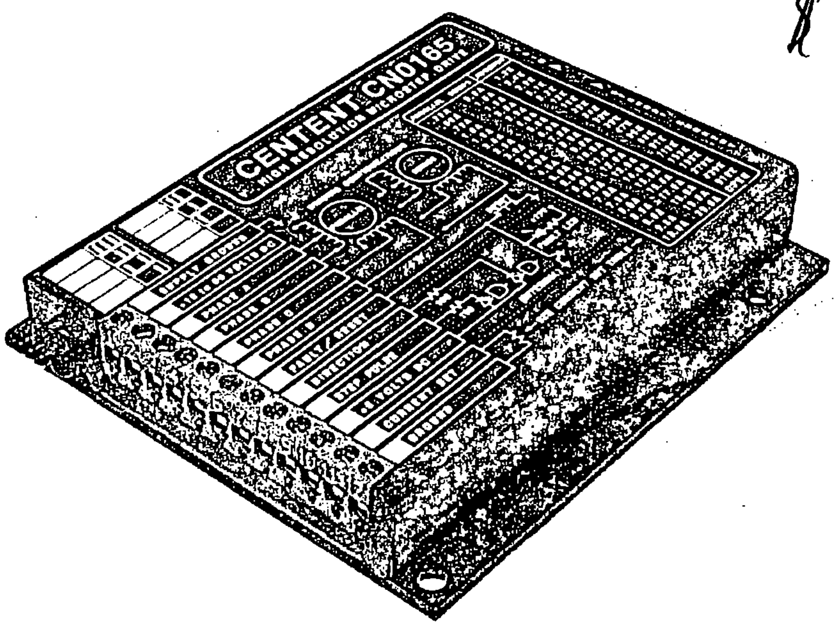
40785 550
3
1650
350
2,000
+3,700
$5,700

CN0165
OPERATING MANUAL



HIGH RESOLUTION MICROSTEP DRIVE

CENTENT COMPANY
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SANTA ANA, CALIFORNIA 92707-5787 U.S.A.

This manual contains information for installing and operating the following Centent Company product:

CN0165 Microstep Drive

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EQUATIONS

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GENERAL DESCRIPTION

The Centent CN0165 is a high resolution step motor drive designed for the operation of hybrid PM step motors rated from 0.1 to 20 amps per phase. The CN0165 operates on a supply voltage of 18-80 volts DC. Drive output current ranges from 0.1 to 10 amps per phase. Maximum step input frequency is 1.5 MHz. The minimum on or off time for the step input is 300 nanoseconds. Motor winding inductance as low as 0.5 millihenrys is permitted.

The CN0165 features eight selectable microstep resolutions per drive. Available resolutions range from full-step to 256 microsteps per full step. The step resolution is selected by configuring the option header located on the face of the drive. The CN0165 is capable of delivering up to 1.5 million microsteps per second to the step motor. The pin-out of the CN0165 is compatible with the Centent CN0142, CN0143 and CN0162 step motor drives.

The design of the CN0165 is a combination of recirculating current and non-recirculating current type chopper drives. It features electronic viscous damping for control of motor mid-band instability (anti--resonance) and a high-speed torque boost circuit. MOSFET transistors are utilized in the 'H' bridge output circuit. Automatic current standby, easily adjustable from zero to full current, reduces motor phase current while the motor is at rest. The combination of these features results in an extremely efficient step motor drive with minimum motor iron losses (heating).

The CN0165 uses high speed opto-isolators for the Step Pulse and the Direction inputs to provide maximum noise immunity. The Step Pulse and Direction inputs are compatible with TTL drivers and require no additional components.

Motor stepping occurs on the high to low transition of the Step Pulse Input. The Direction Input hold time is 1 microsecond after the active edge of the Step Pulse Input. The Direction Input can be updated simultaneously with the active (high to low) transition of the Step Pulse Input.

Over-current conditions (winding shorts, etc.), overheating conditions (insufficient heat sinking), and under-voltage conditions (power supply failure) are sensed by the CN0165. When any of these conditions occurs the CN0165 shuts down, activating the Fault Output and lighting the Fault LED located on the face of the drive.

The Centent CN0165 High Resolution Microstep Drive is compact; measuring 4.00 inches x 4.75 inches x 0.85 inches (102mm x 121mm x 22mm). It comes encapsulated in a heat conductive epoxy and encased in an anodized aluminum cover. This results in a rugged package that resists abuse and contamination, suitable for harsh environments.

