode and 30 mNm if used in high torque mode, without taking into account the efficiency of the gearbox.



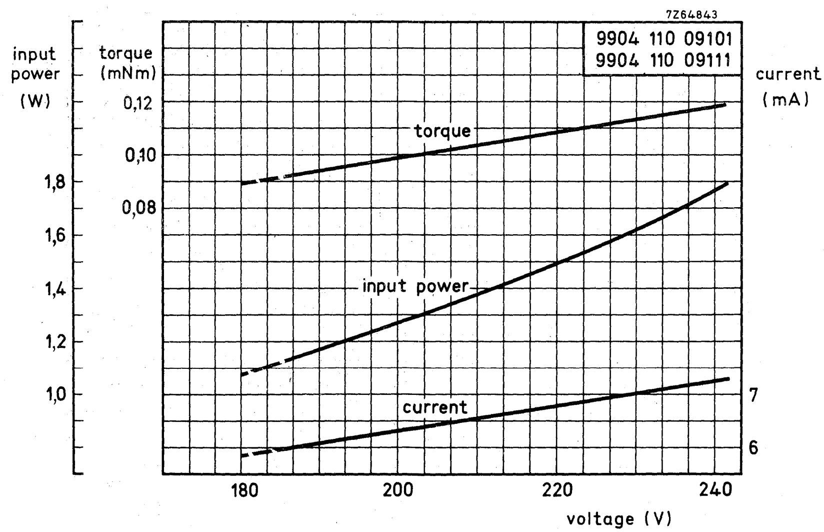
Typical curves for motors used with a series resistor of 12 kΩ.



Typical curves for motors used with a series resistor of 22 kΩ.



Typical curves for motors used with a series resistor of 47 kΩ.



Typical curves for motors used with a series resistor of 30 kΩ.

Silent version

		catalogue number
clockwise rotation		9904 110 09501
counter-clockwise rotation		9904 110 09511
Nominal voltage	(V)	24
Frequency	(Hz)	50
Speed	(rev/min)	375
Current	(mA)	5
Input power	(W)	0,12
Starting torque [1]	(mNm)	0,03
Working torque [2]	(mNm)	0,03
Torque derating	(%)	0,6
Temperature increase of the motor	(^{o}C)	10
Ambient temperature range		
operating	(^{o}C)	-10 to +85
storage	(^{o}C)	-40 to +100
Permissible voltage fluctuations	(%)	-15 to +10
Insulation according to CEE10		class 3
Insulation test voltage	(V)	500
Bearings		sintered bronze
Maximum radial force	(N)	0,05
Maximum axial force	(N)	0,05
Maximum inertial load	(gcm^2)	0,002
Housing		steel, zinc plated
Mass	(g)	14
Noise level [3]	(dB - A scale)	30 (typical value)

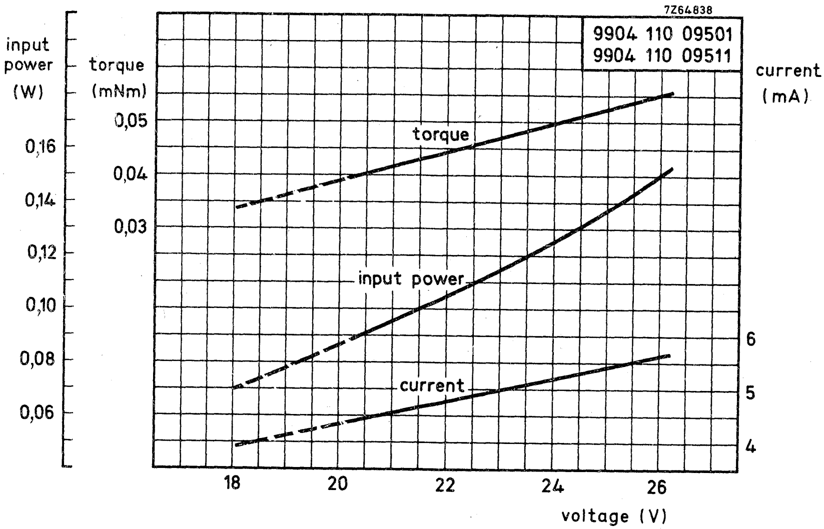
For typical curves, see next page.

This version can also be used for operation from 110 V/220 V, 50 Hz supply, provided that the appropriate resistor or capacitor is in series with the motor coil, see "Additional information".

[1]) If allowed for sufficient free movement of the motor spindle at the initial stage of starting (e.g. a gearbox).

[2]) At 1 rev/min the working torque is 11,2 mNm without taking into account the efficiency of the gearbox.

[3]) Measured with Brüel and Kjaer sonometer, type 2203; microphone at 40 mm from the motor, which is mounted on a gearbox.


7Z64838
9904 110 09501
9904 110 09511
input power (W)
torque (mNm)
current (mA)
0,05
0,04
0,03
0,16
0,14
0,12
0,10
0,08
0,06
6
5
4
torque
input power
current
18
20
22
24
26
voltage (V)

ADDITIONAL INFORMATION

For operation from the mains, a resistor or capacitor must be connected in series with the motor coil of all versions. Any small changes in the specified motor data should then be taken into account [1]. These changes are minimized by using the resistor and capacitor values shown in the table below.

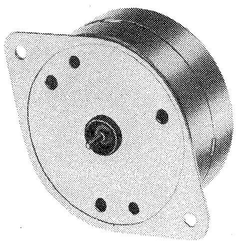
motor	110 V				220 V			
	R ± 5%		C ± 10%, 125 Va.c.		R ± 5%		C ± 10%, 250 Va.c.	
	low torque mode [2]	high torque mode [3]	low torque mode [2]	high torque mode [3]	low torque mode [2]	high torque mode [3]	low torque mode [2]	high torque mode [3]
9904 110 09601 09611	18 kΩ (0, 7 W)	10 kΩ (1, 2 W)	0, 15 μF	0, 22 μF	39 kΩ (1, 4 W)	24 kΩ (2, 0 W)	0, 068 μF	0, 12 μF
9904 110 09701 09711	10 kΩ (1, 4 W)	5, 6 kΩ (2, 2 W)	0, 33 μF	0, 47 μF	20 kΩ (2, 9 W)	12 kΩ (4 W)	0, 15 μF	0, 22 μF
9904 110 09101 09111	22 kΩ (0, 5 W)	12 kΩ (0, 7 W)	0, 12 μF	0, 18 μF	47 kΩ (1, 1 W)	30 kΩ (1, 6 W)	0, 056 μF	0, 082 μF
9904 110 09501 09511	12 kΩ (1 W) [4]		0, 18 μF [4]		27 kΩ (2 W) [4]		0, 082 μF [4]	

1) Not applicable to versions for mains operation with a series resistor.
2) Working torque is 0, 02 mNm.
3) Working torque is 0, 08 mNm.
4) Working torque is 0, 03 mNm.

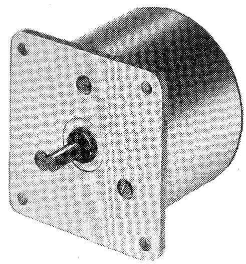
REVERSIBLE SYNCHRONOUS MOTORS

SURVEY

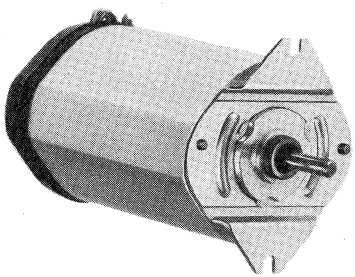
The range of reversible synchronous motors comprises the following types :
- instrument type : 9904 111 04... ;
- instrument type : 9904 111 06... ;
- instrument type : 9904 111 07... ;
- industrial type : 9904 111 27... ;
- instrument type : 9904 111 31....



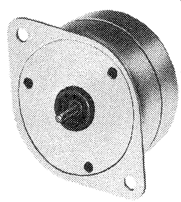
Instrument type
9904 111 04... and
9904 111 31...



Industrial type
9904 111 27...



Instrument type
9904 111 06...



Instrument type
9904 111 07...

REVERSIBLE SYNCHRONOUS MOTORS

instrument type

QUICK REFERENCE DATA				
Nominal voltage				
coils in parallel	220 V	110/117 V	48 V	24 V
coils in series	380 V	220 V	110/117 V	48 V
Frequency	50/60 Hz	50/60 Hz	50/60 Hz	50/60 Hz
Speed	250/300 rev/min	250/300 rev/min	250/300 rev/min	250/300 rev/min
Input power				
coils in parallel	1,8 W	1,8 W	1,8 W	1,8 W
coils in series	3,5 W	3,5 W	3,5 W	3,5 W
Torque				
coils in parallel	12 mNm	12 mNm	12 mNm	12 mNm
coils in series	18 mNm	18 mNm	18 mNm	18 mNm

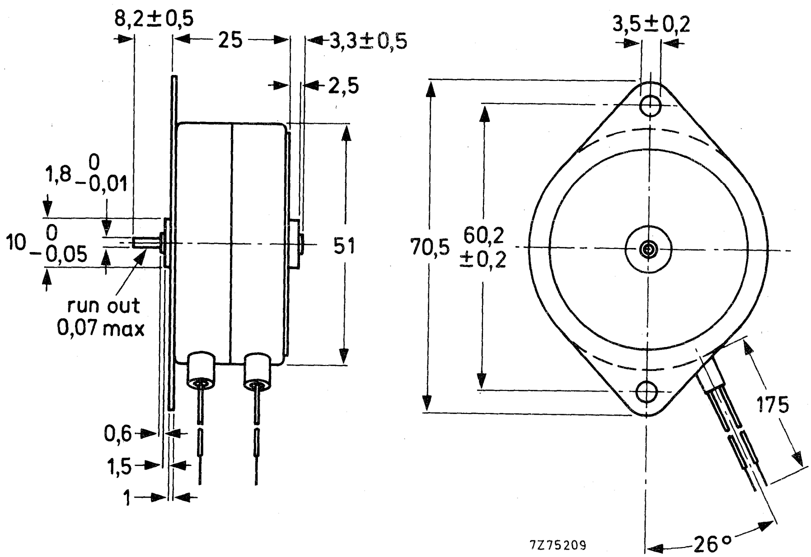
APPLICATION

These motors are designed to operate with parallel-connected or series-connected motor coils.
In parallel the output torque is limited to 12 mNm with a temperature rise of the motor of 25 °C.
In series the output torque increases to 18 mNm and a temperature rise of the motor of 50 °C.
As the maximum permissible motor temperature is 100 °C, parallel operation allows for a maximum ambient temperature of 75 °C, whilst series connection permits a maximum ambient temperature of 50 °C.

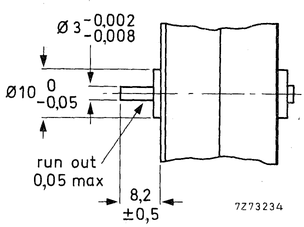
Note : For new designs or applications which require a higher torque in parallel connection, refer to motors 9904 111 31..., as it is our intention to replace motors 9904 111 04... by this type. Motors 9904 111 04... will remain available as maintenance types.

TECHNICAL DATA

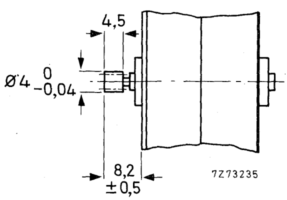
Dimensions in mm



Version with ϕ1, 8 mm spindle.



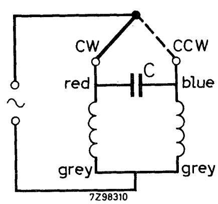
Version with ϕ3 mm spindle.



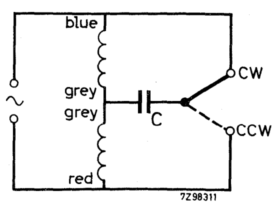
Version with pinion

number of teeth = 10;
module = 0, 3;
addendum modification = +0, 2.

		catalogue number 9904 111 04...							
		coils in parallel [1])							
versions with spindle ϕ3 mm		101		301		401		501	
versions with spindle ϕ1, 8 mm		111		311		411		511	
versions with pinion		131		331		431		531	
Nominal voltage	(V)	220		110	117	48		24	
Frequency	(Hz)	50	60	50	60	50	60	50	60
Speed	(rev/min)	250	300	250	300	250	300	250	300
Current	(mA)	8		18		38		75	
Input power	(W)	1, 8							
Starting torque	(mNm)	12							
Working torque	(mNm)	12							
Torque derating	(%)	0, 4							
Temperature increase of the motor	(°C)	30							
Ambient temperature range	(°C)	−20 to +70							
Permissible voltage fluctuations	(%)	−15 to +10							
Insulation according to CEE10		class 2							
Insulation test voltage	(V)	2500							
Bearings		slide bearings							
Maximum radial force	(N)	5							
Maximum axial force	(N)	1, 5							
Housing		zinc plated							
Mass	(g)	160							
Required phasing capacitor	(μF)	0, 056	0, 047	0, 22	0, 18	1, 2	1	4, 7	3, 9
permissible a.c. voltage	(V)	330		250		160		63	



Coils in parallel



Coils in series

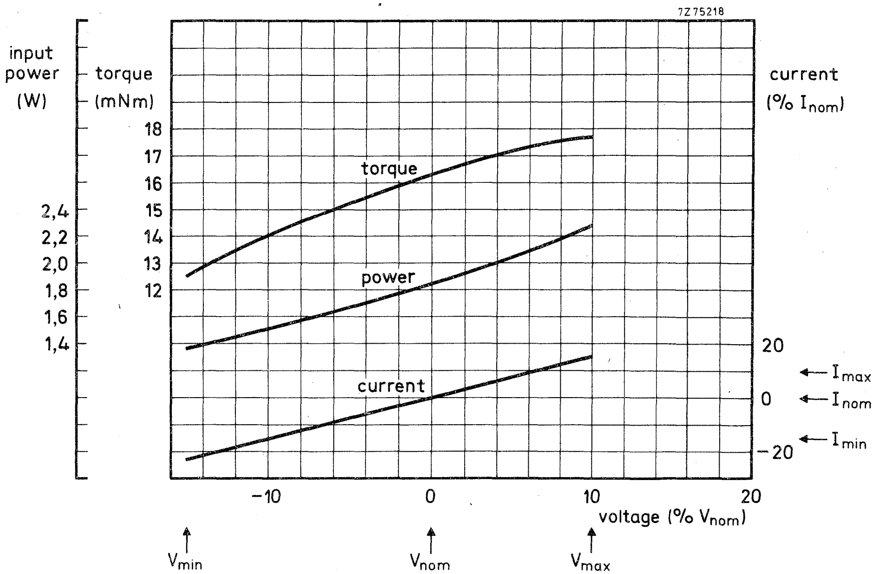
Connection of the phasing capacitor.

1) For data on series-connected motor coils, see next page.

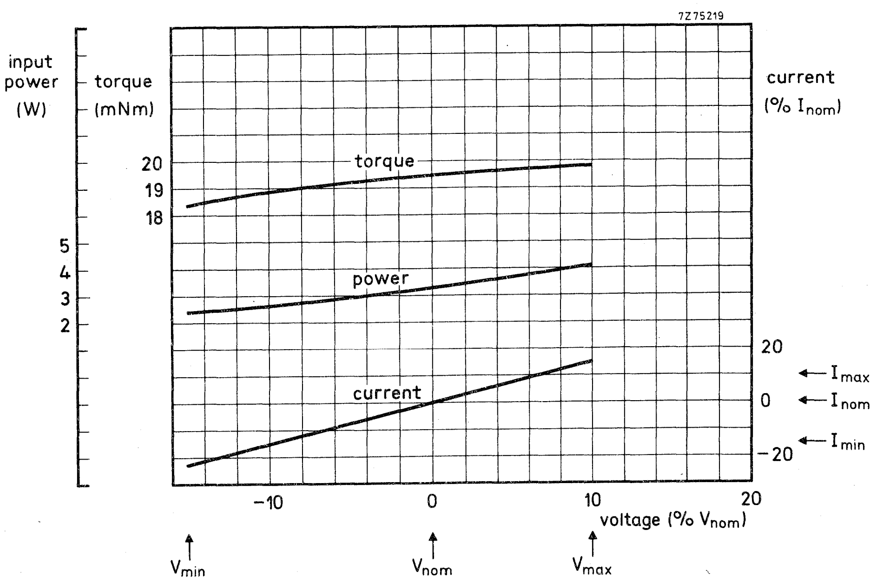
		catalogue number 9904 111 04...							
		coils in series [1]							
versions with spindle ϕ3 mm		101		301		401		501	
versions with spindle ϕ1, 8 mm		111		311		411		511	
versions with pinion		131		331		431		531	
Nominal voltage	(V)	380		220		110	117	48	
Frequency	(Hz)	50	60	50	60	50	60	50	60
Speed	(rev/min)	250	300	250	300	250	300	250	300
Current	(mA)	9		16		32		75	
Input power	(W)	3, 5							
Starting torque	(mNm)	18							
Working torque	(mNm)	18							
Torque derating	(%)	0, 4							
Temperature increase of the motor	(°C)	60							
Ambient temperature range	(°C)	-20 to +50 [2]							
Permissible voltage fluctuations	(%)	-15 to +10							
Insulation according to CEE10		class 2							
Insulation test voltage	(V)	2500							
Bearings		slide bearings							
Maximum radial force	(N)	5							
Maximum axial force	(N)	1, 5							
Housing		zinc plated							
Mass	(g)	160							
Required phasing capacitor	(μF)	0, 15	0, 12	0, 47	0, 39	1, 8	1, 5	10	8
permissible a.c. voltage	(V)	330		250		160		160	

1) For data on parallel-connected motor coils, see preceding page.

2) Continuous operation. Intermittent operation must allow for a maximum permissible stator temperature of 110 °C. See also "Parallel and series connection of the stator coils in reversible motors".



Typical curves; motor coils in parallel.



Typical curves; motor coils in series.

REVERSIBLE SYNCHRONOUS MOTORS

instrument type

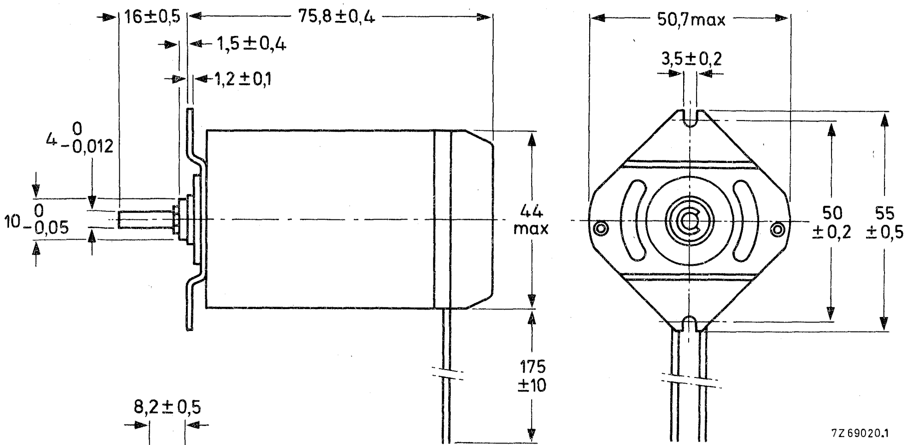
QUICK REFERENCE DATA					
Nominal voltage	220 V	117 V	110 V	48 V	24 V
Frequency	50 Hz	60 Hz	50 Hz	50 Hz	50 Hz
Speed	250 rev/min	300 rev/min	250 rev/min	250 rev/min	250 rev/min
Input power	5 W	6 W	5 W	5 W	5 W
Torque	37,5 mNm	37,5 mNm	37,5 mNm	37,5 mNm	37,5 mNm

APPLICATION

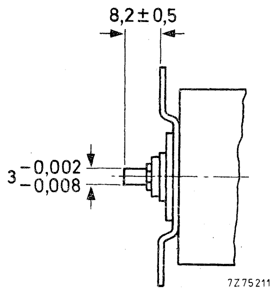
These motors are especially suitable in applications which require high torque and the capability to start relatively high inertia loads, e.g. medical instrumentation.
They have a unique rotor design (see "Principles-starting characteristics") and a slender configuration.
Apart from their widespread use in medical equipment, these motors are to be found in an increasing variety of applications, for example, traffic control equipment, textile machines, and radar displays.

TECHNICAL DATA

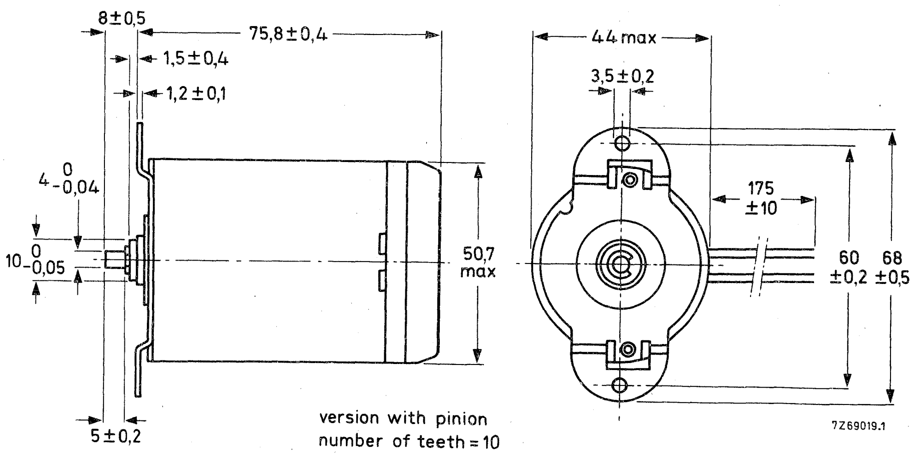
Dimensions in mm



Version with ϕ4 mm spindle.

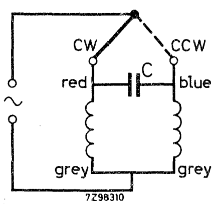


Version with ϕ3 mm spindle.

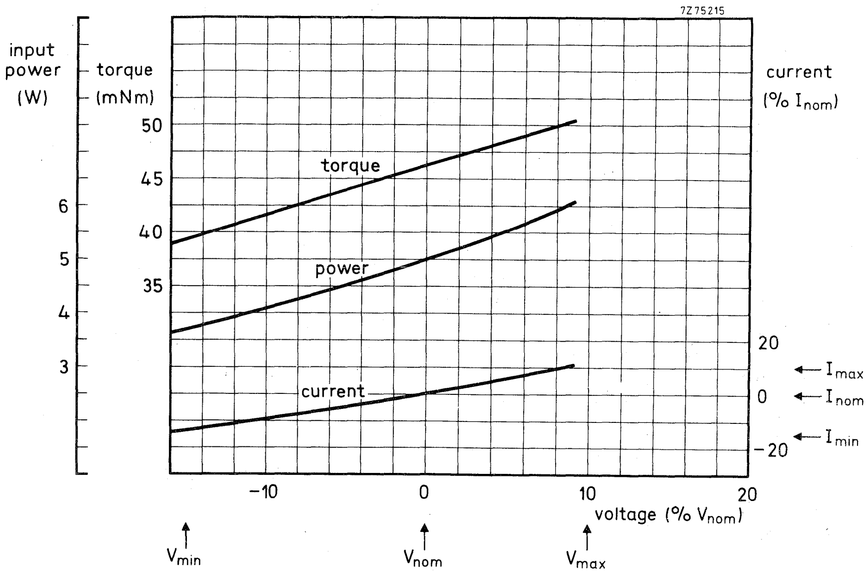


version with pinion
number of teeth = 10
module = 0,3
addendum modification = +0,2

		catalogue number 9904 111 06...				
versions with spindle ϕ3 mm		101	201	301	401	501
versions with spindle ϕ4 mm		111	211	311	411	511
versions with pinion		131		331	431	531
Nominal voltage	(V)	220	117	110	48	24
Frequency	(Hz)	50	60	50	50	50
Speed	(rev/min)	250	300	250	250	250
Current	(mA)	27	60	50	110	200
Input power	(W)	5	6	5	5	5
Starting torque	(mNm)	30	30	30	25	30
Working torque	(mNm)	37,5	37,5	37,5	35	37,5
Torque derating	(%)	0,4	0,4	0,4	0,4	0,4
Temperature increase of the motor	(^{o}C)	35	45	35	35	35
Ambient temperature range	(^{o}C)	-20 to +70				
Permissible voltage fluctuations	(%)	-10 to +10				
Insulation according to CEE10		class 2				
Insulation test voltage	(V)	2500				
Bearings		slide bearings				
Maximum radial force	(N)	15				
Maximum axial force	(N)	1,5				
Housing		aluminium				
Mass	(g)	300				
Required phasing capacitor	(µF)	0,18	0,68	0,68	3,5	14
Permissible a.c. voltage	(V)	330	250	250	160	160



Connection of the phasing capacitor.



Typical curves.

REVERSIBLE SYNCHRONOUS MOTORS

instrument type

QUICK REFERENCE DATA

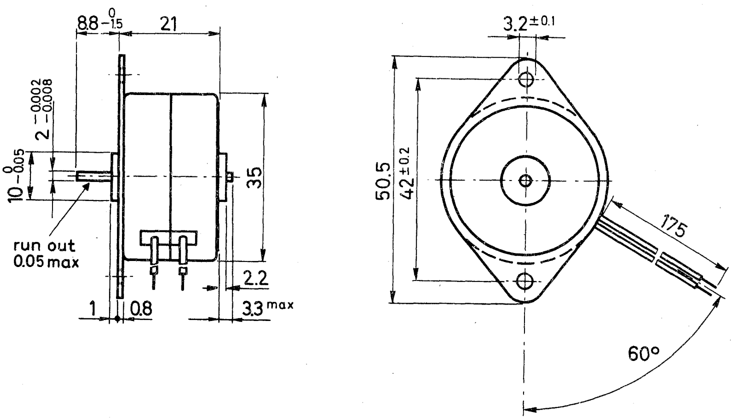
Nominal voltage			
coils in parallel	110/117 V	48 V	24 V
coils in series	220 V	110/117 V	48 V
Frequency	50/60 Hz	50/60 Hz	50/60 Hz
Speed	250/300 rev/min	250/300 rev/min	250/300 rev/min
Input power			
coils in parallel	0,5 W	0,5 W	0,5 W
coils in series	1,3 W	1,3 W	1,3 W
Torque			
coils in parallel	2,5 mNm	2,5 mNm	2,5 mNm
coils in series	4,5 mNm	4,5 mNm	4,5 mNm

APPLICATION

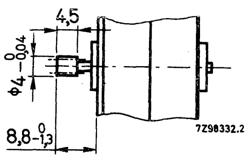
These motors have been designed for optimum performance in equipment where the available space is limited but high torque and reversibility of the motor is required.
In order to keep the dimensions as small as possible, the coils are connected in series for 220 V operation. The motors find their application in control and regulating systems in instrumentation.

TECHNICAL DATA

Dimensions in mm



Version with ϕ2 mm spindle.

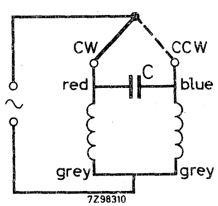


Version with pinion.

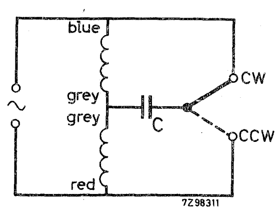
number of teeth = 10
module = 0, 3
addendum modification = +0, 2

Note: - Motors with different voltage ratings, and/or provided with a pinion (see above), are available on request only in minimum order quantities, and involve longer delivery times.

	catalogue number 9904 111 07...					
	coils in parallel			coils in series		
versions with spindle ϕ2 mm	311	411	511	311	411	511
versions with pinion	331	431	531	331	431	531
Nominal voltage (V)	110/117	48	24	220	110/117	48
Frequency (Hz)	50/60					
Speed (rev/min)	250/300					
Current (mA)	4,5	8	18	5,5	12	18
Input power (W)	0,5	0,4	0,45	1,3	1,2	0,9
Starting torque (mNm)		2,5			4,5	
Working torque (mNm)		2,5			4,5	
Torque derating (%)		0,4			0,4	
Temperature increase of the motor (°C)		10			25	
Ambient temperature range (°C)	−20 to +70					
Permissible voltage fluctuations (%)	−15 to +10					
Insulation according to CEE 10	class 1					
Insulation test voltage (V)	2500					
Bearings	slide bearings					
Maximum radial force (N)	2,5					
Maximum axial force (N)	0,75					
Housing	zinc plated					
Mass (g)	75					
Required phasing capacitor (μF)	0,047	0,22	1	0,18	0,68	2
permissible a.c. voltage (V)	250	160	160	160	160	160

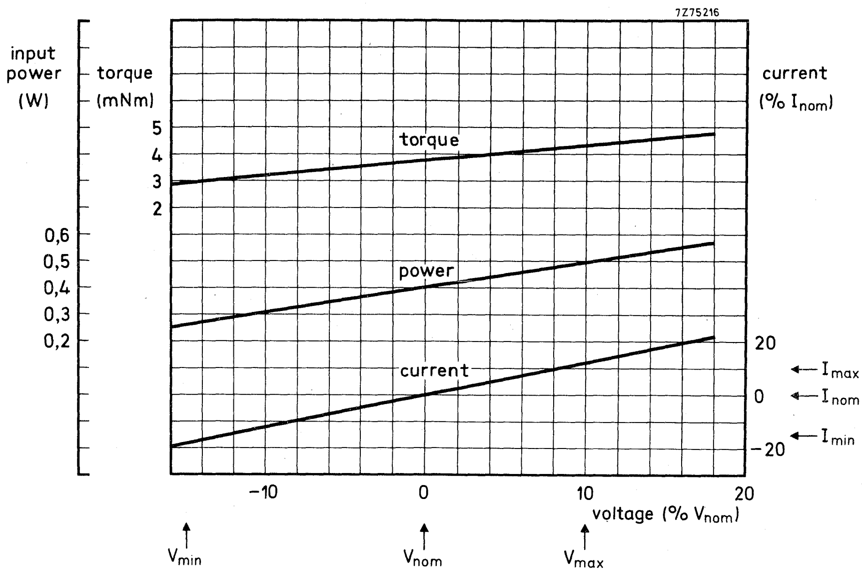


Coils in parallel

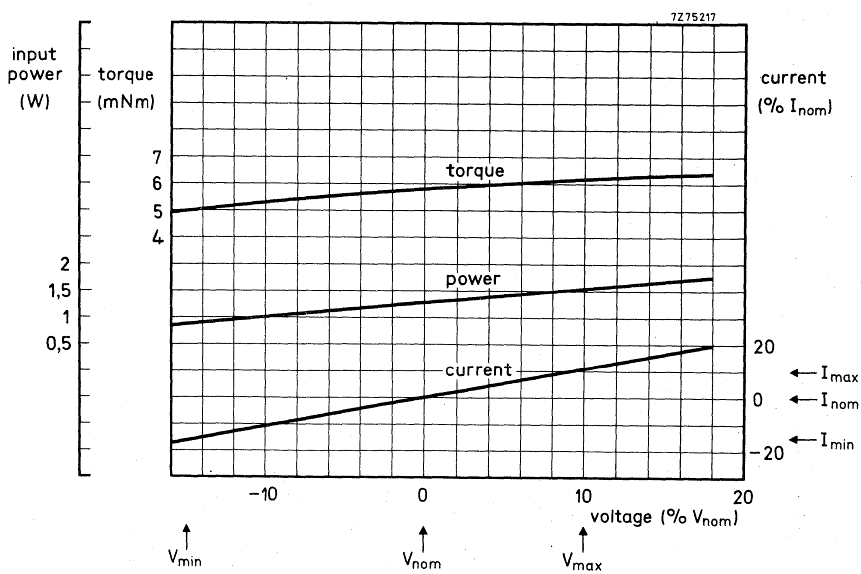


Coils in series

Connection of the phasing capacitor.



Typical curves; motor coils in parallel.



Typical curves; motor coils in series.

REVERSIBLE SYNCHRONOUS MOTORS
industrial type

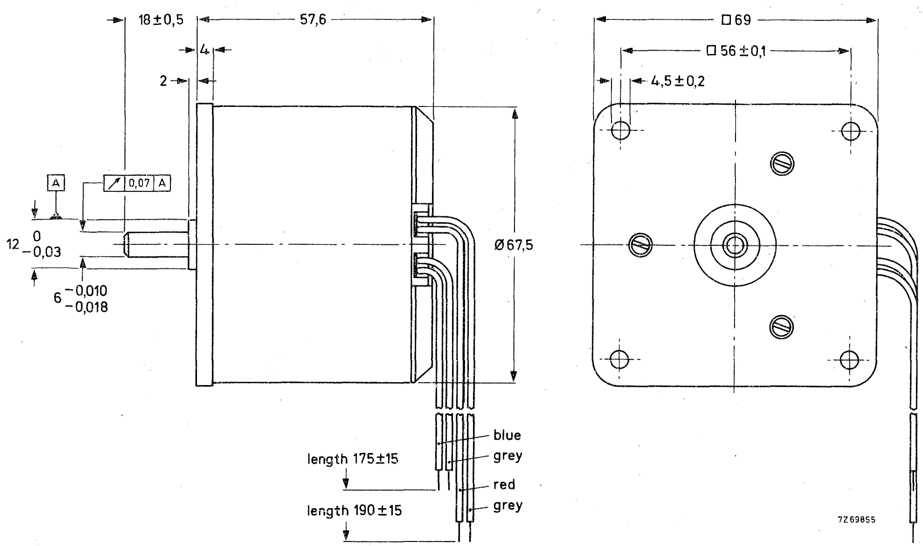
QUICK REFERENCE DATA				
Nominal voltage	220 V	110 V	48 V	24 V
Frequency	50 Hz	50 Hz	50 Hz	50 Hz
Speed	250 rev /min	250 rev/min	250 rev/min	250 rev/min
Input power	6 W	6 W	6 W	6 W
Torque	70 mNm	70 mNm	70 mNm	70 mNm

APPLICATION

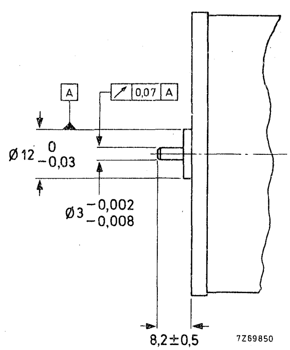
These motors are especially suitable for instrument drives, computer peripherals and office machines. Typical end uses of these motors also include medical pumps, and valve drives in central heating and air-conditioning systems.
A phasing capacitor is used to determine the direction of rotation with a 50 Hz supply. For 60 Hz operation the same capacitor can be used in series with a resistor.

TECHNICAL DATA

Dimensions in mm



Version with Ø 6 mm spindle. The leads are double insulated (AWG22).



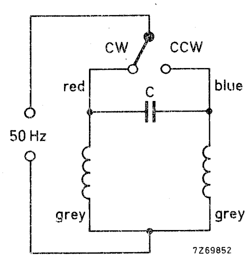
Version with Ø 3 mm spindle.

Note - Motors with different voltage ratings are available on request, only in minimum order quantities, and involve longer delivery times than standard versions.

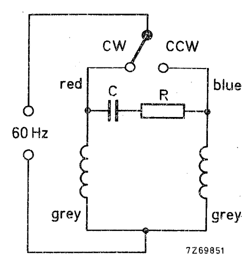
		catalogue number 9904 111 27...			
Versions with spindle ϕ 6 mm		111	311	411	511
Versions with spindle ϕ 3 mm		101	301	401	501
Nominal voltage	(V)	220	110	48	24
Frequency	(Hz)	50	50	50	50
Speed	(rev/min)	250	250	250	250
Current	(mA)	30	55	125	250
Input power	(W)	6			
Starting torque	(mNm)	60			
Working torque	(mNm)	70			
Torque derating	(%)	0,4			
Temperature increase of the motor	(°C)	55			
Ambient temperature range					
Operating	(°C)	−20 to +70			
Storage	(°C)	−40 to +100			
Permissible voltage fluctuations	(%)	−15 to +10			
Insulation according to CEE10		class 2			
Insulation test voltage	(V)	2500			
Bearings		ball bearing (front), slide bearing (rear)			
Maximum radial force	(N)	50			
Maximum axial force	(N)	20			
Housing		aluminium			
Mass	(g)	530			
Required phasing capacitor	(μF)	0,22	0,82	4,7	18
Permissible a.c. voltage	(V)	330	250	160	100

For operation from 60 Hz mains voltage (resulting in a motor speed of 300 rev/min), a resistor must be connected in series with the phasing capacitor; the value of this resistor is:

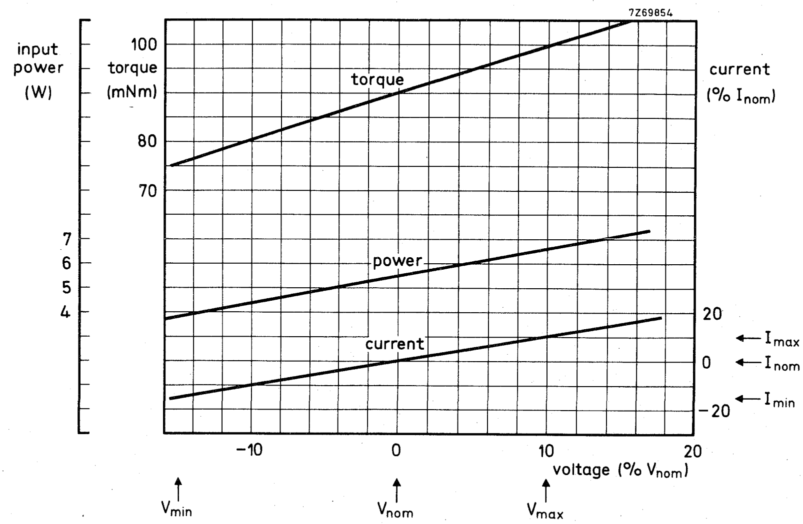
2,7 kΩ, 5 W for 220 V, 60 Hz;
1 kΩ, 5 W for 117 V, 60 Hz;
39 Ω, 5 W for 48 V, 60 Hz;
15 Ω, 5 W for 24 V, 60 Hz.



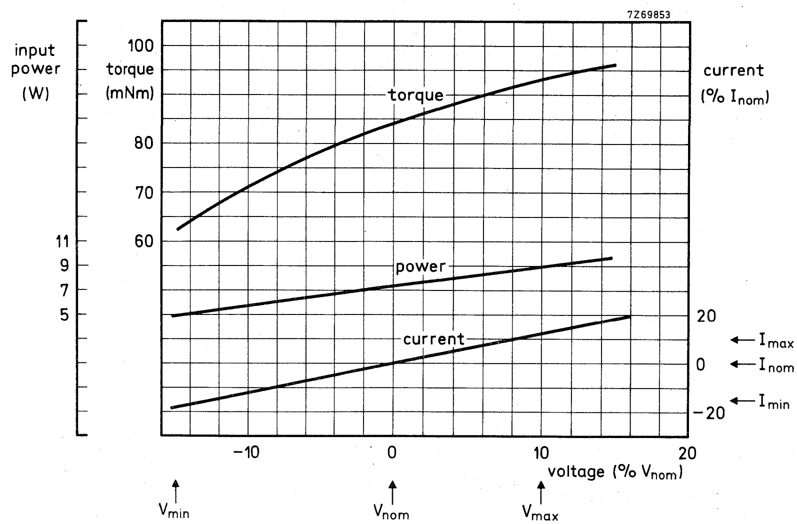
Connection of the phasing capacitor.



Connection of a resistor in series with the phasing capacitor for 60 Hz mains supply.



Typical curves for 50 Hz operation.



Typical curves for 60 Hz operation.

REVERSIBLE SYNCHRONOUS MOTORS
instrument type

QUICK REFERENCE DATA				
Nominal voltage	220 V	110 V	48 V	24 V
Frequency	50 Hz	50 Hz	50 Hz	50 Hz
Speed	250 rev /min	250 rev/min	250 rev/min	250 rev/min
Input power	3,5 W	3,5 W	3,5 W	3,5 W
Torque	20 mNm	20 mNm	20 mNm	20 mNm

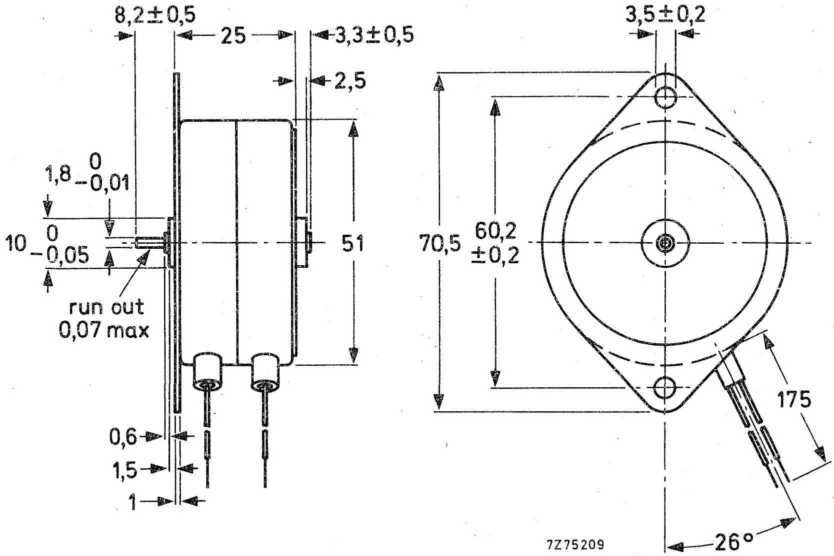
APPLICATION

These motors are especially suitable for a.c. servo systems where instant start/stop and reversibility of the motor is required. The design is similar to that of the 9904 111 04... series, but the motors of the 9904 111 31... series have maximum torque output in the parallel connection. This allows for a switching technique which disconnects the mains supply during the switch-over period to obtain the reversed direction of rotation.

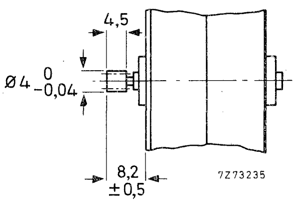
A phasing capacitor is used to determine the direction of rotation with a 50 Hz supply. For 60 Hz operation the same capacitor can be used in series with a resistor.

TECHNICAL DATA

Dimensions in mm

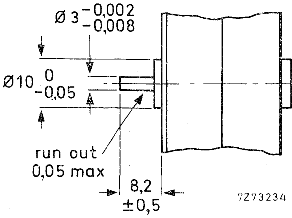


Version with ϕ 1, 8 mm spindle. The leads are double insulated (AWG24).



Version with pinion.

number of teeth = 10;
module = 0, 3;
addendum modification = +0, 2.



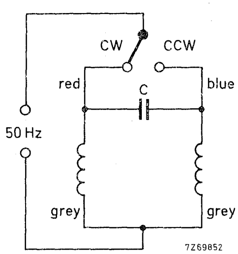
Version with ϕ 3 mm spindle.

	catalogue number 9904 111 31...			
Versions with spindle ϕ 1,8 mm	111	311	411	511
Versions with spindle ϕ 3 mm	101	301	401	501
Versions with pinion	131	331	431	531
Nominal voltage (V)	220	110	48	24
Frequency (Hz)	50	50	50	50
Speed (rev/min)	250	250	250	250
Current (mA)	16	30	80	150
Input power (W)	3,5			
Starting torque (mNm)	20			
Working torque (mNm)	20			
Torque derating (%)	0,4			
Temperature increase of the motor (°C)	60			
Ambient temperature range				
Operating (°C)	−20 to +60			
Storage (°C)	−40 to +100			
Permissible voltage fluctuations (%)	−15 to +10			
Insulation according to CEE 10	class 2			
Insulation test voltage (V)	2500			
Bearings	slide bearings			
Maximum radial force (N)	5			
Maximum axial force (N)	1,5			
Housing	zinc plated			
Mass (g)	160			
Required phasing capacitor (μF)	0,1	0,39	2,2	8
Permissible a.c. voltage (V)	330	250	160	63

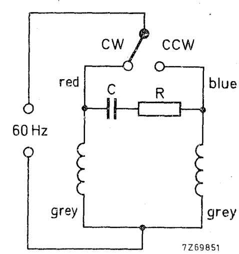
For operation from 60 Hz mains voltage (resulting in a motor speed of 300 rev/min), a resistor must be connected in series with the phasing capacitor; the value of this resistor is:

1,8 kΩ, 0,5 W for 220 V, 60 Hz;
560 Ω, 0,5 W for 117 V, 60 Hz;
68 Ω, 0,5 W for 48 V, 60 Hz.

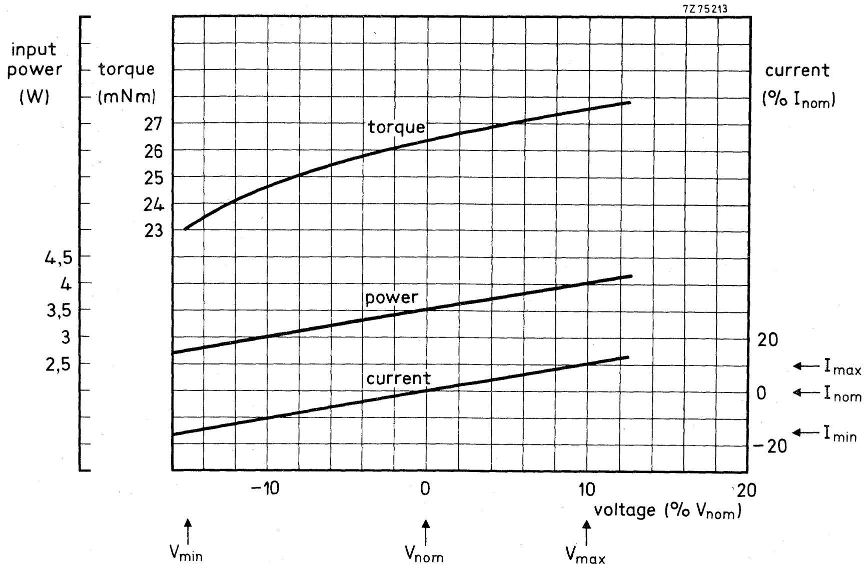
No resistor is required for operation from 24 V, 60 Hz supply.



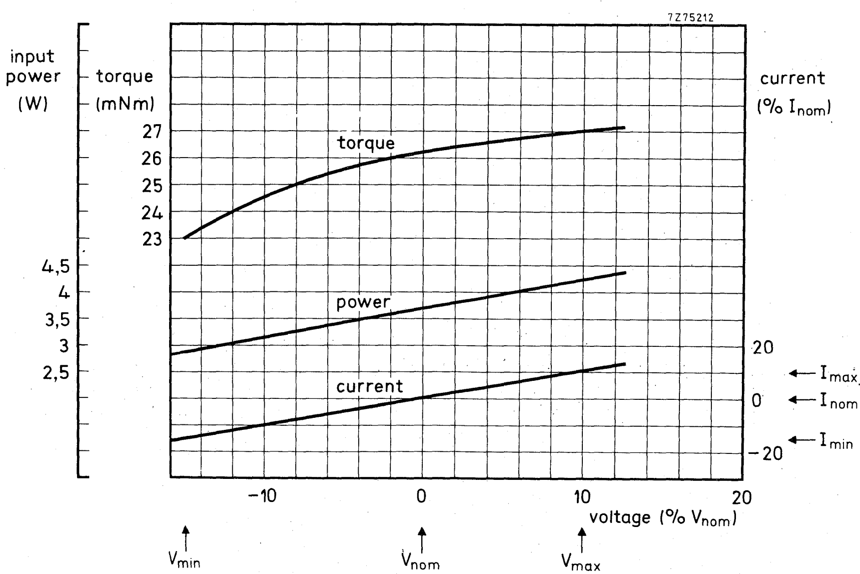
Connection of the phasing capacitor.



Connection of a resistor in series with the phasing capacitor for 60 Hz mains supply.



Typical curves for 50 Hz operation.



Typical curves for 60 Hz operation.

Stepper motors

INTRODUCTION

A stepper motor converts digital information into proportional mechanical movement; it is an electro-mechanical device whose spindle rotates in discrete steps, following command pulses in number and speed, when operated from a source that provides programmed current reversals.

After the appearance of the stepper motor in applications traditionally employing digital control, the advantages of precise and rapid positioning of objects using electronics became more obvious and this, in turn, led to a greater variety of applications. These now include:

- paper and magnetic tape drives
- teletype and strip printers
- camera iris control, film transport and colour film sorting
- co-ordinate plotters, incremental chart recorders and variable speed chart drives
- medical equipment, e.g. blood samplers, lung analysers and kidney pumps
- fuel flow control, valve control and variable speed syringe pumps
- taxi-meters, card readers, production line pulse counters, and automatic weighing and labelling systems
- digital-to-analogue converters and remote position indicating equipment.

All have one thing in common - controlled motion. Wherever controlled movement and/or positioning is necessary, the stepper motor can be applied. And usually to advantage.

From a mechanical viewpoint, the stepper motor has simple positional control, reliability and precision - it has, however, introduced the need for electronics. Where, previously, simple, mechanically operated switches often provided adequate control, the need for a better method has arisen. The advantages of stepper motor systems have been gained at some expense to the simplicity of the motor control: although still unsophisticated by modern standards, some electronic circuits are necessary.

The full benefit of a stepper motor can only be realized if it is correctly driven. It requires a d.c. supply, an electronic switch and a source of control pulses (digital information). The appropriate d.c. supply is routed to the motor via the electronic switch. In effect, the motor moves through one step for each control pulse applied to the electronic switch. The angle of the step depends upon the type of motor and can be from as little as 3^{o} 45' to as much as 15^{o}. Consequently, if 24 pulses are fed to the switch, the shaft of a motor with a 15^{o} step-angle will complete one revolution. The time taken for this action is entirely a function of the rate at which control pulses are applied. These may be generated by an oscillator with adjustable frequency, or derived from one of a variety of sources: perforated tape, magnetic tape, etc.

PRINCIPLES

MOTORS

The position assumed by the spindle of a stepper motor depends upon the relationship between a number of magnetic poles on its stator assembly and a number of magnetic poles on its rotor. Since the latter is a permanent magnet, the poles are fixed. The stator assembly, however, comprises two or more stators, each having a coil through which current is passed to form a magnet. By reversing the direction of current flowing in a coil, therefore, the north and south poles can be transposed. Reversing the current-flow through successive stator coils creates a rotating magnetic field which the permanent-magnet rotor follows. Speed of rotation is thus governed by the rate at which the stator coils (and hence the electro-magnetic poles) are switched and the direction of rotation by the actual switching sequence.

There are two methods by which the current-flow through stator coils can be reversed and this has led to two classes of stepper motor: those designed for uni-polar drive and those for bi-polar drive.

For ease of description, illustrations in this section which give a diagramatic representation of a stepper motor show only a 2-pole rotor although it could have as many as 24: the operating principles, however, are the same.

Motors for Uni-polar Drive

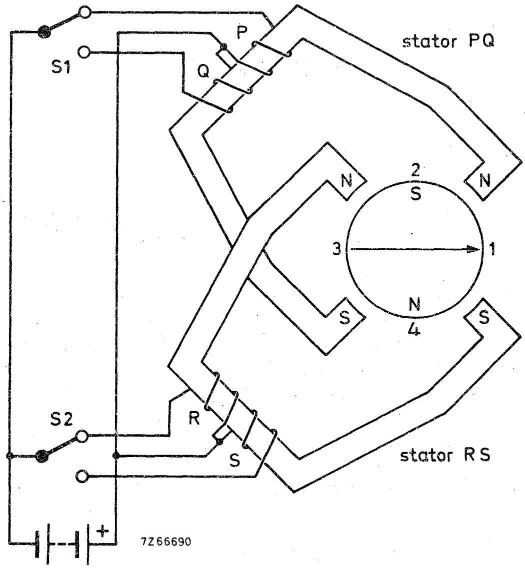
Each stator coil of a motor designed for uni-polar drive is provided with a centre-tap which is connected to one side of the supply, say, the positive. The direction of current flowing through a coil is then determined by the end to which the negative supply line is connected via a switching device. Switching coil-halves results in the magnetic poles of the relevant stator being reversed.

2-stator motors (4-phase)

Fig. 1a shows a 4-phase stepper motor in which phases P and R are energized: the rotor assumes the position indicated. If switch S1 is now operated (phases Q and R energized), the conditions illustrated in Fig. 1b obtain, i.e. the rotor has moved through 90 degrees. From this it can be seen that by operating switches S1 and S2 alternately, the rotor can be made to rotate in 90^{o} steps. The direction of rotation can be reversed by altering the switching sequence.