LOCATION OF COMPONENTS

① MOUNTING PLATE

The base plate also serves as a heat sink, although additional heat sinking may be required. The temperature of the drive must never exceed +75°C (+167°F). Four mounting holes on 3.625 inch (92 mm) centers are provided to secure the drive to the heatsink or bulkhead.

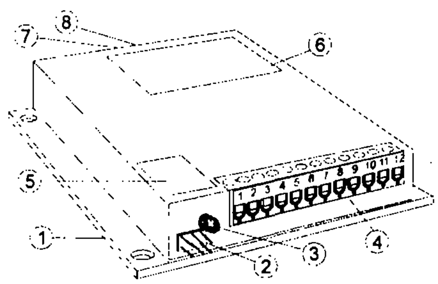


Figure 1 - Component location

② OPTION HEADER

A 6 pin header selects the active microstep resolution or current profile. The user jumpers the desired pins with the shorting bars supplied with the drive. Eight resolutions or current profiles are available in each drive. The value for each selection is printed in the Resolution Table (see ⑤). There are 21 microstep resolutions available for the CN0165 Microstep Drive.

③ FAULT LED

This light emitting diode turns on when the CN0165 enters its fault mode. The fault status is also available on the Fault/Reset Terminal of the connector (see ④). A fault condition is cleared by shorting the Fault/Reset Terminal to ground potential or by recycling (off, and then on) the power supply.

④ TERMINAL CONNECTOR

A 12 position terminal strip provides the connections for the power supply, the motor, the Current Set and the indexer interface (Step Pulse and Direction inputs). Care must be taken not to over-torque the terminal screws to prevent damage to the connector.

⑤ RESOLUTION TABLE

The Resolution Table provides a diagram of each Option Header configuration, and the resolution associated with it. A maximum of eight of the twenty-one possible step resolutions are available in each CN0165.

⑥ CURRENT SET TABLE

This table provides the user with standard 5% values for the Current Set Resistor connected between terminals 11 and 12 of the Terminal Connector ④. Values are given for low performance and high performance operation from 0.25 to 20 amps per phase.

⑦ OFFSET TRIMPOT

This is a fine-tune adjustment for high microstep resolutions. It is used to optimize operation at resolutions of sixteen microsteps or greater.

⑧ STANDBY TRIMPOT

This trimpot sets the current level of the CN0165 during periods of motor inactivity. Standby current may be set from 0% to 100% of operating current.

HEAT SINKING

The protection provided by the internal temperature sensor of the CN0165 is not designed as a substitute for adequate heat sinking. Repeatedly tripping the Fault Output by allowing the drive to overheat causes thermal stress that will eventually lead to failure of the drive. As a practical guide, heat sinking will be necessary for the CN0165 if the drive is operated at 3 amps or more. A fan for forced air circulation may also be required.

The optional HSK-1 heat sink kit for Centent drives consists of heat sink, side rails and screws to secure the drive and side rails. The side rails are reversible, allowing the two mounting configurations shown in Figure 2. Contact Centent Company to order the HSK-1 heat sink kit.

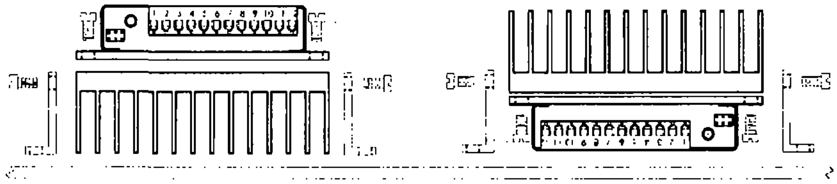


Figure 2 - HSK-1 heat sink kit

Clean the mating surfaces between drive and heat sink before assembly. Use of a commercial transistor heat sink compound enhances the dissipation of heat from the CN0165 drive to the heat sink.

No additional connectors are required when wiring to the Terminal Connector of the CN0165. Either stranded or solid conductor wire may be used. A wire size of 16-22 gauge is recommended. The insulation should be stripped back 0.25 inches (7 mm) for insertion into the terminal block.

CAUTION: DO NOT OVER-TORQUE THE TERMINAL CONNECTOR SCREWS. USE A TORQUE CONTROLLED SCREWDRIVER IF POSSIBLE.