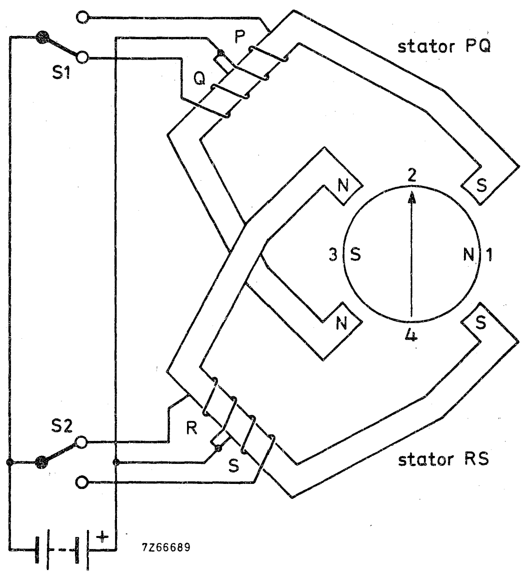
4-stator motors (8-phase)

The 8-phase motor illustrated in Fig. 2 functions in the same manner as the 4-phase motor described previously. In this case, the angle through which the rotor turns at each step is halved. This is because the stator assembly now has twice the number of magnetic poles.



S1
P
Q
stator PQ
N
2
S
N
3
1
S
N
4
S
S2
R
S
stator RS
+
7Z66690

Fig. 1a



S1
P
Q
stator PQ
N
2
S
3
S
N
1
N
4
S
S2
R
S
stator RS
+
7Z66689

Fig. 1b

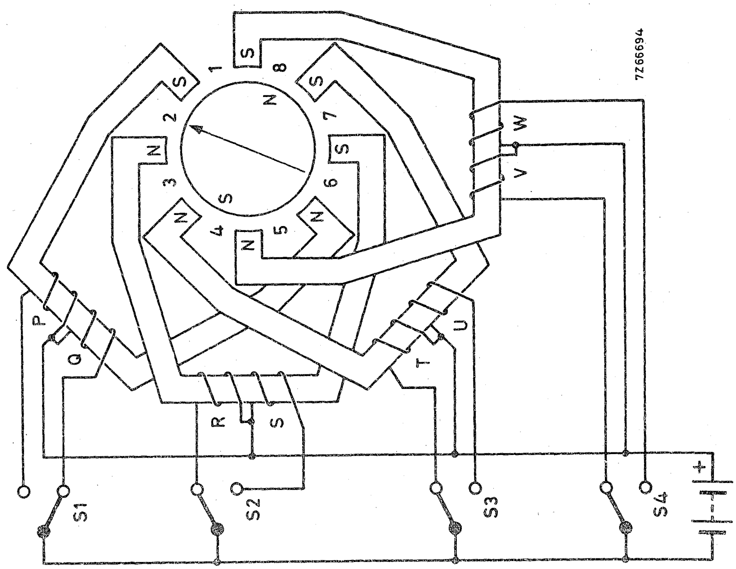


Fig. 2b

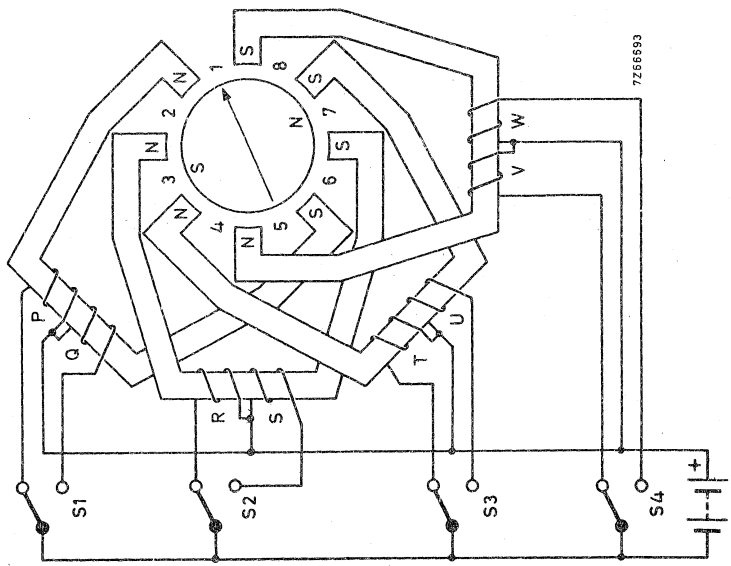


Fig. 2a

Motors for Bi-polar Drive

The stator coils of a motor designed for bi-polar drive have no centre-tap. Instead of using alternate coil-halves to produce a reversal of current-flow through the stator windings (as for uni-polar drive), the current is now reversed through the entire coil by switching both supply lines. Operation of a motor with bi-polar drive is identical to that of one with uni-polar drive.

2-stator motors (2-phase)

Operation of a 2-phase motor with bi-polar drive is shown in Fig.3.

4-stator motors (4-phase)

The 4-phase motor with bi-polar drive is shown in Fig. 4.

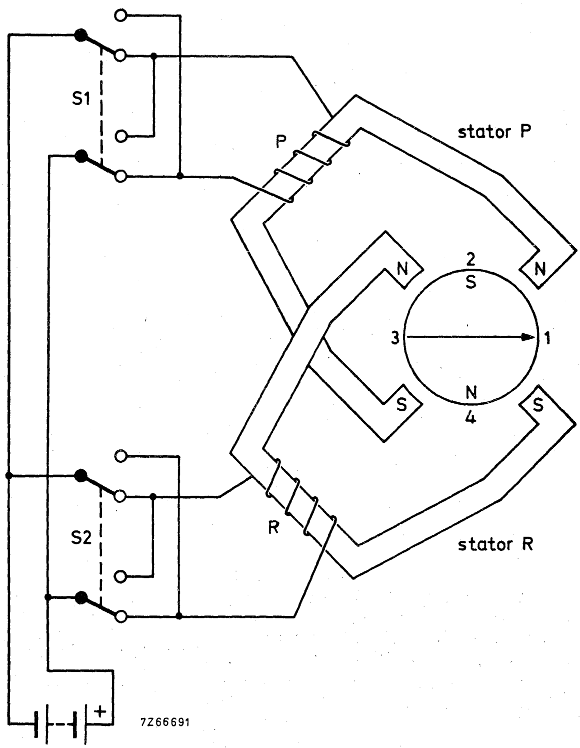


Fig. 3a

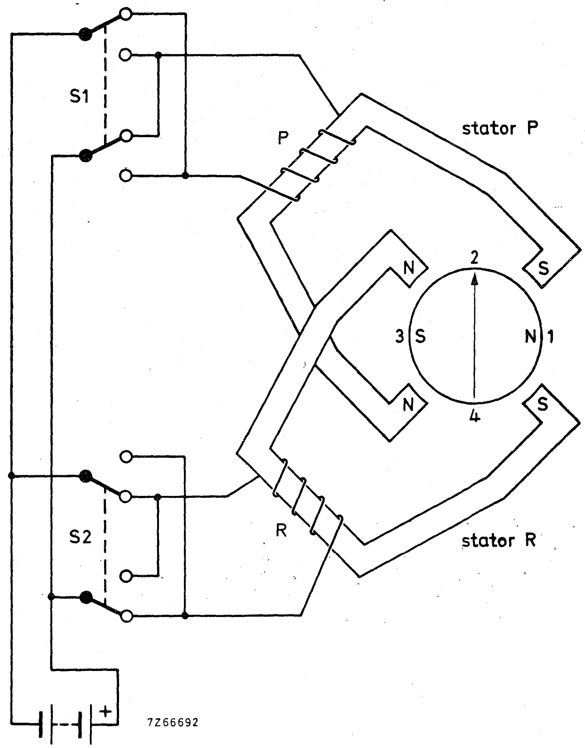


Fig. 3b

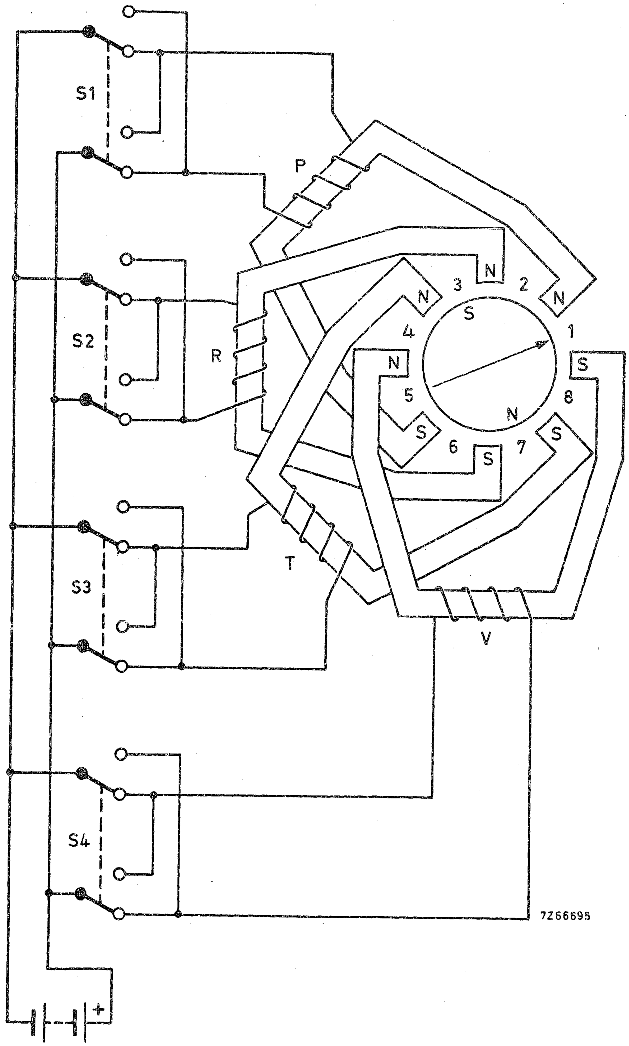


Fig. 4a

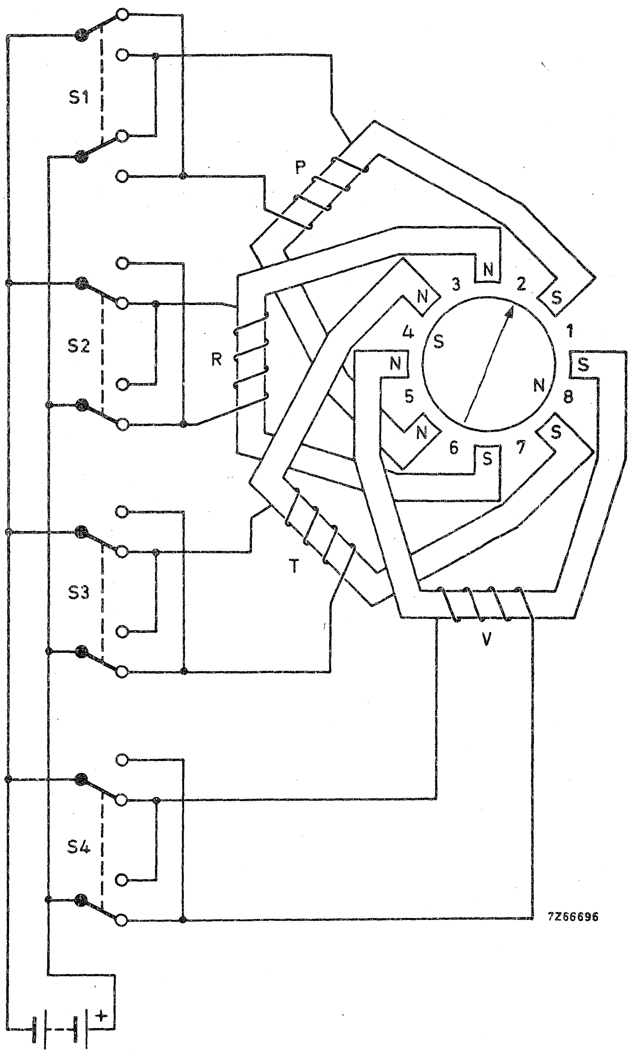


Fig. 4b

Features of the bi-polar drive

The advantages of using motors with bi-polar drive are shown in Fig. 5. This compares the performance of type PD16 motors when employing uni-polar and bi-polar drive. A considerable increase in available torque is apparent using the bi-polar version: the associated electronics, however, are necessarily somewhat more complex.

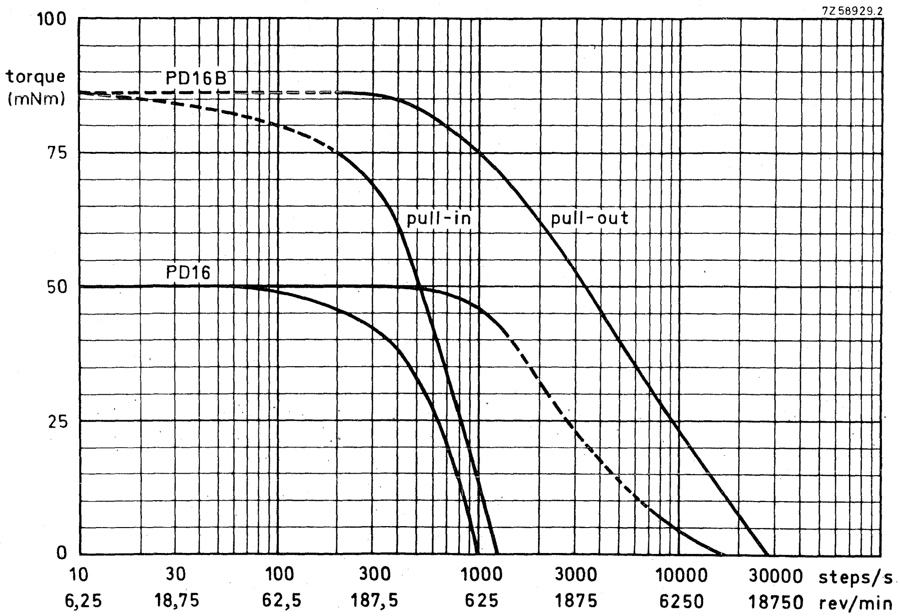


Fig. 5

THE ELECTRONICS

As indicated previously, stepper motors operate from a d.c. supply via sequential switching which produces current reversals through successive stator windings. A d.c. supply, appropriate to the particular motor-type and the method of drive, is usually derived from the a.c. mains by means of a transformer and rectifier circuit. Switching is performed either by a mechanical switch (Fig. 6a) or by an electronic switch (Fig. 6b).

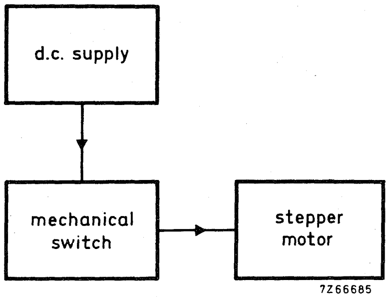


Fig. 6a

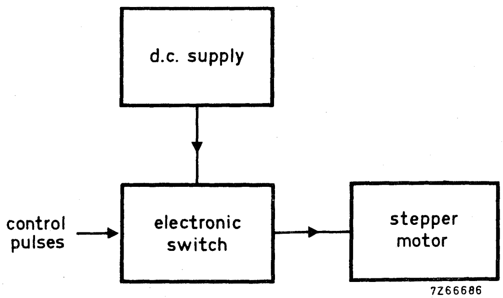


Fig. 6b

The mechanical switch requires a physical force to produce the required switching, whereas the electronic switch provides the necessary control directly from a series of pulses (i.e. digital information). In general, a mechanical system has several disadvantages when compared with its electronic counterpart:

- lower switching speeds
- wear on moving parts and, hence, increased maintenance
- contact vibration, leading to lower efficiency and decreased reliability
- longer switch-over times.

The features listed detract from the characteristics of the stepper motor itself. The electronic switch, however, optimizes the motor characteristics; this is because it has:

- a high switching speed
- high reliability
- no maintenance requirements
- a very short switch-over time
- a low power control capability.

Fig. 7 illustrates the detrimental effect upon current-flow through a coil, and hence torque, caused by the extended switching time inherent in mechanical switches.

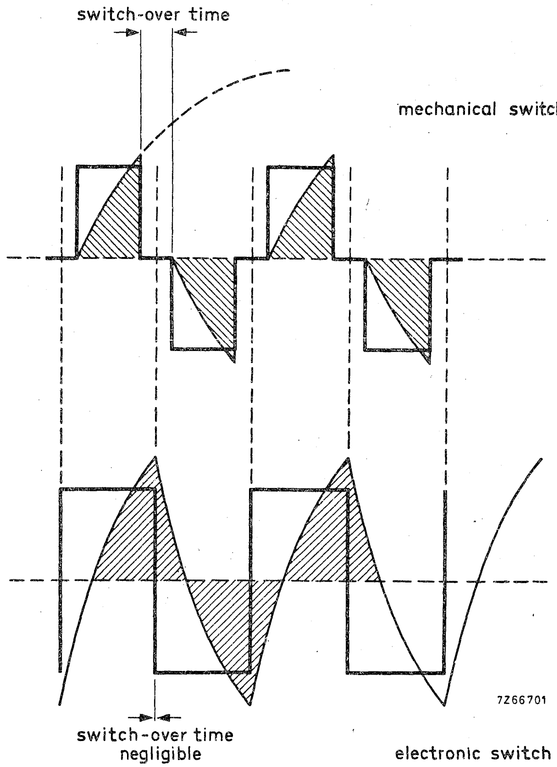


Fig. 7

Uni-polar Drive

Stepper motors operated with a uni-polar drive system require the following electronics (Fig. 8):

- a transformer, to reduce the value of the available a.c. mains
- a rectifier, to convert the low a.c. supply into the appropriate d.c. motor supply voltage
- a source of control pulses (e.g. an oscillator)
- an electronic switch, this arranges the incoming control pulses into the sequential phase switching necessary for the stator coils
- a compensating network, to improve the rise-time of current through a stator coil when power is initially applied.

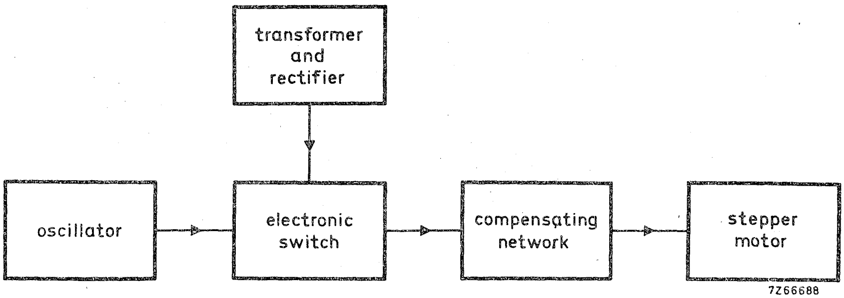


Fig. 8

The compensating network (Fig. 9) consists of a resistor R_V and a capacitor C_V for each phase. The resistor R_V is connected in series with the stator phase P and the capacitor is connected in parallel with the phase and the switching element TR. This arrangement allows the capacitor to discharge, thereby providing a current peak (Fig. 10), at the amount its associated phase is switched into circuit. The capacitor regains its charge during the period for which the switching element is in the off state.

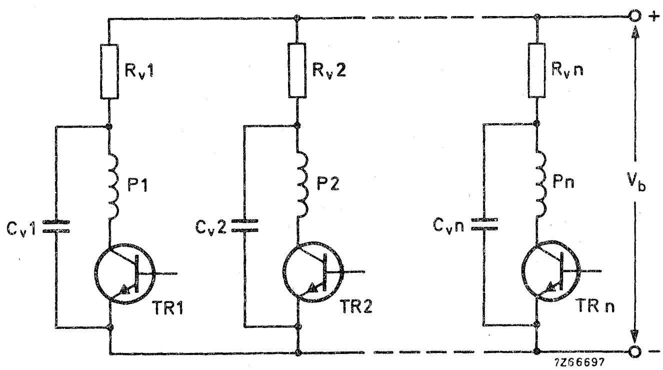


Fig. 9

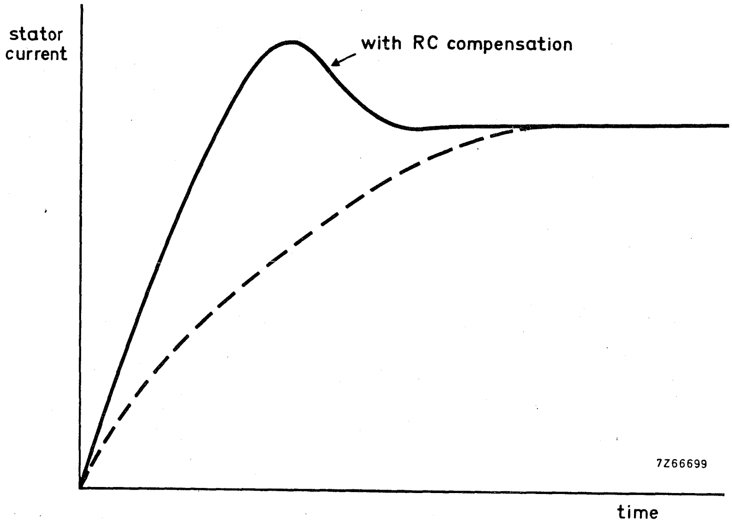


Fig. 10

Bi-polar Drive

Stepper motors operated with a bi-polar drive system require the following electronics (Fig. 11):

- a transformer, to reduce the value of the available a.c. mains
- a rectifier, to convert the low a.c. supply into the appropriate d.c. motor supply voltage
- a source of control pulses (external to the electronics, as such)
- an electronic switch, known as a "bi-polar constant current drive" (BCCD).

The BCCD unit converts the incoming control pulses into the requisite current reversals through successive stator coils, supplying them from a 60 V source which employs a chopper circuit. This ensures that the current through a stator coil reaches its maximum value in the shortest possible time, maintains that value irrespective of opposing currents generated by the rotor and reduces the power consumption of the overall system.

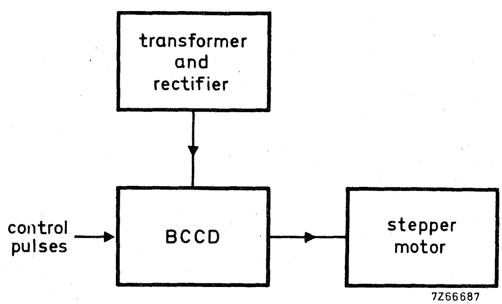


Fig. 11

Fig. 12 shows a basic constant current, bi-polar drive circuit for one stator coil. Transistors TR1 to TR4 perform the bi-polar switching function for a stator coil L and correct sequential switching of a number of these circuits, to provide "step-wise" rotation of the motor in either direction, is controlled by the logic circuit. If TR1 and TR4 are conducting (TR2 and TR3 off), conventional current-flow through the stator coil is from 1 to 2 (Fig. 12): if TR2 and TR3 are conducting (TR1 and TR4 off), it is in the opposite direction i.e. from 2 to 1.

When TR1 and TR4 are switched on by the control logic, current starts to flow and quickly increases exponentially through resistor R1, transistor TR1, stator coil L and transistor TR4. On reaching a predetermined maximum permissible value, the voltage developed across R1 causes the level detector to operate. The output from the level detector is fed to gate A and this switches off TR4 as soon as that value is reached. At this moment, the energy stored in the magnetic field of the stator coil maintains a temporarily increasing voltage across the coil and an exponential fall in current results through the circuit R1, TR1, L and diode D2, reducing the voltage across R1. When a predetermined minimum value is reached, the level detector causes TR4 to conduct again and this action continues for as long as the logic circuit demands the conduction of TR1 and TR4: resultant current-flow is shown in Fig. 13.

A similar action occurs when the control logic demands the conduction of TR2 and TR3 but, in this case, TR3 is switched by gate B.

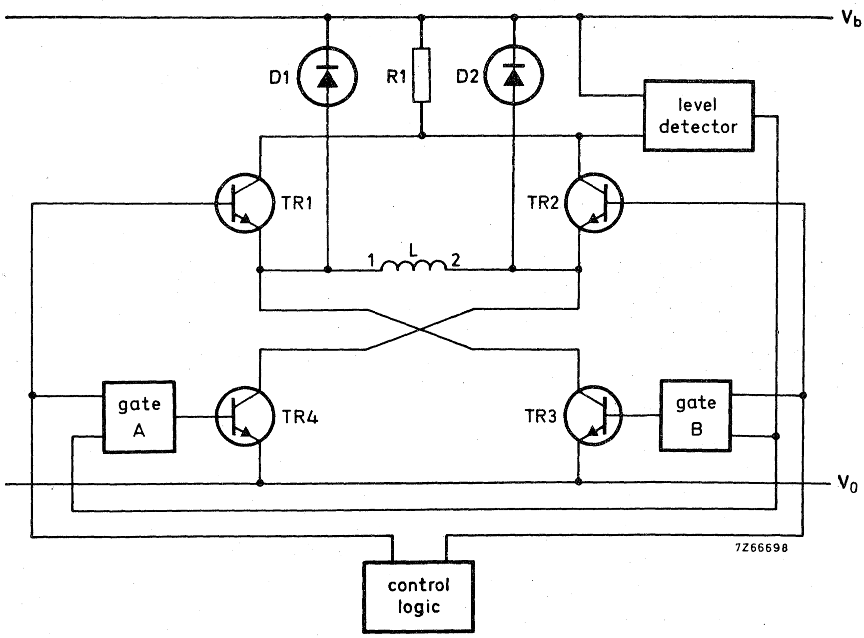


Fig. 12

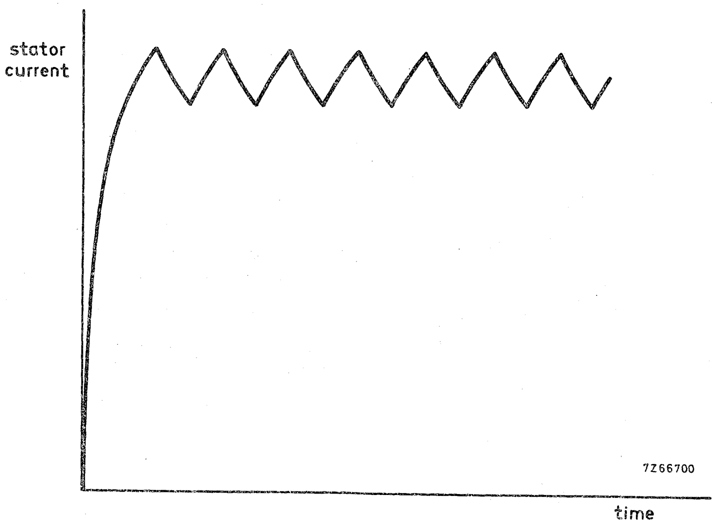


Fig. 13

TERMINOLOGY

(in alphabetical order)

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

Deviation: The change in spindle position from the unloaded holding position when a certain torque is applied to the spindle of an excited motor. Unit: degrees.

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

Maximum Pull-In Rate (Speed): The maximum switching rate (speed) at which an unloaded motor can start without losing steps. Unit: steps/s (rev/min).

Maximum Pull-Out Rate (Speed): The maximum switching rate (speed) which the unloaded motor can follow without losing steps. Unit: steps/s (rev/min).

Maximum Working Torque: The maximum torque that can be obtained from the motor. Unit: mNm.

Overshoot: The maximum amplitude of the oscillation around the final holding position of the rotor after cessation of the switching pulses. Unit: degrees.

Permanent Overshoot: The number of steps the rotor moves after cessation of the switching pulses. Unit: steps.

Phase: Each winding connected across supply voltage.

Pull-In Rate (Speed): The maximum switching rate (speed) at which a frictionally loaded motor can start without losing steps. Unit: steps/s (rev/min).

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

Pull-Out Rate (Speed): The maximum switching rate (speed) which a frictionally loaded motor can follow without losing steps. Unit: steps/s (rev/min).

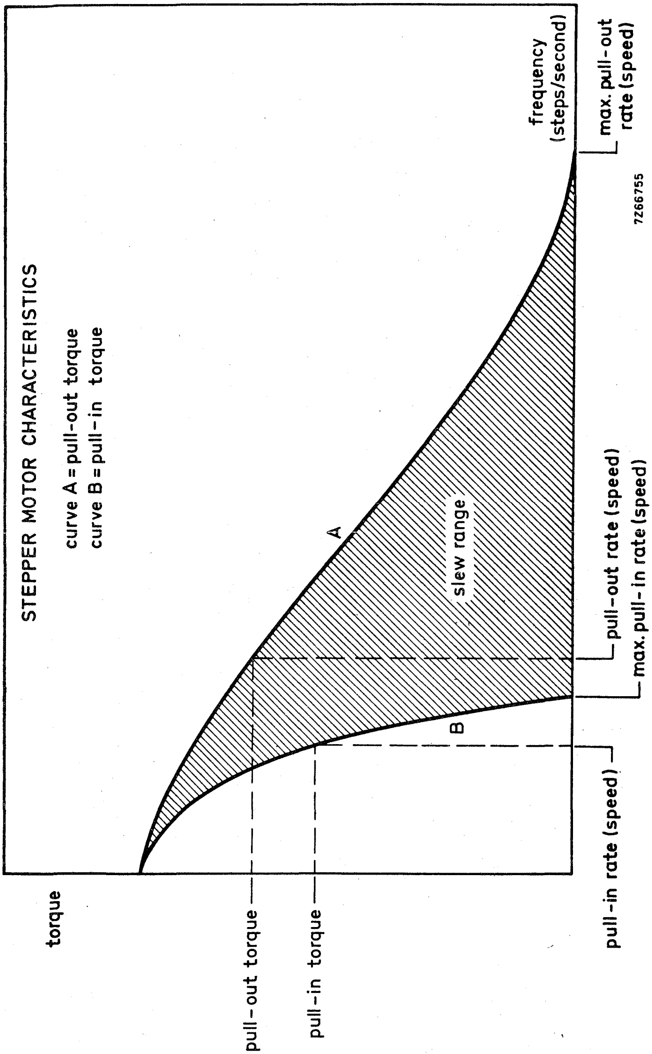
Pull-Out Torque: The maximum torque that can be applied to a motor spindle when running at the pull-out rate. Unit: mNm.

Start Range: The range of switching rates within which a motor can start without losing steps.

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

Stepping Rate: The number of step positions passed by a fixed point on the rotor per second. Unit: steps/s.

Slew Range: The range of switching rates within which a motor can run unidirectionally and follow the switching rate (within a certain maximum acceleration) without losing steps, but cannot start, stop or reverse.



Typical stepper motor curves illustrating the terminology used.

MOTOR SPECIFICATIONS

The following pages contain full specifications for each motor type. Values given are typical, they apply at an ambient temperature of 15 °C to 35 °C, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75 %.

The following points should be noted:

Maximum motor temperatures are as follows:

- PD-series: 125 °C
- ID -series: 100 °C.

Temperature increase in these motors depends upon their power consumption. Motors employing unipolar drive 9904 131 03003, 9904 131 03004, or SAA1027, operate from a low supply voltage and have a low power input which limits the increase in motor temperature. If motors with unipolar drive are operated at low ambient temperatures, a higher supply voltage, giving correspondingly higher torque, is permissible.

Motors employing bipolar constant current drive 4322 027 90070 operate from a high (60 V) supply voltage and have a higher input power which causes a greater increase in motor temperature. They should either be mounted on a surface that will act as a heatsink or have forced cooling (for further details see Description of the bipolar constant current drive).

At ambient temperatures above 25 °C, the torque of motors, both for unipolar and bipolar drive, will decrease by approximately 0, 2 % per °C. There is also a derating at low ambient temperatures, more so for unipolar motors operating in the slew range: pull-in, however, is not affected.

Instability of a stepper motor's performance can occur under certain circumstances. The mass moment of the rotor and its load, together with the magnetic stiffness, forms a spring system which causes:

- a resonance at low stepping rates
- hunting around the required speed at high stepping rates (this is more pronounced with 8-phase motors operating in their slew range).

These unstable areas are indicated by broken lines on the performance curves appearing in this section.

Resonance can be minimized by applying the correct amount of friction to the motor drive-spindle.

Hunting can be minimized by attaching a "Lancaster damper" to the motor spindle. A Lancaster damper basically consists of a disc that is frictionally attached over the motor spindle. Ordinarily the disc rigidly follows the rotational speed of the spindle but when hunting occurs, it moves through a small angle in relation to the spindle and absorbs the fluctuation in speed. The mass moment of the disc and the required friction depend entirely upon the application and must be individually determined in each case.

4-PHASE UNIPOLAR STEPPER MOTORS

This range comprises eight types of permanent magnet stepper motor:

- 6 industrial digital (ID) types;
- 2 professional digital (PD) types.

The ID types are intended for instrumentation and computer peripherals. The PD types may be used in professional applications and equipment which require a high degree of reliability even under very unfavourable environmental conditions.

DESCRIPTION

The motors have a 4-phase stator and a permanent magnet rotor with 24 poles (step angle of 7^{o} 30') or 12 poles (step angle of 15^{o}) in a rugged and simple construction. The motor coils are adapted to the unipolar electronic switch 9904 131 03003 or the unipolar integrated circuit SAA1027 (see relevant data sheets).

CONNECTION DIAGRAMS

ID types with unipolar electronic switch 9904 131 03003

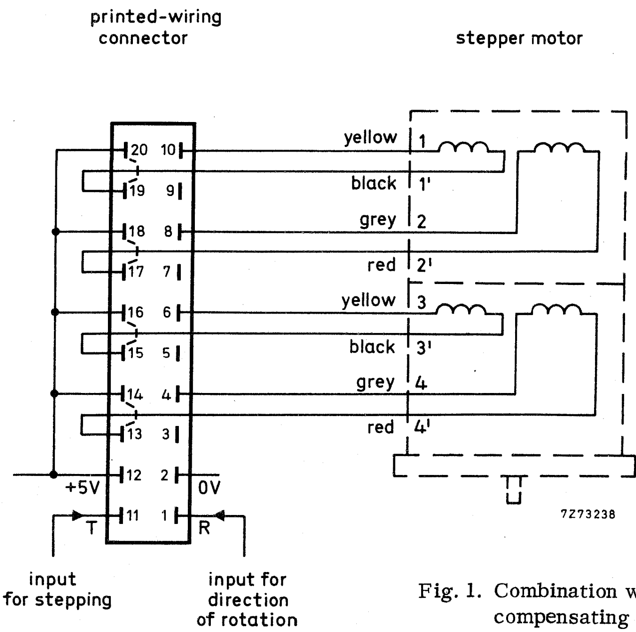


Fig. 1. Combination without compensating network.

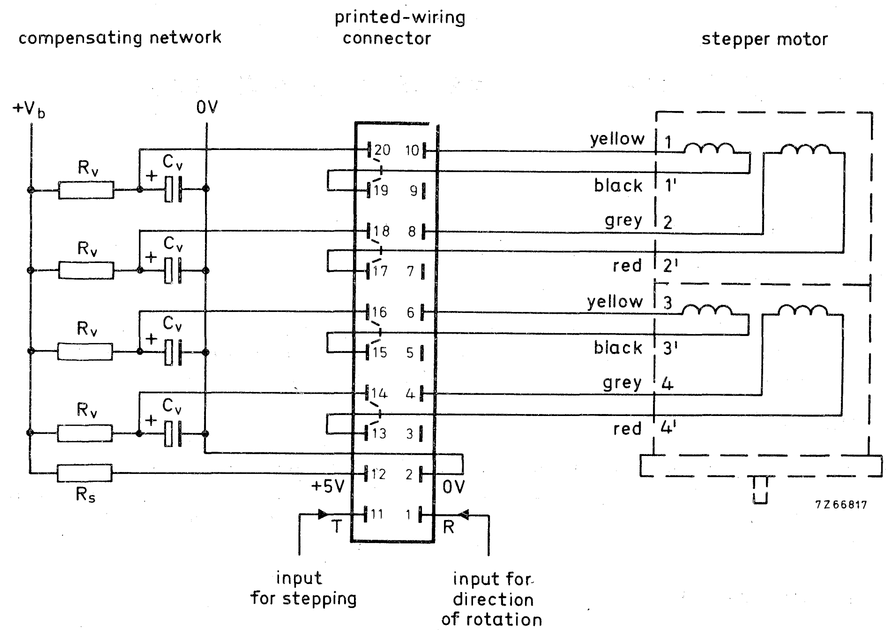


Fig. 2. Combination with compensating network. Resistor and capacitor values can be found in the data sheet of the relevant motor type.

ID types with unipolar integrated circuit SAA1027

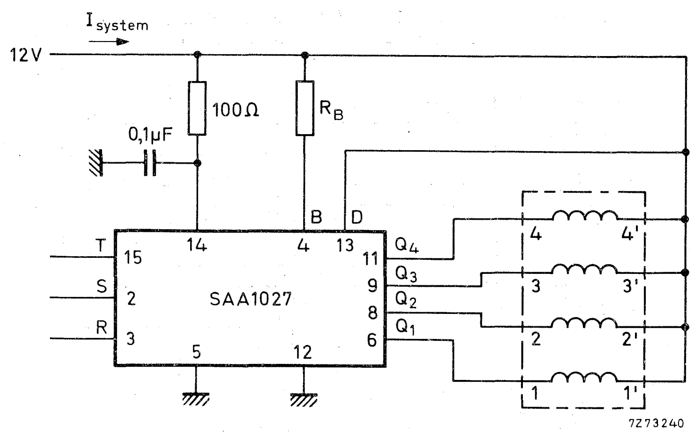


Fig. 3. Resistor value R_B can be found in the data sheet of the relevant motor type.

PD types with unipolar electronic switch 9904 131 03003

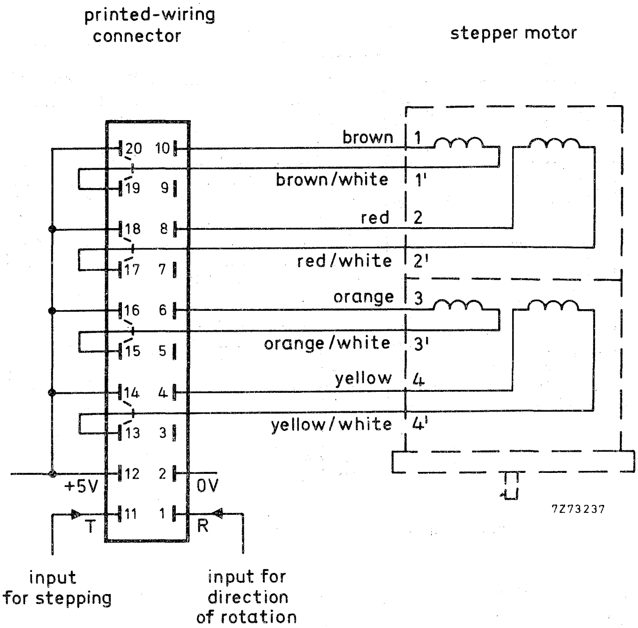


Fig. 4. Combination without compensating network.

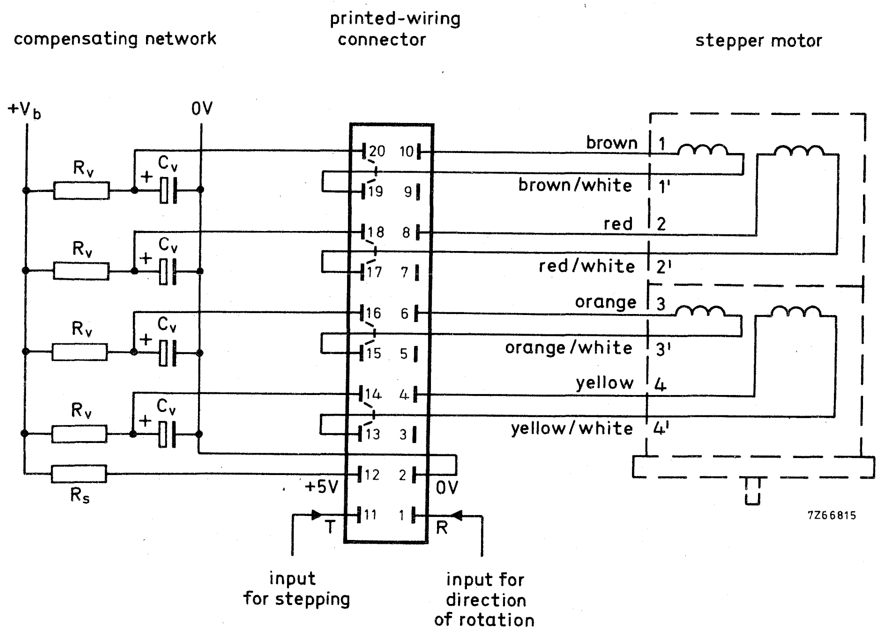


Fig. 5. Combination with compensating network. Resistor and capacitor values can be found in the data sheet of the relevant motor type.

4-PHASE UNIPOLAR STEPPER MOTORS

QUICK REFERENCE DATA			
motor type	9904 112 04002	9904 112 04101	
performance obtained with	integrated circuit SAA1027	electronic switch 9904 131 03003	
		without RC network	with RC network
Step angle	7° 30'	7° 30'	7° 30'
Max. working torque	18 mNm	18 mNm	20 mNm
Holding torque	25 mNm	25 mNm	27 mNm
Max. pull-in rate	230 steps/s	300 steps/s	400 steps/s
Max. pull-out rate	–	350 steps/s	550 steps/s

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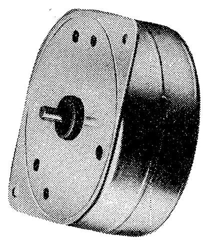


APPLICATION

Motor 9904 112 04002 has coils adapted to the 350 mA per phase output capability of the SAA1027. This motor is intended for applications where the system efficiency factor prevails and circuit complexity is to be kept at a minimum.
Motor 9904 112 04101 operated via electronic switch 9904 131 03003, without RC network, is especially suited for applications where the motor is used only in the pull-in range, and system efficiency is of importance.
Motor 9904 112 04101 operated via electronic switch 9904 131 03003, with RC network, is ideally suited for variable speed drives where the pull-out capabilities of the motor are required.

TECHNICAL DATA

Dimensions (mm)

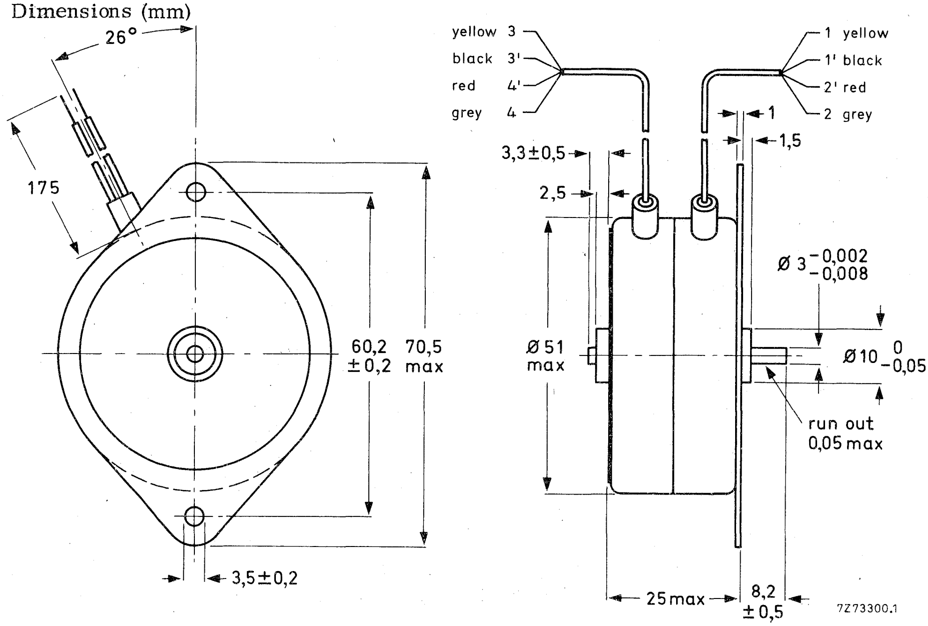


Fig. 1

Marking and connection

The connecting leads are colour-coded (see Fig. 1) and are connected to the electronic switch or to the integrated circuit as shown in General section of 4-phase unipolar stepper motors.

		motor 9904 112 04002	9904 112 04101
Power consumption of motor only	(W)	3	3, 3
Maximum working torque	(mNm)	18	20
Holding torque	(mNm)	25	27
Max. pull-in rate	(steps/s)	230 [1]	400 [2]
Max. pull-out rate	(steps/s)	–	550 [2]
Number of phases		4	4
Resistance per coil	(Ω)	94	15
Inductance per coil	(mH)	260	30
Current per coil	(mA)	125	330
Permissible ambient temperature range	(°C)	−20 to +60	−20 to +70
Permissible storage temperature range	(°C)	−40 to +100	−40 to +100

[1] When driven by integrated circuit SAA1027 (see General section, Fig. 3. R_B = 470 Ω).

[2] When driven by electronic switch 9904 131 03003 with RC network (see General section, Fig. 2. R_V = 22 Ω; C_V = 27 μF; V_b = 12 V d.c.; R_s = (V_b - 5)/0,230 Ω).

Permissible motor temperature	(°C)	100	100
Insulation resistance at 500 V d.c.	(MΩ)	100	100
Step angle		7° 30'	7° 30'
Step-angle tolerance (non-cumulative)		±20'	±20'
Number of steps per revolution		48	48
Direction of rotation		reversible	reversible
Rotor inertia	(gcm^2)	11	11
Bearings		slide	slide
Mass	(g)	160	160
Maximum radial force	(N)	5	5
Maximum axial force	(N)	1,5	1,5

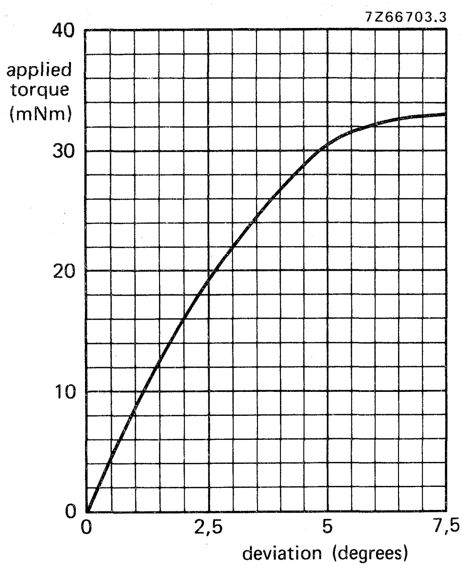


Fig. 2 Applied torque versus deviation.

Motor 9904 112 04002 with integrated circuit SAA1027

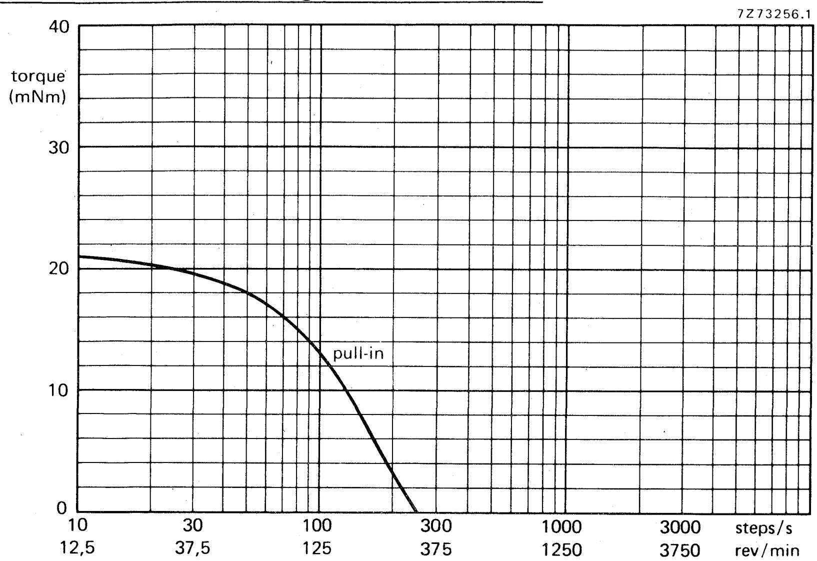


Fig. 3 Torque versus stepping rate, measured at room temperature

Motor 9904 112 04101 with electronic switch 9904 131 03003

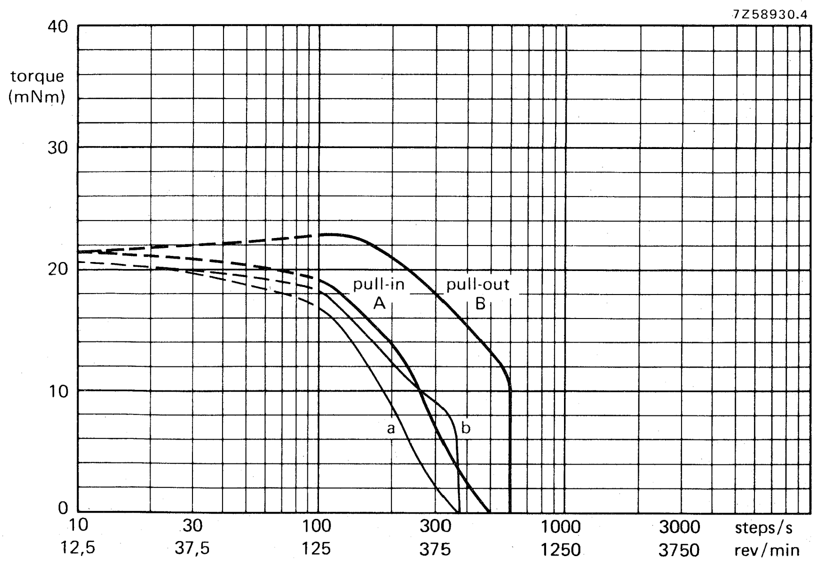


Fig. 4. Torque versus stepping rate, measured at room temperature (thin lines-without RC network, thick lines-with RC network; a and A for pull-in, b and B for pull-out).

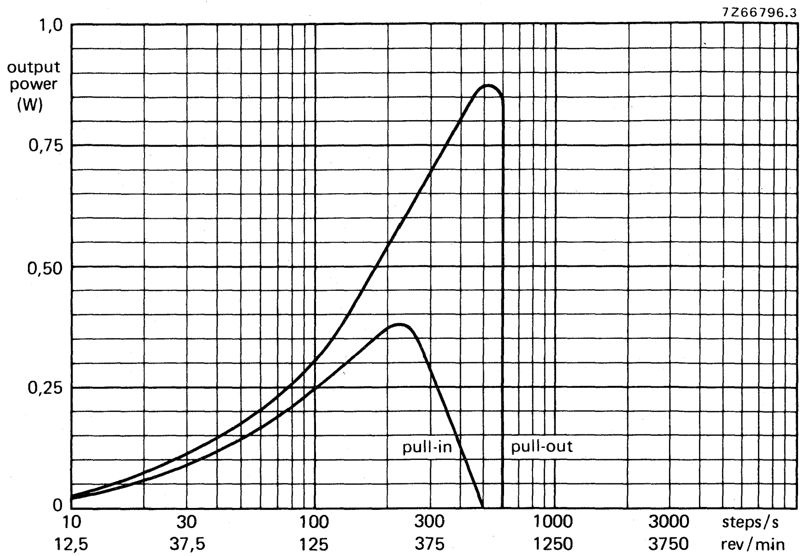
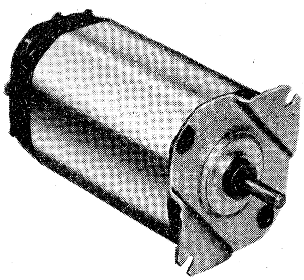


Fig. 5. Output power versus stepping rate measured with RC network at room temperature.

4-PHASE UNIPOLAR STEPPER MOTORS

QUICK REFERENCE DATA			
motor type	9904 112 06001	9904 112 06101	
performance obtained with	integrated circuit SAA 1027	electronic switch 9904 131 03003	
		without RC network	with RC network
Step angle	7° 30'	7° 30'	7° 30'
Max. working torque	40 mNm	40 mNm	50 mNm
Holding torque	60 mNm	70 mNm	70 mNm
Max. pull-in rate	110 steps/s	150 steps/s	200 steps/s
Max. pull-out rate	–	175 steps/s	320 steps/s

RZ 26753-4



APPLICATION

Motor 9904 112 06001 has coils adapted to the 350 mA per phase output capability of the SAA1027. This motor is intended for applications where the system efficiency factor prevails and circuit complexity is to be kept at a minimum.
Motor 9904 112 06101 operated via electronic switch 9904 131 03003, without RC network, is especially suited for applications where the motor is used only in the pull-in range, and system efficiency is of importance.
Motor 9904 112 06101 operated via electronic switch 9904 131 03003, with RC network, is ideally suited for variable speed drives where the pull-out capabilities of the motor are required.