POWER SUPPLY INPUTS

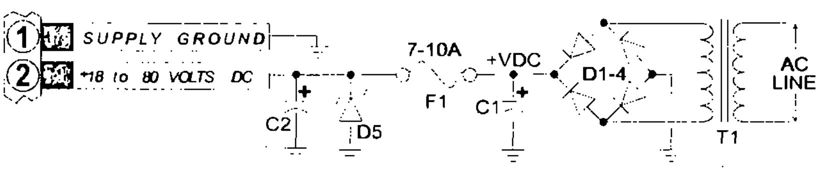


Figure 3 - Power Supply

Terminal 2 connects to the positive output from the power supply. The voltage range is +18 to +80 VDC. The power supply may be unregulated. Limit the ripple voltage (unregulated supplies) to a maximum of 10% of the DC output voltage. Terminal 1 is the ground connection. Do not use Terminal 12 for power supply ground; it is the return connection for the Current Set resistor.

> The power supply terminals should have a capacitor of 470µf or greater connected across them. This is particularly important for regulated power supplies since they usually have little output capacitance. Locate the capacitor as close to Terminals 1 & 2 of the CN0165 as possible (see Figure 3, C2). Be sure the voltage rating for the capacitor is higher than the drive's supply voltage.

For those users that wish to build their own power supply, Figure 3 shows a suggested circuit. Because of the electrical noise generated by these drives, it is not recommended that the supply be shared with low level logic circuitry.

During rapid deceleration of large inertial loads from high speeds, step motors become generators of considerable electrical power. This is returned to the power supply by the step motor drive. If the supply cannot absorb this power, the voltage generated may exceed the 80 volt limit of the CN0165, thus damaging the drive and power supply.

To protect the drive and power supply, the user may connect an external zener diode from Terminal 2 to ground (see Figure 3, D5). This diode will protect the drive from over-voltage conditions. Recommended diodes are 1N4762 (1 watt) or 1N5375 (5 watt). Note the 7-10 amp fuse (F1) placed in series with Terminal 2 and the power supply. Be sure this fuse is located between the power supply and the zener diode. In the event of an over-voltage condition the zener diode and fuse may be destroyed, but the CN0165 and the power supply will be protected from damage.

The power supply current required depends on the motor being used and whether the configuration is for high performance (parallel) or low performance (series) operation. See Motor Winding Configuration in the Performance section of this manual on page 18 for a complete explanation of motor wiring options.

$$I_{SUPPLY} = 2/3 \times I_{PHASE}$$

Equation 1 - Drive Current (Parallel)

High performance (parallel) operation requires a maximum of two thirds of the motor's rated per phase current.

$$I_{SUPPLY} = 1/3 \times I_{PHASE}$$

Equation 2 - Drive Current (Series)

Low performance (series) operation requires a maximum of one third the motor's rated per phase current.

Use the manufacturer's phase current rating for the motor and the motor wiring configuration (high or low performance) to estimate the size of power supply required.

As an example, a 6 lead motor rated by the manufacturer at 4 amps per phase is connected in the full winding (series) configuration. To calculate the current required from the power supply use Equation 3. Assume a transformer with a 25 volt RMS secondary is used. After rectification the transformer will produce a 37 VDC power supply voltage. To calculate the size of the filter capacitor (C1) use the following equation:

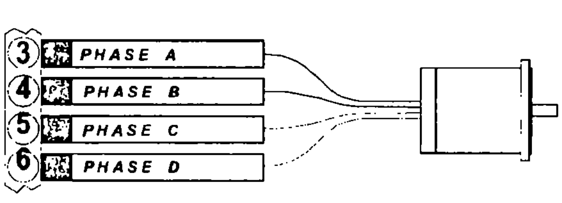
$$C_1 = \frac{(83{,}333)(I_{SUPPLY})}{V_{SUPPLY}} = \frac{(83{,}333)(1.33)}{37} = 2995.48\mu f \approx 3000\mu f$$

Equation 4 - Power Supply filter capacitor

C2 (Figure 3, page 3) is the 470 µf capacitor located close to the CN0165's power supply terminals. C_1 may be made smaller by that amount if desired. Both capacitors must have a voltage rating safely in excess of the power supply voltage; 50 VDC in this example.

More than one CN0165 may be run from a common power supply if the filter capacitor is large enough to handle the combined load of the drives. Each CN0165 must have separate power leads to the supply. Do not daisy-chain power leads from supply to driver to driver.

MOTOR PHASE OUTPUTS



These are the drive's outputs to the step motor phase windings. One motor winding pair goes to Terminals 3 & 4 and the other motor winding pair goes to Terminals 5 & 6.