TECHNICAL DATA

Dimensions (mm)

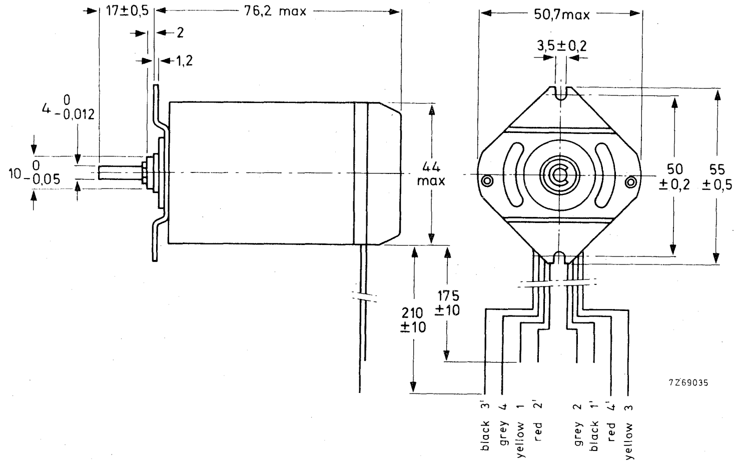


Fig. 1

Marking and connection

The connecting leads are colour-coded (see Fig. 1) and are connected to the electronic switch or to the integrated circuit as shown in General section of 4-phase unipolar stepper motors.

		motor 9904 112 06001	motor 9904 112 06101
Power consumption of motor only	(W)	6,4	4
Maximum working torque	(mNm)	40	50
Holding torque	(mNm)	60	70
Max. pull-in rate	(steps/s)	110 [1]	200 [2]
Max. pull-out rate	(steps/s)	--	320 [2]
Number of phases		4	4
Resistance per coil	(Ω)	45	12
Inductance per coil	(mH)	130	35
Current per coil	(mA)	250	400
Permissible ambient temperature range	(°C)	−20 to +50	−20 to +70
Permissible storage temperature range	(°C)	−40 to +100	−40 to +100

1) When driven by integrated circuit SAA1027 (see General section, Fig. 3. $R_B = 220\ \Omega$).

2) When driven by electronic switch 9904 131 03003 with RC network (see General section, Fig. 2. $R_V = 15\ \Omega$; $C_V = 50\ \mu F$; $V_b = 12$ V d.c.; $R_S = (V_b - 5)/0,230\ \Omega$).

Permissible motor temperature	(°C)	100	100
Insulation resistance at 500 V d.c.	(MΩ)	100	100
Step angle		7° 30'	7° 30'
Step-angle tolerance (non-cumulative)		±20'	±20'
Number of steps per revolution		48	48
Direction of rotation		reversible	reversible
Rotor inertia	(gcm^2)	90	90
Bearings		sleeve	sleeve
Weight	(g)	320	320
Maximum radial force	(N)	15	15
Maximum axial force	(N)	1,5	1,5

Motor 9904 112 06001 with integrated circuit SAA1027

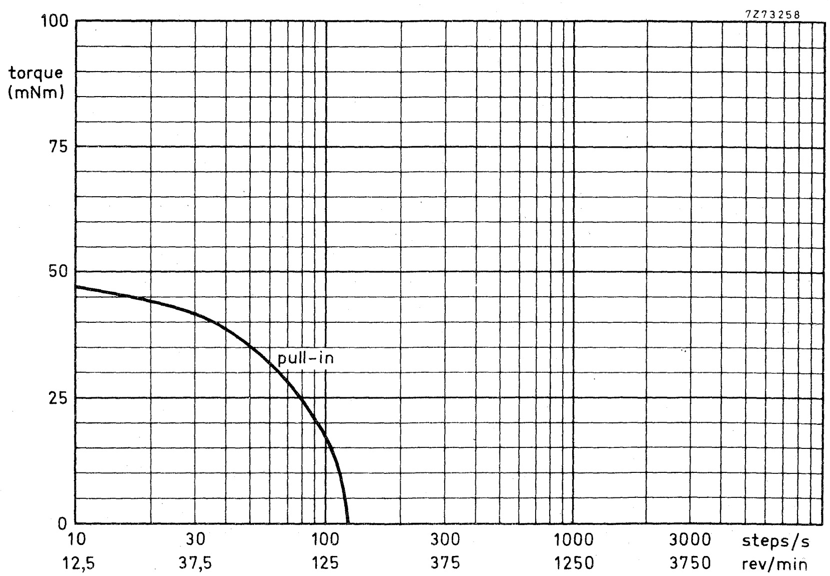


Fig. 2. Torque versus stepping rate, measured at room temperature

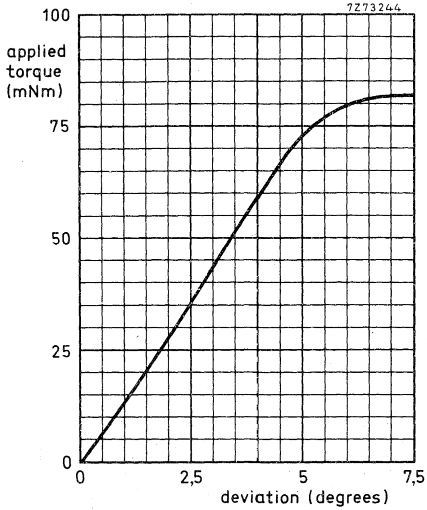


Fig. 3. Applied torque versus deviation.

Motor 9904 112 06101 with electronic switch 9904 131 03003

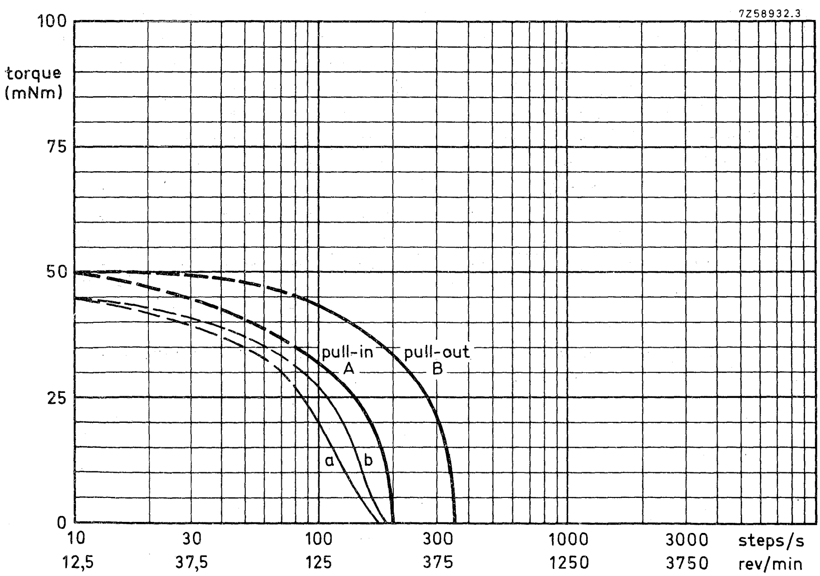


Fig. 4. Torque versus stepping rate, measured at room temperature (thin lines-without RC network, thick lines-with RC network; a and A for pull-in, b and B for pull-out).

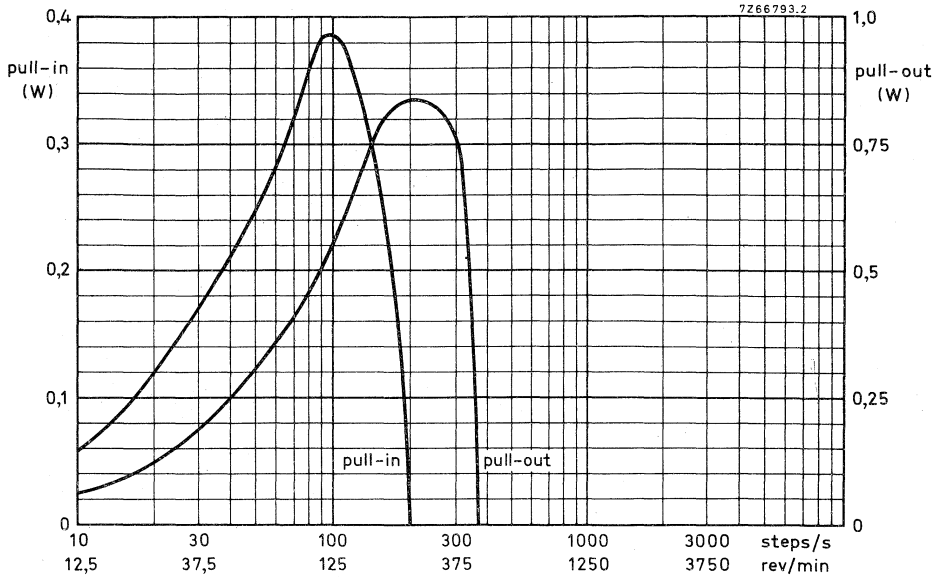


Fig. 5. Output power versus stepping rate measured with RC network at room temperature.

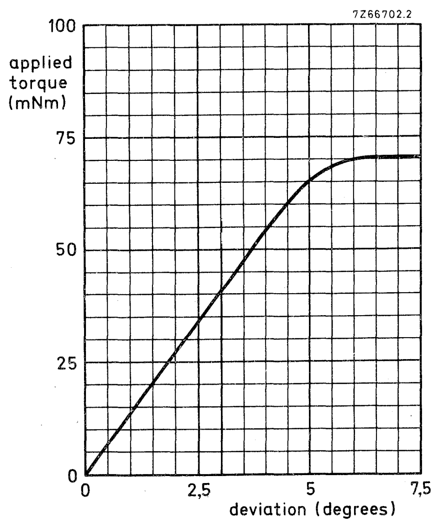
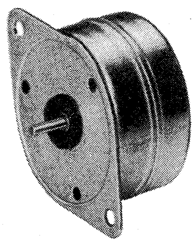


Fig. 6. Applied torque versus deviation.

4-PHASE UNIPOLAR STEPPER MOTORS

QUICK REFERENCE DATA			
motor type	9904 112 07005	9904 112 07101	
performance obtained with	integrated circuit SAA 1027	electronic switch 9904 131 03003	
		without RC network	with RC network
Step angle	7° 30'	7° 30'	7° 30'
Max. working torque	4,5 mNm	6 mNm	6 mNm
Holding torque	6,5 mNm	8 mNm	8 mNm
Max. pull-in rate	350 steps/s	400 steps/s	500 steps/s
Max. pull-out rate	–	750 steps/s	1000 steps/s

RZ 26753-10



APPLICATION

Motor 9904 112 07005 has coils adapted to the 350 mA per phase output capability of the SAA 1027. This motor is intended for applications where the system efficiency factor prevails and circuit complexity is to be kept at a minimum.
Motor 9904 112 07101 operated via electronic switch 9904 131 03003, without RC network, is especially suited for applications where the motor is used only in the pull-in range, and system efficiency is of importance.
Motor 9904 112 07101 operated via electronic switch 9904 131 03003, with RC network, is ideally suited for variable speed drives where the pull-out capabilities of the motor are required.

TECHNICAL DATA

Dimensions (mm)

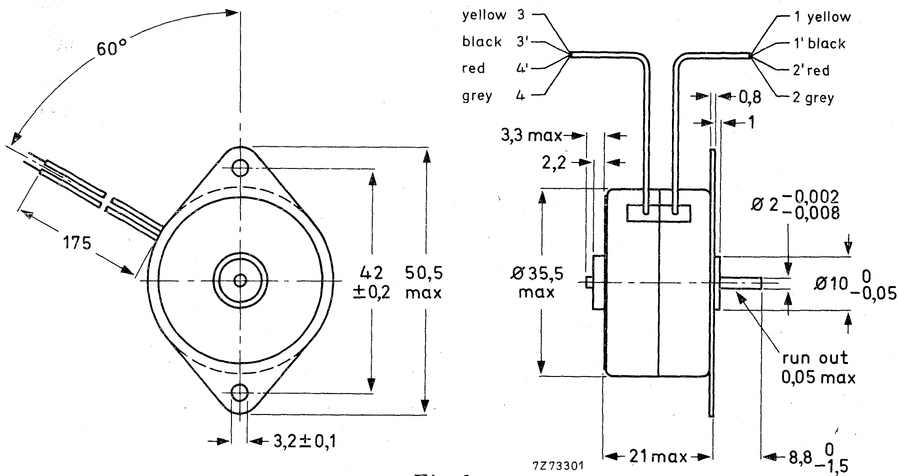


Fig. 1

Marking and connection

The connecting leads are colour-coded (see Fig. 1) and are connected to the electronic switch or to the integrated circuit as shown in General section of 4-phase unipolar stepper motors.

		motor 9904 112 07005	motor 9904 112 07101
Power consumption of motor only	(W)	1,9	1,7
Maximum working torque	(mNm)	4,5	6
Holding torque	(mNm)	6,5	8
Max. pull-in rate	(steps/s)	350 1)	500 2)
Max. pull-out rate	(steps/s)	–	1000 2)
Number of phases		4	4
Resistance per coil	(Ω)	150	25
Inductance per coil	(mH)	150	30
Current per coil	(mA)	80	175
Permissible ambient temperature range	(°C)	−20 to +60	−20 to +70
Permissible storage temperature range	(°C)	−40 to +100	−40 to +100

1) When driven by integrated circuit SAA1027 (see General section, Fig. 3. R_B = 620 Ω).

2) When driven by electronic switch 9904 131 03003 with RC network (see General section, Fig. 2. R_V = 43 Ω; C_V = 27 μF; V_b = 12 V d.c.; R_S = $(V_b - 5)/0,230$ Ω).

		9904 112 07005	9904 112 07101
Permissible motor temperature	(°C)	100	100
Insulation resistance at 500 V d.c.	(MΩ)	100	100
Step angle		7° 30'	7° 30'
Step-angle tolerance (non-cumulative)		±20'	±20'
Number of steps per revolution		48	48
Direction of rotation		reversible	reversible
Rotor inertia	(gcm^2)	2,6	2,6
Bearings		sleeve	sleeve
Weight	(g)	75	75
Maximum radial force	(N)	2,5	2,5
Maximum axial force	(N)	0,75	0,75

Motor 9904 112 07005 with integrated circuit SAA1027

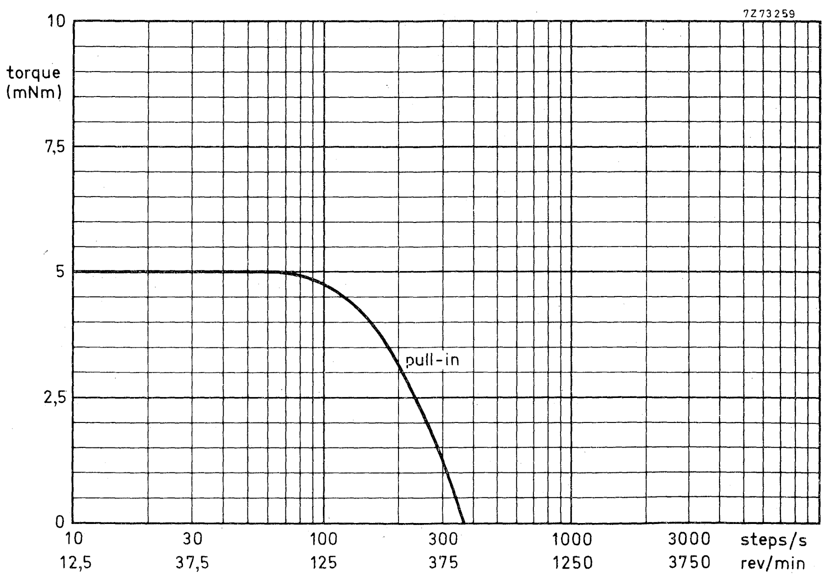


Fig. 2. Torque versus stepping rate, measured at room temperature

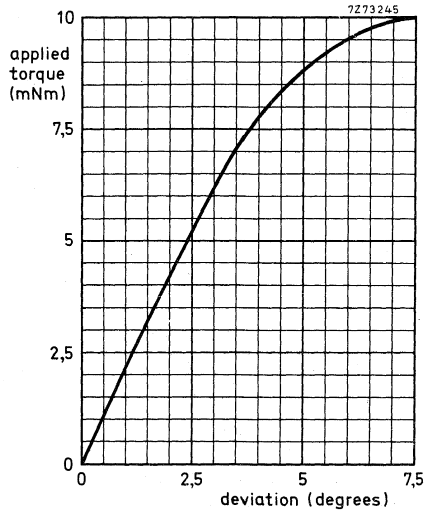


Fig. 3. Applied torque versus deviation.

Motor 9904 112 07101 with electronic switch 9904 131 03003

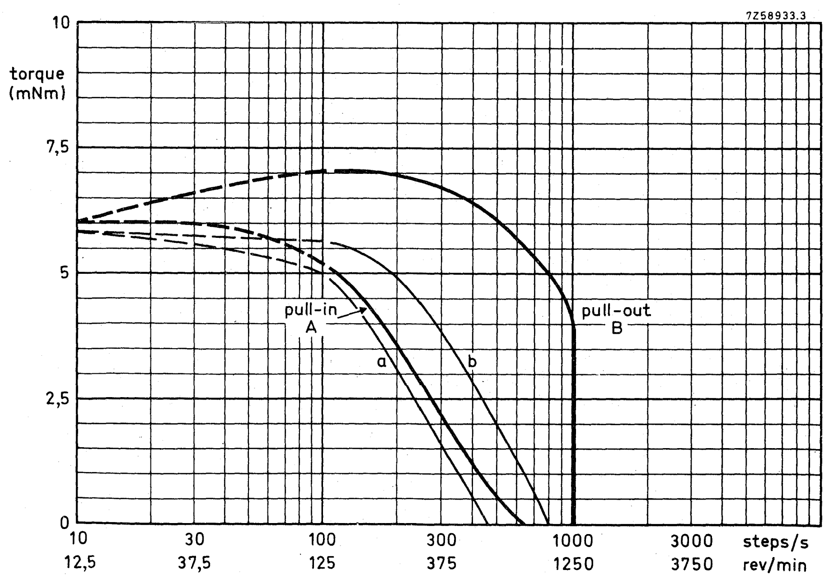


Fig. 4. Torque versus stepping rate, measured at room temperature (thin lines-without RC network, thick lines-with RC network; a and A for pull-in, b and B for pull-out).

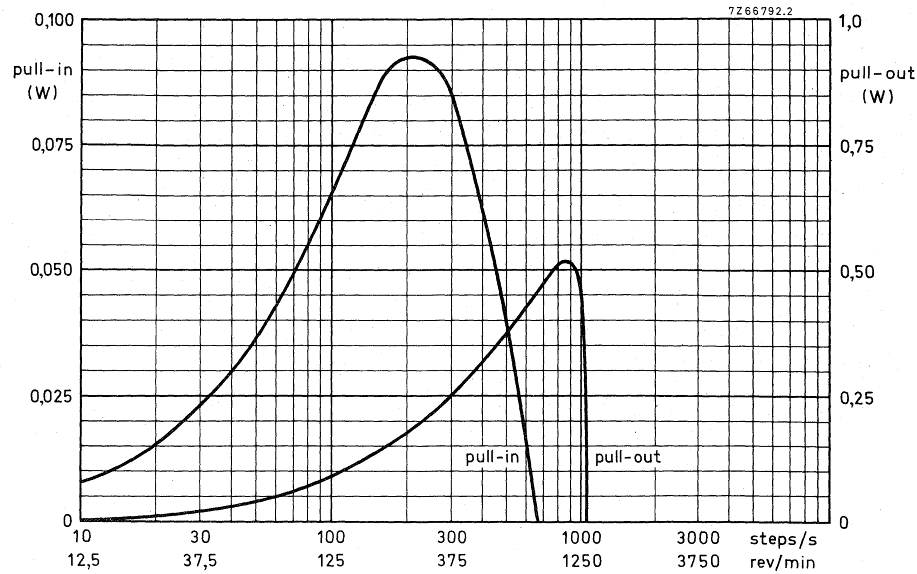


Fig. 5. Output power versus stepping rate measured with RC network at room temperature.

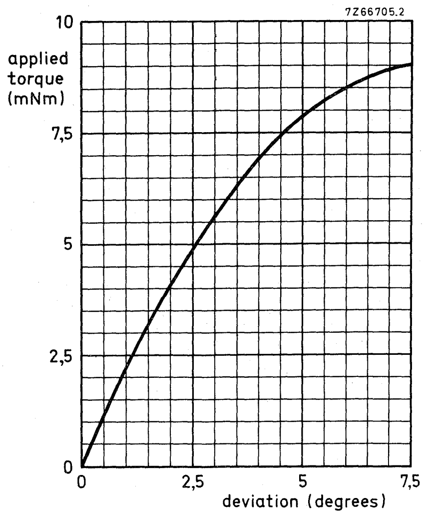


Fig. 6. Applied torque versus deviation.

4-PHASE UNIPOLAR STEPPER MOTOR

QUICK REFERENCE DATA		
performance obtained with	electronic switch 9904 131 03003	
	without RC network	with RC network
Step angle	7° 30'	7° 30'
Max. working torque	7 mNm	7 mNm
Holding torque	10 mNm	10 mNm
Max. pull-in rate	400 steps/s	500 steps/s
Max. pull-out rate	550 steps/s	1000 steps/s

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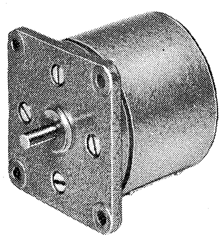

APPLICATION

Motor 9904 112 10001 operated via electronic switch 9904 131 03003, without RC network, is especially suited for applications where the motor is used only in the pull-in range, and system effeciency is of importance. This combination, with RC network, is ideally suited for variable speed drives where the pull-out capabilities of the motor are required.

TECHNICAL DATA

Dimensions (mm)

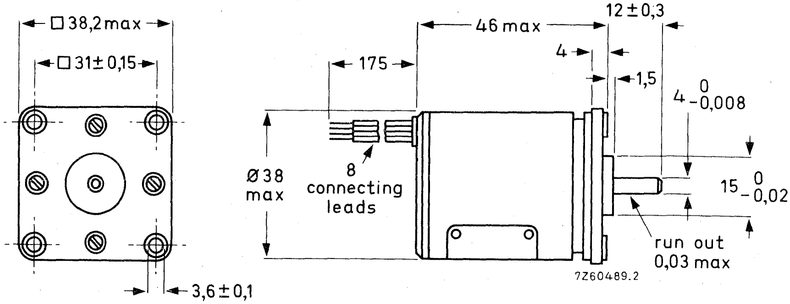

Fig. 1

Marking and connection
The connecting leads are colour-coded and are connected to the electronic switch as shown in General section of 4-phase unipolar stepper motors.

Power consumption of motor only	1,75 W
Maximum working torque	7 mNm
Holding torque	10 mNm
Maximum pull-in rate *)	500 steps/s
Maximum pull-out rate *)	1000 steps/s
Number of phases	4
Resistance per coil	27 Ω
Inductance per coil	20 mH
Current per coil	175 mA
Permissible ambient temperature range	−30 to + 85 °C
Permissible storage temperature range	−62 to + 110 °C
Permissible motor temperature	125 °C
Insulation resistance at 500 V d.c.	100 MΩ
Step angle	7° 30'
Step-angle tolerance	± 20' non-cumulative
Number of steps per revolution	48
Direction of rotation	reversible
Rotor inertia	3,5 gcm^2
Bearings	ball
Weight	140 g
Maximum axial play (axial force 1,5 N)	0,07 mm
Maximum radial force	10 N
Maximum axial force	5 N

*) When driven by electronic switch 9904 131 03003 with RC network (see General section, Fig. 2. R_v = 47 Ω ± 5%, 2 W; C_v = 10 μF, 64 V d.c.; V_b = 12 V d.c.; $R_s = (V_b - 5)/0,230$ Ω).

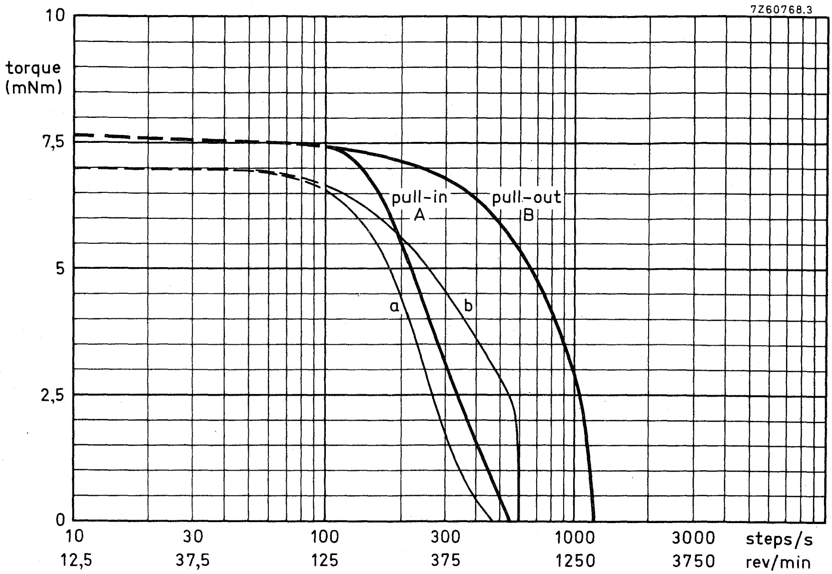

Fig. 2. Torque versus stepping rate, measured at room temperature (thin lines-without RC network, thick lines-with RC network; a and A for pull-in, b and B for pull-out).

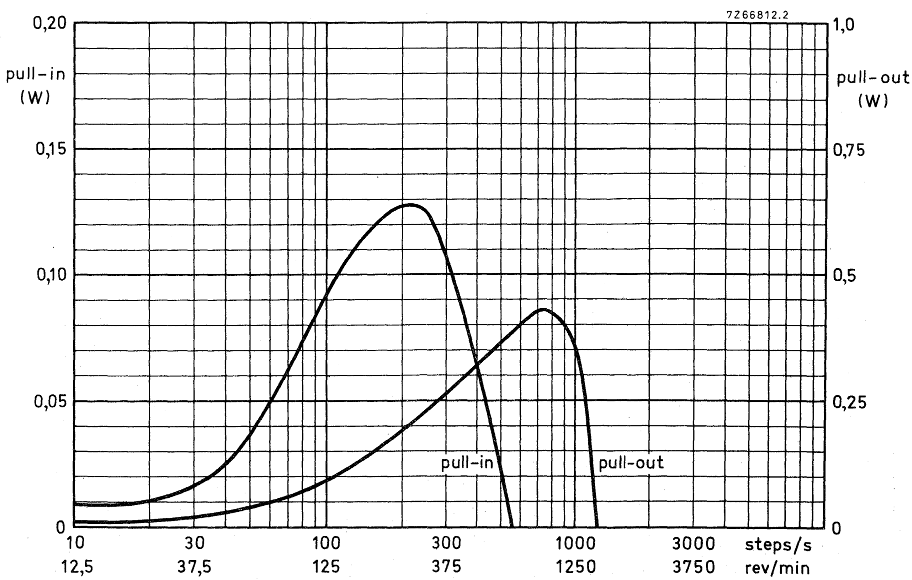

Fig. 3. Output power versus stepping rate, measured with RC network at room temperature.

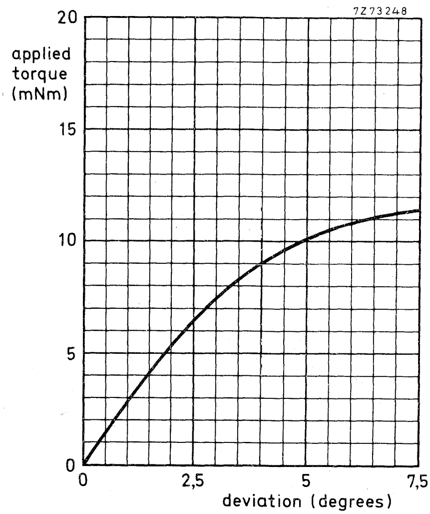

Fig. 4 Applied torque versus deviation.

4-PHASE UNIPOLAR STEPPER MOTOR

QUICK REFERENCE DATA		
performance obtained with	electronic switch 9904 131 03003	
	without RC network	with RC network
Step angle	7° 30'	7° 30'
Max. working torque	25 mNm	25 mNm
Holding torque	32,5 mNm	32,5 mNm
Max. pull-in rate	300 steps/s	360 steps/s
Max. pull-out rate	400 steps/s	550 steps/s

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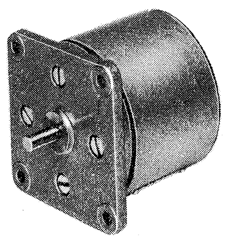


APPLICATION

Motor 9904 112 14001 operated via electronic switch 9904 131 03003, without RC network, is especially suited for applications where the motor is used only in the pull-in range, and system efficiency is of importance. This combination, with RC network, is ideally suited for variable speed drives where the pull-out capabilities of the motor are required.

TECHNICAL DATA

Dimensions (mm)

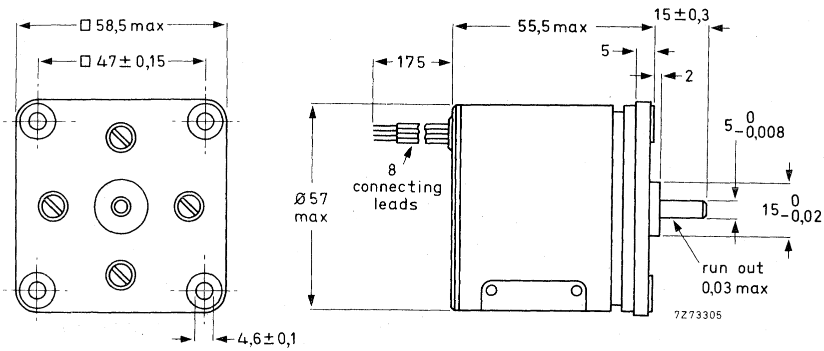


Fig. 1

Marking and connection
The connecting leads are colour-coded and are connected to the electronic switch as shown in General section of 4-phase unipolar stepper motors.

Power consumption of motor only	3,7 W
Max. working torque	25 mNm
Holding torque	32,5 mNm
Maximum pull-in rate *)	360 steps/s
Maximum pull-out rate *)	550 steps/s
Number of phases	4
Resistance per coil	15 Ω
Inductance per coil	25 mH
Current per coil	350 mA
Permissible ambient temperature range	−30 to + 85 °C
Permissible storage temperature range	−62 to + 110 °C
Permissible motor temperature	125 °C
Insulation resistance at 500 V d.c.	100 MΩ
Step angle	7° 30'
Step-angle tolerance	± 10' non-cumulative
Number of steps per revolution	48
Direction of rotation	reversible
Rotor inertia	18 gcm^2
Bearings	ball
Weight	500 g
Maximum axial play of spindle measured with axial force of 5 N	0,07 mm
Maximum radial force	15 N
Maximum axial force	7,5 N

*) When driven by electronic switch 9904 131 03003 with RC network (see General section, Fig. 2. R_v = 18 Ω ± 5%, 5 W; C_v = 50 μF, 40 V d.c.; V_b = 12 V d.c.; $R_s = (V_b - 5)/0,230$ Ω).

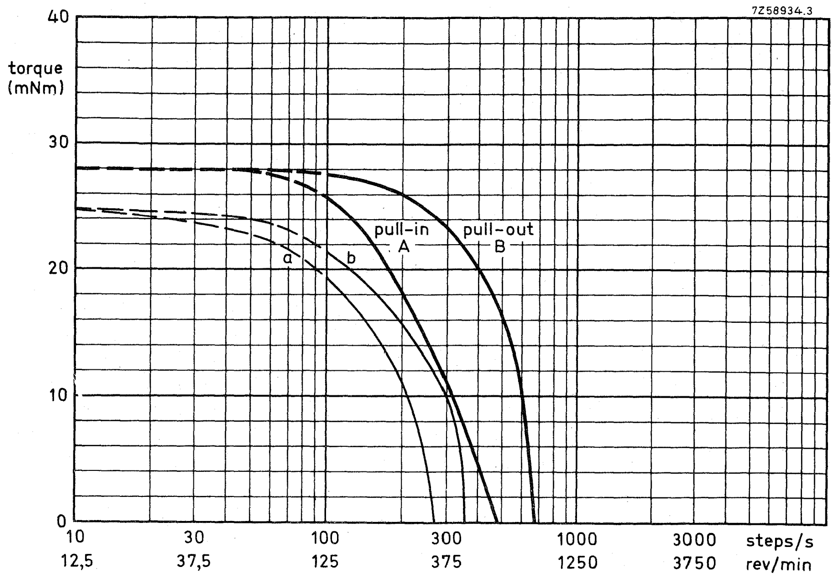


Fig. 2. Torque versus stepping rate, measured at room temperature (thin lines-without RC network, thick lines-with RC network; a and A for pull-in, b and B for pull-out).

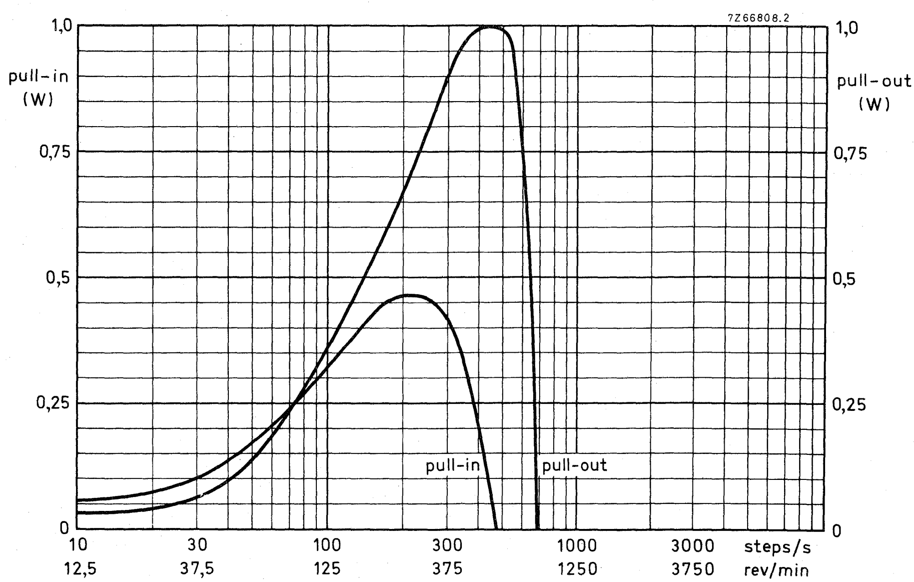


Fig. 3. Output power versus stepping rate, measured with RC network at room temperature.

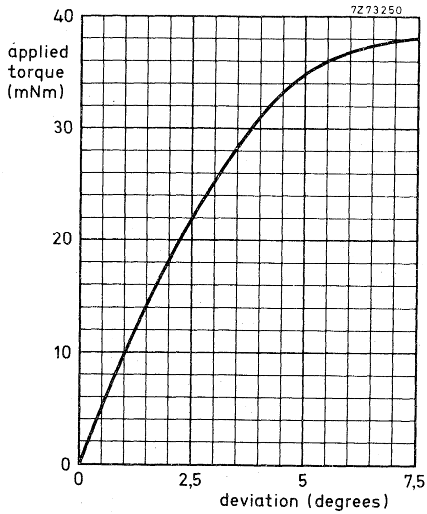
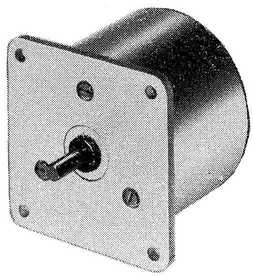


Fig. 4 Applied torque versus deviation.

4-PHASE UNIPOLAR STEPPER MOTORS

QUICK REFERENCE DATA			
motor type	9904 112 27001	9904 112 27101	
performance obtained with	integrated circuit SAA 1027	electronic switch 9904 131 03003 without RC network	electronic switch 9904 131 03003 with RC network
Step angle	7^{o} 30'	7^{o} 30'	7^{o} 30'
Max. working torque	100 mNm	85 mNm	110 mNm
Holding torque	140 mNm	120 mNm	150 mNm
Max. pull-in rate	80 steps/s	150 steps/s	275 steps/s
Max. pull-out rate	–	175 steps/s	275 steps/s



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APPLICATION

Motor 9903 112 27001 has coils adapted to the 350 mA per phase output capability of the SAA 1027. This motor and I.C. driver offer an economic and maintenance-free solution for stepwise rotational functions in a variety of applications and can replace complex and expensive mechanisms.

Motor 9904 112 27101, operated via electronic switch 9904 131 03003 (with or without RC network), will serve the same functions, however the output power capability of the electronic switch allows for higher torque and speed.

The ID27-Series finds its application in chart drives and X-Y plotters and is an ideal component to drive the paper-feed mechanism of terminal and telex printers. Industrial control and medical instrumentation range among the possible end use of these stepper motors.

TECHNICAL DATA

Dimensions (mm)

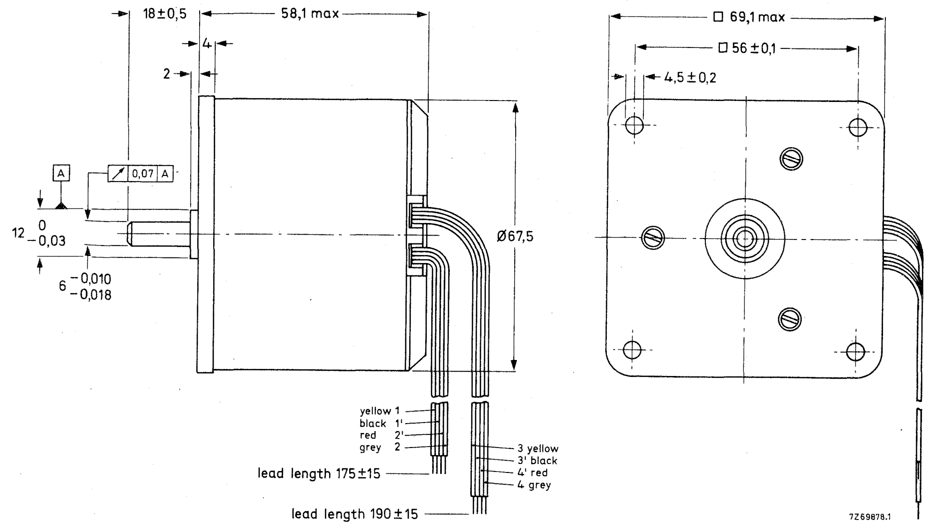

Fig. 1a. Standard version

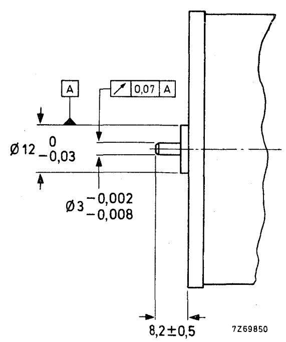

Fig. 1b. Version having a spindle with a diameter of 3 mm *).

Marking and connection

The connecting leads are colour-coded (see Fig. 1) and are connected to the electronic switch or to the integrated circuit as shown in General section of 4-phase unipolar stepper motors.

*) These motors are available on request in minimum order quantities, and involve longer delivery times than standard versions.

		motor	
		9904 112 27001	9904 112 27101
Power consumption of motor only	(W)	6,8	6,8
Maximum working torque	(mNm)	100	110
Holding torque	(mNm)	140	150
Max. pull-in rate	(steps/s)	80 [1]	275 [2]
Max. pull-out rate	(steps/s)	–	275 [2]
Number of phases		4	4
Resistance per coil	(Ω)	39	9,8
Inductance per coil	(mH)	240	60
Current per coil	(mA)	290	580
Permissible ambient temperature range	(^{o}C)	−20 to +70	−20 to +70
Permissible storage temperature range	(^{o}C)	−40 to +100	−40 to +100
Permissible motor temperature	(^{o}C)	120	120
Insulation resistance at 500 V (d.c.)	(MΩ)	> 2	> 2
Step angle		7^{o} 30'	7^{o} 30'
Step-angle tolerance (non-cumulative)		±15'	±15'
Number of steps per revolution		48	48
Direction of rotation		reversible	reversible
Rotor inertia	(gcm^2)	70	70
Bearings, front		ball	ball
rear		slide (bronze)	slide (bronze)
Mass	(g)	610	610
Maximum radial force	(N)	50	50
Maximum axial force	(N)	20	20

[1]) When driven by integrated circuit SAA1027 (see General section, Fig. 3. R_B = 150 Ω).
[2]) When driven by electronic switch 9904 131 03003 with RC network (see General section, Fig. 2. R_V = 10 Ω; C_V = 50 μF; V_b = 12 V d.c.).

Graphs

Motor 9904 112 27001 with integrated circuit SAA 1027.

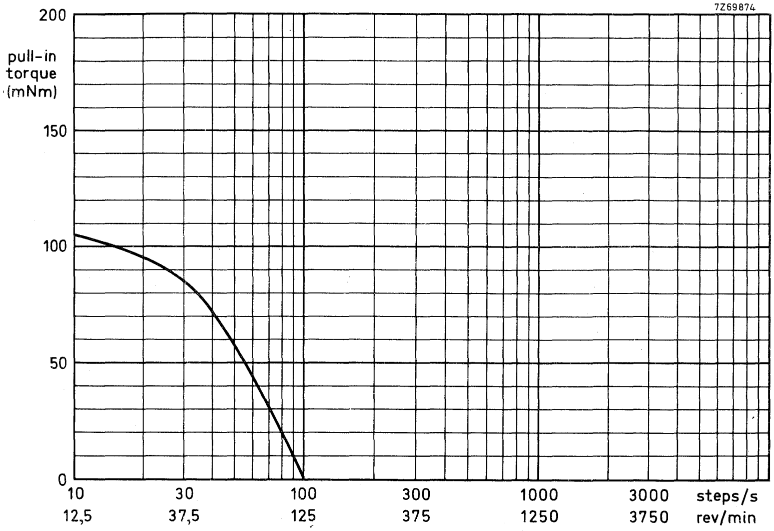

Fig. 2. Pull-in torque versus stepping rate at room temperature.

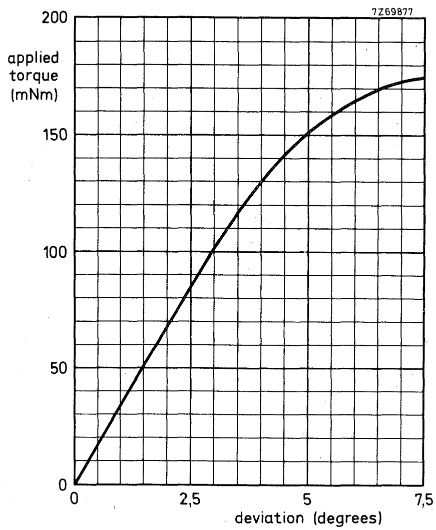

Fig. 3. Applied torque versus stepping rate.

Motor 9904 112 27101 with electronic switch 9904 131 03003.

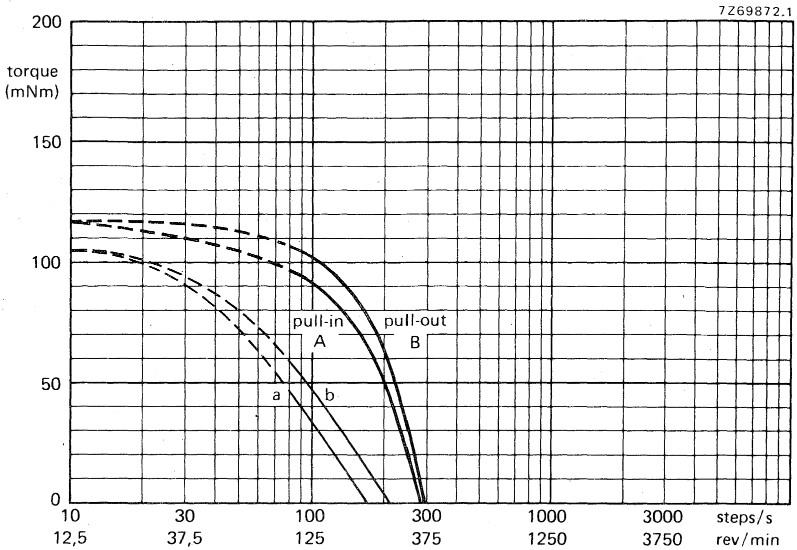

Fig. 4. Torque versus stepping rate, measured at room temperature (thin lines-without RC network, thick lines-with RC network; a and A for pull-in, b and B for pull-out).

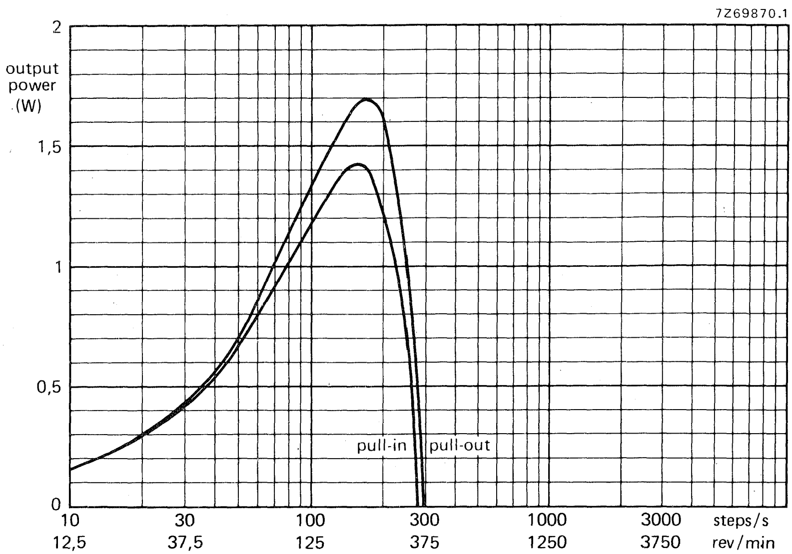

Fig. 5. Output power versus stepping rate measured with RC network at room temperature.

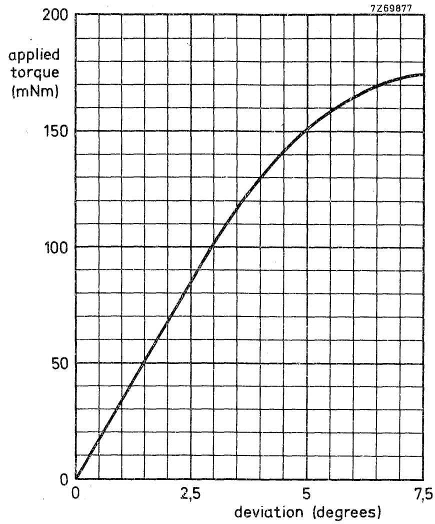

Fig. 6. Applied torque versus deviation.

4-PHASE UNIPOLAR STEPPER MOTORS

QUICK REFERENCE DATA			
motor type	9904 112 28001	9904 112 28101	
performance obtained with	integrated circuit SAA 1027	electronic switch 9904 131 03003	
		without RC network	with RC network
Step angle	15^o	15^o	15^o
Max. working torque	60 mNm	50 mNm	65 mNm
Holding torque	80 mNm	75 mNm	85 mNm
Max. pull-in rate	90 steps/s	140 steps/s	200 steps/s
Max. pull-out rate	–	140 steps/s	250 steps/s

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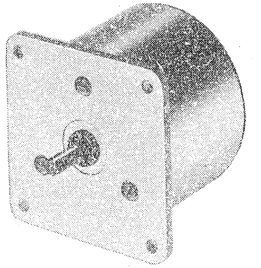

APPLICATION

Motor 9904 112 28001 has coils adapted to the 350 mA per phase output capability of the SAA 1027. This motor and I.C. driver offer an economic and maintenance-free solution for stepwise rotational functions, in a variety of applications and can replace complex and expensive mechanisms.

Motor 9904 112 28101, operated via electronic switch 9904 131 03003 (with or without RC network), will serve the same functions, however the output power capability of the electronic switch allows for higher torque and speed.

The ID28-Series finds its application in chart drives and X-Y plotters and is an ideal component to drive the paper feed mechanism of terminal and telex printers. Industrial control and medical instrumentation range among the possible end use of this stepper motor.

TECHNICAL DATA

Dimensions (mm)

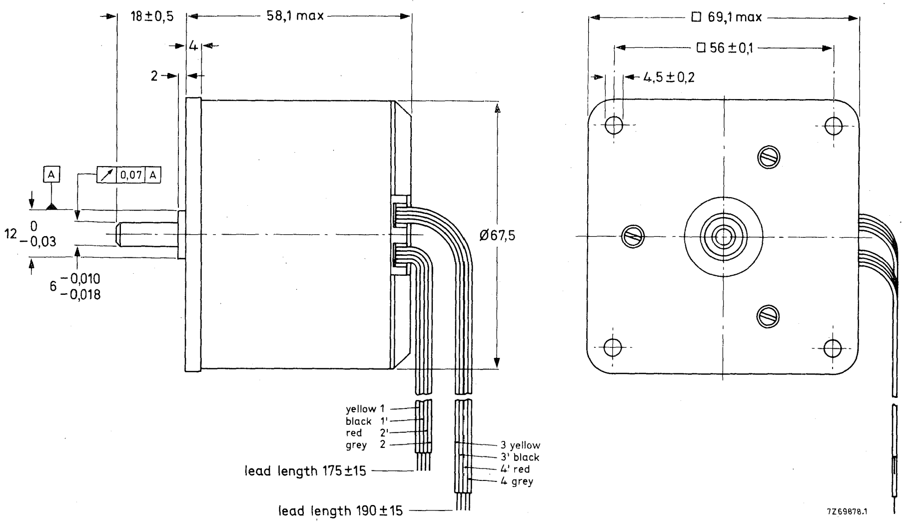

Fig. 1a. Standard version

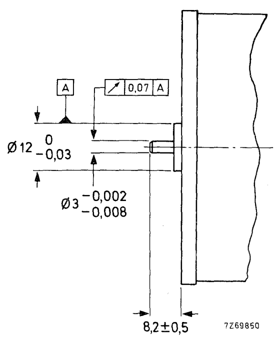

Fig. 1b. Version having a spindle with a diameter of 3 mm *).

Marking and connection

The connecting leads are colour-coded (see Fig. 1) and are connected to the electronic switch or to the integrated circuit as shown in General section of 4-phase unipolar stepper motors.

*) These motors are available on request in minimum order quantities, and involve longer delivery times than standard versions.

		motor	
		9904 112 28001	9904 112 28101
Power consumption of motor only	(W)	6,8	6,8
Maximum working torque	(mNm)	60	65
Holding torque	(mNm)	80	85
Max. pull-in rate	(steps/s)	90 [1]	200 [2]
Max. pull-out rate	(steps/s)	–	250 [2]
Number of phases		4	4
Resistance per coil	(Ω)	39	9,8
Inductance per coil	(mH)	200	45
Current per coil	(mA)	290	580
Permissible ambient temperature range	(°C)	−20 to +70	−20 to +70
Permissible storage temperature range	(°C)	−40 to +100	−40 to +100
Permissible motor temperature	(°C)	120	120
Insulation resistance at 500 V (d.c.)	(MΩ)	> 2	> 2
Step angle		15°	15°
Step-angle tolerance (non-cumulative)		±30'	±30'
Number of steps per revolution		24	24
Direction of rotation		reversible	reversible
Rotor inertia	(gcm^2)	70	70
Bearings, front		ball	ball
rear		slide (bronze)	slide (bronze)
Mass	(g)	610	610
Maximum radial force	(N)	50	50
Maximum axial force	(N)	20	20

[1]) When driven by integrated circuit SAA1027 (see General section, Fig. 3. R_B = 150 Ω).
[2]) When driven by electronic switch 9904 131 03003 with RC network (see General section, Fig. 2. R_V = 10 Ω; C_V = 50 μF; V_b = 12 V d.c.).

Graphs

Motor 9904 112 28001 with integrated circuit SAA 1027.