The CN0165 is designed to drive 4, 6 and 8 lead step motors. When using 6 or 8 lead motors, the motor may be connected in either one of two configurations. The low performance configuration is referred to as Series or Full Winding operation. The high performance configuration is referred to as Parallel or Half Winding operation.

Since a 4 lead motor has only one possible wiring configuration, consider it to be connected in the high performance configuration. See Motor Winding Configuration in the Performance section of this manual (page 18) to determine the best wiring configuration for the application.

The CN0165 is a high frequency switching type drive. Because of the rapid rate of voltage and current change inherent with this type of drive, considerable RFI is generated. The following precautions will prevent noise from coupling back to the inputs and causing erratic operation.

1. Never run the motor leads in the same cable or wiring harness as the Step Pulse, Direction or +5 VDC input lines.
2. Keep power supply leads as short as possible. If the length exceeds 12 inches, use a 0.1 µf capacitor across Terminals 1 & 2 at the drive.
3. Never wire capacitors, inductors or any other components to the motor output terminals.
4. Ground the CN0165 case.
5. Ground the step motor case.

The high performance configuration in a 6 lead motor uses the center-tap and one end to form a winding. The other lead of each phase pair is not connected. For an 8 lead motor the phases are connected as two pairs of parallel windings. See Figure 4 for details.

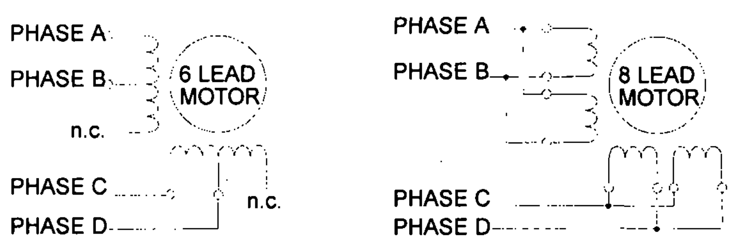


Figure 4 - High performance configuration

The low performance configuration in a 6 lead motor uses the end leads of each phase to constitute a winding. The center-taps are not used. For an 8 lead motor the phases are connected as a pair of series windings. See Figure 5 for details.

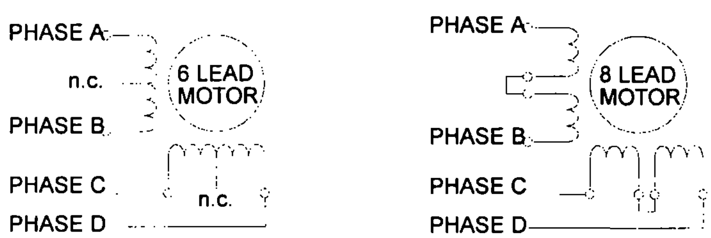


Figure 5 - Low performance configuration

MANUFACTURER	CN0165 TERMINAL			
	3	4	5	6
SUPERIOR ELECTRIC	GREEN/WHITE	GREEN	RED/WHITE	RED
RAPIDSYN	GREEN/WHITE	GREEN	RED/WHITE	RED
IMC	GREEN/WHITE	GREEN	RED/WHITE	RED
EASTERN AIR DEV.	GREEN/WHITE	GREEN	RED/WHITE	RED
PACIFIC SCIENTIFIC	BLACK	ORANGE	RED	YELLOW
WARNER ELECTRIC	BROWN	ORANGE	RED	YELLOW
VEXTA	BLUE	RED	BLACK	GREEN
JAPAN SERVO	BLUE	RED	YELLOW	GREEN

Table 1 - Full Winding Operation

MANUFACTURER	CN0165 TERMINAL			
	3	4	5	6
SUPERIOR ELECTRIC	WHITE	GREEN	BLACK	RED
RAPIDSYN	WHITE	GREEN	BLACK	RED
IMC	WHITE	GREEN	BLACK	RED
EASTERN AIR DEV.	WHITE	GREEN	BLACK	RED
PACIFIC SCIENTIFIC	BLACK	ORG./BLACK	RED	RED/YEL.
WARNER ELECTRIC	BLACK	ORANGE	RED	WHITE
VEXTA	BLUE	WHITE	YELLOW	GREEN
JAPAN SERVO	BLUE	WHITE*	WHITE*	GREEN
* White leads are not interchangeable. Use ohm meter to find WHITE-BLUE & WHITE-GREEN pairs.				

Table 2 - Half Winding Operation

MANUFACTURER	CN0165 TERMINAL			
	3	4	5	6
SUPERIOR ELECTRIC	RED	RED/WHITE	GREEN	GRN./WHT.
	BLACK Ö WHITE		ORANGE Ö BLACK/WHITE	
PACIFIC SCIENTIFIC	BLACK	ORANGE	RED	YELLOW
	BLACK/WHITE Ö ORANGE/WHITE		RED/WHITE Ö YEL./WHITE	
BODINE	BROWN	ORANGE	RED	YELLOW
	BRN./WHITE Ö ORANGE/WHITE		RED/WHITE Ö YEL./WHITE	
PORTESCAP	BROWN	ORG./WHITE	RED	YEL./WHITE
	BROWN/WHITE Ö ORANGE		RED/WHITE Ö YELLOW	
DIGITAL MOTOR	BLACK	ORANGE	RED	YELLOW
	BLACK/WHITE Ö ORANGE/WHITE		RED/WHITE Ö YEL./WHITE	

Table 3 - Series Winding Operation

MANUFACTURER	CN0165 TERMINAL			
	3	4	5	6
SUPERIOR ELECTRIC	RED WHITE	BLACK RED/WHITE	GREEN BLACK/WHITE	ORANGE GRN./WHITE
PACIFIC SCIENTIFIC	BLACK ORANGE/WHITE	BLACK/WHITE ORANGE	RED YEL./WHITE	RED/WHITE YELLOW
BODINE	BROWN ORG./WHITE	BRN./WHITE ORANGE	RED/WHITE YELLOW	RED YEL./WHITE
PORTESCAP	BROWN ORANGE	BRN./WHITE ORG./WHITE	RED YELLOW	RED/WHITE YEL./WHITE
DIGITAL MOTOR	BLACK ORANGE/WHITE	BLACK/WHITE ORANGE	RED YEL./WHITE	RED /WHITE YELLOW

Table 4 - Parallel Winding Operation

Tables 1 & 2, page 7, show various manufacturer's color codes for 6 lead motors and the connections to the CN0165 for half winding and full winding operation. Tables 3 & 4 show how to connect various manufacturer's 8 lead motors for series and parallel operation.

Note that the leads connected together for series operation do not connect to a terminal on the CN0165. These leads should not be left exposed; insulate them with electrical tape or heat-shrink tubing.

Consult the motor manufacturer's catalog for motors not listed in tables 1 through 4.

FAULT / RESET (INPUT/OUTPUT)

Terminal 7 is the Fault/Reset Terminal. This serves both as an output, to indicate when a fault has occurred; and as an input, to reset the drive.

The CN0165 has protection circuitry to shut down the drive when potentially damaging conditions exist. The state of the protection circuitry is available on the Fault/Reset Terminal. The Fault LED (light emitting diode) provides visual indication of the fault condition.

The Fault Output latches low and the LED stays on for either of the following fault conditions:

- A short circuit of the motor windings (or motor lead wiring)
- Overheating: temperature of CN0165 exceeds 75°C

A short circuit reset is distinguished from an overheating reset by observing the case temperature of the CN0165. A short-circuit reset will shut down the drive before it reaches a high temperature. If the case temperature is low immediately after a reset occurs the cause is a short circuit.

Do not continue to operate the CN0165 if it is resetting due to overheating. Heat-sinking must be provided to prevent the drive from repeatedly entering thermal shut-down.

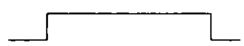
THE PROTECTION PROVIDED BY THE INTERNAL TEMPERATURE SENSOR OF THE CN0162 IS NOT A SUBSTITUTE FOR ADEQUATE HEAT SINKING. REPEATEDLY TRIPPING THE FAULT OUTPUT BY ALLOWING THE DRIVE TO OVERHEAT CAUSES THERMAL STRESS THAT WILL EVENTUALLY LEAD TO FAILURE OF THE DRIVE.

The Fault Output goes low (LED on), but does not latch, if the power supply voltage drops below 18 volts DC. When no fault condition exists, the Fault Output is pulled up to 12 volts DC by an internal 470 ohm resistor and the LED is turned off. The Fault Output is capable of sinking up to 20 milliamps of current.

While the Fault Output is low, the internal counters reset to microstep zero and the phase outputs are held low. The CN0165 ceases all switching activity and the motor phase current goes to zero. A latched fault condition is cleared by a Reset (take Terminal 7 to ground) or by recycling the power supply to the drive (power off, then on).

Terminal 7 also functions as a Reset input. By taking the Fault/Reset Terminal to ground the motor phase currents are shut off and the internal counters are reset. When Terminal 7 is released from ground the motor is located at microstep zero. A current of 20 milliamps will flow from the Fault/Reset Terminal when it is shorted to ground.