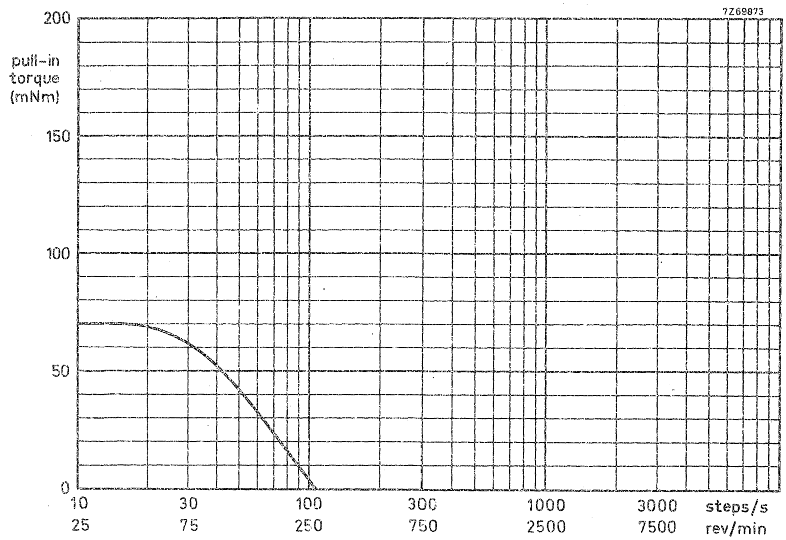

Fig. 2. Pull-in torque versus stepping rate at room temperature.

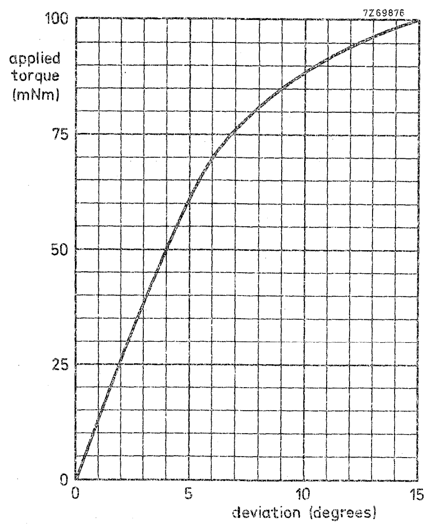

Fig. 3. Applied torque versus stepping rate.

Motor 9904 112 28101 with electronic switch 9904 131 03003.

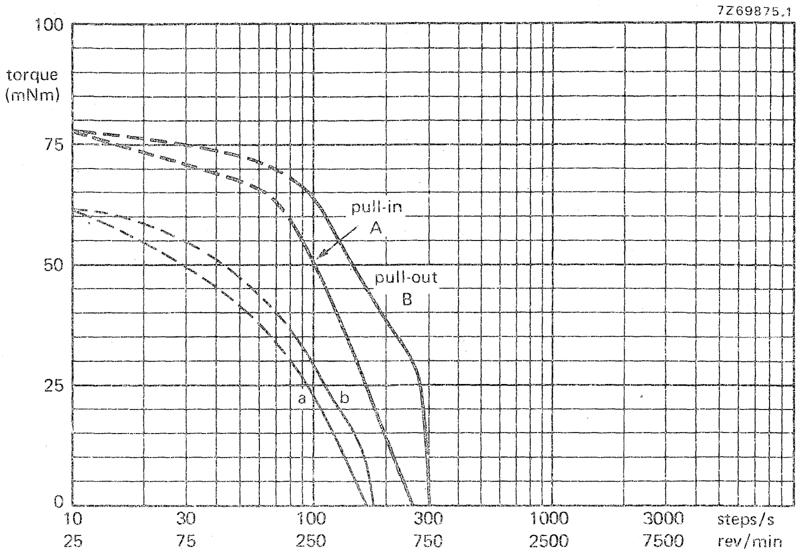

Fig. 4. Torque versus stepping rate, measured at room temperature (thin lines-without RC network, thick lines-with RC network; a and A for pull-in, b and B for pull-out).

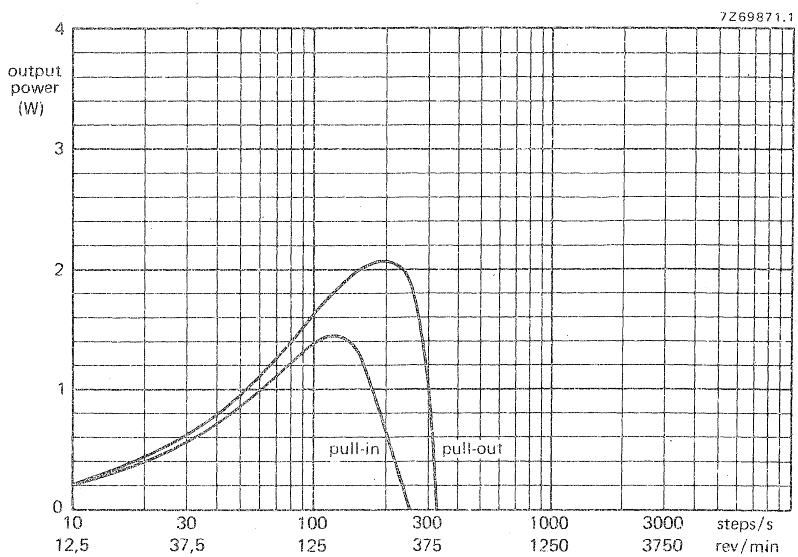

Fig. 5. Output power versus stepping rate measured with RC network at room temperature.

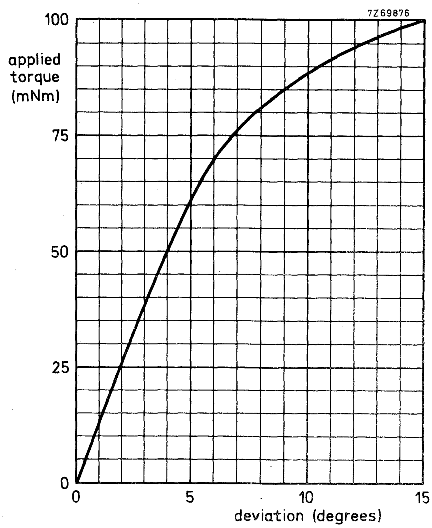

Fig. 6. Applied torque versus stepping rate.

4-PHASE UNIPOLAR STEPPER MOTORS

QUICK REFERENCE DATA			
motor type	9904 112 31001	9904 112 31101	
performance obtained with	integrated circuit SAA1027	electronic switch 9904 131 03003	
		without RC network	with RC network
Step angle	7° 30'	7° 30'	7° 30'
Max. working torque	22 mNm	22 mNm	24 mNm
Holding torque	30 mNm	30 mNm	34 mNm
Max. pull-in rate	180 steps/s	250 steps/s	400 steps/s

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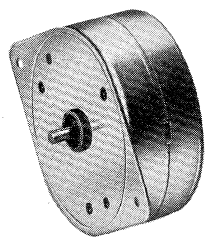

APPLICATION

The ID 31-Series is designed to operate in the pull-in area with optimum torque and speed.

Motor 9904 112 31001 has coils adapted to the 350 mA per phase output capability of the SAA1027.
This motor is intended for applications where the system efficiency factor prevails and circuit complexity is to be kept at a minimum.
Motor 9904 112 31101 operated via electronic switch 9904 131 03003, without RC network, is especially suited for applications which require a higher speed whilst retaining a modest total system power consumption.
Motor 9904 112 31101 operated via electronic switch 9904 131 03003, with RC network, is ideally suited for applications which require maximum torque and speed, such as variable speed drives.

TECHNICAL DATA

Dimensions (mm)

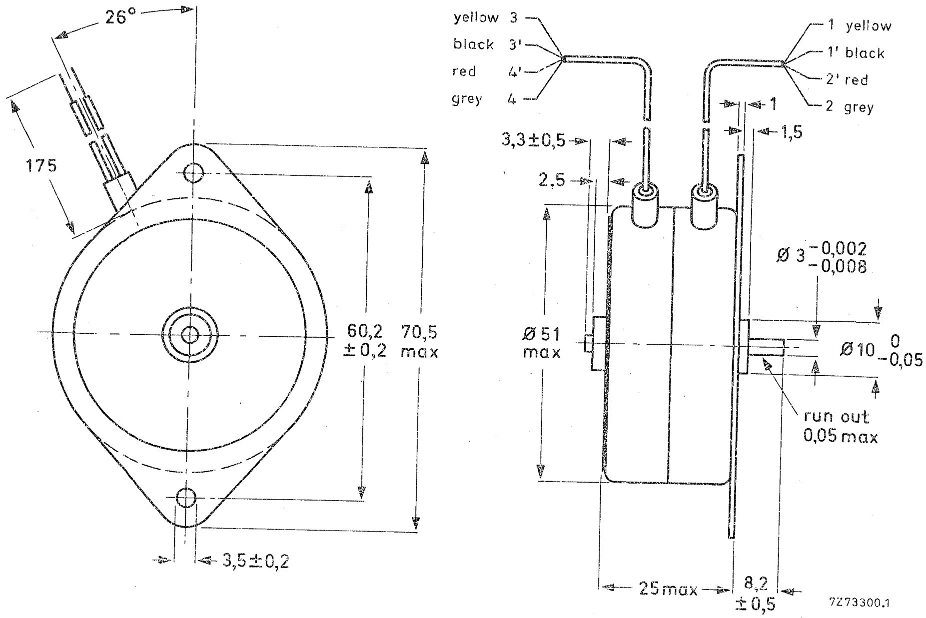

Fig. 1

Marking and connection

The connecting leads are colour-coded (see Fig. 1) and are connected to the electronic switch or to the integrated circuit as shown in General section of 4-phase unipolar stepper motors.

		motor	
		9904 112 31001	9904 112 31101
Power consumption of motor only	(W)	4	4
Maximum working torque	(mNm)	22	24
Holding torque	(mNm)	30	34
Max. pull-in rate	(steps/s)	180 [1]	400 [2]
Max. pull-out rate	(steps/s)	–	400 [2]
Number of phases		4	4
Resistance per coil	(Ω)	62	17
Inductance per coil	(mH)	160	45
Current per coil	(mA)	190	325
Permissible ambient temperature range	(^oC)	−20 to +70	−20 to +70
Permissible storage temperature range	(^oC)	−40 to +100	−40 to +100
Permissible motor temperature	(^oC)	120	120
Insulation resistance at 500 V (d.c.)	(MΩ)	> 2	> 2
Step angle		7^o 30'	7^o 30'
Step-angle tolerance (non-cumulative)		± 20'	± 20'
Number of steps per revolution		48	48
Direction of rotation		reversible	reversible
Rotor inertia	(gcm^2)	11	11
Bearings		slide	slide
Mass	(g)	200	200
Maximum radial force	(N)	5	5
Maximum axial force	(N)	1,5	1,5

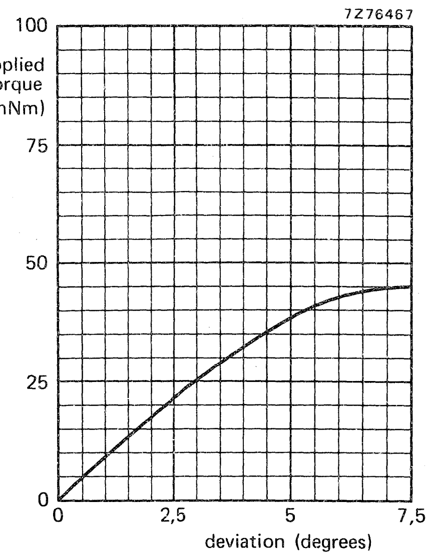

Fig. 2. Applied torque versus deviation.

[1]) When driven by integrated circuit SAA1027 (see General section, Fig. 3. R_B = 180 Ω).
[2]) When driven by electronic switch 9904 131 03003 with RC network (see General section, Fig. 2. R_V = 18 Ω; C_V = 33 μF; V_b = 12 V d.c.).

Motor 9904 112 31001 with integrated circuit SAA1027

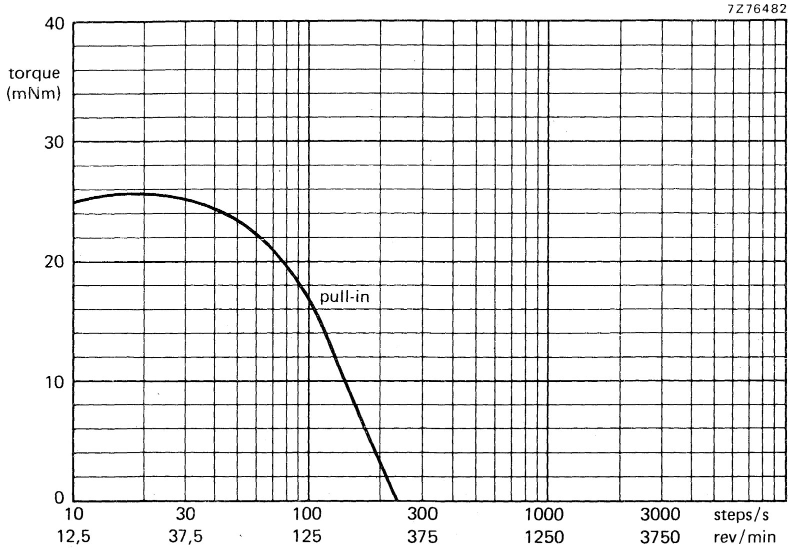

Fig. 3. Torque versus stepping rate, measured at room temperature.

Motor 9904 112 31101 with electronic switch 9904 131 03003

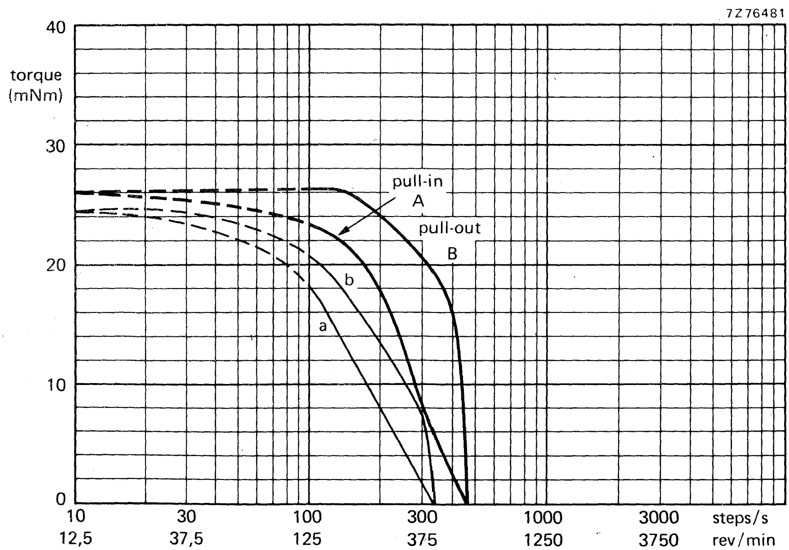

Fig. 4. Torque versus stepping rate, measured at room temperature (thin lines-without RC network, thick lines-with RC network; a and A for pull-in, b and B for pull-out).

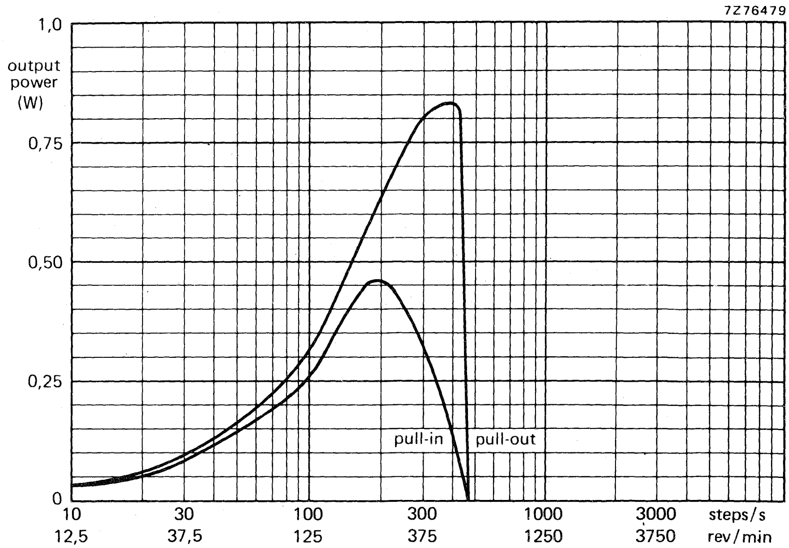

Fig. 5. Output power versus stepping rate, measured at room temperature.

8-PHASE UNIPOLAR STEPPER MOTORS

This range comprises four types of permanent magnet stepper motor:

- 2 industrial digital (ID) types;
- 2 professional digital (PD) types.

The ID types are intended for instrumentation and computer peripherals. The PD types may be used in professional applications and equipment which require a high degree of reliability even under very unfavourable environmental conditions.

DESCRIPTION

The motors have an 8-phase stator and a permanent magnet rotor with 24 poles (step angle of 3° 45') or 12 poles (step angle of 7° 30') in a rugged and simple construction. The motor coils are adapted to the unipolar electronic switch 9904 131 03004 (see relevant data sheet).

CONNECTION DIAGRAMS

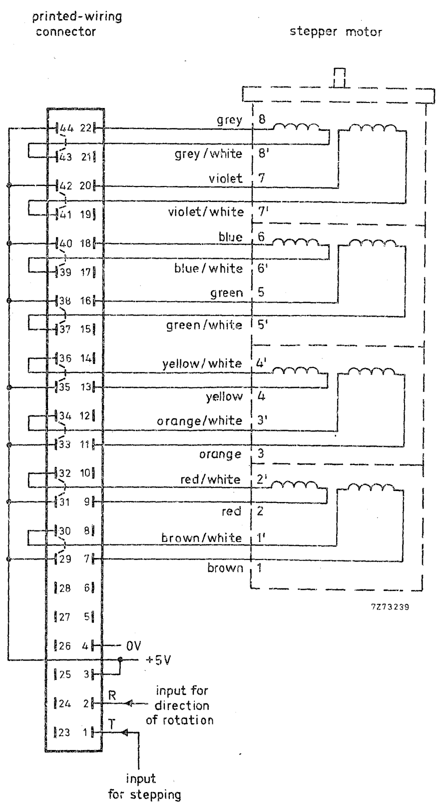

Fig. 1
Diagram for connecting the motor to the electronic switch 9904 131 03004, without compensating network.

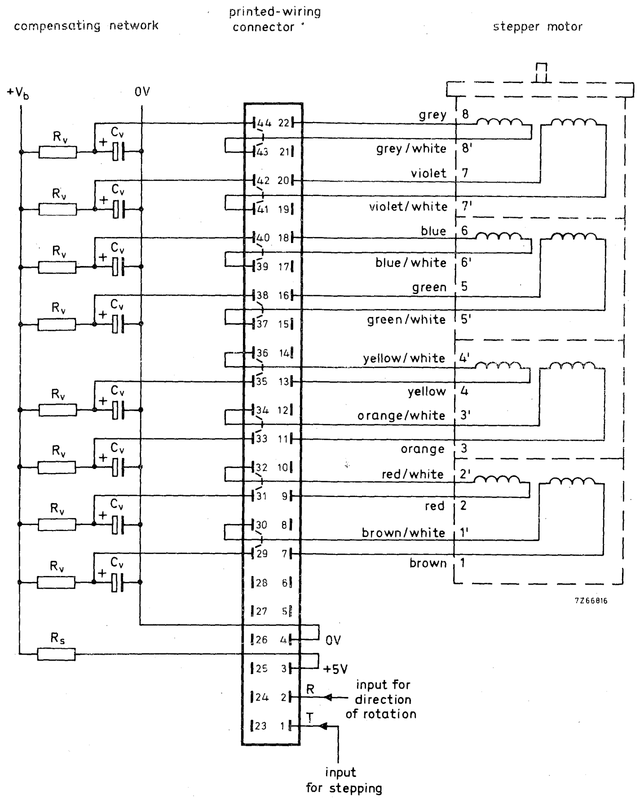

Fig. 2. Diagram for connecting the motor to the electronic switch 9904 131 03004, with compensating network.

8-PHASE UNIPOLAR STEPPER MOTOR

QUICK REFERENCE DATA		
performance obtained with	electronic switch 9904 131 03004	
	without RC network	with RC network
Step angle	3^{o} 45'	3^{o} 45'
Max. working torque	15 mNm	15 mNm
Holding torque	18 mNm	18 mNm
Max. pull-in rate	800 steps/s	1200 steps/s
Max. pull-out rate	1000 steps/s	16000 steps/s

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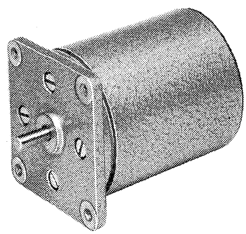

APPLICATION

Motor 9904 112 12001 operated via electronic switch 9904 131 03004, without RC network, is especially suited for applications where the motor is used only in the pull-in range, and system efficiency is of importance.
This combination, with RC network, is ideally suited for variable speed drives where the pull-out capabilities of the motor are required.

TECHNICAL DATA

Dimensions (mm)

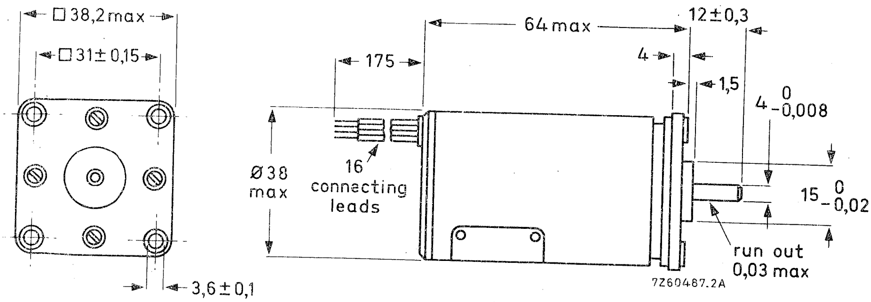

Fig. 1

Marking and connection

The connecting leads are colour-coded and are connected to the electronic switch as shown in General section of 8-phase unipolar stepper motors.

Power consumption of motor only	3,5 W
Maximum working torque	15 mNm
Holding torque	18 mNm
Maximum pull-in rate *)	1200 steps/s
Maximum pull-out rate *)	16000 steps/s
Number of phases	8
Resistance per coil	27 Ω
Inductance per coil	20 mH
Current per coil	175 mA
Permissible ambient temperature range	-30 to +85 °C
Permissible storage temperature range	-62 to +110 °C
Permissible motor temperature	125 °C
Insulation resistance at 500 V d.c.	100 MΩ
Step angle	3° 45'
Step-angle tolerance	±20' non-cumulative
Number of steps per revolution	96
Direction of rotation	reversible
Rotor inertia	7 gcm^2
Bearings	ball
Weight	220 g
Maximum axial play of spindle measured with axial force of 1,5 N	0,07 mm
Maximum radial force	10 N
Maximum axial force	5 N

*) When driven by electronic switch 9904 131 03004 with RC network (see General section, Fig. 1. R_v = 91 Ω ± 5%, 5 W; C_v = 10 μF, 64 V d.c.; V_b = 20 V d.c.; $R_s = (V_b - 5)/0,440$ Ω).

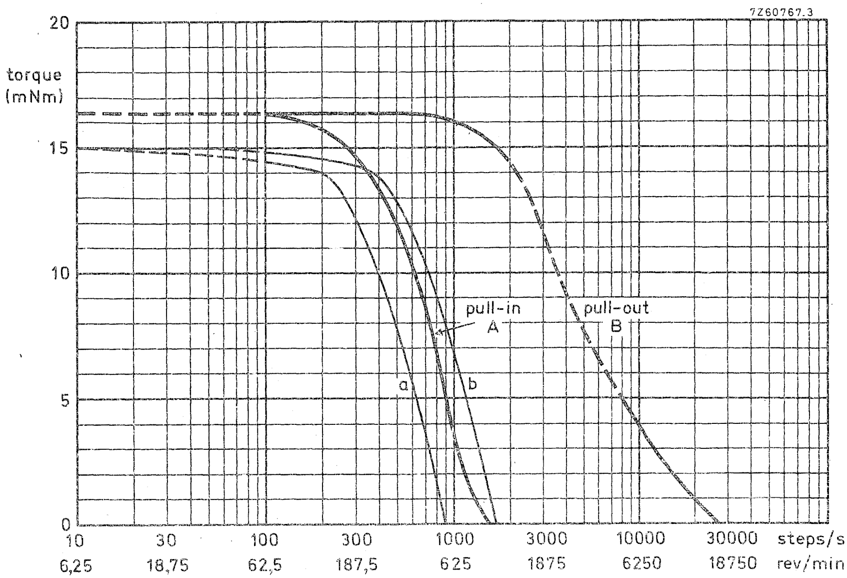

Fig. 2. Torque versus stepping rate, measured at room temperature (thin lines-without RC network, thick lines-with RC network; a and A for pull-in, b and B for pull-out).

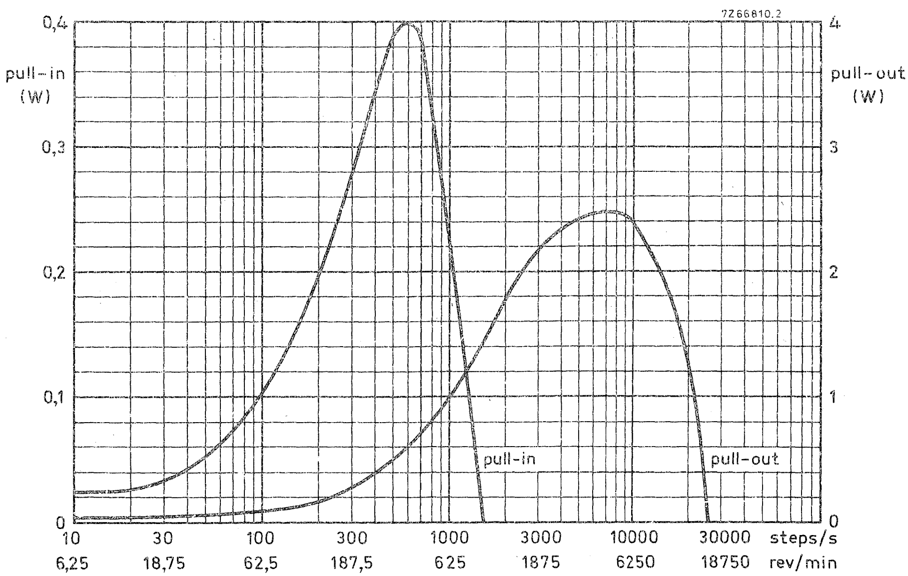

Fig. 3. Output power versus stepping rate, measured with RC network at room temperature.

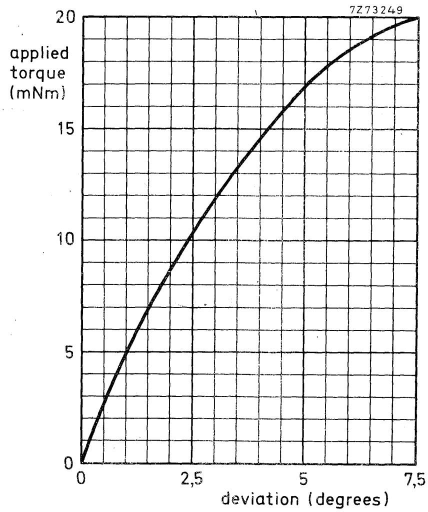

Fig. 4 Applied torque versus deviation.

8-PHASE UNIPOLAR STEPPER MOTOR

QUICK REFERENCE DATA		
performance obtained with	electronic switch 9904 131 03004	
	without RC network	with RC network
Step angle	3° 45'	3° 45'
Max. working torque	40 mNm	40 mNm
Holding torque	50 mNm	50 mNm
Max. pull-in rate	700 steps/s	900 steps/s
Max. pull-out rate	900 steps/s	7500 steps/s

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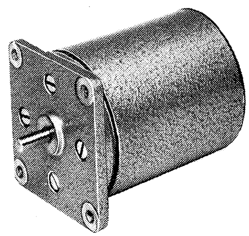

APPLICATION

Motor 9904 112 16001 operated via electronic switch 9904 131 03004, without RC network, is especially suited for applications where the motor is used only in the pull-in range, and system efficiency is of importance.
This combination, with RC network, is ideally suited for variable speed drives where the pull-out capabilities of the motor are required.

TECHNICAL DATA

Dimensions (mm)

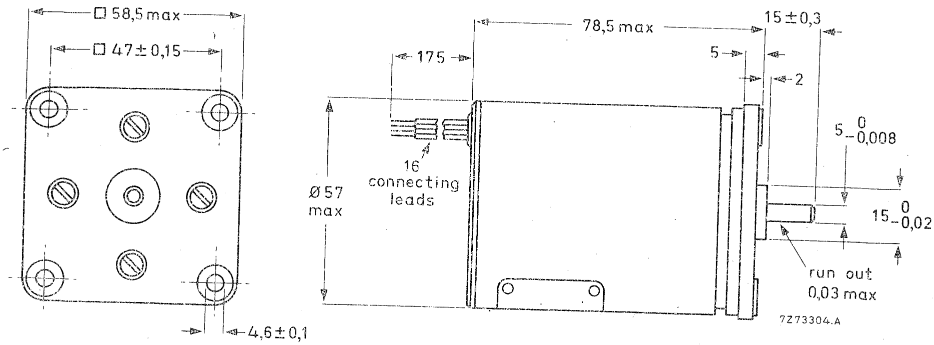

Fig. 1

Marking and connection

The connecting leads are colour-coded and are connected to the electronic switch as shown in General section of 8-phase unipolar stepper motors.

Power consumption of motor only	6,5 W
Maximum working torque	40 mNm
Holding torque	50 mNm
Maximum pull-in rate *)	900 steps/s
Maximum pull-out rate *)	7500 steps/s
Number of phases	8
Resistance per coil	15 Ω
Inductance per coil	25 mH
Current per coil	350 mA
Permissible ambient temperature range	−30 to +85 °C
Permissible storage temperature range	−62 to +110 °C
Permissible motor temperature	125 °C
Insulation resistance at 500 V d.c.	100 MΩ
Step angle	3° 45'
Step-angle tolerance	± 10' non-cumulative
Number of steps per revolution	96
Direction of rotation	reversible
Rotor inertia	32 gcm^2
Bearings	ball
Weight	600 g
Maximum axial play of spindle measured with axial force of 1,5 N	0,07 mm
Maximum radial force	15 N
Maximum axial force	7,5 N

*) When driven by electronic switch 9904 131 03004 with RC network (see General section, Fig. 2. R_V = 50 Ω ± 5%, 8 W; C_V = 25 µF, 40 V d.c.; V_b = 20 V d.c.; $R_s = (V_b - 5)/0,440$ Ω).

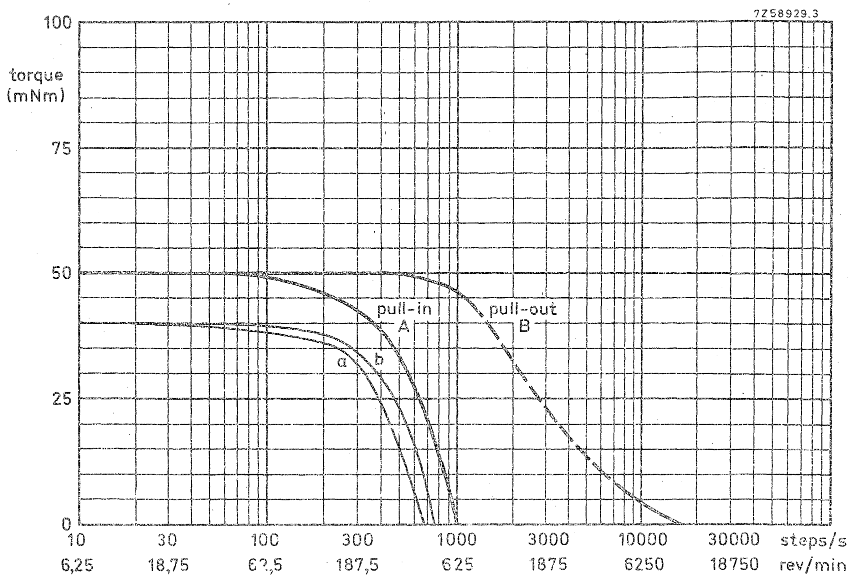

Fig. 2. Torque versus stepping rate, measured at room temperature (thin lines-without RC network, thick lines-with RC network; a and A for pull-in, b and B for pull-out).

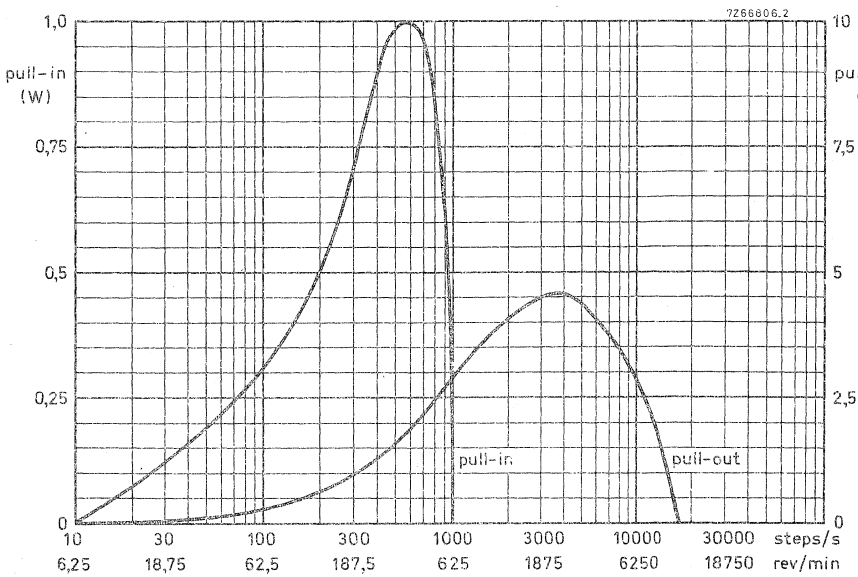

Fig. 3. Output power versus stepping rate, measured with RC network at room temperature.

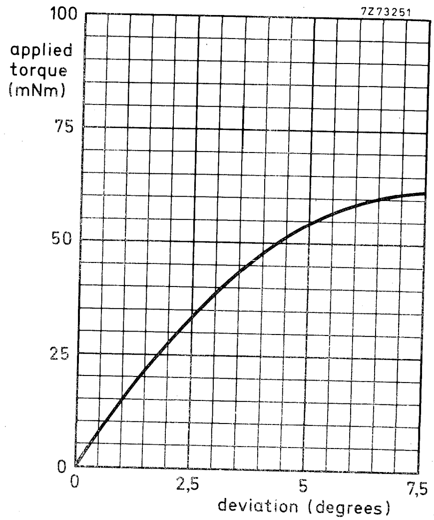

Fig. 4 Applied torque versus deviation.

8-PHASE UNIPOLAR STEPPER MOTOR

QUICK REFERENCE DATA		
performance obtained with	electronic switch 9904 131 03004	
	without RC network	with RC network
Step angle	3° 45'	3° 45'
Max. working torque	180 mNm	250 mNm
Holding torque	200 mNm	270 mNm
Max. pull-in rate	280 steps/s	700 steps/s
Max. pull-out rate	–	6500 steps/s

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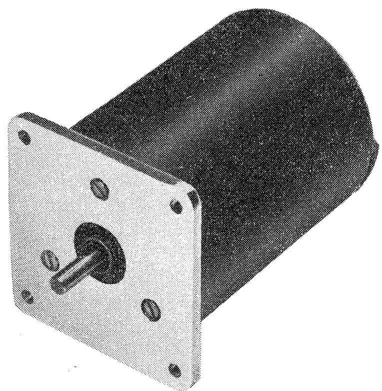


APPLICATION

Motor 9904 112 29101 has coils adapted to the 600 mA per phase output capability of electronic switch 9904 131 03004.
The motor, operated via this switch without RC network, is especially suited for applications where it is used only in the pull-in range and system efficiency is of importance. With an additional RC network, use can be made of the motors pull-out characteristics which are ideal for variable speed drives. The high speed and torque capabilities of this motor make it suitable for applications which require large speed variations and a high degree of positional accuracy.
It is a valuable component for digital servo systems and can often advantageously be used instead of d.c. servo motors as it has the required characteristics and, because of the absence of brushes and commutator, a long operational life.

TECHNICAL DATA

Dimensions (mm)

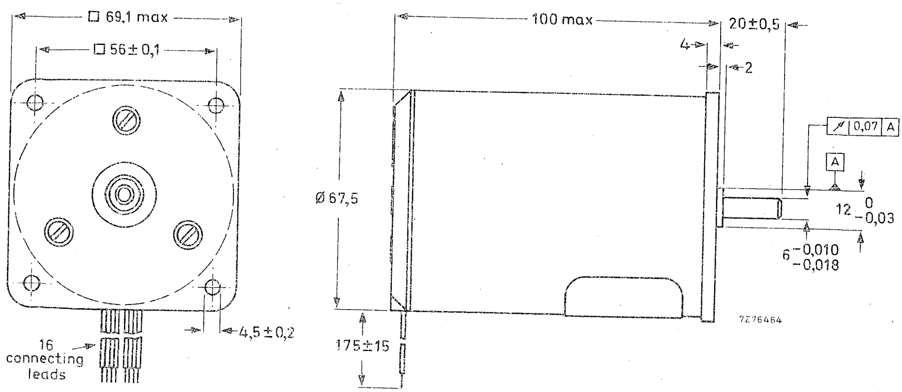


Fig. 1

Marking and connection

The connecting leads are colour-coded and are connected to the electronic switch as shown in General section of 8-phase unipolar stepper motors.

Power consumption of motor only	11 W
Maximum working torque	250 mNm
Holding torque	270 mNm
Maximum pull-in rate *)	700 steps/s
Maximum pull-out rate *)	6500 steps/s
Number of phases	8
Resistance per coil	10 Ω
Inductance per coil	60 mH
Current per coil	530 mA
Permissible ambient temperature range	-20 to +70 °C
Permissible storage temperature range	-40 to +100 °C
Permissible motor temperature	120 °C
Insulation resistance at 500 V d.c.	> 2 MΩ
Step angle	3° 45'
Step-angle tolerance	±15'
Number of steps per revolution	96
Direction of rotation	reversible
Rotor inertia	160
Bearings, front	ball
rear	slide
Mass	1100 g
Maximum axial play of spindle measured with axial force of 1,5 N	0,3 mm
Maximum radial force	50 N
Maximum axial force	20 N

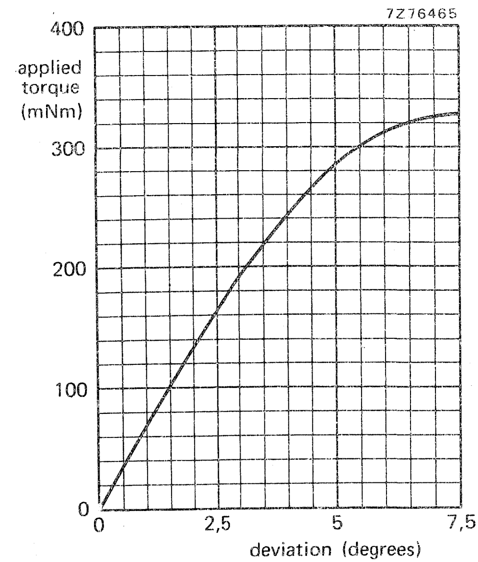


Fig. 2. Applied torque versus deviation.

*) When driven by electronic switch 9904 131 03004 with RC network (see General section, Fig. 2. R_V = 33 Ω ± 5%; C_V = 50 μF, 64 V d.c.; V_b = 24 V d.c.).

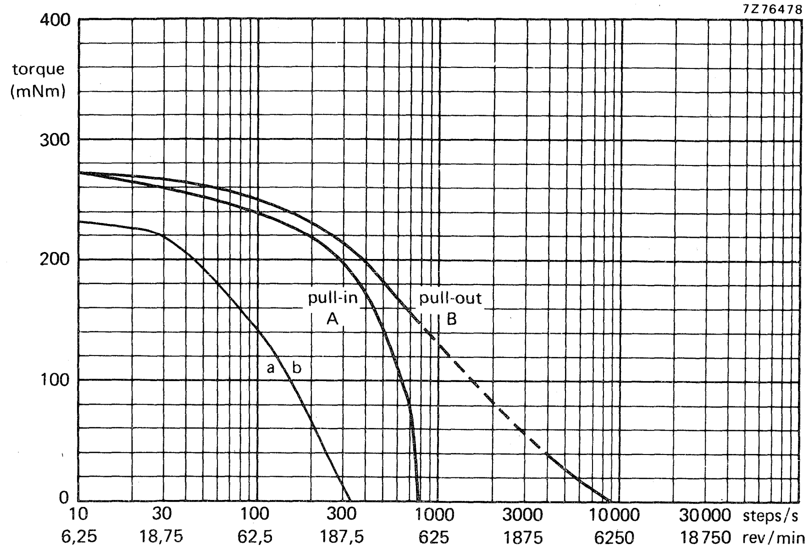


Fig. 3. Torque versus stepping rate, measured at room temperature (thin line-without RC network, thick lines-with RC network; a and A for pull-in, b and B for pull-out).

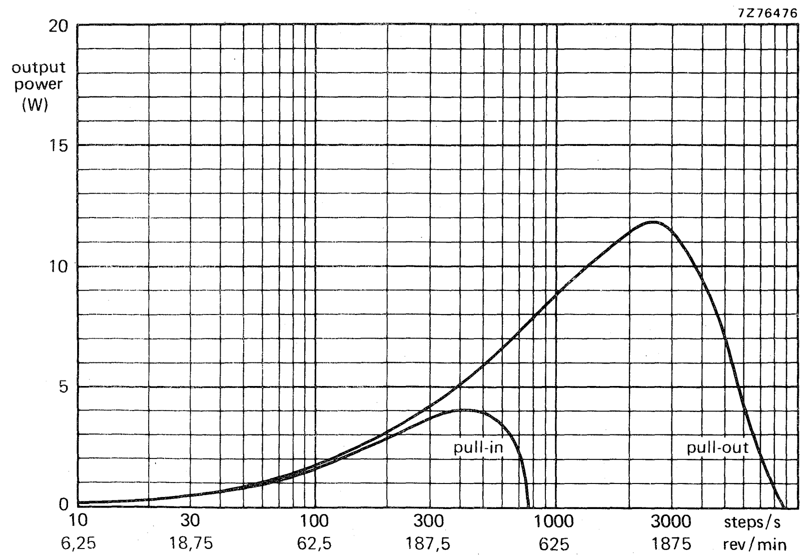
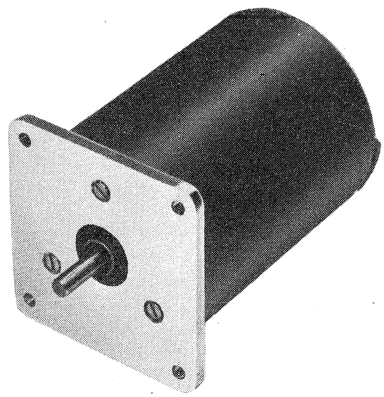


Fig. 4. Output power versus stepping rate, measured with RC network at room temperature.

8-PHASE UNIPOLAR STEPPER MOTOR

QUICK REFERENCE DATA		
performance obtained with	electronic switch 9904 131 03004	
	without RC network	with RC network
Step angle	$7^{\circ} 30'$	$7^{\circ} 30'$
Max. working torque	140 mNm	165 mNm
Holding torque	150 mNm	180 mNm
Max. pull-in rate	270 steps/s	500 steps/s
Max. pull-out rate	300 steps/s	3500 steps/s

770104-14-01



APPLICATION

Motor 9904 112 30101 has coils adapted to the 600 mA per phase output capability of electronic switch 9904 131 03004.
The motor, operated via this switch without RC network, is especially suited for applications where it is used only in the pull-in range and system efficiency is of importance. With an additional RC network, use can be made of the motors pull-out characteristics which are ideal for variable speed drives. The high speed and torque capabilities of this motor make it suitable for applications which require large speed variations and a high degree of positional accuracy.
It is a valuable component for digital servo systems and can often advantageously be used instead of d.c. servo motors as it has the required characteristics and, because of the absence of brushes and commutator, a long operational life.

TECHNICAL DATA

Dimensions (mm)

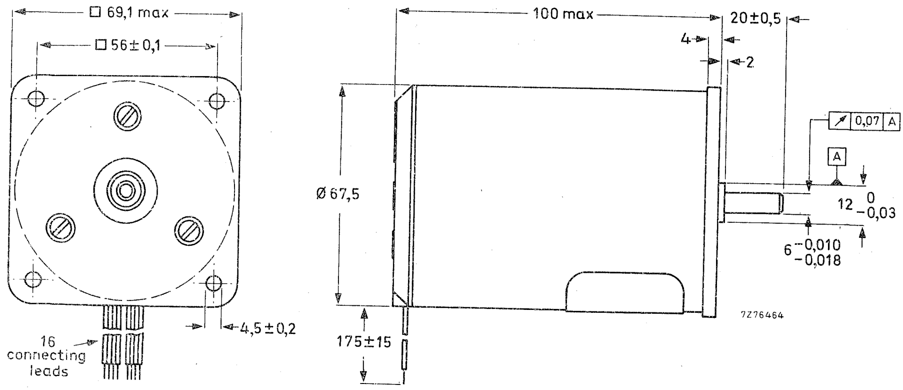


Fig. 1

Marking and connection

The connecting leads are colour-coded and are connected to the electronic switch as shown in General section of 8-phase unipolar stepper motors.

Power consumption of motor only	11 W
Maximum working torque	165 mNm
Holding torque	180 mNm
Maximum pull-in rate *)	500 steps/s
Maximum pull-out rate *)	3500 steps/s
Number of phases	8
Resistance per coil	10 Ω
Inductance per coil	45 mH
Current per coil	530 mA
Permissible ambient temperature range	−20 to +70 °C
Permissible storage temperature range	−40 to +100 °C
Permissible motor temperature	120 °C
Insulation resistance at 500 V d.c.	> 2 MΩ
Step angle	7° 30'
Step-angle tolerance	± 30'
Number of steps per revolution	48
Direction of rotation	reversible
Rotor inertia	160 gcm^2
Bearings, front	ball
rear	slide
Mass	1100 g
Maximum axial play of spindle measured with axial force of 1,5 N	0,3 mm
Maximum radial force	50 N
Maximum axial force	20 N

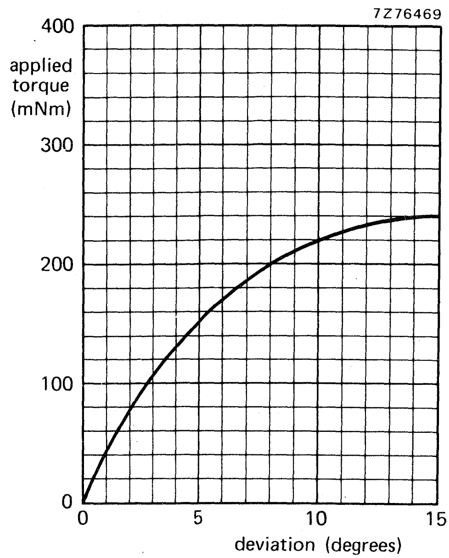


Fig. 2. Applied torque versus deviation.

*) When driven by electronic switch 9904 131 03004 with RC network (see General section, Fig. 2. R_V = 33 Ω ± 5%; C_V = 50 μF, 64 V d.c.; V_b = 24 V d.c.).

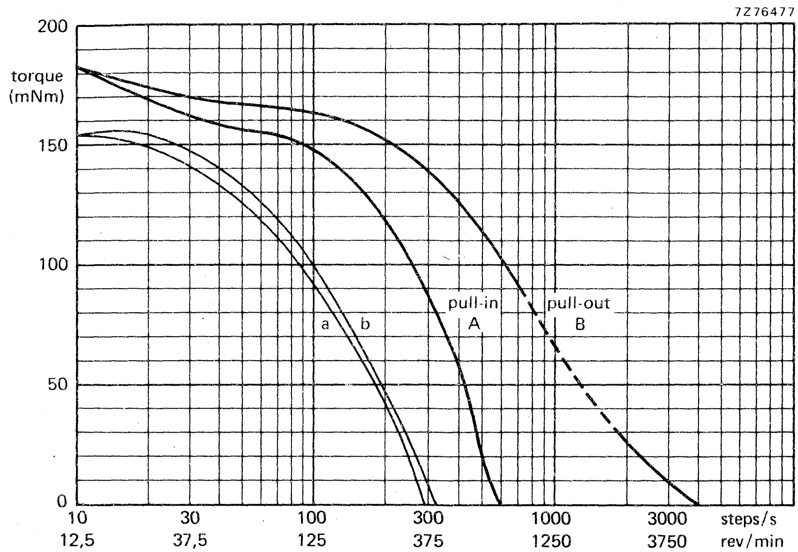


Fig. 3. Torque versus stepping rate, measured at room temperature (thin lines-without RC network, thick lines-with RC network; a and A for pull-in, b and B for pull-out).

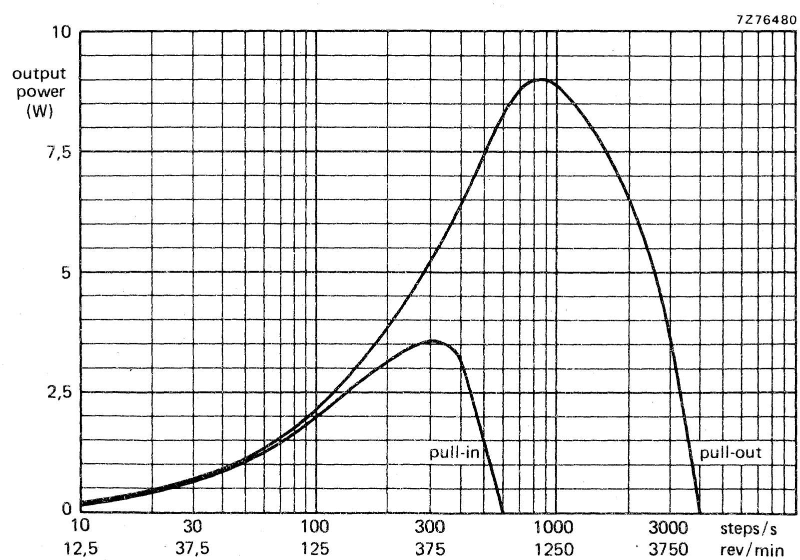


Fig. 4. Output power versus stepping rate, measured with RC network at room temperature.

2-PHASE BIPOLAR STEPPER MOTORS

This range comprises four types of permanent magnet stepper motor:

- 2 industrial digital (ID) types;
- 2 professional digital (PD) types.

They are ideally suited for incremental motion control in telecommunication equipment and computer peripherals. The ID types 9904 112 27201 and 9904 112 28201 represent alternatives for the unipolar types 9904 112 27101 and 9904 112 28101 respectively, if short periods of extremely high speed in the slew range are required.

DESCRIPTION

The motors have a 2-phase stator and a permanent magnet rotor with 24 poles (step angle of 7^{o} 30') or 12 poles (step angle of 15^{o}) in a rugged and simple construction. They are derived from the 4-phase unipolar motors, so that their design is similar. The motor coils are adapted to the bipolar constant current drive (BCCD) 4322 027 90070 (see relevant data sheet). Driven via the BCCD unit the stepper motors are able to achieve extremely high stepping rates in the slew range. However, it should be noted that the motors are NOT designed for continuous operation at these high stepping rates since the iron losses within the motor result in an unacceptable temperature rise.

CONNECTION DIAGRAM

See next page.

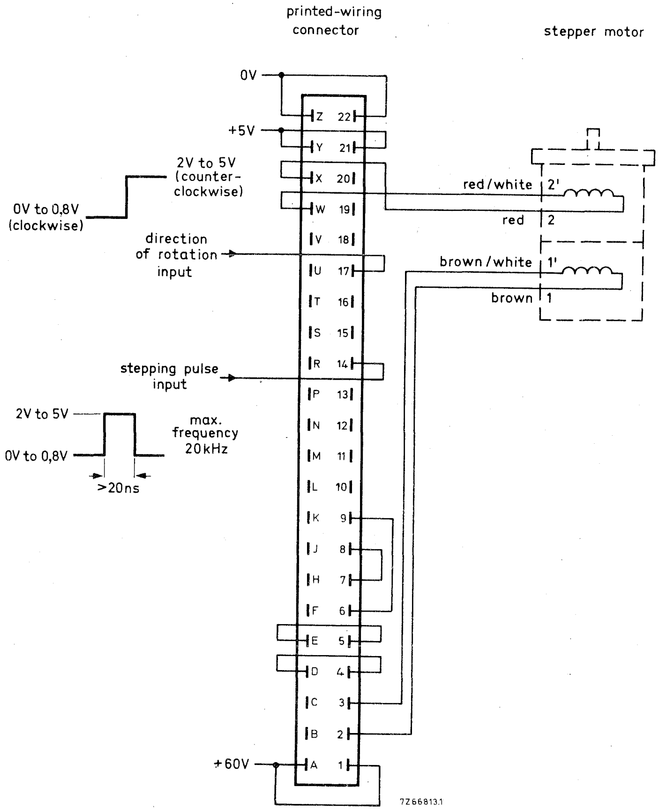


Diagram for connecting the motor to the bipolar constant current drive 4322 027 90070 via a printed-wiring connector.

2-PHASE BIPOLAR STEPPER MOTOR

QUICK REFERENCE DATA	
performance obtained with bipolar constant current drive 4322 027 90070	
Step angle	7° 30'
Maximum working torque	13 mNm
Holding torque	16 mNm
Maximum pull-in rate	750 steps/s
Maximum pull-out rate	15000 steps/s

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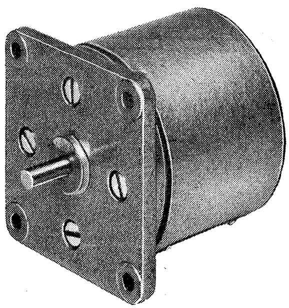

TECHNICAL DATA

Dimensions (mm)

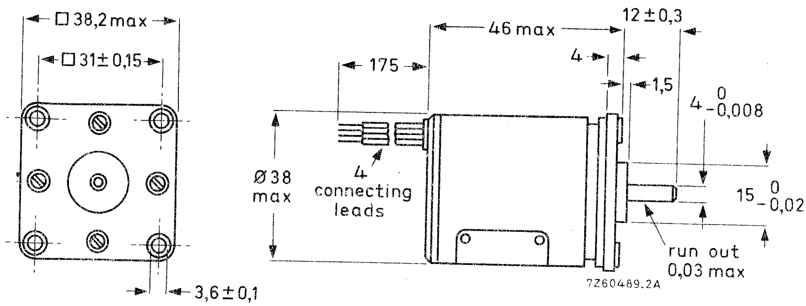

Fig. 1

Marking and connection

The connecting leads are colour-coded and are connected to the bipolar constant current drive as shown in General section of 2-phase bipolar stepper motors.

Power consumption of motor only	3,25 W
Maximum working torque	13 mNm
Holding torque	16 mNm
Maximum pull-in rate *)	750 steps/s
Maximum pull-out rate *)	15000 steps/s
Number of phases	2
Resistance per coil	6,5 Ω
Inductance per coil	10 mH
Current per coil	500 mA
Permissible ambient temperature range	see General section of Stepper motors
Permissible storage temperature range	-62 to + 110 °C
Permissible motor temperature	125 °C
Insulation resistance at 500 V d.c.	100 MΩ
Step angle	7° 30'
Step-angle tolerance	±20' non-cumulative
Number of steps per revolution	48
Direction of rotation	reversible
Rotor inertia	3,5 gcm^2
Bearings	ball
Weight	140 g
Maximum axial play (axial force 1,5 N)	0,07 mm
Maximum radial force	10 N
Maximum axial force	5 N

*) When driven by BCCD unit 4322 027 90070.

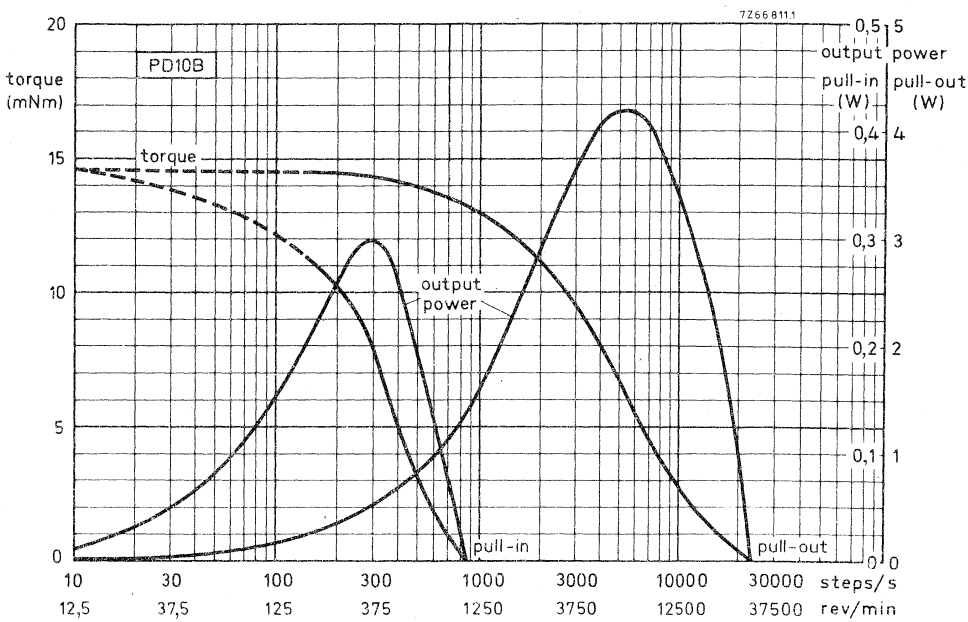

Fig. 2 Torque (left scale) and relevant output power (right scale) versus stepping rate, measured at room temperature.

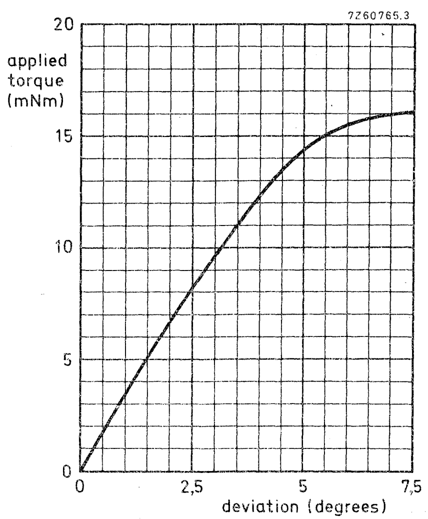

Fig. 3 Applied torque versus deviation.

2-PHASE BIPOLAR STEPPER MOTOR

QUICK REFERENCE DATA	
performance obtained with bipolar constant current drive 4322 027 90070	
Step angle	7^{o} 30'
Maximum working torque	30 mNm
Holding torque	40 mNm
Maximum pull-in rate	580 steps/s
Maximum pull-out rate	12000 steps/s

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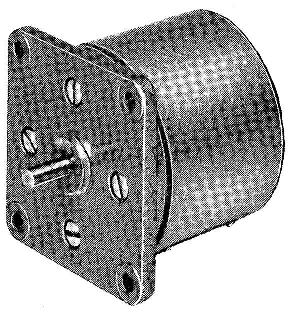

TECHNICAL DATA

Dimensions (mm)

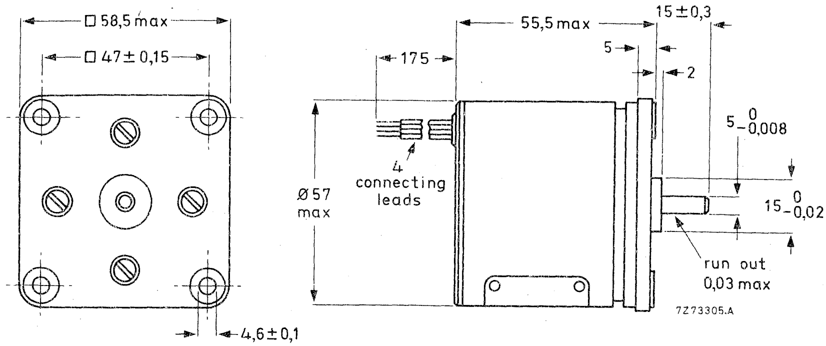

Fig. 1

Marking and connection
The connecting leads are colour-coded and are connected to the bipolar constant current drive as shown in General section of 2-phase bipolar stepper motors.

Power consumption of motor only	4 W
Maximum working torque	30 mNm
Holding torque	40 mNm
Maximum pull-in rate *)	580 steps/s
Maximum pull-out rate *)	12000 steps/s
Number of phases	2
Resistance per coil	8 Ω
Inductance per coil	25 mH
Current per coil	500 mA
Permissible ambient temperature range	see General section of Stepper motors
Permissible storage temperature range	−62 to + 110 °C
Permissible motor temperature	125 °C
Insulation resistance at 500 V d.c.	100 MΩ
Step angle	7° 30'
Step-angle tolerance	± 10' non-cumulative
Number of steps per revolution	48
Direction of rotation	reversible
Rotor inertia	18 gcm^2
Bearings	ball
Weight	500 g
Maximum axial play (axial force 5 N)	0,07 mm
Maximum radial force	15 N
Maximum axial force	7,5 N

*) When driven by BCCD unit 4322 027 90070.

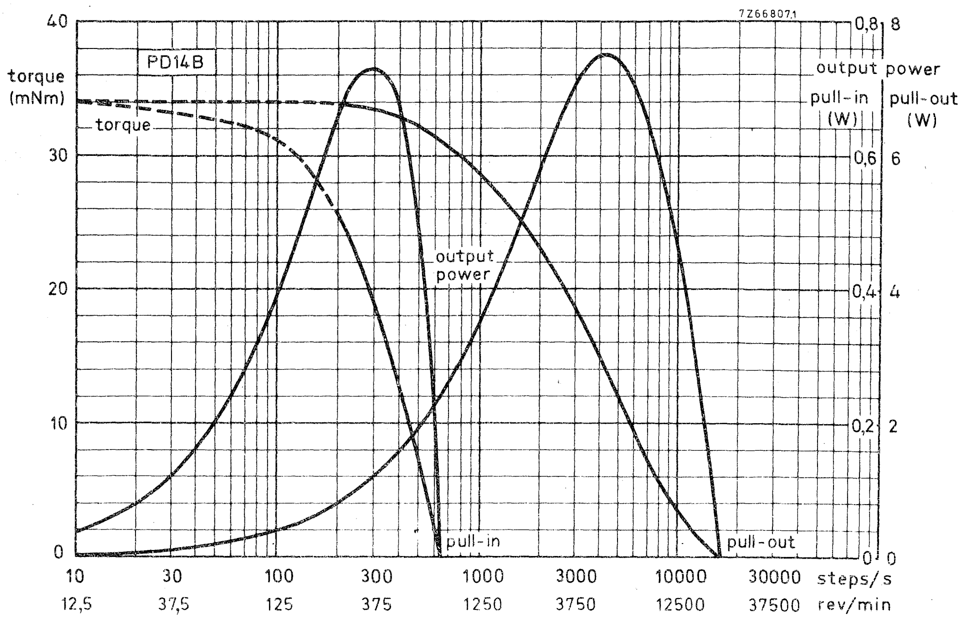

Fig. 2 Torque (left scale) and relevant output power (right scale) versus stepping rate, measured at room temperature.

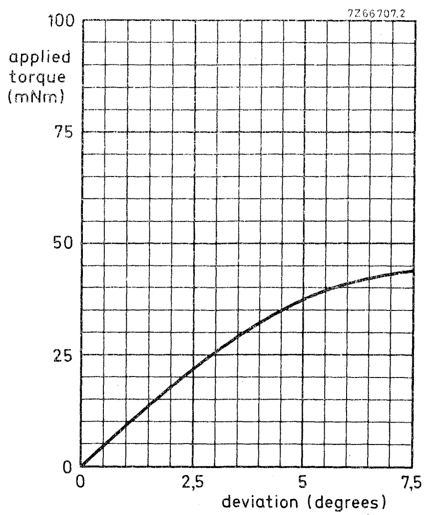

Fig. 3 Applied torque versus deviation.

2-PHASE BIPOLAR STEPPER MOTOR

QUICK REFERENCE DATA	
performance obtained with bipolar constant current drive 4322 027 90070	
Step angle	7° 30'
Maximum working torque	130 mNm
Holding torque	170 mNm
Maximum pull-in rate	450 steps/s
Maximum pull-out rate	5000 steps/s

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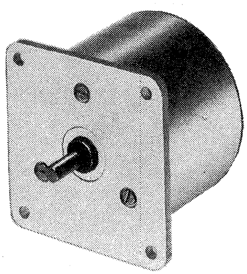

TECHNICAL DATA

Dimensions (mm)

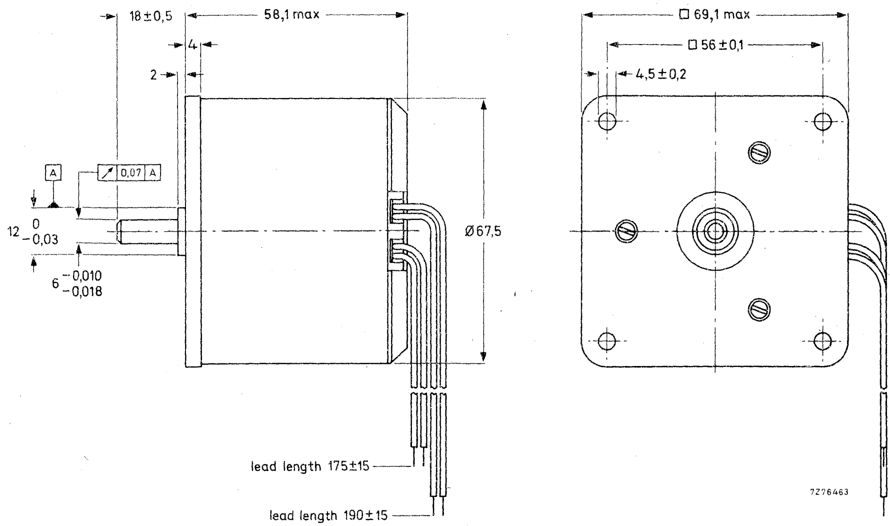

Fig. 1a. Standard version.

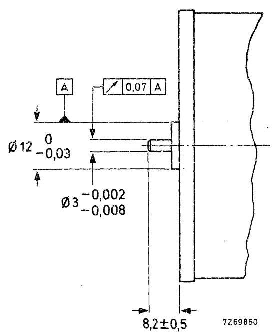

Fig. 1b. Version having a spindle with a diameter of 3 mm *).

Marking and connection

The connecting leads are colour-coded and are connected to the bipolar constant current drive as shown in General section of 2-phase bipolar stepper motors.

*) These motors are available on request in minimum order quantities, and involve longer delivery times than standard versions.

Power consumption of motor only	3,75 W
Maximum working torque	130 mNm
Holding torque	170 mNm
Maximum pull-in rate *)	450 steps/s
Maximum pull-out rate *)	5000 steps/s
Number of phases	2
Resistance per coil	7,5 Ω
Inductance per coil	90 mH
Current per coil	500 mA
Permissible ambient temperature range	see General section of Stepper motors
Permissible storage temperature range	-40 to +100 °C
Permissible motor temperature	120 °C
Insulation resistance at 500 V d.c.	> 2 MΩ
Step angle	7° 30'
Step-angle tolerance	±15' non-cumulative
Number of steps per revolution	48
Direction of rotation	reversible
Rotor inertia	70 gcm^2
Bearings, front	ball
rear	slide
Mass	610 g
Maximum axial play (axial force 5 N)	0,3 mm
Maximum radial force	50 N
Maximum axial force	20 N

*) When driven by BCCD unit 4322 027 90070.

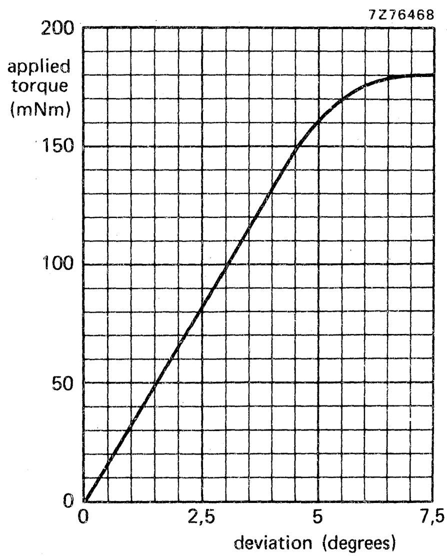

Fig. 2. Applied torque versus deviation.

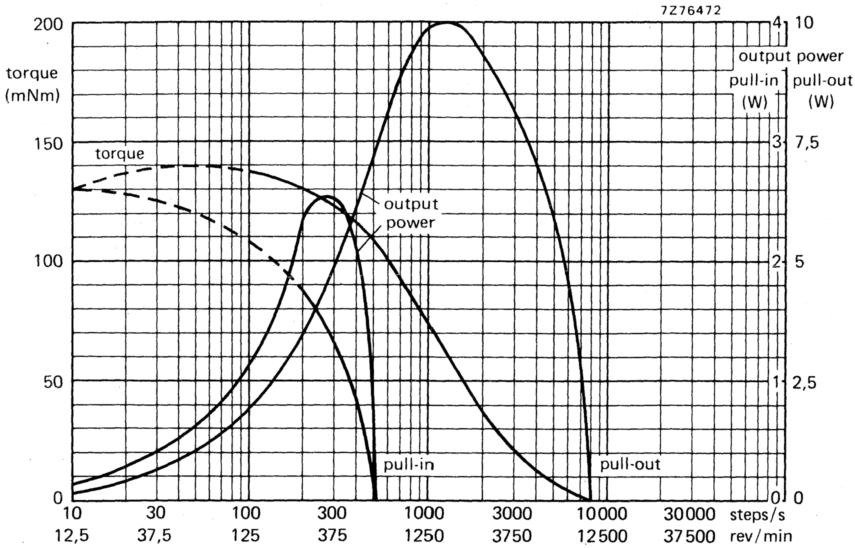

Fig. 3. Torque (left scale) and relevant output power (right scale) versus stepping rate, measured at room temperature.

2-PHASE BIPOLAR STEPPER MOTOR

QUICK REFERENCE DATA	
performance obtained with bipolar constant current drive 4322 027 90070	
Step angle	15°
Maximum working torque	90 mNm
Holding torque	110 mNm
Maximum pull-in rate	275 steps/s
Maximum pull-out rate	3200 steps/s

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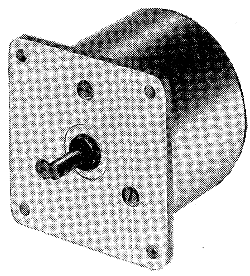

TECHNICAL DATA

Dimensions (mm)

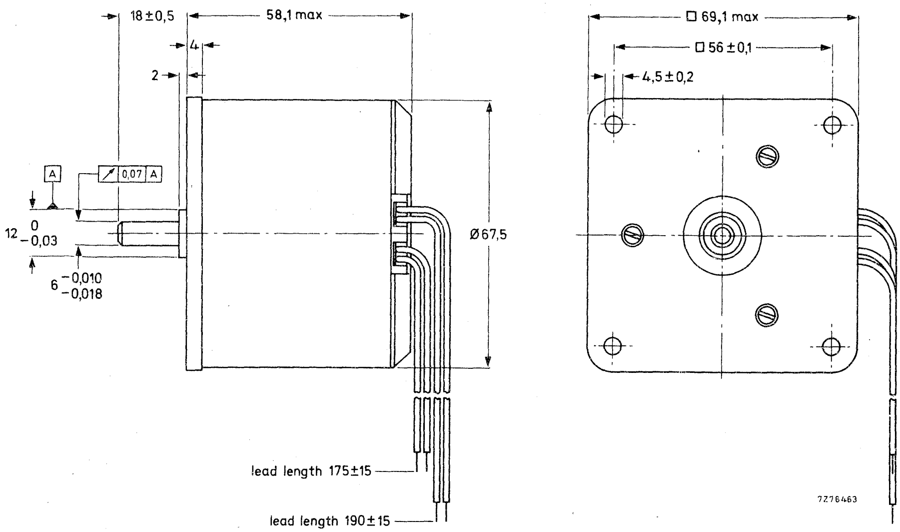

Fig. 1a. Standard version.

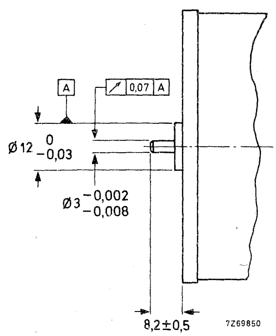

Fig. 1b. Version having a spindle with a diameter of 3 mm *).

Marking and connection

The connecting leads are colour-coded and are connected to the bipolar constant current drive as shown in General section of 2-phase bipolar stepper motors.

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*) These motors are available on request in minumum order quantities, and involve longer delivery times than standard versions.

Power consumption of motor only	3,75 W
Maximum working torque	90 mNm
Holding torque	110 mNm
Maximum pull-in rate *)	275 steps/s
Maximum pull-out rate *)	3200 steps/s
Number of phases	2
Resistance per coil	7,5 Ω
Inductance per coil	70 mH
Current per coil	500 mA
Permissible ambient temperature range	see General section of Stepper motors
Permissible storage temperature range	−40 to +100 °C
Permissible motor temperature	120 °C
Insulation resistance at 500 V d.c.	> 2 MΩ
Step angle	15°
Step-angle tolerance	± 30' non-cumulative
Number of steps per revolution	24
Direction of rotation	reversible
Rotor inertia	70 gcm^2
Bearings, front	ball
rear	slide
Mass	610 g
Maximum axial play (axial force 5 N)	0,3 mm
Maximum radial force	50 N
Maximum axial force	20 N

*) When driven by BCCD unit 4322 027 90070.

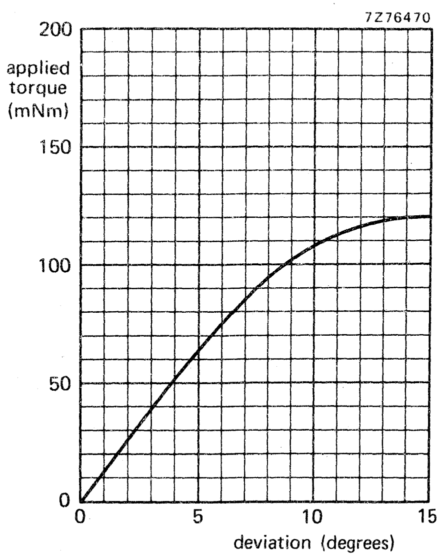

Fig. 2. Applied torque versus deviation.

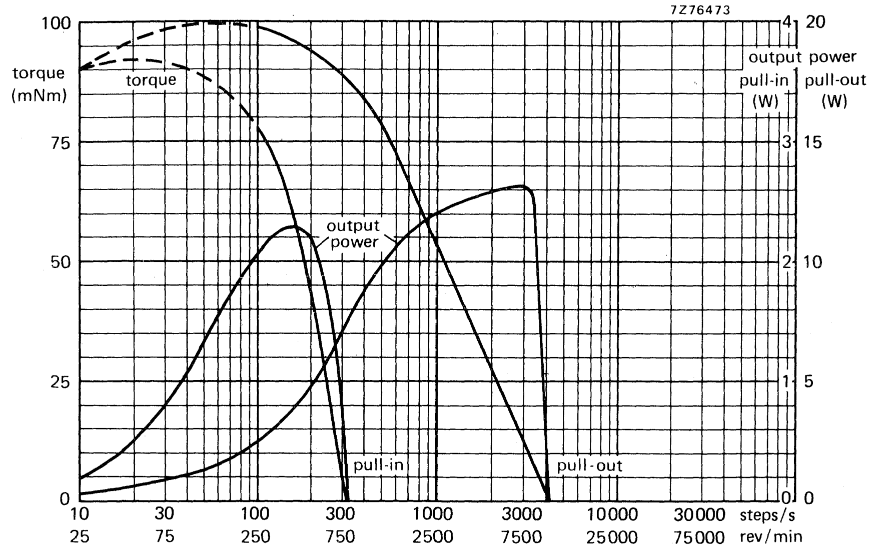

Fig. 3. Torque (left scale) and relevant output power (right scale) versus stepping rate, measured at room temperature.

4-PHASE BIPOLAR STEPPER MOTORS

This range comprises four types of permanent magnet stepper motor:

- 2 industrial digital (ID) types;
- 2 professional digital (PD) types.

The high torque, high speed and small step angle make these motors very suitable for accurate and fast positioning functions in telecommunication equipment and computer peripherals. The ID types 9904 112 29201 and 9904 112 30201 represent alternatives for the unipolar types 9904 112 29101 and 9904 112 30101 respectively, if short periods of extremely high speed in the slew range are required.

DESCRIPTION

The motors have a 4-phase stator and a permanent magnet rotor with 24 poles (step angle of 3^{o} 45') or 12 poles (step angle of 7^{o} 30') in a rugged and simple construction. They are derived from the 8-phase unipolar motors, so that their design is similar. The motor coils are adapted to the bipolar constant current drive (BCCD) 4322 027 90070 (see relevant data sheet). Two BCCD units are required to operate one of the 4-phase bipolar motors.
Driven via the BCCD unit the stepper motors are able to achieve extremely high stepping rates in the slew range. However, it should be noted that the motors are NOT designed for continuous operation at these high stepping rates since the iron losses inside the motor result in an unacceptable temperature rise.

CONNECTION DIAGRAM

See next page.

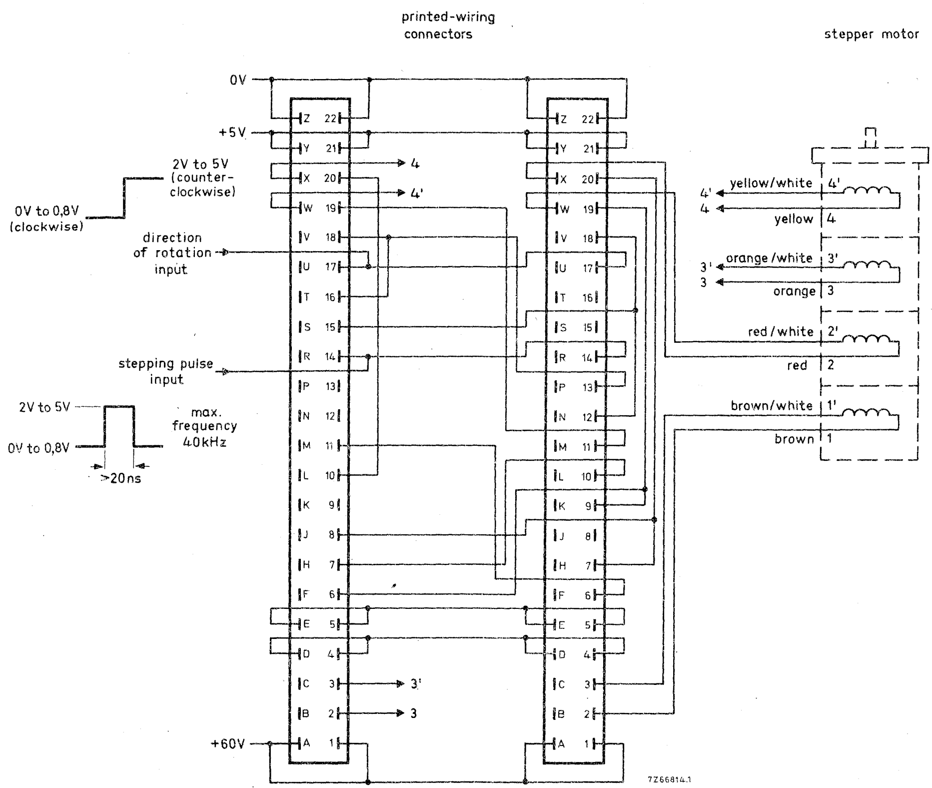

Diagram for connecting the motor to the two bipolar constant current drives 4322 027 90070 via printed-wiring connectors.

4-PHASE BIPOLAR STEPPER MOTOR

QUICK REFERENCE DATA	
performance obtained with bipolar constant current drives 4322 027 90070	
Step angle	3° 45'
Maximum working torque	25 mNm
Holding torque	27 mNm
Maximum pull-in rate	1500 steps/s
Maximum pull-out rate	2500 steps/s

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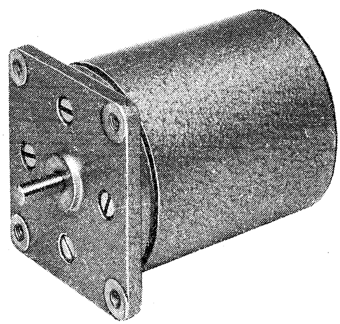

TECHNICAL DATA

Dimensions (mm)

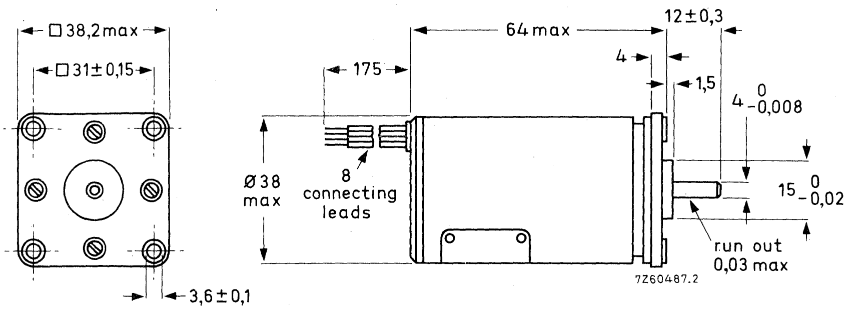

Fig. 1

Marking and connection
The connecting leads are colour-coded and are connected to the bipolar constant current drives as shown in General section of 4-phase bipolar stepper motors.

Power consumption of motor only	6,5 W
Maximum working torque	25 mNm
Holding torque	27 mNm
Maximum pull-in rate *)	1500 steps/s
Maximum pull-out rate *)	25000 steps/s
Number of phases	4
Resistance per coil	6,5 Ω
Inductance per coil	10 mH
Current per coil	500 mA
Permissible ambient temperature range	see General section of Stepper motors
Permissible storage temperature range	−62 to + 110 °C
Permissible motor temperature	125 °C
Insulation resistance at 500 V d.c.	100 MΩ
Step angle	3° 45'
Step-angle tolerance	±20' non-cumulative
Number of steps per revolution	96
Direction of rotation	reversible
Rotor inertia	7 gcm^2
Bearings	ball
Weight	220 g
Maximum axial play (axial force 1,5 N)	0,07 mm
Maximum radial force	10 N
Maximum axial force	5 N

*) When driven by two BCCD units 4322 027 90070.

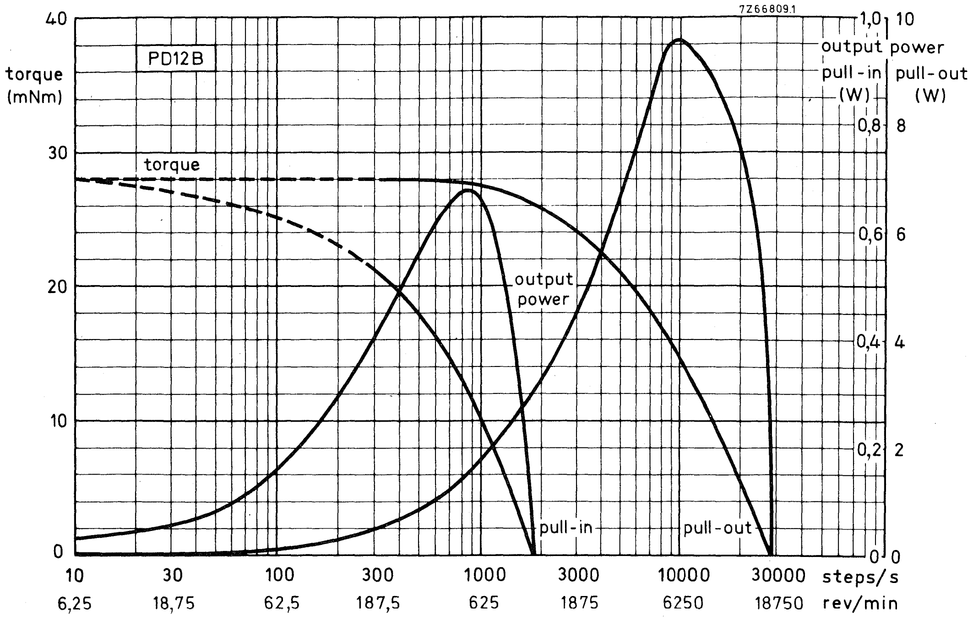

Fig. 2 Torque (left scale) and relevant output power (right scale) versus stepping rate, measured at room temperature.

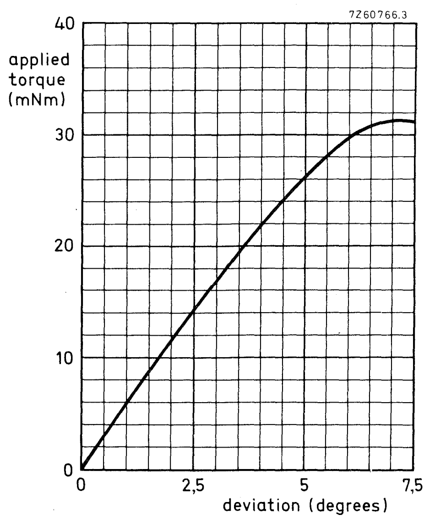

Fig. 3 Applied torque versus deviation.

4-PHASE BIPOLAR STEPPER MOTOR

QUICK REFERENCE DATA	
performance obtained with bipolar constant current drives 4322 027 90070	
Step angle	3° 45'
Maximum working torque	75 mNm
Holding torque	83 mNm
Maximum pull-in rate	1150 steps/s
Maximum pull-out rate	20000 steps/s

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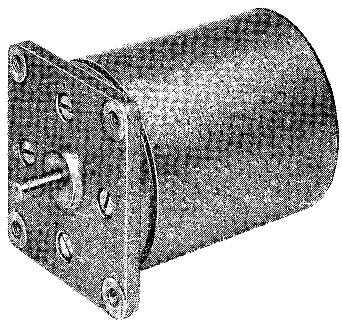

TECHNICAL DATA

Dimensions (mm)

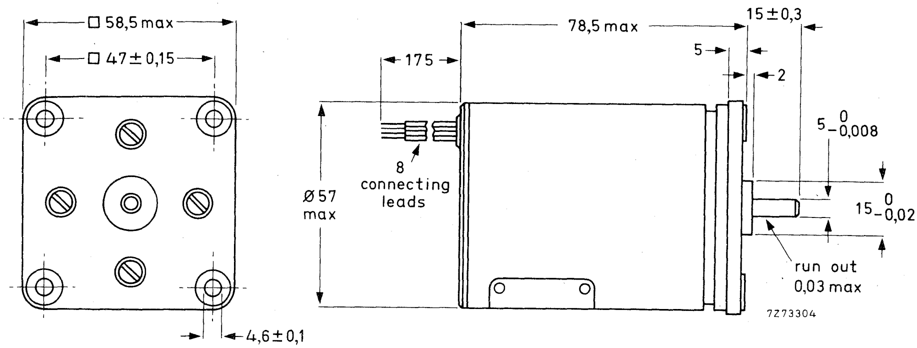

Fig. 1

Marking and connection
The connecting leads are colour-coded and are connected to the bipolar constant current drives as shown in General section of 4-phase bipolar stepper motors.

Power consumption of motor only	8 W
Maximum working torque	75 mNm
Holding torque	83 mNm
Maximum pull-in rate *)	1150 steps/s
Maximum pull-out rate *)	20000 steps/s
Number of phases	4
Resistance per coil	8 Ω
Inductance per coil	25 mH
Current per coil	500 mA
Permissible ambient temperature range	see General section of Stepper motors
Permissible storage temperature range	−62 to + 110 °C
Permissible motor temperature	125 °C
Insulation resistance at 500 V d.c.	100 MΩ
Step angle	3° 45'
Step-angle tolerance	± 10' non-cumulative
Number of steps per revolution	96
Direction of rotation	reversible
Rotor inertia	32 gcm^2
Bearings	ball
Weight	600 g
Maximum axial play (axial force 1,5 N)	0,07 mm
Maximum radial force	15 N
Maximum axial force	7,5 N

*) When driven by two BCCD units 4322 027 90070.

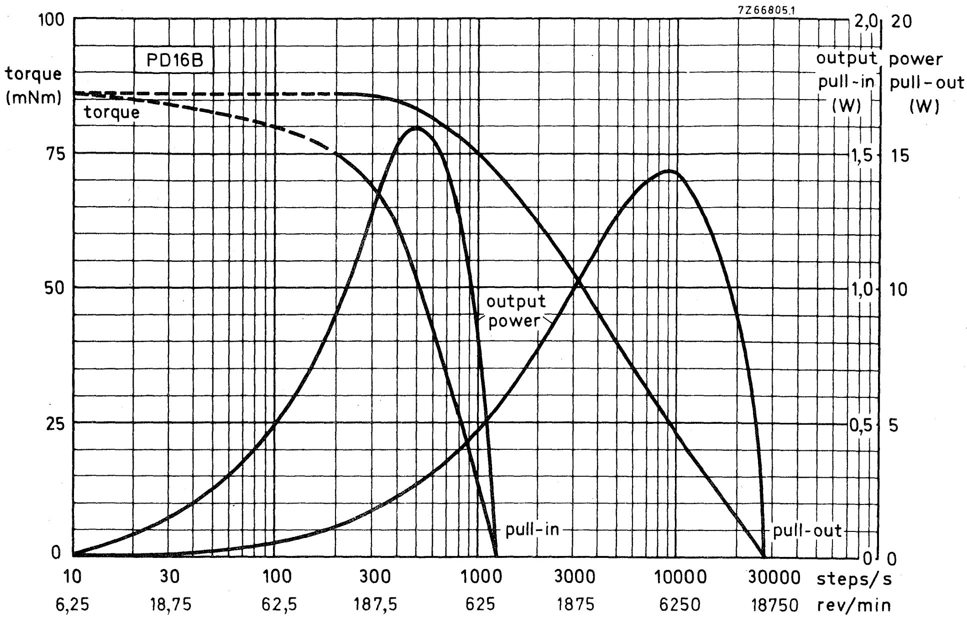

Fig. 2 Torque (left scale) and relevant output power (right scale) versus stepping rate, measured at room temperature.

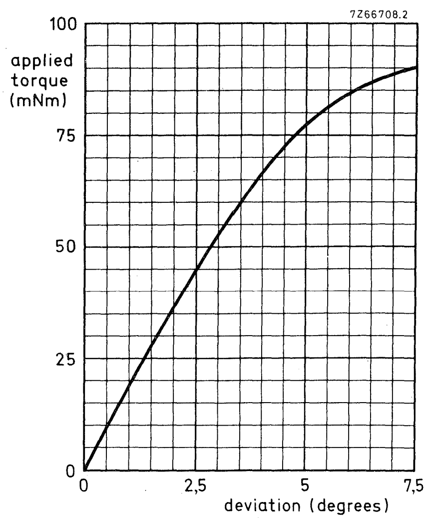

Fig. 3 Applied torque versus deviation.

4-PHASE BIPOLAR STEPPER MOTOR

QUICK REFERENCE DATA	
performance obtained with bipolar constant current drives 4322 027 90070	
Step angle	3° 45'
Maximum working torque	280 mNm
Holding torque	300 mNm
Maximum pull-in rate	900 steps/s
Maximum pull-out rate	12 000 steps/s

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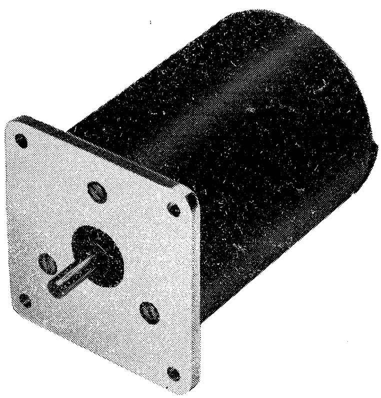


TECHNICAL DATA

Dimensions (mm)

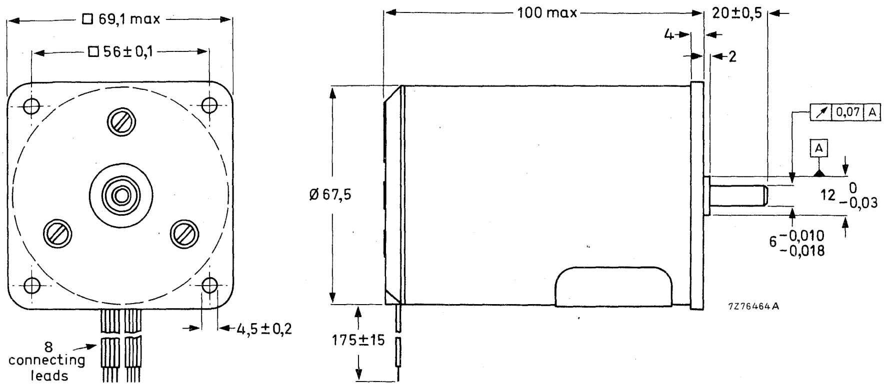


Fig. 1

Marking and connection

The connecting leads are colour-coded and are connected to the bipolar constant current drives as shown in General section of 4-phase bipolar stepper motors.

Power consumption of motor only	7,5 W
Maximum working torque	280 mNm
Holding torque	300 mNm
Maximum pull-in rate *)	900 steps/s
Maximum pull-out rate *)	12 000 steps/s
Number of phases	4
Resistance per coil	7,5 Ω
Inductance per coil	90 mH
Current per coil	500 mA
Permissible ambient temperature range	see General section of Stepper motors
Permissible storage temperature range	−40 to +100 °C
Permissible motor temperature	120 °C
Insulation resistance at 500 V d.c.	> 2 MΩ
Step angle	3° 45'
Step-angle tolerance	±15' non-cumulative
Number of steps per revolution	96
Direction of rotation	reversible
Rotor inertia	160 gcm^2
Bearings, front	ball
rear	slide
Mass	1100 g
Maximum axial play (axial force 1,5 N)	0,3 mm
Maximum radial force	50 N
Maximum axial force	20 N

*) When driven by two BCCD units 4322 027 90070.

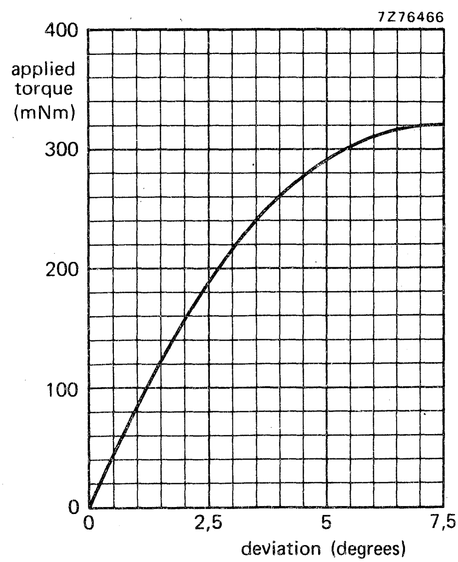


Fig. 2. Applied torque versus deviation.

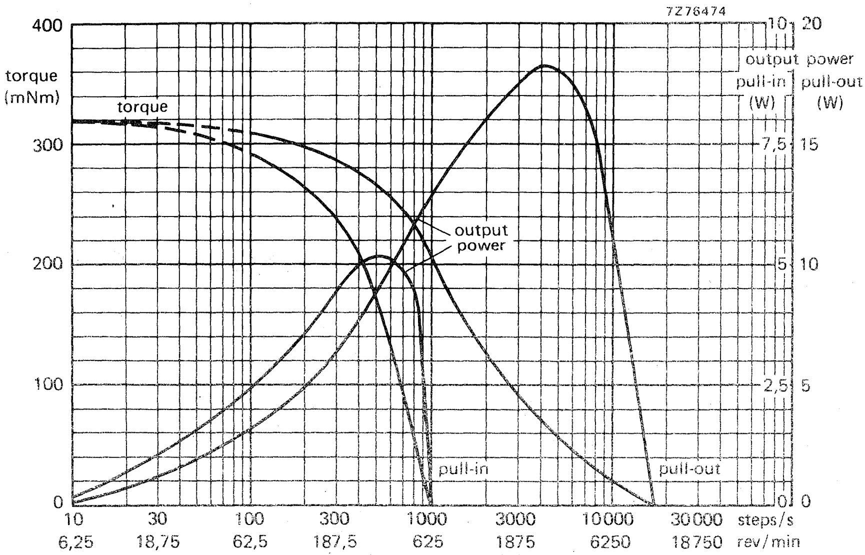
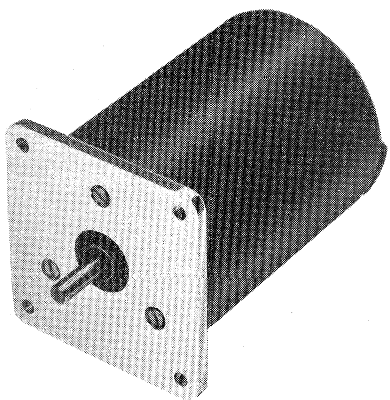


Fig. 3. Torque (left scale) and relevant output power (right scale) versus stepping rate, measured at room temperature.

4-PHASE BIPOLAR STEPPER MOTOR

QUICK REFERENCE DATA	
performance obtained with bipolar constant current drives 4322 027 90070	
Step angle	7° 30'
Maximum working torque	190 mNm
Holding torque	210 mNm
Maximum pull-in rate	520 steps/s
Maximum pull-out rate	7000 steps/s

770104-14-01



TECHNICAL DATA

Dimensions (mm)

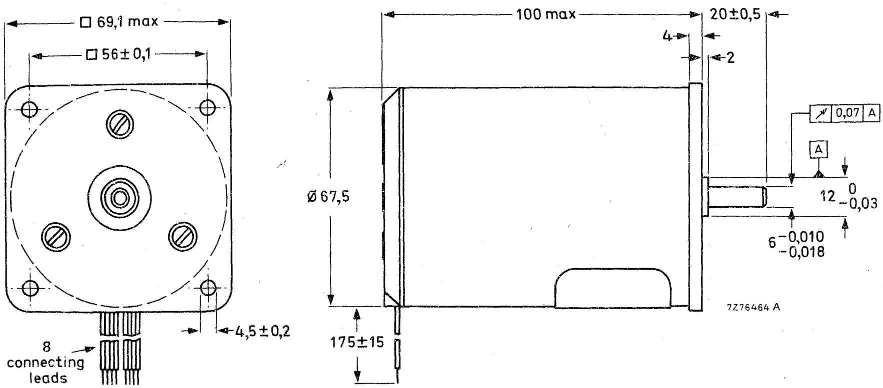


Fig. 1

Marking and connection
The connecting leads are colour-coded and are connected to the bipolar constant current drives as shown in General section of 4-phase bipolar stepper motors.

Power consumption of motor only	7,5 W
Maximum working torque	190 mNm
Holding torque	210 mNm
Maximum pull-in rate *)	520 steps/s
Maximum pull-out rate *)	7000 steps/s
Number of phases	4
Resistance per coil	7,5 Ω
Inductance per coil	70 mH
Current per coil	500 mA
Permissible ambient temperature range	see General section of Stepper motors
Permissible storage temperature range	−40 to +100 °C
Permissible motor temperature	120 °C
Insulation resistance at 500 V d.c.	> 2 MΩ
Step angle	7° 30'
Setp-angle tolerance	± 30' non-cumulative
Number of steps per revolution	48
Direction of rotation	reversible
Rotor inertia	160 gcm²
Bearings, front	ball
rear	slide
Mass	1100 g
Maximum axial play (axial force 1,5 N)	0,3 mm
Maximum radial force	50 N
Maximum axial force	20 N

*) When driven by two BCCD units 4322 027 90070.

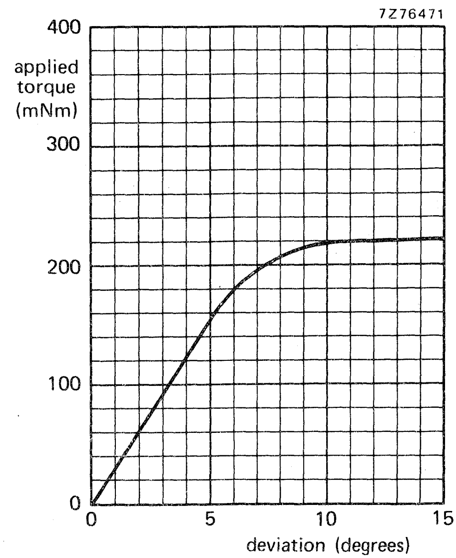


Fig. 2. Applied torque versus deviation.

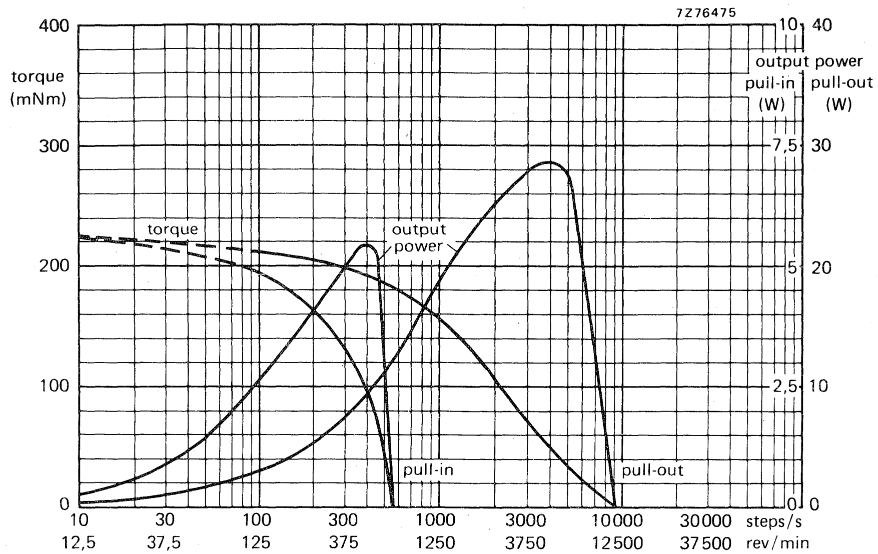


Fig. 3. Torque (left scale) and relevant output power (right scale) versus stepping rate, measured at room temperature.

Miniature direct current motors

CONSTRUCTION

Our direct current motors are available in two basic types:

- iron rotor motors;
- ironless rotor motors.

Iron rotor motors (Fig. 1)

All motors of this type have a three-pole laminated iron rotor and a flat commutator. A VDR (voltage dependent resistor) disc spark suppressor, mounted between the commutator and coils, provides interference suppression and also considerably increases brush life. All motors except those of the 9904 120 52... series have a gold-plated commutator; the two-leaf metal brushes are silver-plated and damped so that long life and low noise level are guaranteed. The stator consists of a Ferroxdure ring and the magnetic circuit is closed by the motor housing.
In the motors of the 9904 120 52... series, carbon brushes and copper commutators are used; a steel ring closes the magnetic circuit and also provides a foundation for the plastic motor housing. In all other respects these motors are the same as the other iron rotor motors.

Fig. 1

1 = rotor

2 = rotor winding

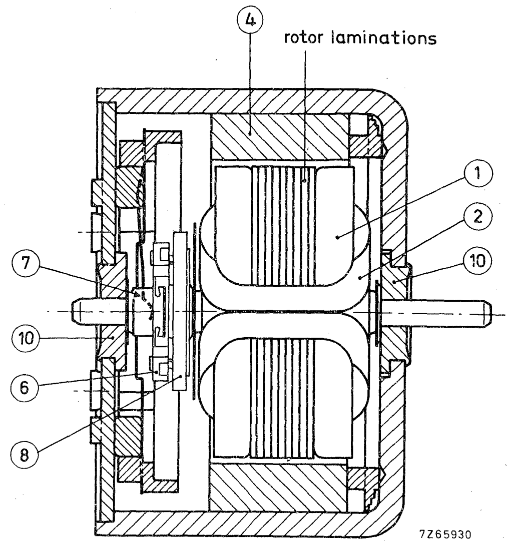
4 = stator magnet

6 = commutator

7 = brush

8 = VDR

10 = bearing



Ironless rotor motors (Fig. 2)

In this type of motor, the rotor consists of a plastic cup moulded onto the spindle and upon which nine coils are wound. A nine-segment precious-metal-plated flat commutator is used. Voltage peaks during commutation are so small in this type of motor that no special arrangements for interference suppression are necessary. The stator is a Ticonal cylindrical magnet located inside the rotor before the latter is wound. Upon assembly, a spigot in the housing is pressed into the stator magnet ring, leaving the rotor free to rotate in its bearings with the stator supported inside the rotor windings. The motor housing completes the magnetic circuit. The silver-plated brushes have three or four leaves each but are otherwise similar in form and damping to those in the iron rotor motors.