8 DIRECTION



DIRECTION INPUT

Terminal 8 is the Direction Input. This input is sampled by the CN0165 on every step pulse input to determine which direction the step motor will move.

The state of the Direction Input must be held 1 microsecond after the active edge of the Step Pulse Input to insure correct direction. The Direction Input can be updated simultaneously with the active (high to low) transition of the Step Pulse Input.

The CN0165 uses a high speed opto-isolator for the Direction Input. The purpose of the opto-isolator is to isolate the Direction Input from the driver's power supply. The user must provide a +5 VDC supply to operate the opto-isolator. This permits the use of current sink drivers, such as TTL logic or open collector transistors, to operate the input. The minimum current required to operate the opto-isolator is 3.5 milliamps.

9 STEP PULSE

STEP PULSE INPUT

Microstepping in the CN0165 occurs on the high to low transition of the step pulse input.

The CN0165 employs a high speed opto-isolator to isolate the Step Pulse Input from the driver's power supply. The user must provide a +5 VDC supply (shared with the Direction Input) to operate the opto-isolator circuitry. This permits the use of current sink drivers, such as TTL logic or open collector transistors, to operate the input.

The minimum current required to operate the opto-isolator is 3.5 milliamps. The maximum Step Pulse rate is 1.0 MHz. The minimum on or off time is 500 nanoseconds. There are no rise or fall time limits.

+5 VDC INPUT

This input is connected internally to the anodes of the Step Pulse and the Direction opto-isolator LEDs. The external +5 VDC supply provides the source of LED current for the Step Pulse and Direction inputs. A minimum of 7 mA is required (Step ,and Direction both 'on' @ 3.5 mA per opto-isolator).

Power supply voltages higher than 5 VDC may be used for this input. Both the Step Pulse and the Direction Input will require external resistors to limit the current to the opto-isolators if the operating voltage is higher than 5 volts. The following equation determines the value for these resistors and limits the supply current to the opto-isolator LEDs to approximately 5 milliamps.

$$R = \frac{(V-5)}{.01}$$

Equation 5 - External Opto-isolator resistor

For example, if a +12 volt supply is to be used:

$$R = \frac{(12-5)}{.01} = 700 \approx 680\Omega$$

Place 680 ohm resistors between Terminal 8 and the Direction source and between Terminal 9 and the Step Pulse source.

IMPORTANT: DO NOT PUT A RESISTOR IN SERIES WITH THE +5 VDC TERMINAL.

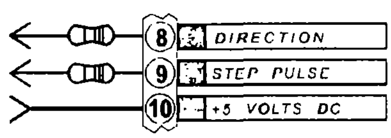


Figure 6 - External Opto-isolator resistors

CURRENT SET

The Current Set Input determines the magnitude of the motor phase currents. This is done by connecting a 1/4 watt resistor between terminals 11 & 12. Terminal 11 is the Current Set Input and Terminal 12 is the ground reference.

Table 5, page 12, lists resistors to the nearest 5% standard value, for both parallel (half winding) and series (full winding) operation. An abbreviated table is printed on the case of the CN0165 for user convenience. Use the parallel values for operating 4 lead motors.

The resistor values in Table 5 and on the case of the CN0165 are derived by using the following equation:

$$R_{SET} = \frac{(4700)(I_{SET})}{10 - I_{SET}}$$

Where:

R_{SET} = *current set resistor*
I_{SET} = *desired current.*

Equation 6 - Current Set resistor

Zero operating current is obtained by shorting terminals 11 and 12 together.

The maximum phase current of 10 amps is obtained with no resistor installed across the terminals. Be sure the motor is large enough, and the drive heat sinking is adequate to handle the current if Terminal 11 is left unconnected.

DO **NOT** USE TERMINAL 12 FOR POWER SUPPLY GROUND.
TERMINAL 12 IS FOR CURRENT REFERENCE ONLY.

TERMINAL 1 IS THE POWER SUPPLY GROUND.

For best low speed smoothness, the motor phase current should not differ from the manufacturer's suggested phase current rating by more than ± 20%. Currents above or below this level may affect microstep accuracy and increase low speed vibration.

The Current Set Input is used in conjunction with the Standby Current Trimpot (see page 14) to set the current levels for active (motor moving) and standby (motor idle) conditions.

The Current Set Input may also be driven by external circuitry such as an operational amplifier or a digital to analog converter from a programmable controller.