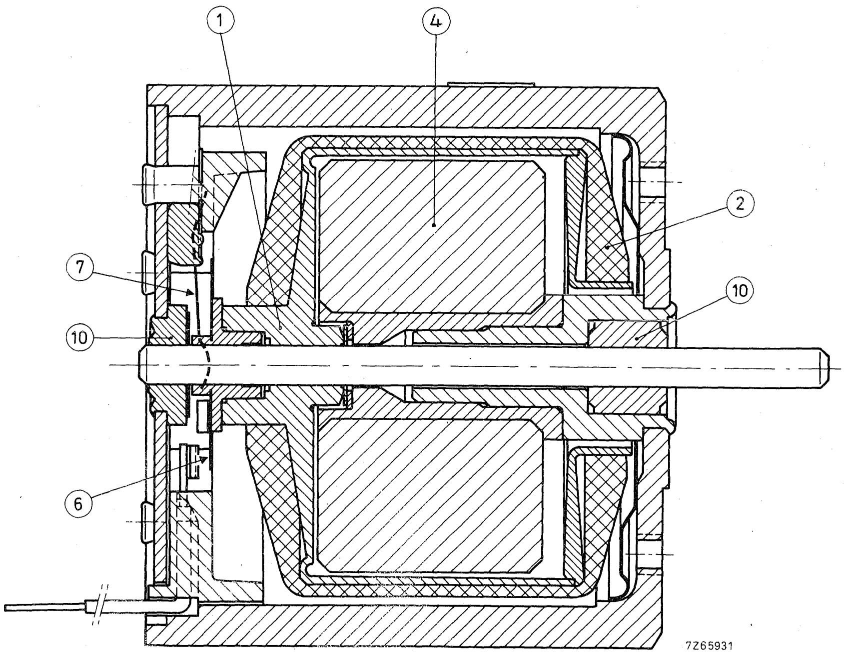


Fig. 2

1 = rotor	6 = commutator
2 = rotor winding	7 = brush
4 = stator magnet	10 = bearing

APPLICATION

All direct current motors have properties - good and bad - that are more or less important depending upon the particular application. These properties are listed in the table below, and each type of motor is graded 1,2 or 3 (1 being the best) for each property. Thus, for a given application, the most suitable type of motor can be chosen. One of the factors in the table is the price; this of course depends of the motor size and also on production quantities, the comparison shown being for motors of approximately similar power and based upon similar quantities.

Comparison of d. c. motor properties

	iron rotor motors	ironless rotor motors
life	1000 h	2000 h
audible noise	3	3
electrical noise	3	2
reliability	3	3
efficiency	3	1
acceleration	2	1
wow and flutter	2	1
price	x	1, 5x

Iron rotor motors are used in those applications which require an optimum compromise between technical properties and economic price.

Applications: cassette recorders;
record players;
calculators;
dictating machines;
telephone answering equipment;
weather balloons;
rotating light for vehicles;
car head-lamp wipers.

Ironless rotor motors are used in those applications requiring better performance in certain properties, such as shorter acceleration time and lower wow and flutter levels, even though the price is higher than that of the iron rotor types.

Applications: hi-fi reel-to-reel recorders;
hi-fi cassette recorders;
educational recorders;
video recorders;
digital computer cassette and cartridge recorders;
recording measuring equipments;
printer drive calculators and computer printers;
ribbon transport computer printers;
card readers.

SURVEY

type	nom. voltage (V)	speed at nom. load (rev/min)	nom. torque (mNm)	dimensions (mm)	catalogue number
iron rotor	4,3	2000	1	Ø 34 x 23,6	9904 120 01501
	7	2000	1	Ø 34 x 23,6	9904 120 01806
	7	2000	1	Ø 34 x 32,7	9904 120 01809 1)
	5,2	2000	1,5	Ø 27,2 x 22,4 x 20,5	9904 120 03501
	12 2)	330 3)	25	Ø 38,6 x 64	9904 120 52602
	12 2)	60 3)	150	Ø 38,6 x 64	9904 120 52605
	12 2)	23 3)	150	Ø 38,6 x 64	9904 120 52607
	12 2)	8,2 3)	150	Ø 38,6 x 64	9904 120 52609
	3	100 3)	15	Ø 27,2 x 22,4 x 35,5	9904 120 53101
ironless rotor	12	2815	10	Ø 40 x 39,6	4322 010 75110
	24	2815	10	Ø 40 x 39,6	4322 010 75060
	24	2815	10	Ø 42 x 50,5	9904 120 10804 1)
	16	3000	24	Ø 40 x 40,6	4322 010 75040
	12	3900	5	Ø 29 x 39,5	9904 120 12601
	24	4050	5	Ø 29 x 39,5	9904 120 12701
	12	3900	5	Ø 29 x 48,4	9904 120 12603 1)
	9	5300	0,3	Ø 19 x 15	4322 010 77000

1) Provided with frequency tachogenerator.

2) Also available in 6 V (9904 120 524..) and 24 V (9904 120 527..) versions.

3) Motors with reduction.

DIRECT CURRENT MOTORS

QUICK REFERENCE DATA		
	9904 120 01501	9904 120 01806
Nominal voltage (d.c.)	4,3 V	7 V
Nominal speed	2050 rev/min	2050 rev/min
Nominal torque	1 mNm	1 mNm

APPLICATION

These motors have been designed for applications which require low noise level, smooth running and accurate speed control by an electronic speed control unit.

Examples:

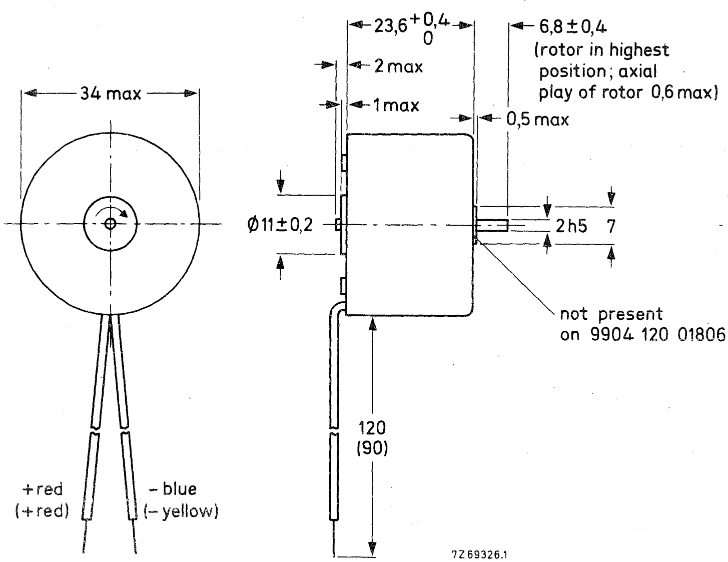
- cassette recorders and players
- record players
- telephone answering equipment
- dictating machines
- echo sounders

DESCRIPTION

The motor has been provided with a permanent magnet system, consisting of a ring magnet with which a very low holding torque has been obtained.
The gold-plated flat commutator with 3 segments and the silver-plated brushes of two parts ensure optimum commutation; the built-in spark suppressor (VDR) also increases the collector life considerably.
The motor has a nickel-plated deep drawn steel housing.

TECHNICAL DATA

Dimensions in mm



The lead length and lead colour given between brackets apply to motor 9904 120 01806.
The direction of rotation is given in connection with the polarity.

Mass approx. 82 g

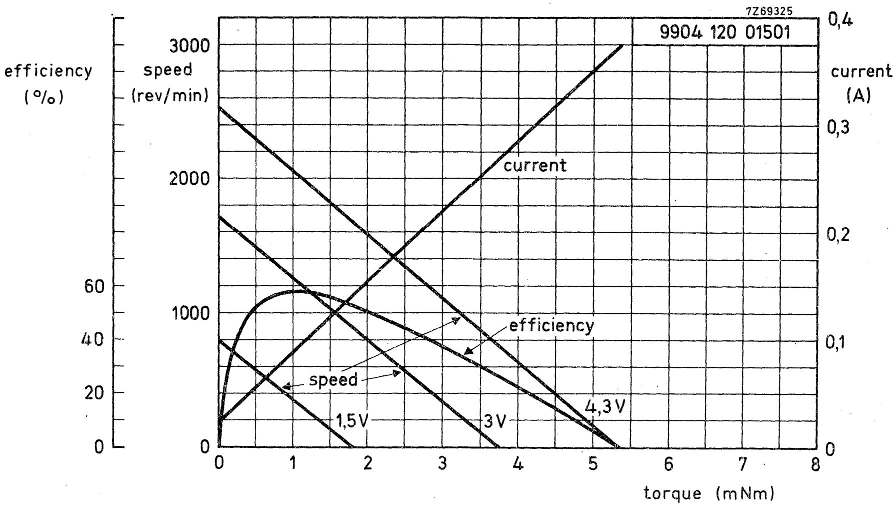
The values given below apply at an ambient temperature of 22 ± 5 °C, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

	9904 120 01501	9904 120 01806
Voltage (d.c.)	4,3 V	7 V
Torque	1 mNm	1 mNm
Speed at nominal load at no load	2050 ± 300 rev/min 2550 ± 300 rev/min	2050 ± 300 rev/min 2550 ± 315 rev/min
Current at nominal load at no load	max. 110 mA max. 35 mA	max. 65 mA max. 25 mA
Starting torque	4,6 mNm	4,4 mNm
Specific input current	60,4 to 72,1 mA/mNm	37,1 to 44,5 mA/mNm
Induced voltage	1,45 to 1,73 mV per rev/min	2,35 to 2,82 mV per rev/min
Rotor resistance	10 Ω ± 10%	27 Ω ± 10%
Direction of rotation	reversible	reversible
Ambient temperature range	−10 to +50 °C	−10 to +50 °C
Rotor moment of inertia	10 gcm^2	10 gcm^2
Motor constant	typ. 44 ms	typ. 44 ms
Bearings	slide bearings	slide bearings
Maximum radial force, 4 mm from bearing	1 N	1 N
Maximum axial force	0,1 N	0,1 N
Maximum axial play	0,6 mm	0,6 mm
Housing material	steel	steel

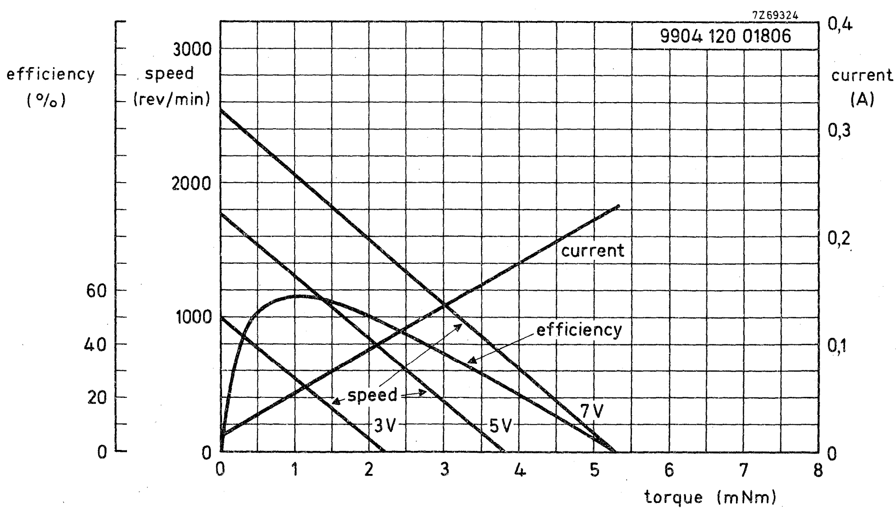
Limiting conditions

The following maximum values indicate those circumstances under which the motor can run continuously without being damaged, but under these circumstances the motor life is greatly reduced.

	9904 120 01501	9904 120 01806
Maximum voltage (d.c.)	6 V	10 V
Maximum permissible load	2 mNm	2 mNm
Max, permissible current	150 mA	90 mA
Maximum speed	3500 rev/min	3500 rev/min
Maximum output power	0,5 W	0,5 W



Typical curves at T_{amb} = 20 °C



Typical curves at T_{amb} = 20 °C

DIRECT CURRENT MOTOR
with frequency tachogenerator

QUICK REFERENCE DATA			
Motor		**Tachogenerator**	
Nominal voltage (d.c.)	7 V	Number of pole pairs	72
Nominal speed	2000 rev/min	Generated voltage at 2000 rev/min	≥ 1535 mV_{p-p}
Nominal torque	1 mNm	Frequency wobble at 3000 Hz	≤ 0,1%

APPLICATION

This motor-tachogenerator combination has been designed for applications which require a direct current drive system the speed of which can be controlled in a very accurate and reliable way (no mechanical contacts).
Examples:
- hi-fi cassette recorders;
- hi-fi record players;
- recording measuring instruments.

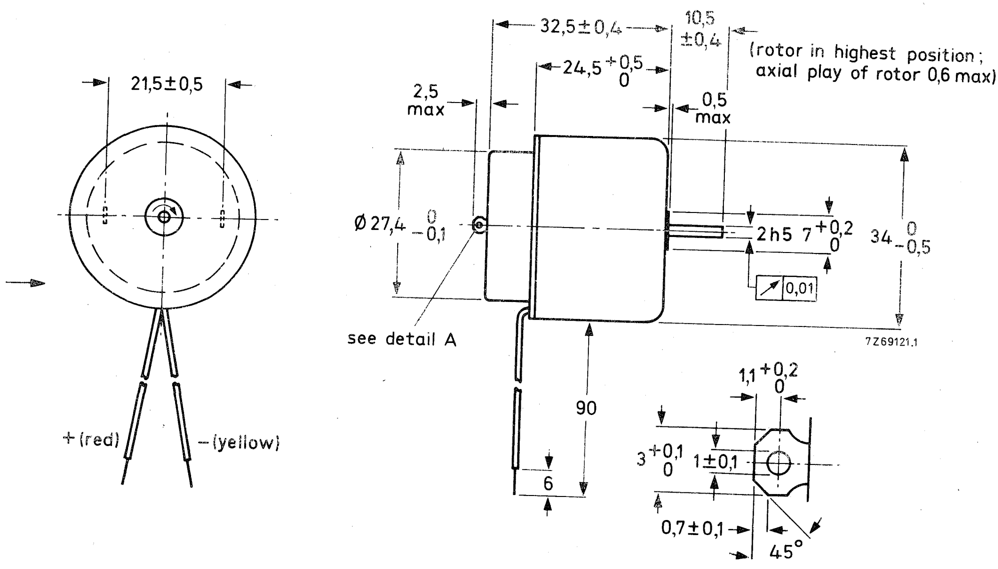
DESCRIPTION

The motor has been provided with a permanent magnet system, consisting of a ring magnet with which a very low holding torque has been obtained.
The gold-plated flat commutator with 3 segments and the two-piece silver-plated brushes ensure optimum commutation; the built-in spark suppressor (VDR) also increases the collector life considerably.
The motor has a nickel-plated, deep drawn, steel housing.

The frequency tachogenerator has a gearwheel rotor (72 teeth) which is mounted on the protruding spindle of the motor. The stator consists of a deep drawn steel housing, a magnet strip of plastic-bonded ceramic material which has been magnetized with 72 pole pairs, and a coil.
The alternating flux, which arises by rotation of the gearwheel in the magnetic field, is enclosed by the coil in which the tachogenerator voltage is generated.
The frequency of this tachogenerator voltage is determined by the speed of the motor and the number of pole pairs of the tachogenerator.

TECHNICAL DATA

Dimensions in mm



The direction of rotation is given in connection with the polarity.

Mass	100 g

The values given below apply to an ambient temperature of 22 ± 5 °C, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

Direct current motor

Nominal voltage (d.c.)		7 V
Nominal torque		1 mNm
Speed	at nominal load	2000 ± 350 rev/min
	at no load	2500 ± 350 rev/min
Current	at nominal load	max. 76 mA
	at no load	max. 32 mA
Starting torque		min. 4,5 mNm
Input power		max. 0,53 W
Specific input current		37,0 to 44,9 mA/mNm
Rotor resistance		26 Ω ± 10%
Rotor moment of inertia		11 gcm^2
Bearings		slide bearings
Maximum radial force, 4 mm from bearing		1,5 N
Maximum axial force		0,1 N
Maximum axial play		0,6 mm
Housing material		steel, deep drawn
	finish	nickel plated

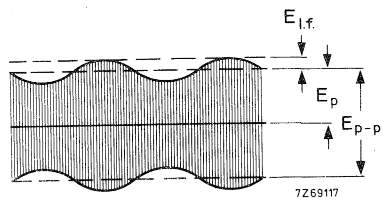
Limiting conditions

The following maximum values indicate those circumstances under which the motor can run continuously without being damaged, but under these circumstances the motor life is greatly reduced.

Maximum voltage (d.c.)	12 V
Maximum permissible load	2,0 mNm
Maximum permissible input current	110 mA
Maximum speed	3500 rev/min
Maximum output power	0,5 W

Tachogenerator

Number of pole pairs	72
Generated voltage, peak to peak value, at 2000 rev/min (E_{p-p})	≥ 1535 mV
Amplitude variation for 1 rev ($\frac{E_{l.f.}}{E_p}$ x 100%)	≤ 15%

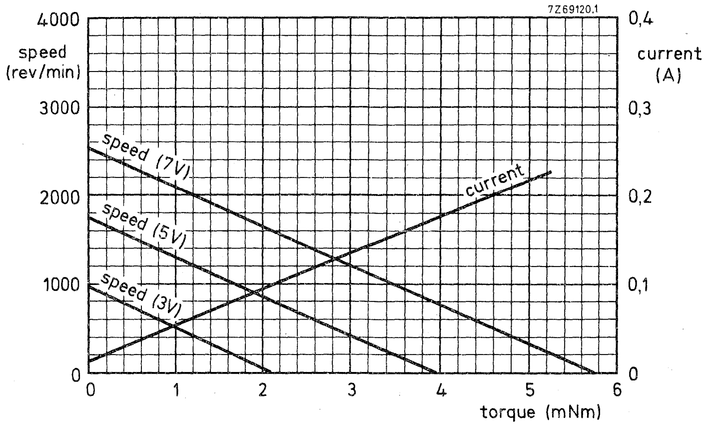


Frequency	$\frac{n.72}{60}$ Hz (n = number of rev/min)
Frequency wobble at 3000 Hz	≤ 0, 1% [1]
Temperature coefficient of the generated voltage	−0, 2%/°C
Resistance	930 Ω ± 12%
Inductance	640 mH ± 15%
Housing, material	steel, deep drawn
finish	nickel plated

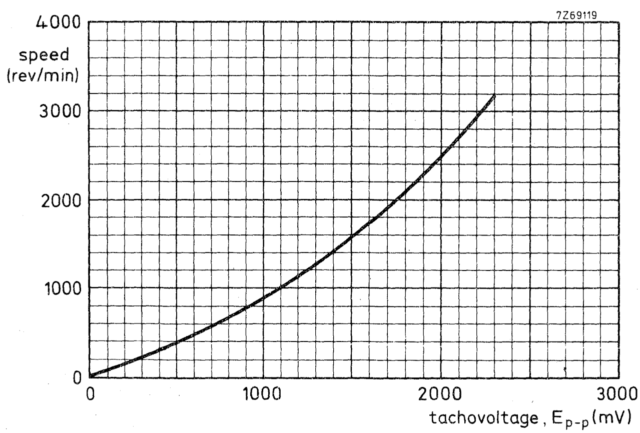
General

Direction of rotation	reversible
Ambient temperature range	−10 to +60 °C

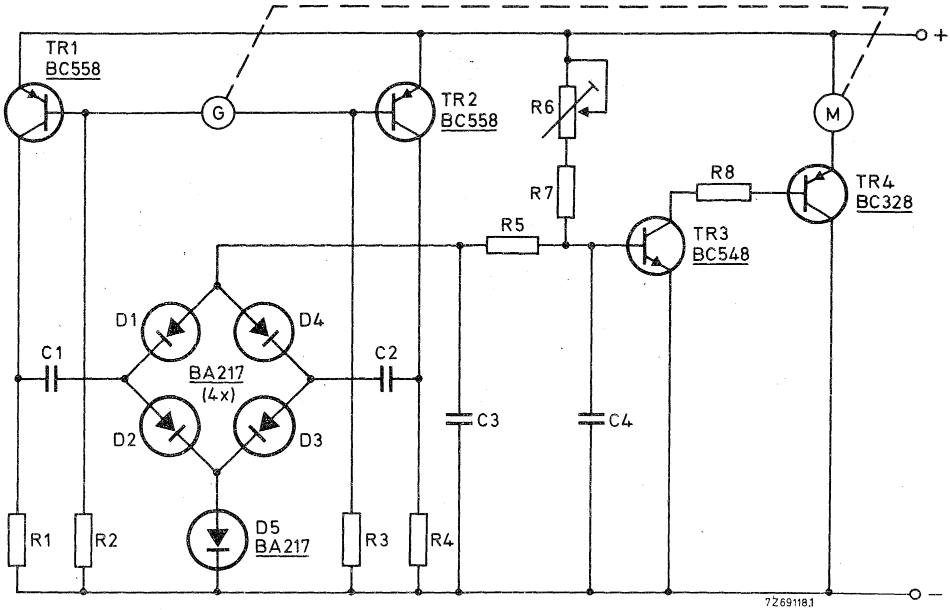
1) Measured with EMT measuring instrument type 420 A, position linear.



Typical motor curves



Typical tachogenerator curves



Example of an electronic speed control system

DIRECT CURRENT MOTOR

QUICK REFERENCE DATA	
Nominal voltage (d.c.)	5,2 V
Nominal speed	2000 rev/min
Nominal torque	1,5 mNm

APPLICATION

This motor has been designed for applications which require low noise level, smooth running, small size and accurate electronic speed control.

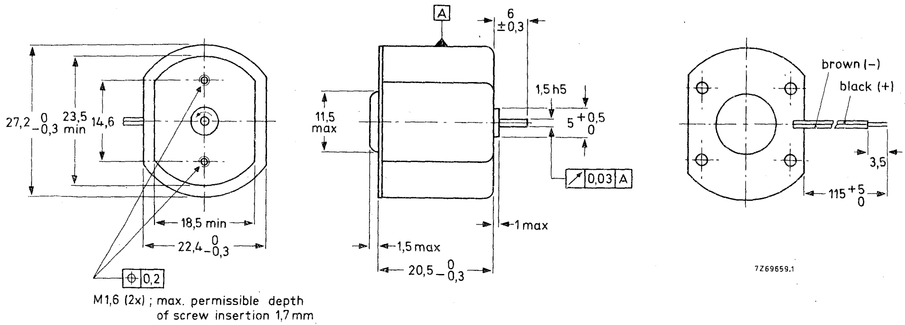
Examples:
- cassette recorders and players;
- portable dictating machines;
- telephone answering equipment.

DESCRIPTION

The motor has a permanent magnet stator system, consisting of plastic-bonded ceramic material, with which a very low holding torque has been obtained.
The gold-plated flat commutator and silver-plated brushes ensure optimum commutation, thus making the motor suitable for accurate electronic speed control. This commutator/brush construction, together with the special stator magnet material and the sintered bearings, ensure smooth running and long life.
The built-in spark suppressor (VDR) minimizes interference and considerably increases the commutator and brush life.
The motor has a nickel-plated, deep drawn, steel housing.

TECHNICAL DATA

Dimensions in mm



The direction of rotation is given in connection with the polarity.

Mass	approx. 45 g

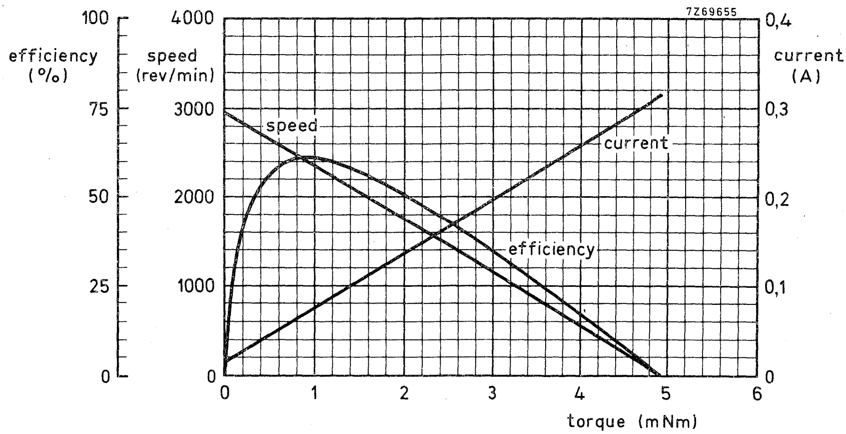
The values given below apply to an ambient temperature of 22 ± 5 °C, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

Nominal voltage (d.c.)	5,2 V
Nominal torque	1,5 mNm
Speed	
at nominal load	1970 ± 275 rev/min
at no load	2940 ± 315 rev/min
Current	
at nominal load	max. 125 mA
at no load	max. 25 mA
Starting torque	min. 4,1 mNm
Starting voltage	min. 0,7 V
Specific input current	56 to 67 mA/mNm
Induced voltage	1,53 to 1,82 mV/rev/min
Rotor resistance	15,8 Ω ± 10%
Rotor moment of inertia	4,2 gcm^2
Friction torque at 2000 rev/min	max. 0,32 mNm
Motor constant	typ. 27 ms
Direction of rotation	reversible
Ambient temperature range	−20 to + 60 °C
Bearings	slide bearings
Maximum radial force, 4 mm from bearing	1,5 N
Maximum axial force	0,1 N
Housing material	steel, deep drawn

Limiting conditions

The following maximum values indicate those circumstances under which the motor can run continuously without being damaged, but under these circumstances the motor life is greatly reduced.

Maximum voltage (d.c.)	8 V
Maximum permissible load	2,0 mNm
Maximum permissible input current	150 mA
Maximum speed	3500 rev/min
Maximum output power	0,5 W



Typical curves at 5, 2 V, T_{amb} = 20 ^{o}C

DIRECT CURRENT MOTORS
with reduction

QUICK REFERENCE DATA					
catalogue numbers					
nominal voltage 6 V d.c.	nominal voltage 12 V d.c.	nominal voltage 24 V d.c.	reduction ratio	speed (rev/min)	torque (mNm)
9904 120 52402	9904 120 52602	9904 120 52702	9 : 1	330	25
9904 120 52405	9904 120 52605	9904 120 52705	50 : 1	60	150
9904 120 52407	9904 120 52607	9904 120 52707	150,4 : 1	23	150
9904 120 52409	9904 120 52609	9904 120 52709	451,25: 1	8,2	150

APPLICATION

These small d.c. motors with integrated gearboxes have been designed for applications which require a driving system of good quality and a long life.

Application examples are :
- rotating warning lights e.g. on cars
- positioning of searchlights e.g. on cars
- headlamp wipers on cars
- automation systems
- high quality toys

DESCRIPTION

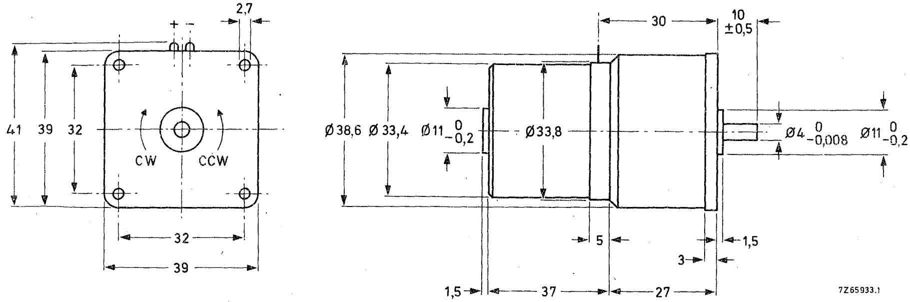
The motor has been provided with a permanent-magnet stator system. A reduction gear-box has been built in with gearwheels made of polyacetal resin ; various reductions are available.
The use of special brushes, a flat commutator and a built-in spark suppressor (voltage dependent resistor) guarantee a long life and a low interference level. The new stator magnet material and the special rotor construction give the motor a high efficiency.
The grey injection-moulded housing of polyacetal resin is highly resistant to chemicals and corrosion.

MOUNTING

Mounting the motor is easy since it is provided with a flange having four holes.
Four screws M 2,5 and washers can be used.

TECHNICAL DATA

Dimensions (mm)



The direction of rotation is given in connection with the polarity (see table next page)

Ambient temperature range	-20 to +60 °C
Bearings	bronze, self lubricating
Maximum axial play	0, 5 mm
Housing, material colour	polyacetal resin grey
Gears, material	polyacetal resin
Weight	125 g approx.

The values given below apply to an ambient temperature of 22 ± 5 °C, an atmospheric pressure of 860 - 1060 mbar and a relative humidity of 45 to 75%.

catalogue number 9904 120 52...	402	602	702	405	605	705	407	607	707	409	609	709	
reduction ratio	9 : 1			50 : 1			150, 4 : 1			451, 25 : 1			

Nominal values

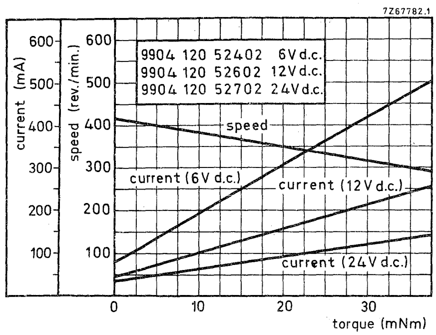
voltage	6	12	24	6	12	24	6	12	24	6	12	24	V d.c.
torque	25			150			150			150			mNm
speed at nom. load at no load	330 415			60 78			23 26			8, 2 8, 5			rev/ min
current at nom. load at no load	360 80	185 45	105 35	360 80	185 45	105 35	180 75	100 40	60 35	110 70	60 40	45 35	mA mA
input power	2, 1	2, 2	2, 5	2,1	2, 2	2, 5	1, 1	1, 2	1, 4	0, 7	0, 7	1, 1	W
direction of rotation (see also dim. drawing)	CW			CW			CCW			CW			
max. radial force on the bearings	2			6			8			10			N
max. axial force	2			6			8			10			N

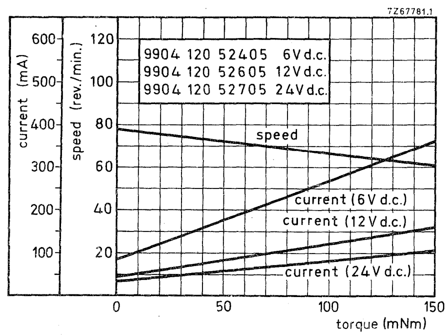
Limiting conditions *)

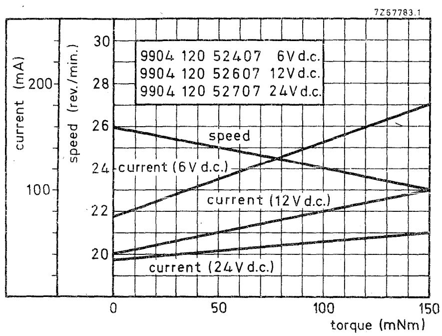
max. voltage	9	18	28	9	18	28	9	18	28	9	18	28	V d.c.
max. perm. load	37, 5			150			150			150			mNm

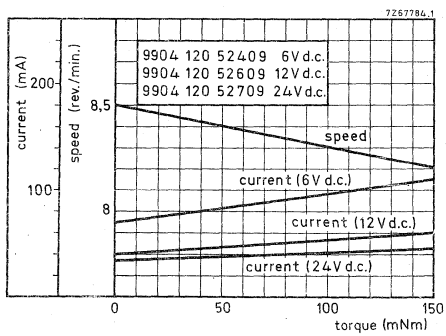
*) These maximum values should never be exceeded.

The curves are measured on an arbitrary motor.









DIRECT CURRENT MOTOR
with gearbox

QUICK REFERENCE DATA	
Nominal voltage (d.c.)	3 V
Nominal speed	103 rev/min
Nominal torque	15 mNm

APPLICATION

This motor with gearbox has been mainly designed for servo purposes in professional and industrial applications, which require high reliability and smooth running.

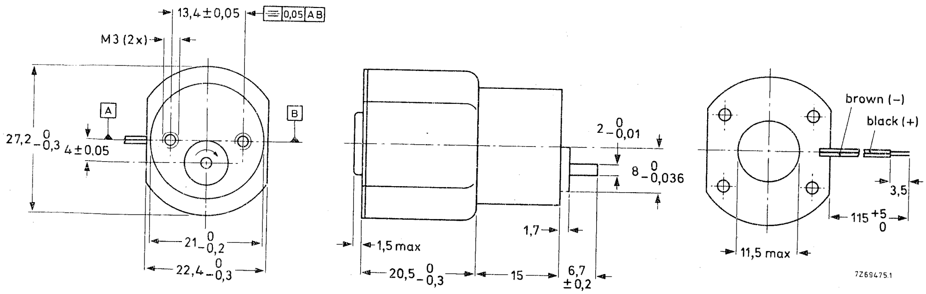
Examples:
- film cameras (film drive and zoom lens drive);
- slide projectors;
- portable recording instruments (chart drive and pen drive);
- instruments for automation.

DESCRIPTION

The motor has been provided with a deep drawn steel housing. A reduction of the motor speed has been obtained by means of a high-precision reduction gear, mounted in a steel housing, which is fitted to the motor.
The special construction of a flat collector, a light brush construction and a built-in spark suppressor (VDR) guarantee smooth running.
The motor is suitable for use with an electronic remote control unit.
It can be used in tropical environments.

TECHNICAL DATA

Dimensions in mm



The direction of rotation is given in connection with the polarity.

Mass	approx. 65 g

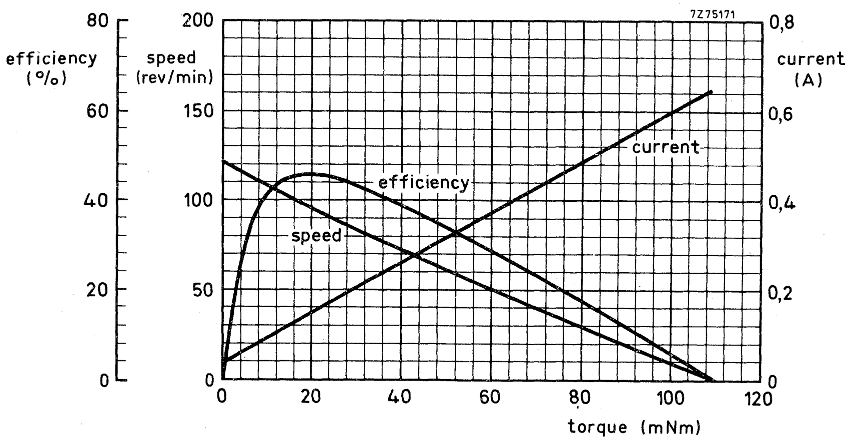
The values given below apply to an ambient temperature of 22 ± 5 °C, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

Nominal voltage (d.c.)	3 V
Nominal torque	15 mNm
Speed at nominal load	103 ± 13 rev/min
at no load	122 ± 14 rev/min
Reduction ratio	27 : 1
Current at nominal load	max. 150 mA
at no load	max. 50 mA
Starting torque	min. 77 mNm
Starting voltage (d.c.) at no load	max. 0,4 V
Input power	max. 0,45 W
Induced voltage	0,78 to 0,95 mV/rev/min
Rotor resistance	4,5 Ω ± 10%
Direction of rotation	reversible
Ambient temperature range	-10 to +50 °C
Rotor moment of inertia	4 gcm^2
Maximum radial force on bearings	2 N
Maximum axial force	1 N
Maximum axial play	0,2 mm
Housing material	steel

Limiting conditions

The following maximum values indicate those circumstances under which the motor can run continuously without being damaged, but under these circumstances the motor life is greatly reduced.

Maximum voltage (d.c.)	4 V
Maximum permissible load	35 mNm
Maximum permissible input current	285 mA
Maximum speed	155 rev/min
Maximum output power	0,33 W



Typical curves at 3 V, T_{amb} = 22 °C

MOUNTING

The motors can be fixed by means of two screws M3 in the mounting holes of the gearbox. The bearing of the spindle can also be used as a centring piece.

DIRECT CURRENT MOTOR
ironless rotor type

QUICK REFERENCE DATA	
Nominal voltage (d. c.)	16 V
Nominal speed	3050 rev/min
Nominal torque	24 mNm

APPLICATION

This motor has been designed for heavy duty applications which require high acceleration and many start/stops. There is no magnetic holding torque thus the motor is extremely smooth running.

Examples :
- digital cassette and cartridge recorders;
- printers (head drive, head positioner, paper drive etc.);
- recording measuring instruments.

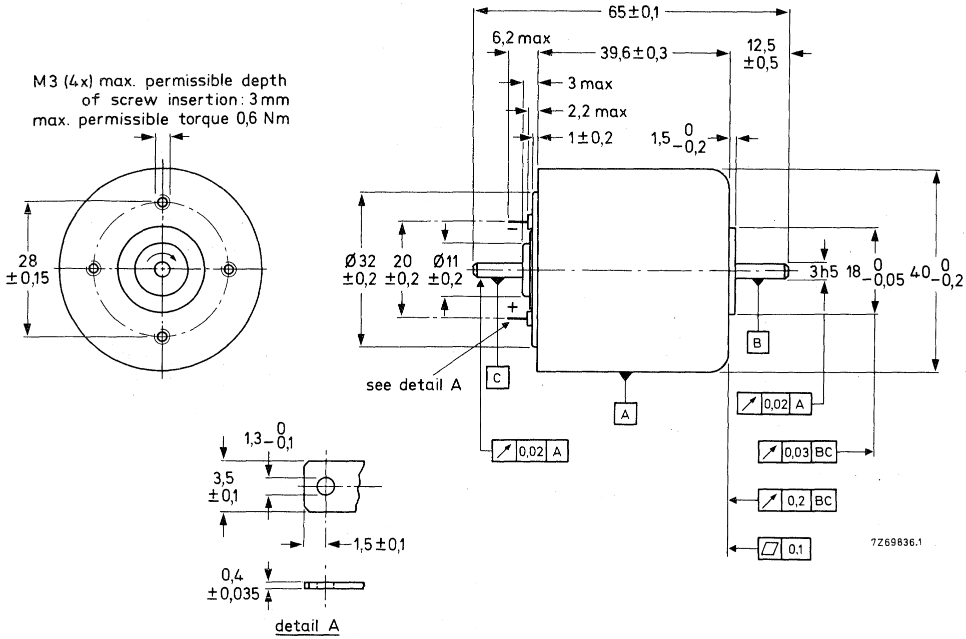
DESCRIPTION

The motor owes its special characteristics to the following design :

- ironless rotor with oblique winding;
- the low moment of inertia and the high starting torque yield a motor constant of no more than 22 ms;
- the robust commutator/brush construction (silver-palladium-plated commutator with 9 segments and four-piece silver-plated brushes) and the built-in interference suppression system make the motor suitable for heavy duty applications;
- the commutator/brush construction together with the sintered slide bearings with extra oil reservoirs, ensure a long life, smooth running and a low audible and electrical noise level.

TECHNICAL DATA

Dimensions in mm



The direction of rotation is given in connection with the polarity.

The values given below apply to an ambient temperature of 22 ± 5 °C, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

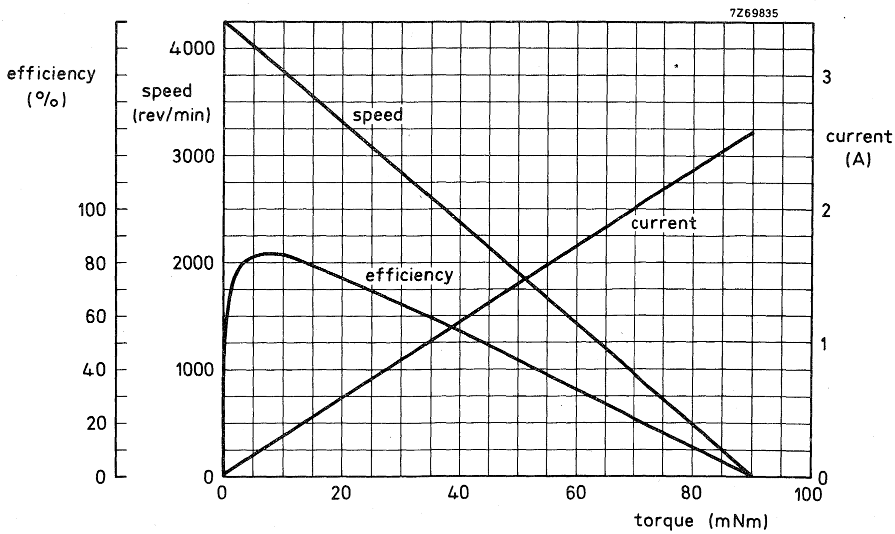
Nominal voltage (d.c.)	16 V
Nominal torque	24 mNm
Speed	
at nominal load	3050 ± 320 rev/min
at no load	4385 ± 545 rev/min
Current	
at nominal load	max. 815 mA
at no load	max. 31 mA
Starting torque	94 ± 21 mNm
Input power	max. 13 W
Specific input current	25,5 to 32,4 mA/mNm
Induced voltage	3,23 to 4,1 mV per rev/min
Rotor resistance	6,2 Ω ± 8%

Direction of rotation	reversible
Ambient temperature range	−5 to +60 °C
Rotor moment of inertia	43 gcm^2
Motor constant	22 ms
Bearings	slide bearings
Maximum radial force, 8 mm from bearing	5 N
Maximum axial force	0,5 N
Maximum axial play of rotor	0,4 mm
Housing material	steel

Limiting conditions

The following maximum values indicate those circumstances under which the motor can run continuously without being damaged, but under these circumstances the motor life is greatly reduced.

Maximum voltage (d.c.)	18 V
Maximum permissible load	27 mNm
Maximum permissible input current	925 mA
Maximum speed	4000 rev/min
Maximum output power	8,5 W
Locked rotor	max. 40 s at 16 V



Typical curves at 16 V, T_{amb} = 22 °C

DIRECT CURRENT MOTORS

ironless rotor type

QUICK REFERENCE DATA		
	4322 010 75110	4322 010 75060
Nominal voltage (d. c.)	12 V	24 V
Nominal speed	2815 rev/min	2815 rev/min
Nominal torque	10 mNm	10 mNm

APPLICATION

These motors have been designed for applications which require high acceleration, high efficiency and smooth running (no magnetic holding torque).

Examples:

- hi-fi reel-to-reel recorders (capstan and reel drive);
- hi-fi cassette recorders (reel drive);
- video recorders (capstan, reel and drum drive);
- digital cassette and cartridge recorders;
- card readers;
- printers (paper transport and head positioner);
- recording measuring instruments.

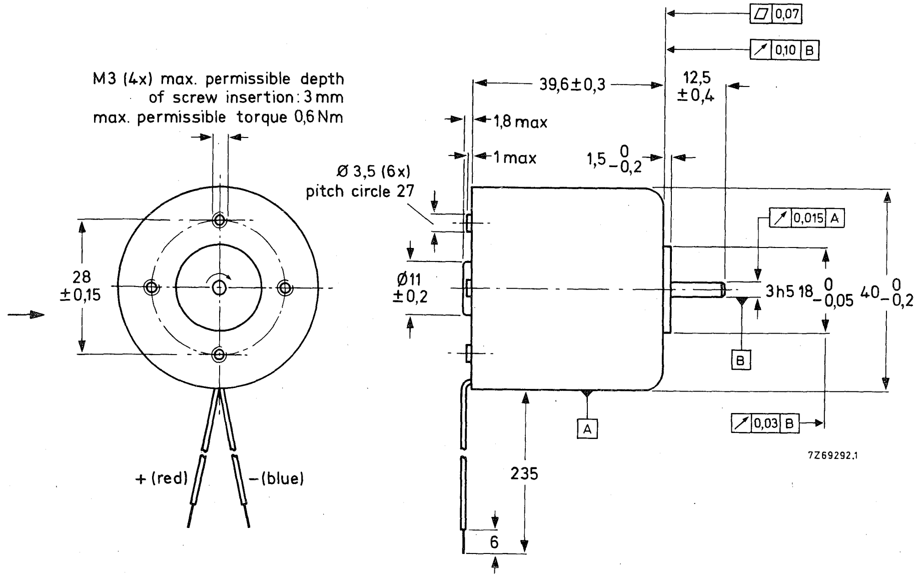
DESCRIPTION

The motor owes its special characteristics to the following design:

- ironless rotor with oblique winding;
- the low moment of inertia and the high starting torque yield a motor constant of no more than 19,6 ms;
- a precious-metal-plated commutator with 9 segments and three-piece silver-plated brushes ensure optimum commutation, thus making the motor suitable for accurate electronic control and optimum functioning as a servo motor or tachogenerator;
- the powerful cylindrical steel permanent magnet, around which the rotor rotates, makes for high efficiency;
- the above-mentioned commutator/brush construction together with the sintered slide bearings ensures a long life, smooth running and low noise level.

TECHNICAL DATA

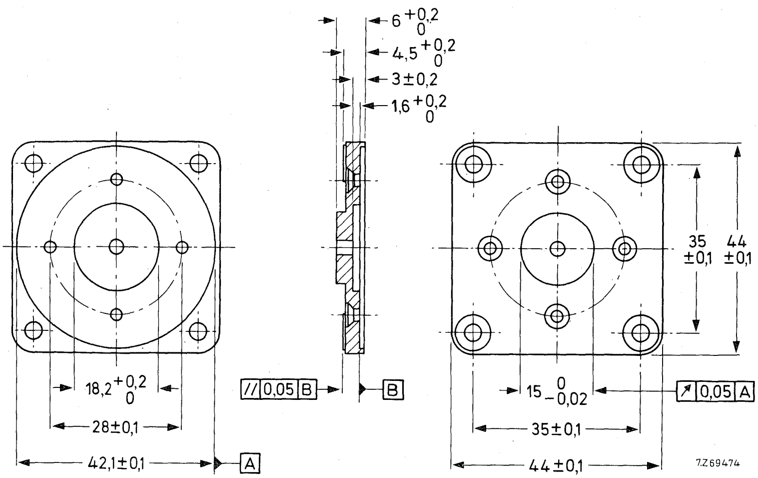
Dimensions in mm



The direction of rotation is given in connection with the polarity.

Mass approx. 205 g

Note - A square flange (figure below), which can be fitted to the motor, can be supplied under catalogue number 4322 010 66090.



The values given below apply at an ambient temperature of 22 ± 5 °C, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

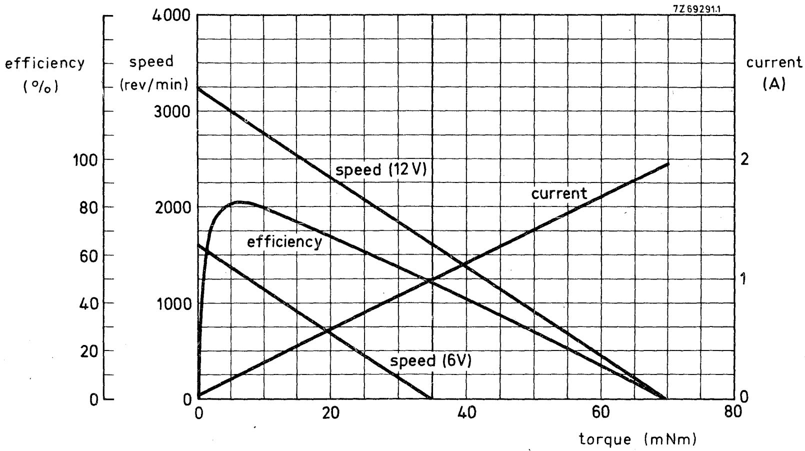
	4322 010 75110	4322 010 75060
Nominal voltage (d.c.)	12 V	24 V
Nominal torque	10 mNm	10 mNm
Speed at nominal load	2815 ± 385 rev/min	2815 ± 385 rev/min
at no load	3310 ± 460 rev/min	3310 ± 460 rev/min
Current at nominal load	max. 365 mA	max. 180 mA
at no load	max. 30 mA	max. 15 mA
Starting torque	70 ± 17 mNm	70 ± 17 mNm
Input power	max. 4,3 W	max. 4,3 W
Specific input current	25,1 to 33,1 mA/mNm	12,5 to 16,6 mA/mNm
Induced voltage	3,17 to 4,17 mV per rev/min	6,33 to 8,33 mV per rev/min
Rotor resistance	6,2 Ω ± 10%	24,5 Ω ± 10%
Direction of rotation	reversible	reversible
Ambient temperature range	−5 to +70 °C	−5 to +70 °C
Rotor moment of inertia	39,2 gcm^2	39,2 gcm^2
Motor constant	typ. 19,6 ms	typ. 19,6 ms
Bearings	slide bearings	slide bearings
Maximum radial force 8 mm from mounting plane	5 N	5 N
Maximum axial force [1]	0,5 N	0,5 N
Maximum axial play	0,6 mm	0,6 mm
Housing material	steel	steel

Limiting conditions

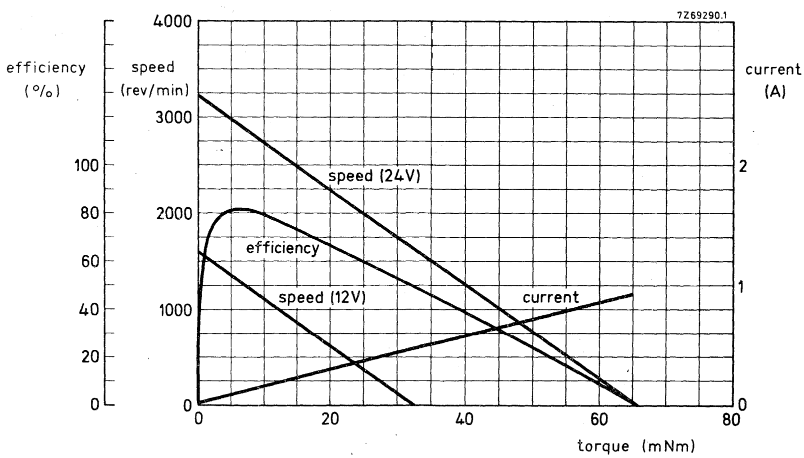
The following maximum values indicate those circumstances under which the motor can run continuously without being damaged, but under these circumstances the motor life is greatly reduced.

	4322 010 75110	4322 010 75060
Maximum voltage (d.c.)	15 V	30 V
Maximum permissible load	20 mNm	20 mNm
Max. permissible current	550 mA	275 mA
Maximum speed	4000 rev/min	4000 rev/min
Maximum output power	5 W	5 W
Locked rotor	max. 2 min at 12 V	max. 2 min at 24 V

1) Directed towards the connections.



Typical curves of motor 4322 010 75110 at 12 V and 6 V, T_{amb} = 20 °C



Typical curves of motor 4322 010 75060 at 24 V and 12 V, T_{amb} = 20 °C

DIRECT CURRENT MOTOR

ironless rotor type

QUICK REFERENCE DATA	
Nominal voltage (d.c.)	9 V
Nominal speed	5430 rev/min
Nominal torque	0,3 mNm

APPLICATION

This motor has been designed for applications which require low noise level, smooth running, small size, high acceleration and accurate electronic speed control.

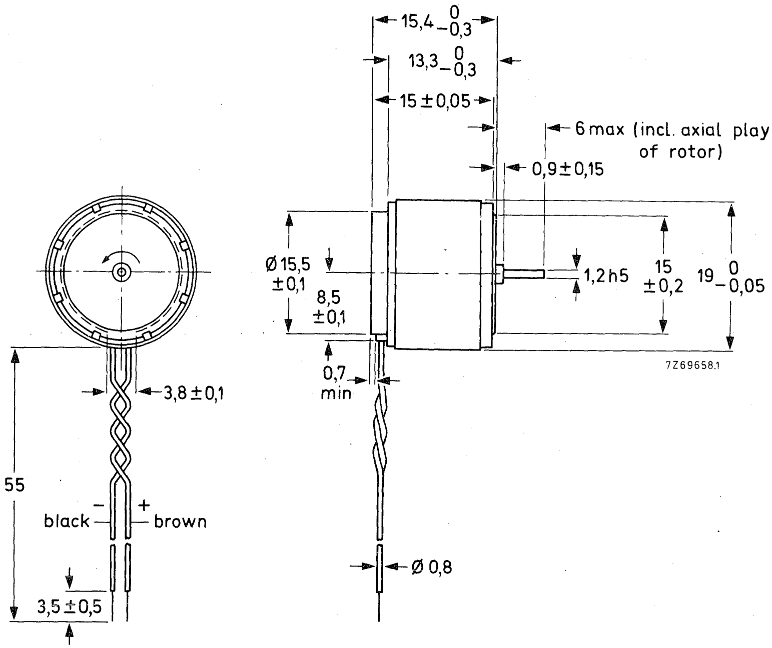
Examples :
- portable dictating machines;
- film cameras;
- process control systems (as a servo motor or tachogenerator).

DESCRIPTION

The motor has an ironless rotor with oblique winding. The low moment of inertia (0,76 gcm^2), and the high starting torque yield a motor constant of no more than 50 ms.
A gold-plated commutator with 5 segments and three-piece silver-plated brushes ensure optimum commutation, thus making the motor suitable for accurate electronic control and optimum functioning as a servo motor or tachogenerator.
The powerful cylindrical steel permanent magnet, around which the rotor rotates, makes for high efficiency.
The commutator/brush construction, together with the sintered bearings, ensures long life, smooth running and low noise level.

TECHNICAL DATA

Dimensions in mm



The direction of rotation is given in connection with the polarity.

Mass approx. 17 g

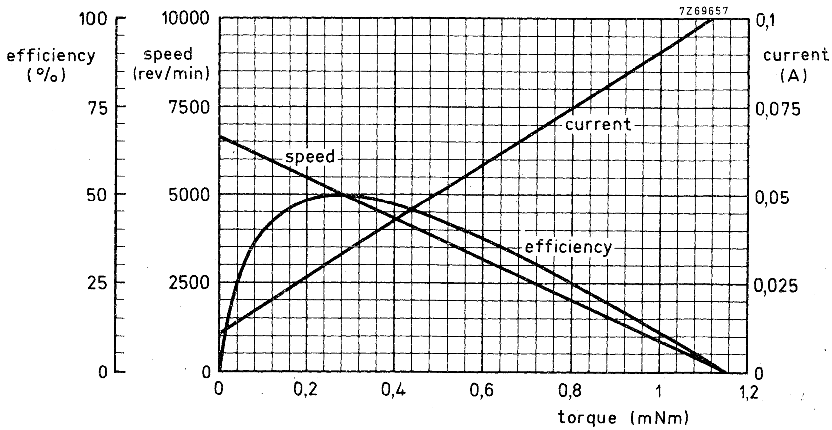
The values given below apply to an ambient temperature of 22 ± 5 °C, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

Nominal voltage (d.c.)	9 V
Nominal torque	0,3 mNm
Speed at nominal load	5430 ± 910 rev/min
at no load	7440 ± 1320 rev/min
Current at nominal load	max. 41 mA
at no load	max. 9 mA
Starting torque	min. 0,82 mNm
Starting voltage	min. 0,8 V
Specific input current	76,6 to 104,7 mA/mNm
Induced voltage	1,0 to 1,37 mV/rev/min
Rotor resistance	85,5 Ω ± 10%
Rotor moment of inertia	0,76 gcm^2
Friction torque at 5300 rev/min	max. 0,09 mNm
Motor constant	typ. 50 ms
Direction of rotation	reversible
Ambient temperature range	-10 to +50 °C
Bearings	slide bearings
Maximum radial force, 1,6 mm from bearing	0,5 N
Maximum axial force	0,1 N
Maximum axial play	0,1 mm
Housing material	steel

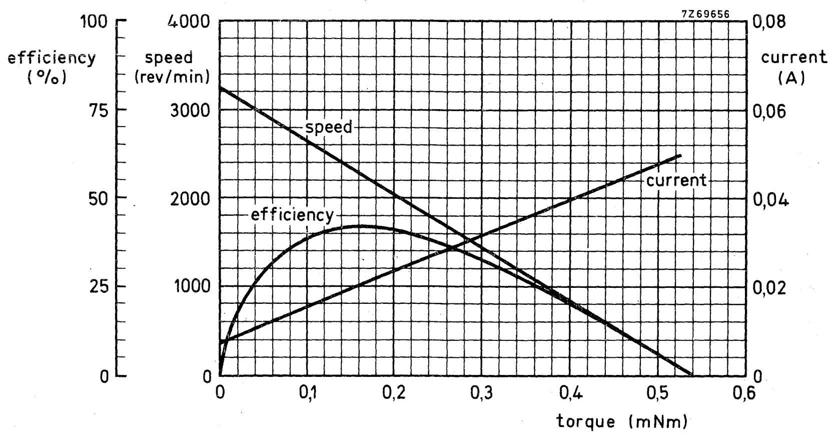
Limiting conditions

The following maximum values indicate those circumstances under which the motor can run continuously without being damaged, but under these circumstances the motor life is greatly reduced.

Maximum voltage (d.c.)	12 V
Maximum permissible load	0,5 mNm
Maximum permissible input current	60 mA
Maximum speed	9000 rev/min
Maximum output power	0,25 W



Typical curves at 9 V, T_{amb} = 20 °C



Typical curves at 4,5 V, T_{amb} = 20 °C

DIRECT CURRENT MOTOR
with frequency tachogenerator

QUICK REFERENCE DATA			
Motor		Tachogenerator	
Nominal voltage (d.c.)	24 V	Number of pole pairs	72
Nominal speed	2800 rev/min	Generated voltage at 2000 rev/min	≥ 1535 mV_{p-p}
Nominal torque	10 mNm	Frequency wobble at 3000 Hz	≤ 0,1%

APPLICATION

This motor-tachogenerator combination has been designed for applications which require a direct current drive system the speed of which can be controlled in a very accurate and reliable way, and where high acceleration, high efficiency and smooth running are preferred.

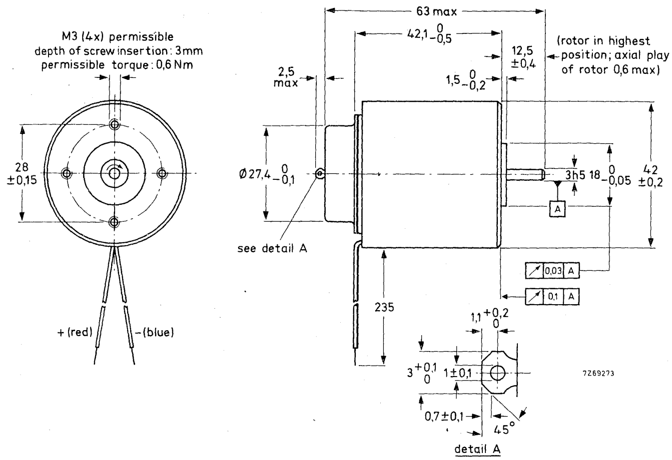
Examples:
- hi-fi reel-to-reel recorders (capstan drive);
- video recorders (capstan, reel and drum drive);
- digital cassette and cartridge recorders;
- card readers;
- recording measuring instruments.

DESCRIPTION

The motor has an ironless rotor with oblique winding. The low moment of inertia (38 gcm^2), and the high starting torque (69 mNm) yield a motor constant of no more than 19 ms.
A gold-plated commutator with 9 segments and three-piece silver-plated brushes ensure optimum commutation, thus making the motor suitable for accurate electronic control and optimum functioning as a servo motor or tachogenerator.
The powerful cylindrical steel permanent magnet, around which the rotor rotates, makes for high efficiency.
The above mentioned commutator/brush construction together with the sintered slide bearings ensures a long life, smooth running and low noise level.

The frequency tachogenerator has a gearwheel rotor (72 teeth) which is mounted on the protruding spindle of the motor. The stator consists of a deep drawn steel housing, a magnet strip of plastic-bonded ceramic material which has been magnetized with 72 pole pairs and a coil.
The alternating flux, which arises by rotation of the gearwheel in the magnetic field, is enclosed by the coil in which the tachogenerator voltage is generated.
The frequency of this tachogenerator voltage is determined by the speed of the motor and the number of pole pairs of the tachogenerator.

TECHNICAL DATA Dimensions in mm



The direction of rotation is given in connection with the polarity.

Mass	approx. 250 g

The values given below apply to an ambient temperature of 22 ± 5 °C, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

Direct current motor

Nominal voltage (d.c.)	24 V
Nominal torque	10 mNm
Speed	
at nominal load	2800 ± 350 rev/min
at no load	3300 ± 400 rev/min
Current	
→ at nominal load	max. 180 mA
at no load	max. 15 mA
Starting torque	69 ± 15,5 mNm
Input power	max. 4,2 W
→ Specific input current	12,5 to 16,5 mA/mNm
Rotor resistance	24,5 Ω ± 10%
Rotor moment of inertia	38 gcm^2
→ Motor constant	typ. 20 ms
Bearings	slide bearings
Maximum radial force, 8 mm from bearing	5 N
Maximum axial force	0,5 N
Maximum axial play	0,6 mm
Housing material	sintered iron

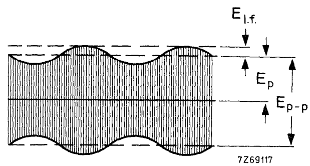
Limiting conditions

The following maximum values indicate those circumstances under which the motor can run continuously without being damaged, but under these circumstances the motor life is greatly reduced.

Maximum voltage (d.c.)	30 V
Maximum permissible load	20 mNm
Maximum permissible input current	275 mA
Maximum speed	4000 rev/min
Maximum output power	5 W
Locked rotor	max. 2 min at 24 V

Tachogenerator

Number of pole pairs	72
Generated voltage, peak to peak value, at 2000 rev/min (E_{p-p})	≥ 1535 mV
Amplitude variation for 1 rev ($\frac{E_{l.f.}}{E_p}$ x 100%)	≤ 15%

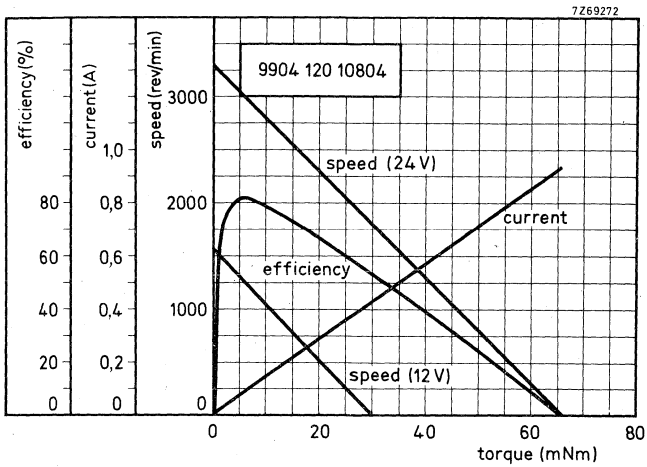


Frequency	$\frac{n.72}{60}$ Hz (n = number of rev/min)
Frequency wobble at 3000 Hz	≤ 0,1% [1]
Temperature coefficient of the generated voltage	−0,2%/°C
Resistance	930 Ω ± 12% ←
Inductance	640 mH ± 15% ←
Housing, material	steel, deep drawn
finish	nickel plated

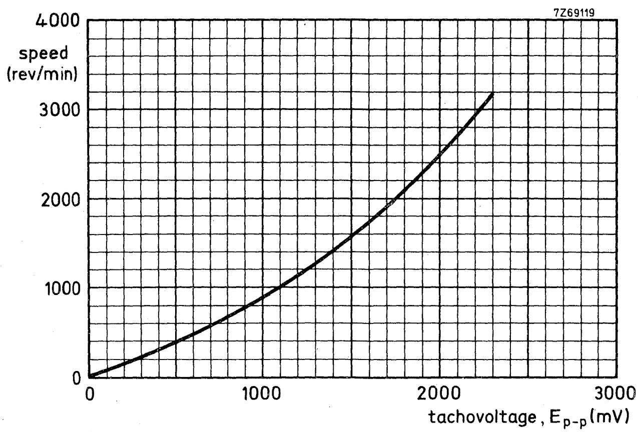
General

Direction of rotation	reversible
Ambient temperature range	−5 to +70 °C

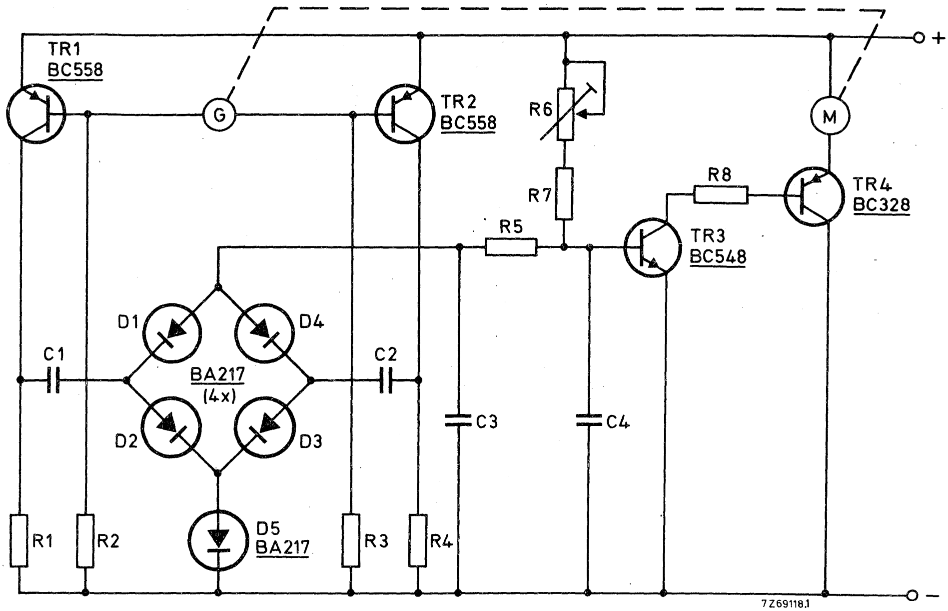
[1]) Measured with EMT measuring instrument type 420 A, position linear.



Typical motor curves



Typical tachogenerator curves



Example of an electronic speed control system

DIRECT CURRENT MOTORS
ironless rotor type

QUICK REFERENCE DATA		
	9904 120 12601	9904 120 12701
Nominal voltage (d.c.)	12 V	24 V
Nominal speed	3900 rev/min	4050 rev/min
Nominal torque	5 mNm	5 mNm

APPLICATION

These motors have been designed for applications which require high acceleration, high efficiency, smooth running (no magnetic holding torque).

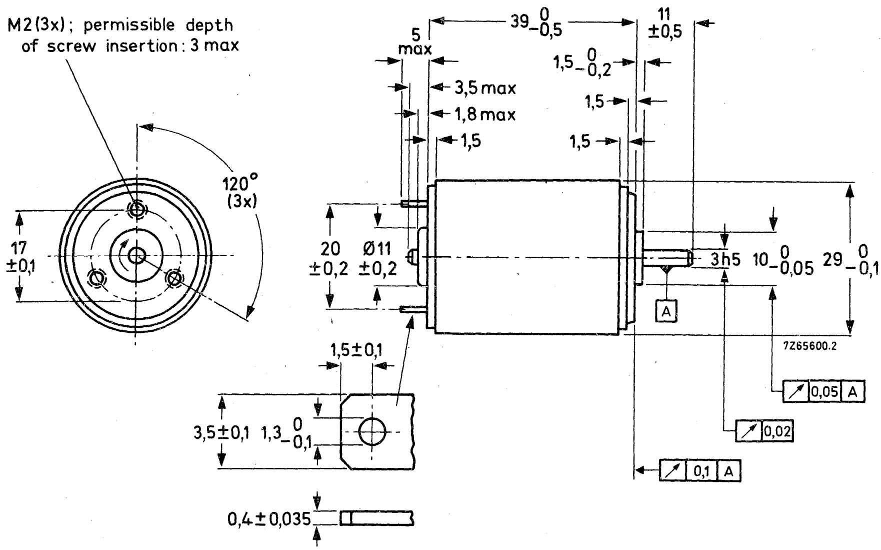
Examples:
- hi-fi cassette recorders;
- video recorders;
- digital cassette recorders (reel and capstan drive);
- recording measuring instruments (chart and pen drive);
- calculating machines;
- process control systems (servo motor or tachogenerator).

DESCRIPTION

These motors have an ironless rotor with oblique windings. The low moment of inertia (9 gcm^2), and the high starting torque (23 mNm), yield a motor constant of no more than 23 ms.
A silver-palladium-plated commutator with 9 segments and silver-plated brushes of four parts ensure optimum commutation, thus making the motor suitable for accurate electronic control and optimum functioning as a servo motor or tachogenerator.
The powerful cylindrical steel permanent magnet, around which the rotor rotates, makes for high efficiency.
The above mentioned commutator/brush construction together with the sintered slide bearings ensures a long life, smooth running and low noise level.

TECHNICAL DATA

Dimensions in mm



The direction of rotation is given in connection with the polarity indicated on the terminals.

Mass	approx. 100 g

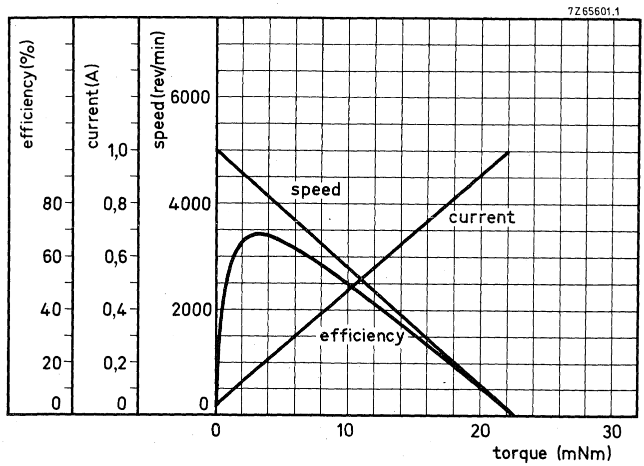
The values given below apply to an ambient temperature of 22 ± 5 °C, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

	9904 120 12601	9904 120 12701
Nominal voltage (d.c.)	12 V	24 V
Nominal torque	5 mNm	5 mNm
Speed at nominal load	3900 ± 525 rev/min	4050 ± 550 rev/min
at no load	5125 ± 675 rev/min	5300 ± 700 rev/min
Current at nominal load	260 ± 40 mA	135 ± 25 mA
at no load	max. 45 mA	max. 20 mA
Starting torque	23 ± 6 mNm	23 ± 6 mNm
Input power	max. 3,6 W	max. 3,7 W
Specific input current	40 to 50,5 mA/mNm	21 to 27 mA/mNm
Induced voltage	2,03 to 2,57 mV per rev/min	4,0 to 5,0 mV per rev/min
Rotor resistance	11,8 Ω ± 10%	45 Ω ± 10%
Direction of rotation	reversible	reversible
Ambient temperature range	−5 to +70 °C	−5 to +70 °C
Rotor moment of inertia	9 gcm^2	9 gcm^2
Motor constant	typ. 23 ms	typ. 23 ms
Bearings	slide bearings	slide bearings
Maximum radial force 10 mm from bearing	3,4 N	3,4 N
Maximum axial force	0,5 N	0,5 N
Maximum axial play	0,4 mm	0,4 mm
Housing material	steel	steel

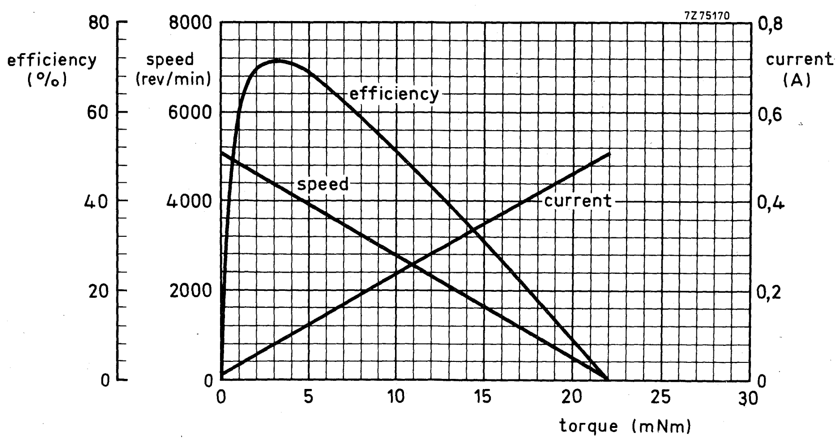
Limiting conditions

The following maximum values indicate those circumstances under which the motor can run continuously without being damaged, but under these circumstances the motor life is greatly reduced.

	9904 120 12601	9904 120 12701
Maximum voltage (d.c.)	16 V	32 V
Maximum permissible load	6,5 mNm	6,5 mNm
Max. permissible current	375 mA	225 mA
Maximum speed	6000 rev/min	6000 rev/min
Maximum output power	3 W	3 W
Locked rotor	max. 2 min at 12 V	max. 2 min at 24 V



Typical curves of motor 9904 120 12601 at 12 V, T_{amb} = 22 °C



Typical curves of motor 9904 120 12701 at 24 V, T_{amb} = 22 °C

DIRECT CURRENT MOTOR
with frequency tachogenerator

QUICK REFERENCE DATA

Motor		Tachogenerator	
Nominal voltage (d.c.)	12 V	Number of pole pairs	72
Nominal speed	3960 rev/min	Generated voltage at 3000 rev/min	≥ 650 mV(r.m.s.)
Nominal torque	5 mNm	Frequency wobble at 3150 Hz	≤ 0,11%

APPLICATION

This motor-tachogenerator combination has been designed for applications which require a direct current drive system the speed of which can be controlled in a very accurate and reliable way, and where high acceleration, high efficiency and smooth running are preferred.

Examples:
- hi-fi reel-to-reel recorders (capstan drive);
- video recorders (capstan drive);
- hi-fi cassette recorders (capstan drive);
- digital cassette recorders (capstan and reel drive);
- card readers;
- recording measuring instruments.

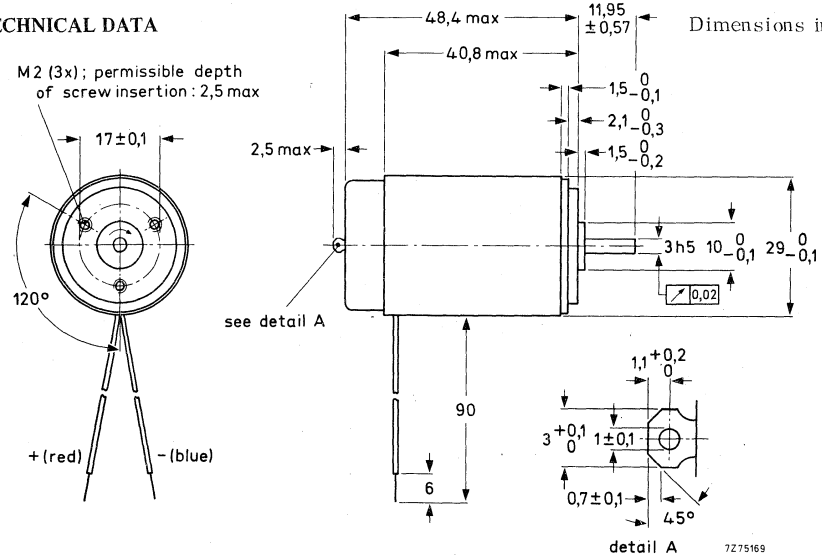
DESCRIPTION

The motor has an ironless rotor with oblique winding. The low moment of inertia (10,5 gcm^2), and the high starting torque (22 mNm) yield a mechanical time constant of no more than 25,7 ms.
A gold-plated commutator with 9 segments and silver-plated brushes of four parts ensure optimum commutation, thus making the motor suitable for accurate electronic control and optimum functioning as a servo motor or tachogenerator.
The powerful cylindrical steel permanent magnet, around which the rotor rotates, makes for high efficiency.
The above-mentioned commutator/brush construction together with the sintered slide bearings ensures a long life, smooth running and low noise level.

The frequency tachogenerator has a gearwheel rotor (72 teeth) which is mounted on the protruding spindle of the motor. The stator consists of a deep drawn steel housing, a magnet strip of plastic-bonded ceramic material which has been magnetized with 72 pole pairs and a coil.
The alternating flux, which arises by rotation of the gearwheel in the magnetic field, is enclosed by the coil in which the tachogenerator voltage is generated.
The frequency of this tachogenerator voltage is determined by the speed of the motor and the number of pole pairs of the tachogenerator.

TECHNICAL DATA

Dimensions in mm



The direction of rotation is given in connection with the polarity.
The position of the mounting holes with respect to the connecting leads is arbitrary.

Mass	approx. 126 g

The values given below apply to an ambient temperature of 22 ± 5 °C, an atmospheric pressure of 860 to 1060 mbar and a relative humidity of 45 to 75%.

Direct current motor

Nominal voltage (d.c.)	12 V
Nominal torque	5 mNm
Speed at nominal load	3960 ± 540 rev/min
at no load	5135 ± 735 rev/min
Current at nominal load	max. 310 mA
at no load	max. 51 mA
Starting torque	22,25 ± 5,7 mNm
Input power	max. 3,72 W
Specific input current	40,0 to 52,36 mA/mNm
Rotor resistance	11,8 Ω ± 10%
Rotor moment of inertia	10,5 gcm^2
Mechanical time constant [1]	typ. 25,7 ms
Bearings	slide bearings
Maximum radial force	5 N
Maximum axial force	0,5 N
Maximum axial play	0,4 mm
Housing material	steel

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1) According to $n_t = n_o\,(1 - e^{\frac{-t}{\tau}})$.

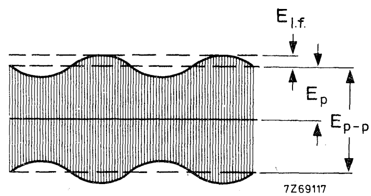
Limiting conditions

The following maximum values indicate those circumstances under which the motor can run continuously without being damaged, but under these circumstances the motor life is greatly reduced.

Maximum voltage (d.c.)	16 V
Maximum permissible load	6,5 mNm
Maximum permissible input current	375 mA
Maximum speed	6000 rev/min
Maximum output power	3 W

Tachogenerator

Number of pole pairs	72
Generated voltage, peak to peak value, at 3000 rev/min	≥ 650 mV(r.m.s.)
Amplitude variation for 1 rev $(\frac{E_{l.f.}}{E_p} \times 100\%)$	≤ 15%

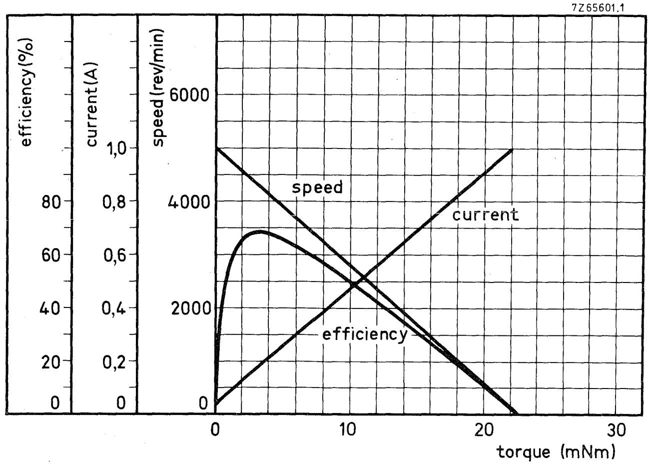


Frequency	$\frac{n.72}{60}$ Hz (n = number of rev/min)
Frequency wobble at 3150 Hz	≤ 0,11% [1]
Temperature coefficient of the generated voltage	approx. −0,2%/°C
Resistance	930 Ω ± 15%
Inductance	640 mH ± 15%
Housing, material	steel, deep drawn
finish	nickel plated

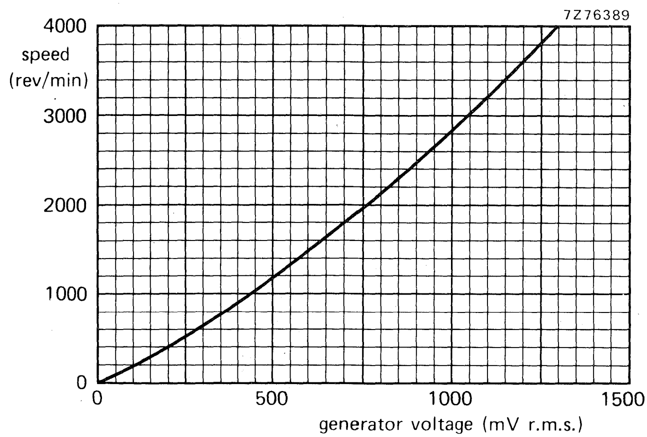
General

Direction of rotation	reversible
Ambient temperature range	−10 to +70 °C

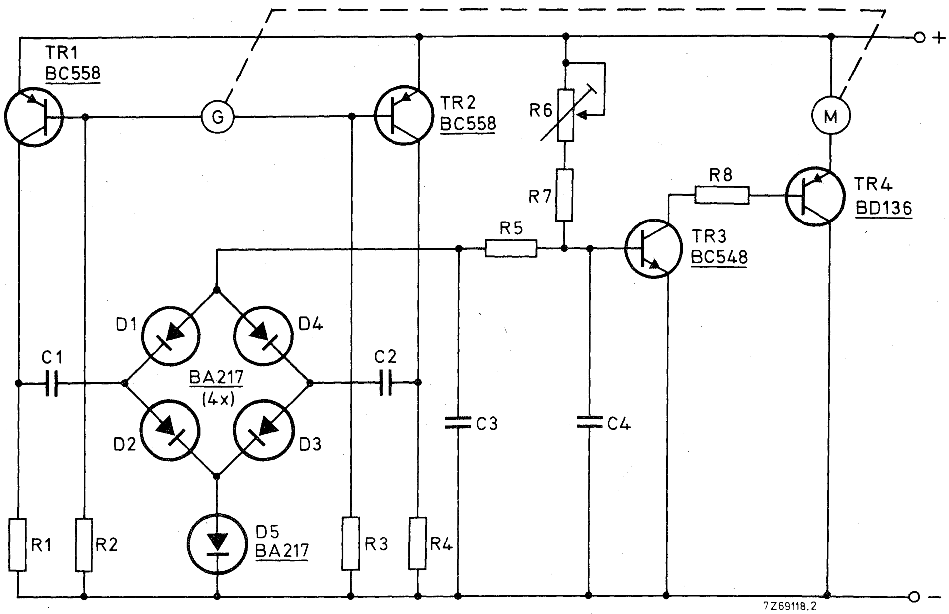
[1]) Measured with EMT measuring instrument type 420 A, position linear, DIN.



Typical motor curves



Typical tachogenerator curves

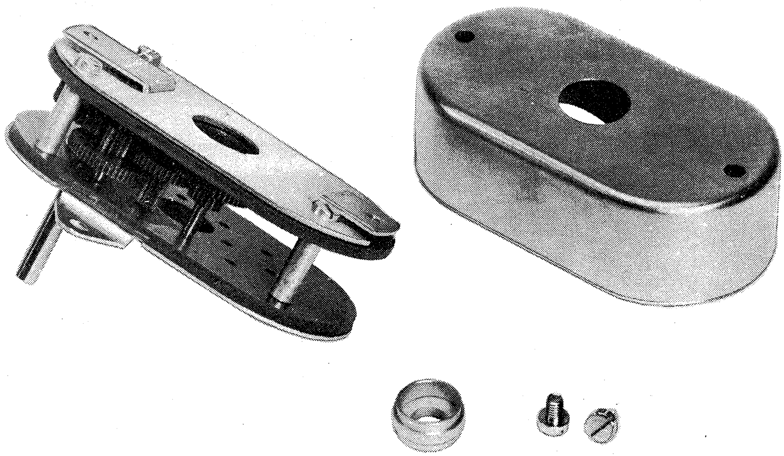


Example of an electronic speed control system

Accessories

GEARBOXES

for unidirectional synchronous motors



GENERAL

The reduction gearboxes of the 9904 130 01... series have been designed for use with the synchronous motors, provided with a pinion. They are supplied separately but can easily be mounted to any of these motors.

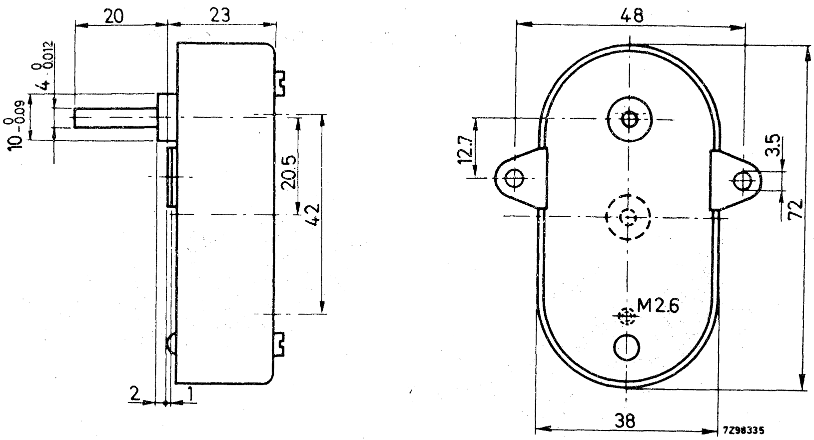
To attach the motor to the gearbox, place the reversible centring bush in position so that it fits the centring rim on the motor casing, and fasten the motor by means of the two screws in the gearbox cover. For fastening the motors 9904 110 05... and 9904 110 06... the gearbox is provided with two threaded holes M2,6.

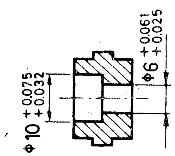
Many different gear ratios can be built into the same metal casing; there are 19 standard gear ratios.
The gearboxes are meant for small series and professional applications with versatility as the main property. As a rule small quantities can be supplied from stock.

For all data necessary for selecting the appropriate gearbox from the series, see the survey.

TECHNICAL DATA

Dimensions in mm





centring bush

Maximum permissible load	200 mNm
Maximum permissible radial force	10 N
Maximum permissible axial force	2 N

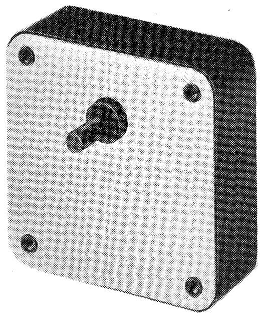
SURVEY

gear ratio	number of revolutions of outgoing spindle when coupled to a motor operating from		direction of rotation of outgoing spindle compared to motor spindle [1]	efficiency	catalogue number
	50 Hz mains	60 Hz mains			
25:6	60 rev/min	72 rev/min	same	0,64	9904 130 01001
25:4	40 rev/min	48 rev/min	same	0,64	01003
25:3	30 rev/min	36 rev/min	same	0,64	01004
10:1	25 rev/min	30 rev/min	same	0,64	01005
25:2	20 rev/min	24 rev/min	same	0,64	01006
50:3	15 rev/min	18 rev/min	opposite	0,51	01008
20:1	12,5 rev/min	15 rev/min	same	0,64	01009
25:1	10 rev/min	12 rev/min	opposite	0,51	01011
100:3	7,5 rev/min	9 rev/min	opposite	0,51	01014
125:3	6 rev/min	7,2 rev/min	opposite	0,51	01016
50:1	5 rev/min	6 rev/min	opposite	0,51	01017
125:2	4 rev/min	4,8 rev/min	opposite	0,51	01019
250:3	3 rev/min	3,6 rev/min	same	0,41	01021
125:1	2 rev/min	2,4 rev/min	opposite	0,51	01023
250:1	1 rev/min	1,2 rev/min	same	0,41	01027
500:1	30 rev/h	36 rev/h	same	0,41	01034
750:1	20 rev/h	24 rev/h	opposite	0,33	01037
1250:1	12 rev/h	14,4 rev/h	opposite	0,33	01041
15000:1	1 rev/h	1,2 rev/h	opposite	0,21	01062

[1]) When the direction of rotation of the outgoing spindle is not the one which is desired a motor with the reverse direction of rotation should be chosen.

GEARBOXES

for reversible synchronous motors



GENERAL

The reduction gearboxes of the 9912 200 000.. series have been designed for use with all reversible synchronous motors with $\phi 3$ mm or $\phi 2$ mm spindles. They are supplied with two pinions, one with a bore of 3 mm, one with a bore of 2 mm. The locating hole in the gearbox has a diameter of 12 mm and mates with the centring rim of motors 9904 111 27... A centring bush is provided for motors with a centring rim of 10 mm.

Precision cut, brass gearwheels and impregnated bronze bearings, pressed into the aluminium side frames, ensure a long, trouble free life. The side frames are shielded from the outside with a layer of stainless steel to prevent migration of the bearing oil. A dust cover encloses the gearbox assembly to protect the rotating parts against penetration of foreign particles.

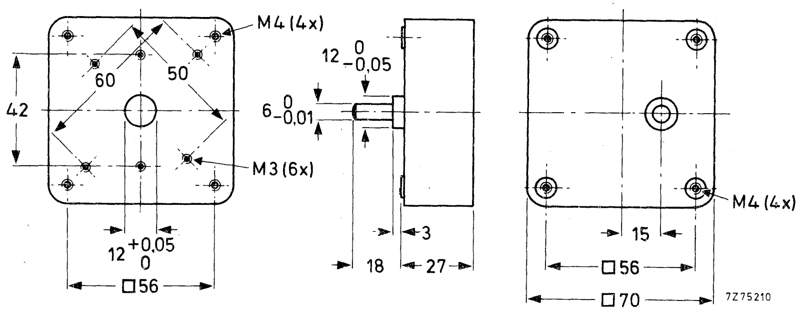
Before mounting the motor onto the gearbox, the proper pinion must be pressed onto the motor spindle. Make sure that during the press-fit operation, **the motor spindle is supported from the other side.**
The motors 9904 111 04..., 9904 111 07... and 9904 111 31... have an open-ended rear cover, so support of the spindle is simple.
The motors 9904 111 06... and 9904 111 27... have a closed rear cover, **which should be removed** to support the spindle properly.

After removing this rear cover the spindle of motors 9904 111 27... can easily be reached, whilst the spindle of motors 9904 111 06... remains invisible, but can be supported through the threaded hole in the bearing bracket.
To avoid dislocation of the connecting leads adhesive tape can be used to keep the leads in place during this operation.

The gearbox is provided with threaded holes M3 for fastening the motors 9904 111 04..., 9904 111 06..., 9904 111 07... and 9904 111 31... . The four corner pillars are provided with threaded holes M4 for fastening motors 9904 111 27... . For mounting the motor-gearbox assembly to the application, use can be made of the threaded holes M4 at the other side of the pillars.

TECHNICAL DATA

Dimensions in mm



Maximum permissible load	3000 mNm
Maximum permissible radial force	50 N
Maximum permissible axial force	20 N
Ambient temperature range	−20 to +70 °C
Side frames	aluminium
Bearings	sleeve bearings
Gearwheels	brass
Mass	approx. 400 g

SURVEY

Preferred range

gear ratio	number of revolutions of outgoing spindle when coupled to a motor operating from		catalogue number
	50 Hz mains	60 Hz mains	
25 : 6	60 rev/min	72 rev/min	9912 200 00001
25 : 3	30 rev/min	36 rev/min	00004
25 : 2	20 rev/min	24 rev/min	00006
50 : 1	5 rev/min	6 rev/min	00017
250 : 1	1 rev/min	1, 2 rev/min	00027
1000 : 1	15 rev/h	18 rev/h	00039
5000 : 1	3 rev/h	3, 6 rev/h	00054
15000 : 1	1 rev/h	1, 2 rev/h	00062

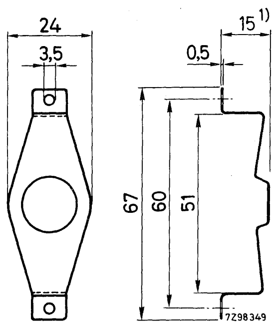
Non-preferred range – Gearboxes listed below are available on request only in minimum order quantities and involve longer delivery times.

gear ratio	number of revolutions of outgoing spindle when coupled to a motor operating from		catalogue number
	50 Hz mains	60 Hz mains	
25 : 4	40 rev/min	48 rev/min	9912 200 00003
10 : 1	25 rev/min	30 rev/min	00005
50 : 3	15 rev/min	18 rev/min	00008
20 : 1	12, 5 rev/min	15 rev/min	00009
25 : 1	10 rev/min	12 rev/min	00011
100 : 3	7, 5 rev/min	9 rev/min	00014
125 : 3	6 rev/min	7, 2 rev/min	00016
125 : 2	4 rev/min	4, 8 rev/min	00019
250 : 3	3 rev/min	3, 6 rev/min	00021
125 : 1	2 rev/min	2, 4 rev/min	00023
500 : 1	30 rev/h	36 rev/h	00034
750 : 1	20 rev/h	24 rev/h	00037
1250 : 1	12 rev/h	14, 4 rev/h	00041

MOUNTING BRACKET

for small synchronous motors 9904 110 02...

A special bracket, catalogue number 9904 131 01001 has been made available for mounting the unidirectional motors of the series 9904 110 02... to some piece of equipment, which may be a gearbox.



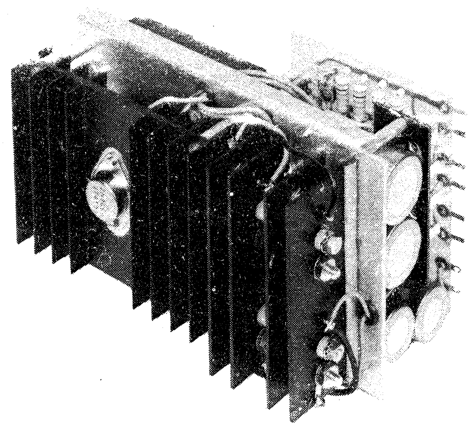
1) In mounted position.

POWER SUPPLY UNIT

for bipolar constant current drive

QUICK REFERENCE DATA	
Input voltage	220 V, 50 to 60 Hz
Output	+60 V, 1,5 A + 5 V, 2,5 A

750528-15-01



APPLICATION

The power supply unit has been designed to supply the required voltages and currents for one or two BCCD units, catalogue number 4322 027 90070, to drive a bipolar stepper motor. A current of maximum 2 A from the 5 V supply can be used for additional logic.

DESCRIPTION

The unit consists mainly of a transformer and a rectifier. The mains voltage of 220 V is transformed into two voltages which, after being rectified, are matched to the BCCD unit supply requirements (5 V and 60 V). Provision is made in the unit so that the 60 V supply becomes available later than the 5 V supply when the unit is switched on. When the unit is switched off, electrolytic capacitors in the unit must be discharged so that the 5 V supply is maintained until the 60 V supply has dropped below 30 V. This can be achieved with a double-pole, double-throw switch.

MECHANICAL DATA

Dimensions in mm

Outlines

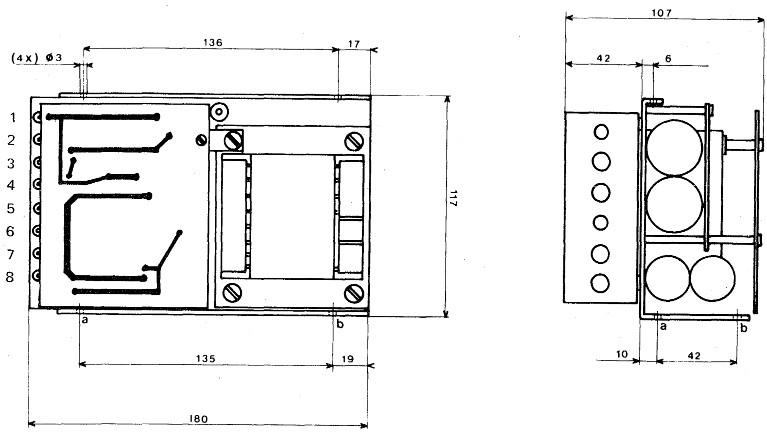


Fig. 1

Mass 3,2 kg approximately

Connections (see Fig. 1)

Terminal 1 = +5 V supply (V_L)
2 = +60 V supply (V_D)
3 = 0 V of V_L
4 = 0 V of V_D
5 = discharge terminal of V_L
6 = discharge terminal of V_D
7 = } 220 V, 50/60 Hz input terminals
8 = }

The terminals are suitable for direct soldering.

Mounting

The unit has four mounting holes of 3 mm as indicated in Fig. 1.

ELECTRICAL DATA

Input

Voltage	220 V, +10/−15%
Current with 2-ph. motor with 4-ph. motor	max. 450 mA max. 650 mA
Frequency	50 to 60 Hz
Fuse (F1) *)	thermal, at 0 A for T_{amb} = 138 °C at 4 A for T_{amb} = 52 °C

Output

BCCD supply

Voltage (V_D)	+60 V, +20/−30%
Current	max. 1,5 A
Fuse (F3) *)	2 A, slow

Logic supply

Voltage (V_L)	+5 V ± 5%
Current	max. 2,5 A
Internal resistance	max. 12 mΩ
Ripple voltage	max. 20 mV
Fuse (F2) *)	4 A, slow

Automatic short-circuit protection.

Ambient temperature range

Operating	0 to +70 °C
Storage	−40 to +70 °C

Caution: when using the power supply in combination with BCCD unit 4322 027 90070, a double-pole double-throw switch must be used to discharge electrolytic capacitors in the power supply (terminals 5 and 6) at switching off. See also data sheet of BCCD unit.

*) Easily replaceable.

Circuit diagram

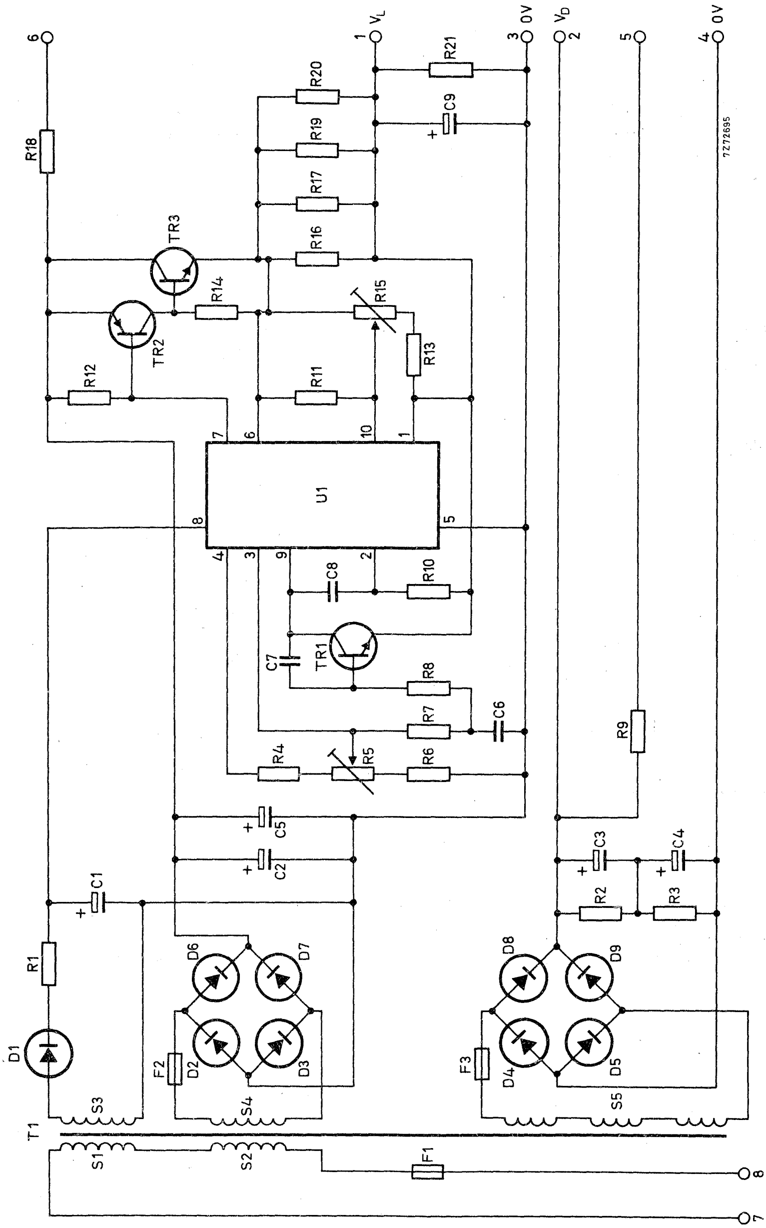


Fig. 2

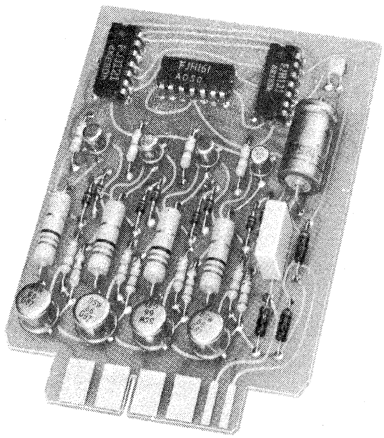
Parts list

D1	diode	BA148
D2, D3, D4, D5	diode	BYX42 - 300 R
D6, D7, D8, D9	diode	BYX42 - 300
TR1	transistor	BC148
TR2	transistor	BD132
TR3	transistor	BDY20
U1	integrated circuit	μA723 CL
C1	capacitor	10 μF, 63 V
C2, C5	capacitor	6800 μF, 25 V
C3, C4	capacitor	3300 μF, 40 V
C6	capacitor	0,33 μF, 100 V
C7	capacitor	1000 pF, 100 V
C8	capacitor	680 pF, 100 V
C9	capacitor	100 μF, 10 V
R1, R8	carbon resistor	120 Ω, 5%, 0,33 W
R2, R3, R7, R11	carbon resistor	10000 Ω, 5%, 0,33 W
R4	carbon resistor	750 Ω, 5%, 0,33 W
R5	carbon preset potentiometer	470 Ω
R6	carbon resistor	2200 Ω, 5%, 0,33 W
R9	carbon resistor	56 Ω, 5%, 1,15 W
R10, R12	carbon resistor	680 Ω, 5%, 0,33 W
R13	carbon resistor	200 Ω, 5%, 0,33 W
R14	carbon resistor	56 Ω, 5%, 0,33 W
R15	carbon preset potentiometer	220 Ω
R16, R17, R19, R20	carbon resistor	1 Ω, 5%, 1,15 W
R18	carbon resistor	12 Ω, 5%, 1,15 W
R21	carbon resistor	68 Ω, 5%, 0,5 W
T1	transformer	primary (S1+S2) : 220 V, 50/60 Hz
		secondary S3 : 16 V, 0,01 A
		S4 : 11 V, 3,7 A
		S5 : 46,5 V, 1,5 A
F1	temperature fuse	0 A : T_{amb} = 138 °C
		4 A : T_{amb} = 52 °C
F2	miniature fuse	4 A, slow
F3	miniature fuse	2 A, slow

ELECTRONIC SWITCH

for 4-phase unipolar stepper motors

RZ26753-1



APPLICATION

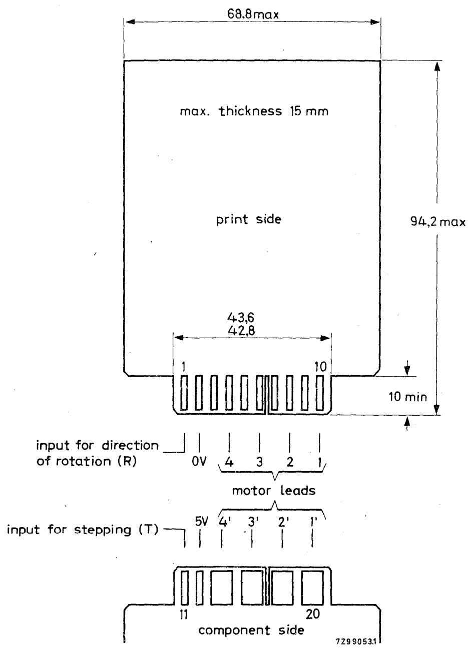
The electronic switch changes a train of input pulses into a sequential pulse output which provides the required pulse pattern for driving 4-phase unipolar stepper motors.

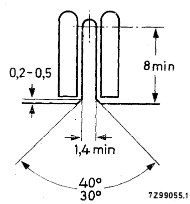
DESCRIPTION

The electronic switch is essentially a reversible ring counter, each of its 4 outputs being followed by an output stage. The ring counter is built up with IC s of the GFB family which need a supply voltage of 5 V. For this reason the whole unit has been designed for this voltage. The unit has two inputs : the first one receives the order for the rotor to perform the step, the second one determines the direction of rotation by means of a d.c. level. The output stages are equipped with silicon transistors developed for switching inductive loads. All components are mounted on a double-sided printed-wiring board that mates with a printed-wiring connector with two rows of 10 contacts and a contact pitch of 0, 156 inch.

TECHNICAL DATA

Dimensions (mm) and terminal location





Detailed view of the slot

Weight 40 g

Ambient temperature range

operating	0 to + 70 °C
storage	−40 to +70 °C

Power supply

voltage (V_b)	+5 V ± 5%
current (at V_b = 5 V)	230 mA ± 10%

Input data

Direction of rotation

The level of V_R may change state only when the input pulse for stepping is LOW.