Motor phase current is a linear function of the voltage on Terminal 11. The voltage applied to Terminal 11 should range from zero (phase current = 0 amps) to 2.5 volts (phase current = 10 amps). Do not apply voltages higher than 2.5 volts to Terminal 11 as it may result in permanent damage to the drive.

CURRENT SET TABLE			
MODE OF OPERATION			*RESISTOR*
HALF WINDING (PARALLEL)	FULL WINDING (SERIES)		STANDARD ±5% (OHMS)
0.1 A	0.2 A		470Ω
0.2 A	0.4 A		1.0 K
0.3 A	0.6 A		1.5 K
0.4 A	0.8 A		2.0 K
0.5 A	1.0 A		2.4 K
0.6 A	1.2 A		3.0 K
0.7 A	1.4 A		3.6 K
0.8 A	1.6 A		3.9 K
0.9 A	1.8 A		4.7 K
1.0 A	2.0 A		5.1 K
1.25A	2.50 A		6.8 K
1.50 A	3.00 A		8.2 K
1.75 A	3.50 A		10 K
2.00 A	4.00 A		12 K
2.25A	4.50 A		13 K
2.50 A	5.00 A		16 K
2.75 A	5.50 A		18 K
3.00 A	6.00 A		20 K
3.25A	6.50 A		22 K
3.50 A	7.00 A		24 K
3.75 A	7.50 A		27 K
4.00 A	8.00 A		30 K
4.25A	8.50 A		36 K
4.50 A	9.00 A		39 K
4.75 A	9.50 A		43 K
5.00 A	10.00 A		47 K
5.25A	10.50 A		51 K
5.50 A	11.00 A		56 K
5.75 A	11.50 A		62 K
6.00 A	12.00 A		68 K
6.25A	12.50 A		75 K
6.50 A	13.00 A		91 K
6.75 A	13.50 A		100 K
7.00 A	14.00 A		110 K
7.25A	14.50 A		120 K
7.50 A	15.00 A		150 K
7.75 A	15.50 A		160 K
8.00 A	16.00 A		180 K
8.25A	16.50 A		220 K
8.50 A	17.00 A		270 K
8.75 A	17.50 A		330 K
9.00 A	18.00 A		430 K
9.25A	18.50 A		560 K
9.50 A	19.00 A		910 K
9.75 A	19.50 A		1.8 M
10.00 A	20.00 A		OPEN

Table 5 - Current Set

OPTION HEADER: RESOLUTION SELECTION

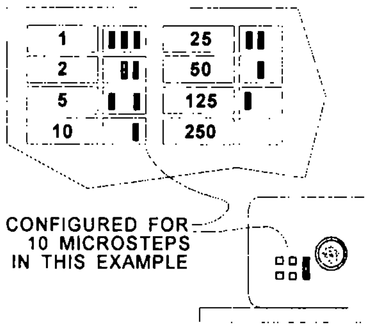


Figure 7 - Resolution Header

The Option Header selects a microstep resolution from the eight available in the drive. The header is located on the face of the drive, next to the Fault LED.

The jumper configuration for each of the eight selections is printed on the cover of the CN0165 adjacent to the Option Header. The step rate for each selection is shown. To select a resolution, install the jumper(s) as indicated for the desired microstep.

There are twenty-one different microstep resolutions available in the CN0165. The drive is supplied to the user with up to 8 of the 21 available. Not all combinations of step resolutions are possible. All eight step resolutions for a given CN0165 must come from a single option column (A, B, C or D) of Table 6.

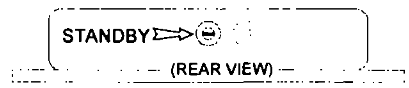
It is permissible to switch the Option Header selection dynamically. To accomplish this the shorting bars are replaced with TTL compatible drivers. No damage will occur if the microstep resolution or current profile is changed while the motor is running. Switching must occur at the full step location to maintain accurate step position.

As well as choosing between microstep resolutions the Option Header may be used to select different phase current profiles. Any combination of microstep resolutions and phase current profiles may be specified, provided all step resolutions come from the same column of Table 6. For more information on current profiles, see Current Profile Option on page 24.