V_R, HIGH (clockwise)	≥ 2,0 V, ≤ 5 V
LOW (counter-clockwise)	≥ 0 V, ≤ 0,8 V
V_R, limiting value *)	max. 5,5 V
I_R, at V_R HIGH	max. 0,12 mA
$-I_R$, at V_R LOW	max. 4,8 mA
$-I_R$, limiting value *)	20 mA

Stepping

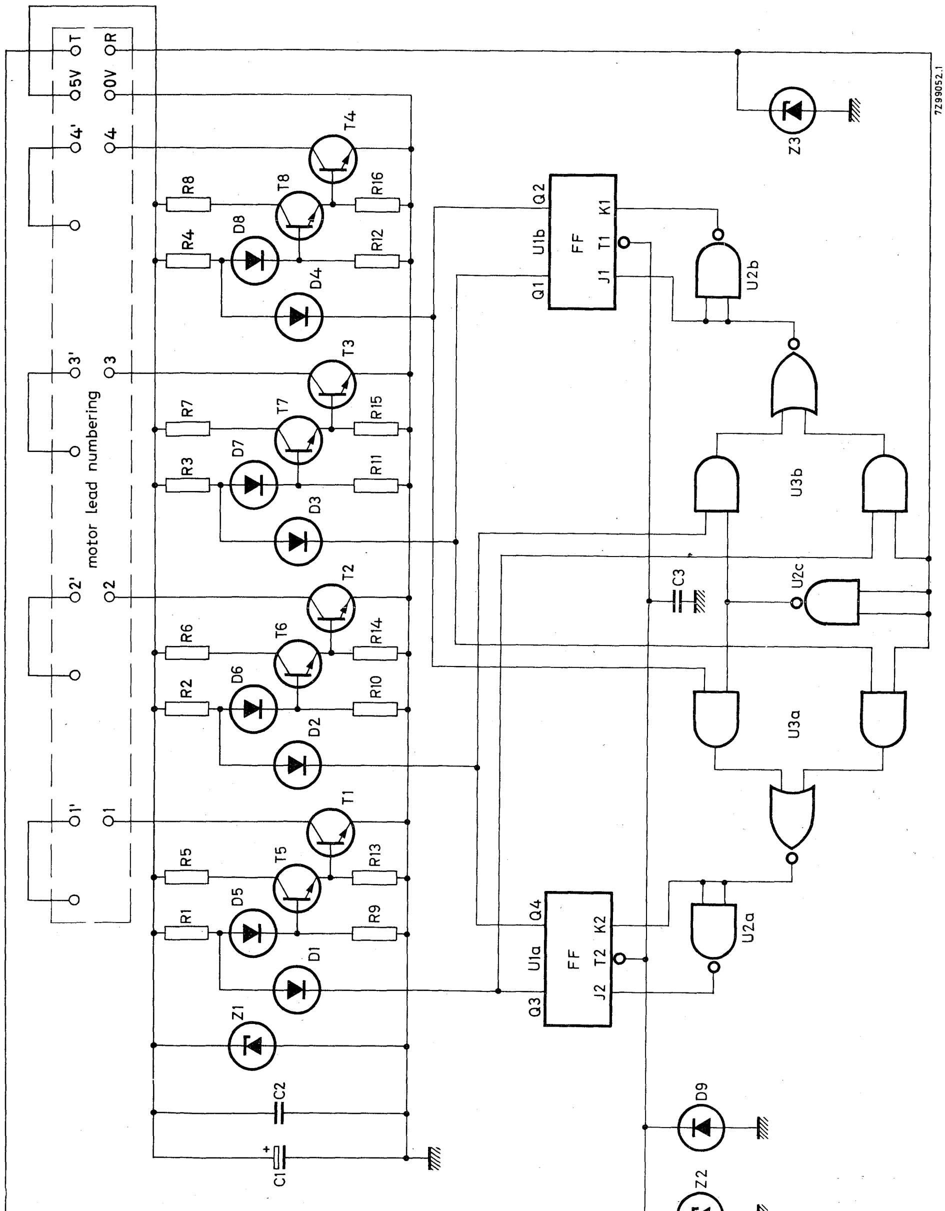
V_T, HIGH	≥ 2,0 V, ≤ 5 V
LOW	≥ 0 V, ≤ 0,8 V
V_T, limiting value *)	max. 5,5 V
I_T, at V_T HIGH	max. 0,25 mA
$-I_T$, at V_T LOW	max. 6,4 mA
$-I_T$, limiting value *)	20 mA
Pulse width, V_T HIGH	min. 100 ns
Pulse frequency	max. 25 kHz

Output data

Permissible voltage (at each output)	max. 100 V
Permissible current (per output)	max. 600 mA
Saturation voltage (V_{CE})	max. 500 mV

*) In accordance with the Absolute Maximum Rating System as defined in IEC publication 134.

Circuit diagram

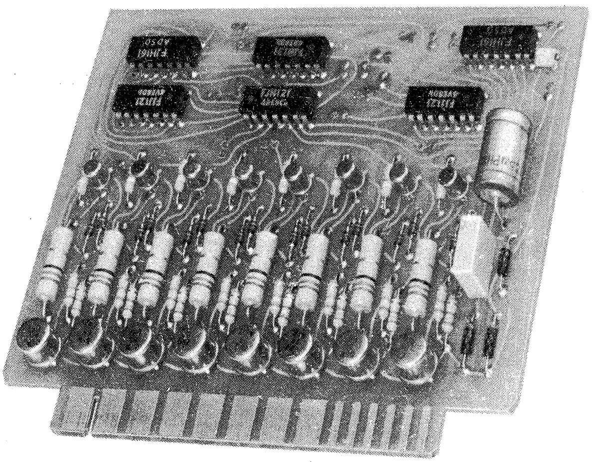


Parts list

component	description	value	tolerance
C1	capacitor	125 μF, 10 V	-10/+50%
C2	capacitor	0,1 μF	10%
C3	capacitor	1 nF	10%
D1 -D8	diode	BAX13	
D9	diode	AAZ18	
U1	integrated circuit	GFB7473D	
U2	integrated circuit	GFB7400D	
U3	integrated circuit	GFB7451D	
R1 -R4	carbon resistor	390 Ω, 0,2 W	5%
R5 -R8	carbon resistor	51 Ω, 0,7 W	5%
R9 -R12	carbon resistor	6,8 kΩ, 0,2 W	5%
R13-R16	carbon resistor	180 Ω, 0,2 W	5%
T1 -T4	transistor	BSW66	
T5 -T8	transistor	BC107	
Z1	voltage regulator diode	BZY88-C5V6	
Z2 -Z3	voltage regulator diode	BZY88-C5V1	

ELECTRONIC SWITCH

for 8-phase unipolar stepper motors



RZ 26753-2

APPLICATION

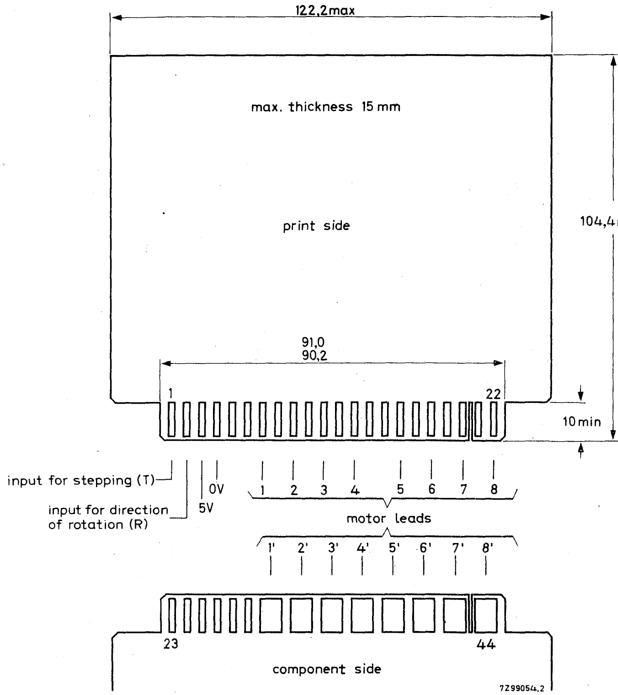
The electronic switch changes a train of input pulses into a sequential pulse output which provides the required pulse pattern for driving 8-phase unipolar stepper motors.

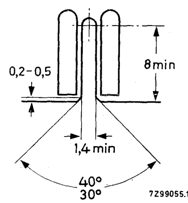
DESCRIPTION

The electronic switch is essentially a reversible ring counter, each of its 8 outputs being followed by an output stage. The ring counter is built up with IC s of the GFB family which need a supply voltage of 5 V. For this reason the whole unit has been designed for this voltage. The unit has two inputs: the first one receives the order for the rotor to perform the step, the second one determines the direction of rotation by means of a d. c. level. The output stages are equipped with silicon transistors developed for switching inductive loads. All components are mounted on a double-sided printed-wiring board that mates with printed-wiring connector with two rows of 22 contacts and a contact pitch of 0, 156 inch.

TECHNICAL DATA

Dimensions (mm) and terminal location





Detailed view of the slot

Weight 80 g

Ambient temperature range

operating	0 to +70 °C
storage	−40 to +70 °C

Power supply

voltage (V_b)	+5 V ± 5%
current (at V_b = 5 V)	440 mA ± 10%

Input data

Direction of rotation

The level of V_R may change state only when the input pulse for stepping is LOW.

V_R , HIGH (clockwise)	≥ 2,0 V, ≤ 5 V
LOW (counter-clockwise)	≥ 0 V, ≤ 0,8 V
V_R , limiting value *)	max. 5,5 V
I_R , at V_R HIGH	max. 0,2 mA
$-I_R$, at V_R LOW	max. 8 mA
$-I_R$, limiting value *)	20 mA

Stepping

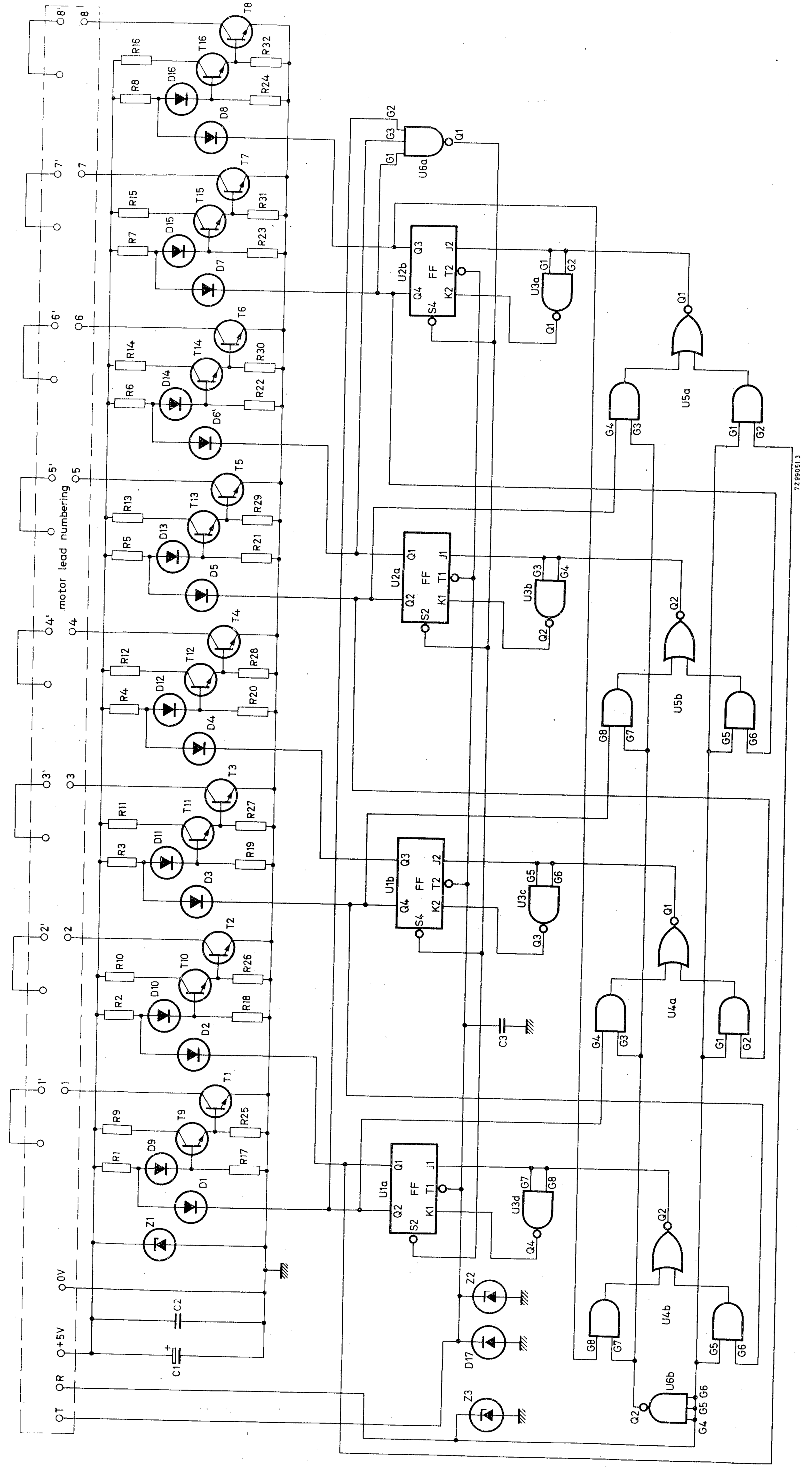
V_T , HIGH	≥ 2,0 V, ≤ 5 V
V_T , LOW	≥ 0 V, ≤ 0,8 V
V_T , limiting value *)	max. 5,5 V
I_T , at V_T HIGH	max. 0,4 mA
$-I_T$, at V_T LOW	max. 12,8 mA
$-I_T$, limiting value *)	20 mA
Pulse width, V_T HIGH	min. 100 ns
Pulse frequency	max. 25 kHz

Output data

Permissible voltage (at each output)	max. 100 V
Permissible current (per output)	max. 600 mA
Saturation voltage (V_{CE})	max. 500 mV

*) In accordance with the Absolute Maximum Rating System as defined in IEC publication 134.

Circuit diagram



Parts list

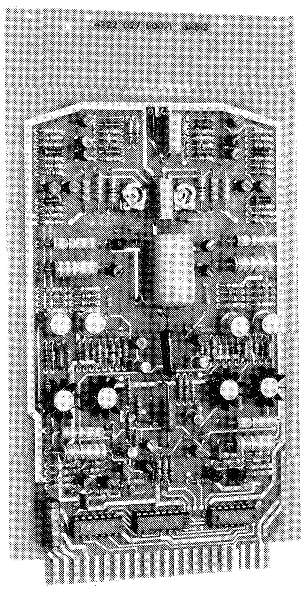
component	description	value	tolerance
C1	capacitor	125 μF, 10 V	−10/+50%
C2	capacitor	0,1 μF	10%
C3	capacitor	1 nF	10%
D1 -D16	diode	BAX13	
D17	diode	AAZ18	
U1	integrated circuit	GFB7473D	
U2	integrated circuit	GFB7473D	
U3	integrated circuit	GFB7400D	
U4	integrated circuit	GFB7451D	
U5	integrated circuit	GFB7451D	
U6	integrated circuit	GFB7410D	
R1 -R8	carbon resistor	390 Ω, 0,2 W	5%
R9 -R16	carbon resistor	51 Ω, 0,7 W	5%
R17-R24	carbon resistor	6,8 kΩ, 0,2 W	5%
R25-R32	carbon resistor	180 Ω, 0,2 W	5%
T1 -T8	transistor	BSW66	
T9 -T16	transistor	BC107	
Z1	voltage regulator diode	BZY88-C5V6	
Z2 -Z3	voltage regulator diode	BZY88-C5V1	

BIPOLAR CONSTANT CURRENT DRIVE

for 2- and 4-phase stepper motors

QUICK REFERENCE DATA	
Supply voltages	5 V ± 5 % 60 V +20/−30 %
Output currents	2 x max. 500 mA
Control inputs for direction of rotation and stepping	TTL compatible

750527-17-04



APPLICATION

The BCCD unit is designed to drive bipolar stepper motors. It converts the input data into the requisite current reversals through successive stator coils of 2- and 4-phase bipolar motors. Two drive units are needed for 4-phase bipolar motors.

DESCRIPTION

A simplified circuit diagram is shown in Fig. 1 (the complete circuit diagram is given in Fig. 5). The unit consists of two parts: a logic control circuit and a motor drive circuit. The logic control circuit needs a supply voltage of 5 V and has two inputs: input (T) (Figs 3, 4 and 5) receives the command for the rotor to perform the step, input (R) determines the direction of rotation. The motor drive circuit needs a supply voltage of 60 V and forms the output stages which drive the stator coils of the motor. The maximum current through the stator coils is controlled by a level detector (chopper), see Fig. 1. This ensures that the current through a stator coil reaches its maximum value in the shortest possible time and reduces the power consumption of the overall system. The current remains constant over the greater part of the stepping rate. Consequently the motor temperature increases with the increase of the stepping rate due to the iron losses within the motor.

It should be noted that the bipolar stepper motors in conjunction with the BCCD unit, are not designed for continuous operation in the pull-out range but are intended for applications requiring rapid positioning in which the pull-out operation is limited to a few seconds. Prolonged duty cycles in the pull-out range may result in an unacceptable temperature rise of the motor.

The unit has four different current settings to match the drive current to the application requirements. The torque characteristics in the pull-in and pull-out range will be affected by the current setting, however, the maximum pull-out rate will not be reduced.

All components are mounted on a double-sided printed-wiring board, which mates with printed-wiring connector type F047, having two rows of 22 contacts and a contact pitch of 0,156 inch.

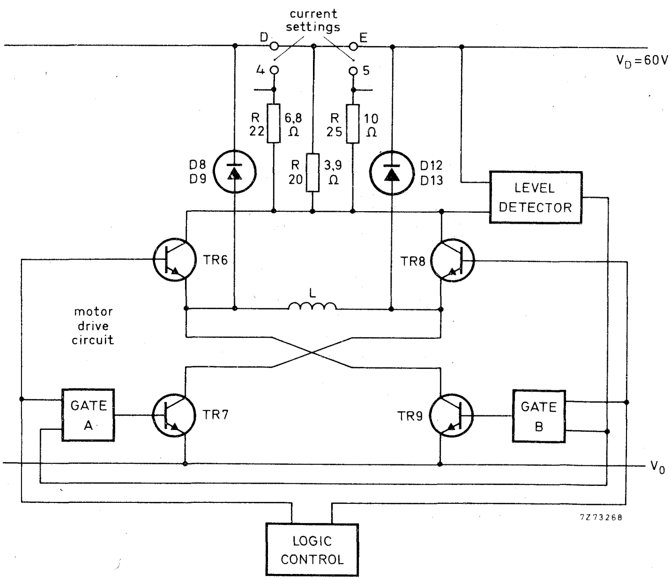
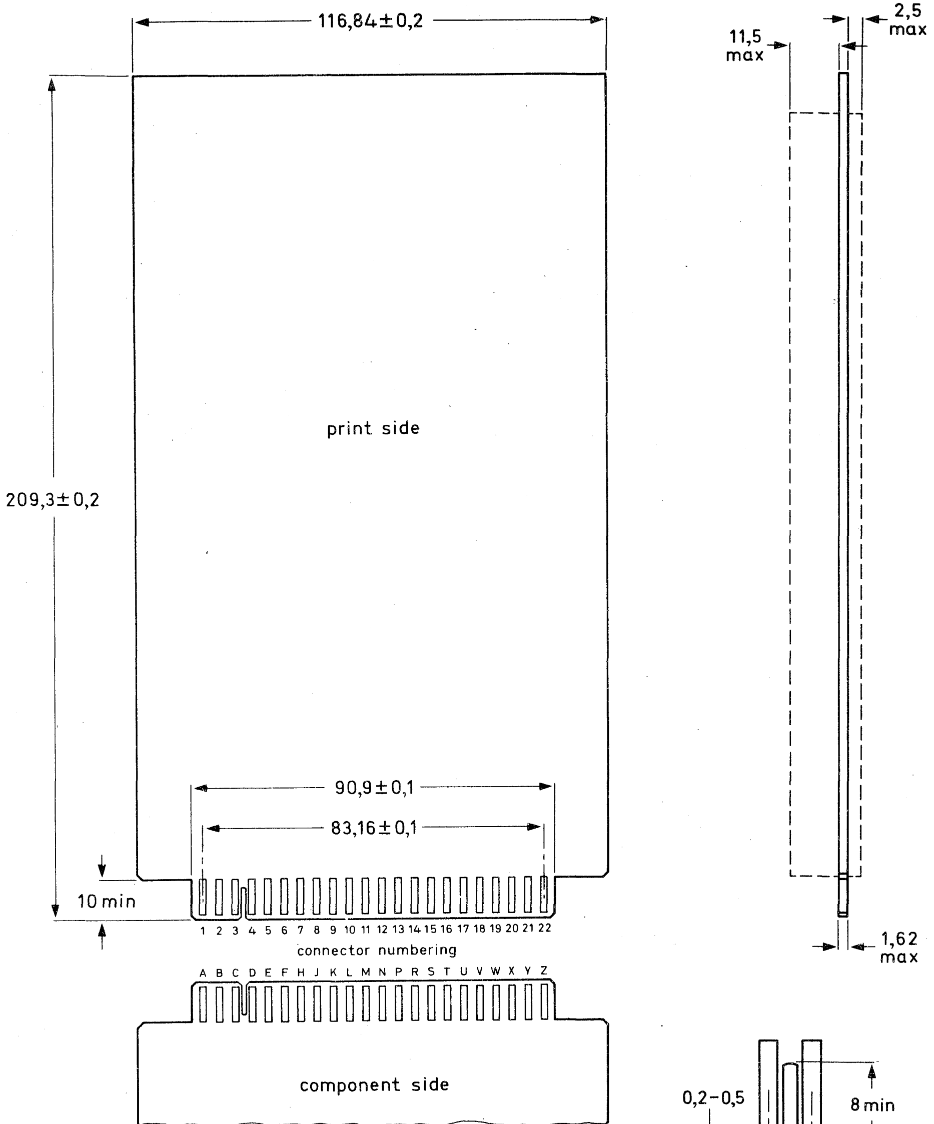


Fig. 1 Basic bipolar constant current drive circuit for one stator coil (L).

MECHANICAL DATA

Dimensions (mm)



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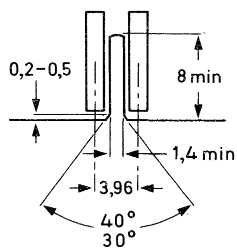


Detailed view
of the slot

Weight 80 g

Connections

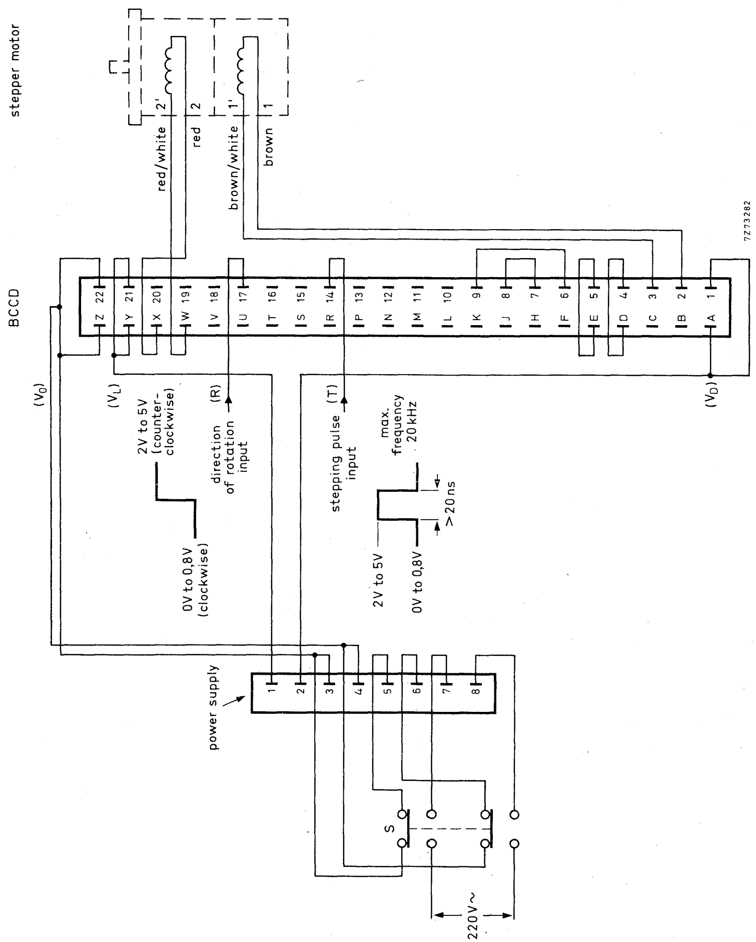


Fig. 3. Connection diagram for a BCCD unit, a 2-phase bipolar motor and power supply unit 9904 132 02001. A double-pole double-throw switch is needed to discharge electrolytic capacitors in the power supply unit when it is switched off.

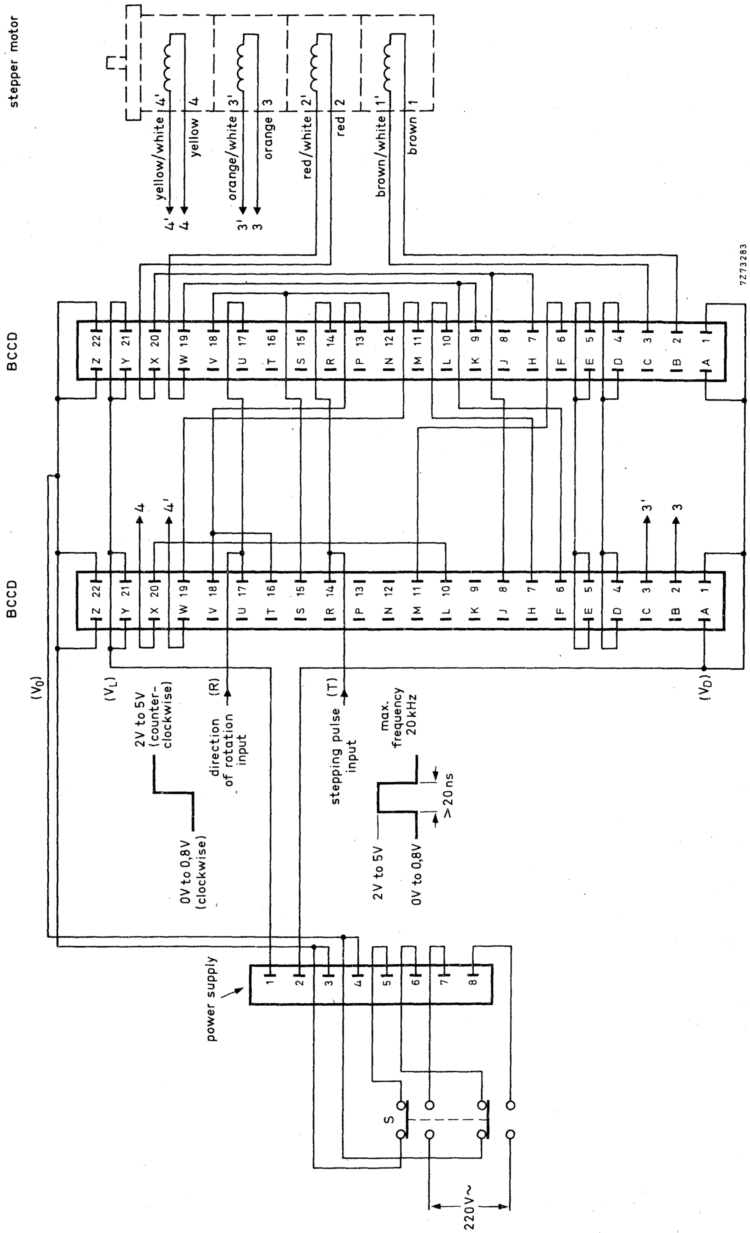


Fig. 4. Connection diagram for two BCCD units, a 4-phase bipolar motor and power supply unit 9904 132 02001. A double-pole double-throw switch is needed to discharge electrolytic capacitors in the power supply unit when it is switched off.

ELECTRICAL DATA

Input data

Direction of rotation

The level of V_R may change state only when the input pulse for stepping is LOW.

V_R, HIGH (clockwise)	≥ 2 V, ≤ 5 V
LOW (counter-clockwise)	≥ 0 V, ≤ 0,8 V
V_R, limiting values *)	−max. 2 V **)
	max. 5,5 V
I_R, at V_R HIGH, Fig. 3	max. 0,12 mA
Fig. 4	max. 0,24 mA
$-I_R$, at V_R LOW, Fig. 3	max. 4,8 mA
Fig. 4	max. 9,6 mA

Stepping

V_T, HIGH	≥ 2 V, ≤ 5 V
LOW	≥ 0 V, ≤ 0,8 V
V_T, limiting values *)	−max. 2 V **)
	max. 5,5 V
I_T, at V_T HIGH, Fig. 3	max. 0,16 mA
Fig. 4	max. 0,32 mA
$-I_T$, at V_T LOW, Fig. 3	max. 6,4 mA
Fig. 4	max. 12,8 mA
Pulse width, V_T HIGH	min. 20 ns
Pulse frequency, Fig. 3	max. 20 kHz
Fig. 4	max. 40 kHz

*) In accordance with the Absolute Maximum Rating System as defined in IEC publication 134.
**) Pulse duration 20 ns, frequency 5 MHz, source resistance minimum 75 Ω.

Output data

Four drive current settings can be obtained by interconnecting the following connector terminals:

set current (mA)	power consumption of motor	terminals to be interconnected
500	P nominal	4 and D
		5 and E
400	2/3 P_{nom}	4 and D
350	1/2 P_{nom}	5 and E
250	1/4 P_{nom}	–

Interconnection shunts R20 (in Fig. 1) so that the level detector which controls the maximum current chopper operates at a higher current level.

Caution: Two BCCD units are required for 4-phase stepper motors. Be sure that both units are set for the same output current.

The BCCD unit has been developed to drive bipolar stepper motors having coil windings adapted for this form of drive. Do not replace the motor by other electrical components to simulate the load conditions and do not connect other electrical components in series or in parallel with the motor coils. To do so may damage the unit.

Power supply requirements

Logic circuit

Voltage V_L	+5 V ±5 %
Current I_L (per unit)	160 mA

Drive circuit

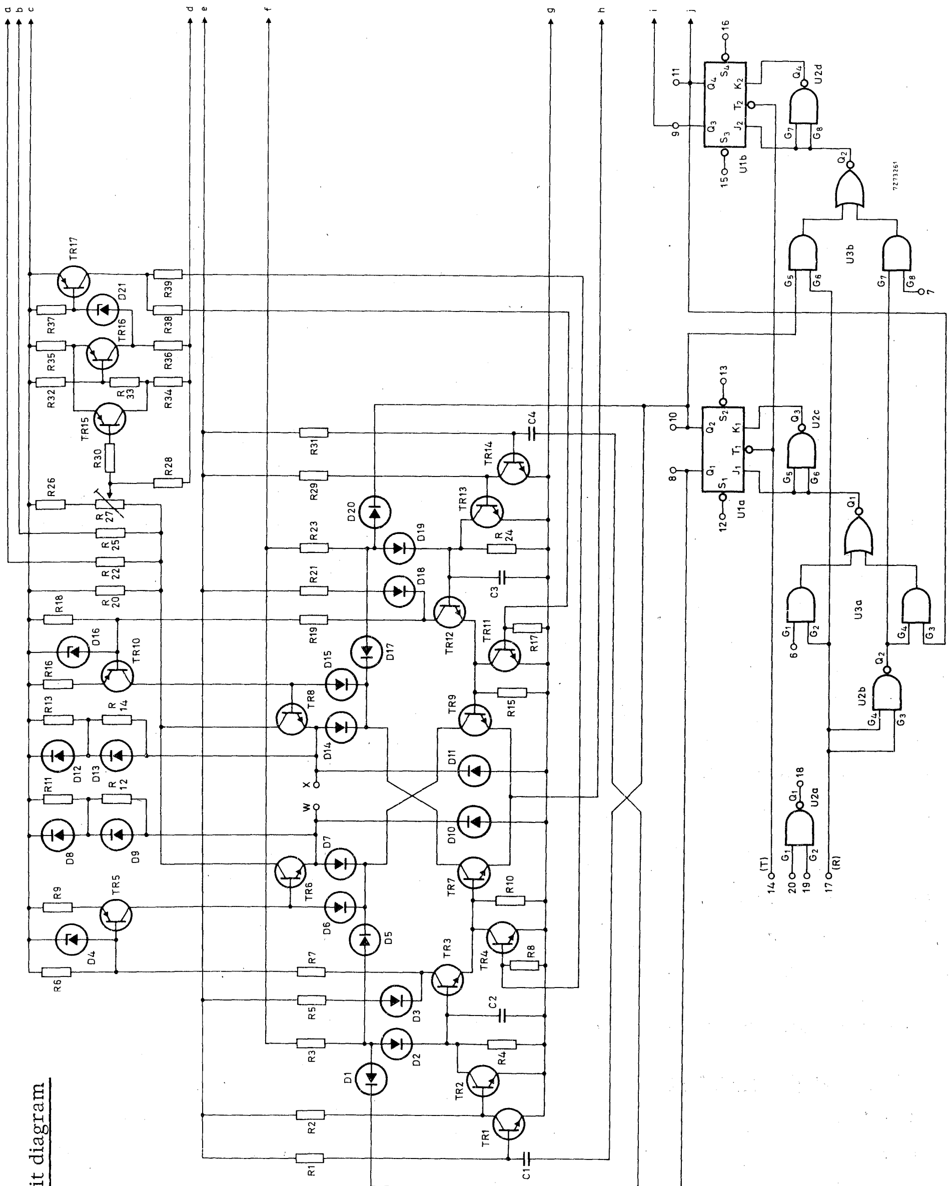
Voltage V_D	60 V +20/−30 %
Current I_D (per unit)	
no load	45 mA
full load	750 mA

Note: See under Precautions below.

Ambient temperature range

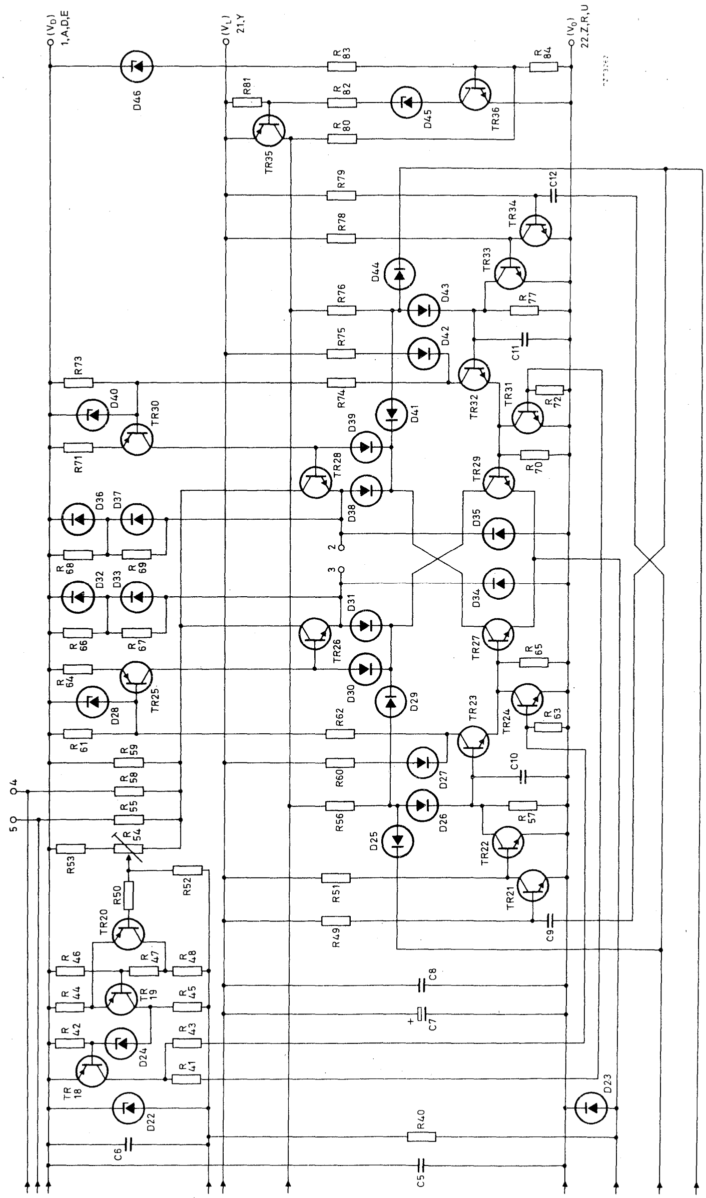
Operating	0 to +70 °C
Storage	−40 to +70 °C

BIPOLAR CONSTANT CURRENT DRIVE
for 2- and 4-phase stepper motors



Circuit diagram

June 1975


(V_D) 1,A,D,E
(V_L) 21,Y
(V_D) 22,Z,R,U
D46
R81
R83
R82
R80
R84
D45
TR35
TR36
R79
C12
R78
TR34
D44
TR33
R76
D43
R77
R75
D42
C11
R73
TR32
D40
TR30
R74
D41
TR31
R72
R71
D39
TR28
TR29
R70
D36
D37
D38
D35
R68
R69
2
3
D32
D33
D31
D34
R66
R67
TR26
TR27
R64
TR25
D30
R65
D28
D29
TR24
R63
R61
R62
TR23
R59
4
R58
D27
C10
5
R55
R60
R54
R56
D26
R57
R53
D25
TR22
R52
R50
R51
TR21
TR20
R49
C9
R46
R47
R48
R44
TR19
R45
C8
C7
R42
D24
R43
TR18
R41
D23
D22
R40
C6
C5
a
b
c
d
e
f
g
h
i
j

Parts list

D1, D2, D3, D6, D15, D18, D19, D20, D25, D26, D27, D30, D39, D42, D43, D44	diode	BAW62
D4, D16, D28, D40	stabistor	BZX75-C1V4
D5, D17, D29, D41	diode	BAV19
D7, D14, D31, D38	diode	BAX18
D8, D9, D12, D13, D32, D33, D36, D37	diode	BAV10
D10, D11, D34, D35	diode	BY206
D23	diode	BV126
D21, D24	stabistor	BZX79-C4V7
D22	voltage regulator diode	BZX61-C20
D45	voltage regulator diode	BZY88-C3V3
D46	voltage regulator diode	BZX79-C36
TR1, TR2, TR13, TR14, TR21, TR22, TR33, TR34, TR36	transistor	BC548
TR3, TR12, TR23, TR32	transistor	BSS38
TR4, TR11, TR24, TR31	transistor	BSX20
TR5, TR10, TR17, TR18, TR25, TR30	transistor	BSS68
TR6, TR7, TR8, TR9, TR26, TR27, TR28, TR29	transistor	BSW66
TR15, TR16, TR19, TR20, TR35	transistor	BC558
U1	integrated circuit	GFB7476D
U2	integrated circuit	GFB7400D
U3	integrated circuit	GFB7451D
C1, C2, C3, C4	capacitor 4700 pF, 100 V	
C5	capacitor 0,47 µF, 100 V	
C6	capacitor 0,1 µF, 250 V	
C7	capacitor 15 µF, 10 V	
C8	capacitor 0,1 µF, 250 V	
C9, C10, C11, C12	capacitor 4700 pF, 100 V	
R1, R31, R49, R79	carbon resistor 15 kΩ, 5 %; 0,33 W	
R2, R29, R51, R78	carbon resistor 4,7 kΩ, 5 %; 0,33 W	
R3, R23, R56, R76	carbon resistor 390 Ω, 5 %; 0,33 W	
R4, R10, R15, R24, R30, R50, R57, R65, R70, R77	carbon resistor 1 kΩ, 5 %; 0,33 W	
R5, R21, R60, R75	carbon resistor 39 Ω, 5 %; 0,67 W	
R6, R18, R26, R53, R61, R73	carbon resistor 560 Ω, 5 %; 0,33 W	
R7, R19, R62, R74	carbon resistor 5,6 kΩ, 5 %; 1,15 W	
R8, R17, R63, R72, R81	carbon resistor 560 Ω, 5 %; 0,33 W	
R9, R16, R64, R71	carbon resistor 10 Ω, 5 %; 0,33 W	
R11, R12, R13, R14, R66, R67, R68, R69	carbon resistor 680 kΩ, 5 %; 0,33 W	
R20, R59	carbon resistor 3,9 Ω, 5 %; 0,5 W	
R22, R58	carbon resistor 6,8 Ω, 5 %; 0,5 W	

R25, R55	carbon resistor 10 Ω, 5 %; 0,5 W
R27, R54	carbon pre-set potentiometer 220 Ω
R28, R52	carbon resistor 39 kΩ, 5 %; 0,33 W
R32, R36, R38, R39, R41, R43, R45, R46	
R83	carbon resistor 10 kΩ, 5 %; 0,33 W
R33, R47	metal film resistor 2,2 kΩ, 2 %; 0,4 W
R34, R48	metal film resistor 6,8 kΩ, 2 %; 0,4 W
R35, R44	carbon resistor 56 Ω, 5 %; 0,33 W
R37, R42	carbon resistor 4,7 kΩ, 5 %; 0,33 W
R40,	wirewound resistor 2,2 kΩ, 5 %; 4,2 W
R80	carbon resistor 33 kΩ, 5 %; 0,33 W
R82	carbon resistor 100 Ω, 5 %; 0,33 W
R84	carbon resistor 3,3 kΩ, 5 %; 0,33 W

ACCESSORIES

Power supply

A power supply unit designed for the BCCD unit is available under catalogue number 9904 132 02001.

Connector

The BCCD unit fits a printed-wiring connector F047 with 2 x 22 connections which is available in different versions.

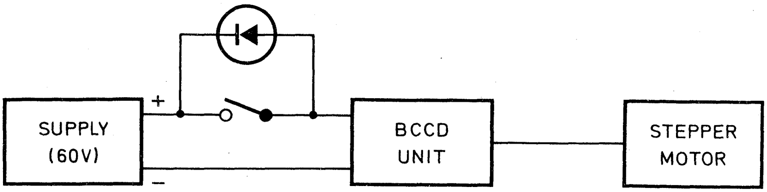
PRECAUTIONS

To be considered when using a power supply which has not been specifically designed to accomodate the BCCD units.

(a) Switching on
V_L must always be switched on FIRST and then V_D, because the drive circuit will be damaged if the logic control levels are not available.

Switching off
For the same reason V_L should not be switched off before V_D has dropped below 30 V. This can be achieved by maintaining the logic supply voltage V_L for a short period after the switch-off by means of electrolytic capacitors.

(b) When a bipolar stepper motor operates, magnetic (field) energy is stored in the motor coils. If the 60 V supply is suddenly interrupted, this energy will cause a high voltage peak which will damage some semiconductors in the BCCD unit.
To avoid this, a diode should be connected in parallel with the interruption switch.



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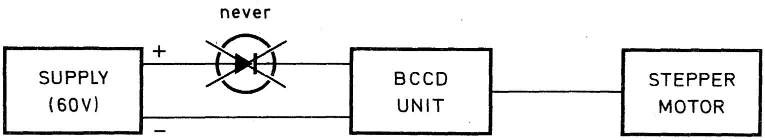
(c) For the same reason, it is clear that a diode should not be connected in series with the 60 V supply line.
This method is commonly used as a safeguard against reverse connection of the supply, but here it would result in a damaged BCCD unit.



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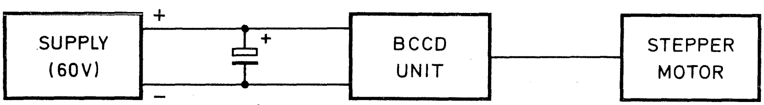
(d) When use is made of a 60 V stabilized (chopper) supply, an electrolytic capacitor of 1200 μF, 100 V must be connected between the positive and negative supply lines to provide the necessary feedback, thus avoiding damage to the BCCD unit.



7Z73266

INTEGRATED CIRCUIT

for driving 4-phase unipolar stepper motors

APPLICATION

The integrated circuit SAA1027 changes a train of input pulses into a sequential pulse output which provides the required pulse pattern for driving 4-phase unipolar stepper motors.
The unit is intended to drive the following motors:

- 9904 112 04002 (ID 04-Series)
- 9904 112 06001 (ID 06-Series)
- 9904 112 07005 (ID 07-Series)
- 9904 112 27001 (ID 27-Series)
- 9904 112 28001 (ID 28-Series)
- 9904 112 31001 (ID 31-Series)

For detailed information on the SAA1027 see Data handbook "Semiconductors and integrated circuits", Part 5a.

DESCRIPTION

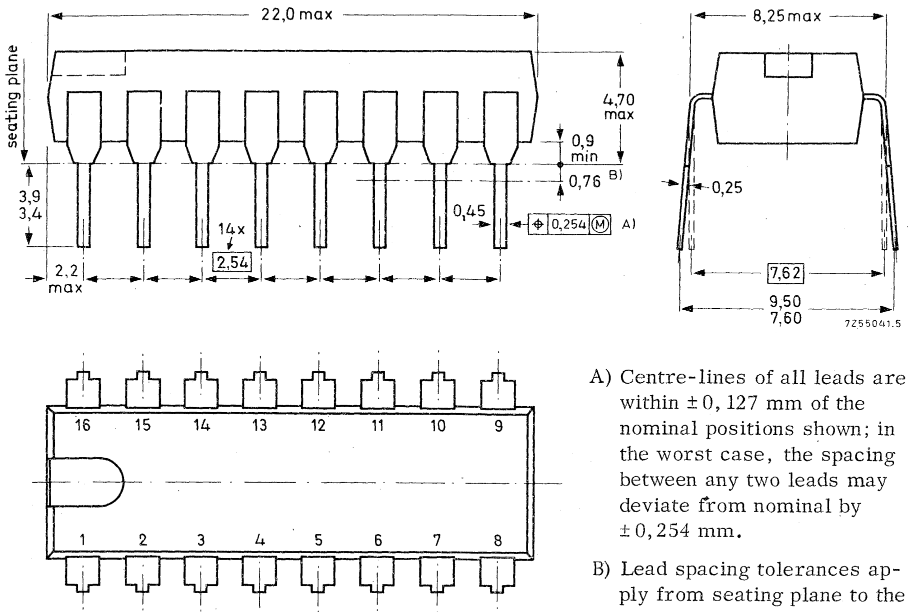
The circuit consists of three input stages, a logic part, and four output stages. The inputs are as follows:

- a trigger input which receives the order for the rotor to perform the step.
- an input which determines the direction of rotation by changing the d.c. level.
- a set input, being an option for setting the logic part at 'zero' before the trigger pulses are applied.

All three inputs are compatible with high noise immunity logic to ensure proper operation, even in noisy environments.
The four output stages can supply 350 mA each. Integrated diodes protect the outputs against transient spikes caused by switching the motor coils.

MECHANICAL DATA

Dimensions (mm)



A) Centre-lines of all leads are within ± 0, 127 mm of the nominal positions shown; in the worst case, the spacing between any two leads may deviate from nominal by ± 0, 254 mm.

B) Lead spacing tolerances apply from seating plane to the line indicated.

Soldering

By hand

Apply the soldering iron below the seating plane (or not more than 2 mm above it).
If its temperature is below 300 °C it must not be in contact for more than 10 seconds; if between 300 °C and 400 °C, for not more than 5 seconds.

By dip or wave

260 °C is the maximum allowable temperature of the solder; it must not be in contact with the joint for more than 5 seconds. The total contact time of successive solder waves must not exceed 5 seconds.
The device may be mounted up to the seating plane, but the temperature of the plastic body must not exceed the specified storage maximum. If the printed-wiring board has been pre-heated, forced cooling may be necessary immediately after soldering to keep the temperature within the allowable limit.

Repairing soldered joints

The same precautions and limits apply as for hand soldering.

Connections

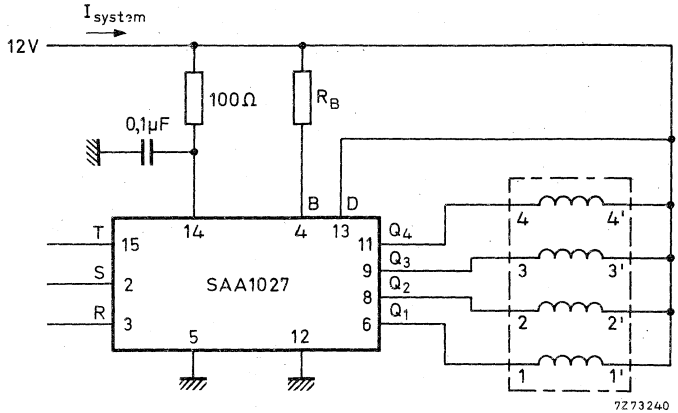


Fig. 2

motor	R_B	I_{system}
9904 112 04002	270 Ω, 0,33 W	300 mA
9904 112 06001	180 Ω, 0,67 W	500 mA
9904 112 07005	330 Ω, 0,33 W	200 mA
9904 112 27001	150 Ω, 1,15 W	600 mA
9904 112 28001	150 Ω, 1,15 W	600 mA
9904 112 31001	180 Ω, 0,67 W	400 mA

ELECTRICAL DATA

Input data

Direction of rotation (pin 3)

V_R, HIGH (counter-clockwise)	7,5 to 12 V
LOW (clockwise)	0 to 4,5 V
I_R, at V_R HIGH	typ. 1 μA
$-I_R$, at V_R LOW	typ. 30 μA

Stepping (pin 15)

V_T, HIGH	7,5 to 12 V
LOW	0 to 4,5 V
I_T, at V_T HIGH	typ. 1 μA
$-I_T$, at V_T LOW	typ. 30 μA

Note: Triggering occurs when T goes from LOW to HIGH.

Set control (pin 2)

V_S, HIGH	7,5 to 12 V
LOW	0 to 4,5 V
I_S, at V_S HIGH	typ. 1 μA
$-I_S$, at V_S LOW	typ. 30 μA

Note: When T is HIGH and S is LOW the outputs are: Q_1 = LOW, Q_2 = HIGH, Q_3 = LOW, Q_4 = HIGH.

Ambient temperature range

Operating: minimum −20 °C

maximum see Table below

Storage : minimum −40 °C

maximum + 125 °C

Remarks

Four integrated diodes dissipate the energy stored in the motor coils when the outputs Q are being switched.

- The common line of these clamping diodes (pin 13) must therefore have the shortest connection to the common line of the motor windings. Due to this effect, the temperature rise of the IC increases with the increase of the stepping rate of the stepper motor. This reduces the max. permissible ambient temperature in which the IC can operate. To overcome this phenomena, external diodes e.g. BAX12, accross the motor windings are recommended (see Fig. 3 and Table).
- To achieve maximum noise immunity, unused inputs must not be left floating, but should be connected to the voltage level appropriate to the required function.
- When both the IC and the motor are connected to the same supply, a simple RC network must be used in the supply line of the logic part to prevent the logic sequence from being discontinued by transient spikes, caused by the switching of the motor coils. This network is depicted in Fig. 2 (and Fig. 3). The capacitor should be connected as close as possible to pin 14 and 5 (or 12).

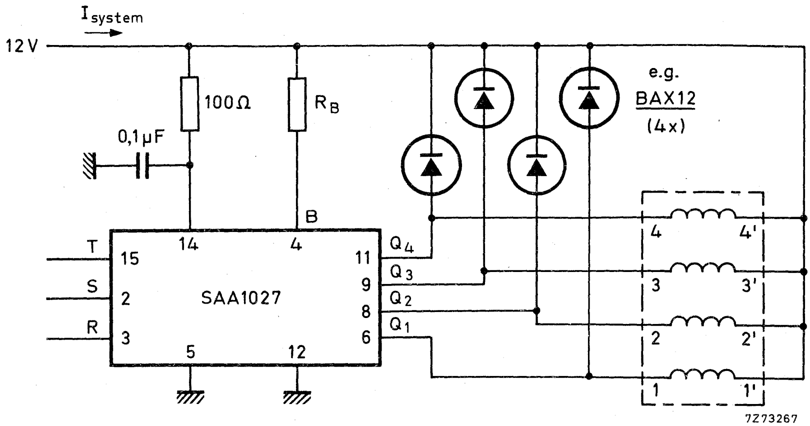


Fig. 3

Table of maximum permissible ambient temperatures (in °C) for SAA1027.

motor	without external diodes	with external diodes
9904 112 04002	80	90
9904 112 06001	65	80
9904 112 07005	80	100
9904 112 27001	55	70
9904 112 28001	65	70
9904 112 31001	70	90

Contents

A		Small synchronous motors
B	general 4-phase unipolar motors 8-phase unipolar motors 2-phase bipolar motors 4-phase bipolar motors	Stepper motors
C	general iron rotor motors ironless rotor motors	Miniature direct current motors
D		Accessories
		Contents

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