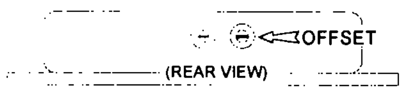
STEP RESOLUTION	OPTION A	OPTION B	OPTION C	OPTION D
full	●	●	●	●
half	●	●	●	●
4		●	●	●
5	●		●	●
8		●	●	●
10	●		●	●
16		●	●	●
20			●	●
25	●		●	
32		●		●
40			●	●
50	●		●	
64		●		●
80			●	●
100			●	
125	●			
128		●		●
160				●
200			●	
250	●			
256		●		

Table 6 - Resolution options

STANDBY CURRENT TRIMPOT



The Standby Trimpot sets the current level of the CN0165 during periods of motor inactivity. Turning the potentiometer to the full counter-clockwise position disables Current Standby. The full clock wise position results in 100% Current Standby (free wheeling). The half-way position (screwdriver slot vertical) results in a Standby current of 50% of operating current. Current Standby becomes active within one second of motor inactivity. Motor phase current is restored to its normal level 2 milliseconds after the next step pulse is received.



OFFSET TRIMPOT

The offset trimpot provides compensation for the distortion that occurs to microstep size near the half-step location. Residual full step cyclic errors, a function of power supply voltage, motor phase inductance and phase current magnitude, can cause an uneven microstep size. These errors can be compensated by adjusting the Offset Trimpot.

The magnitude of the untrimmed error is on the order of 1/16 of a full step, so it is unlikely to be noticeable at resolutions less than 16 microsteps. Trimming is certainly unnecessary at resolutions below 10 microsteps. Compensation is disabled at the half-scale position (screwdriver slot vertical) of the trimpot.

To adjust the CN0165 for optimum microstep compensation:

1. *Disable the microstep compensation by positioning the screwdriver slot of the Offset Trimpot vertical.*
2. *Connect the motor and power supply to the CN0165.*
3. *Connect a 250 Hz source to the Step Pulse Input.*
   (a function generator set to ±5 volt levels is suitable for this purpose)
4. *Apply power to the motor and drive.*
5. *Adjust the Offset Trimpot for minimum vibration by turning clockwise or counter-clockwise.*

FAULT LED

The CN0165 has protection circuitry to shut down the drive when potentially damaging conditions exist. The state of the protection circuit is available on the Fault LED as well as the Fault/Reset Terminal. See Fault/Reset, Terminal 7, on page 8 for details on fault conditions.

POWER ON RESET

The Power-on Reset circuitry of the CN0165 insures that the drive turns on in an organized manner. The motor phase outputs are held low (ground) and the internal counters are held to microstep zero until the power supply voltage rises to the minimum operating voltage level of the drive.

The minimum voltage for operation is 18 VDC. Power-on Reset releases when the power supply voltage reaches this voltage threshold. The motor phase outputs become active, carrying a 13 KHz signal equal in voltage to that of the power supply. The drive is now ready to receive step pulses.

UNDER-VOLTAGE LOCKOUT

Under-voltage Lockout protects the CN0165's output transistors from damage resulting from low power supply voltage. This feature activates when the power supply voltage drops below 18 volts. Below this voltage, the Phase outputs (Terminals 3, 4, 5 & 6) are pulled low. Supply current is removed from the output transistors and the motor stops positioning. When the power supply voltage falls below 5 volts, the Phase outputs go to an open circuit (floating) condition.

While the CN0165 remains in an under-voltage condition, the drive is held in the reset state. Once the power supply voltage rises above 18 volts and all internal voltages have stabilized to their proper levels, the Power-on Reset is automatically executed.

MICROSTEPPING

Microstepping is a technique that electronically multiplies the number of steps a motor takes per revolution. This is useful because it increases motor angular resolution and decreases motor vibration. A 200 step per revolution motor, operated at 100 microstep resolution, will take 20,000 microsteps to complete one revolution of the motor shaft.

Microstepping is normally accomplished by driving the motor windings with sine and cosine weighted currents. A 90° electrical angle change in these currents results in a mechanical angle movement of 1.8° (full step) in a 200 step/revolution motor. The sine-cosine values may be replaced with values compensated for a specific motor type or characteristics. See Current Profile Option, page 24, for further information on compensated current profiles.

Low speed vibration is the result of the start-stop pulsing motion of the motor. This incremental input generates periodic acceleration and deceleration reaction torque at the given step rate. When the step rate matches, or is a sub-harmonic of the mechanical resonant frequency of the motor, the vibrations become severe.

Microstepping divides full step positioning into 'microsteps'; decreasing the magnitude of the reaction torque generated. This results in a decrease in resonant vibration.

Another benefit of microstepping is an increase in the number of resolvable angular positions. However, there are a number of factors that limit the achievable open-loop accuracy of these positions. See the topics under Accuracy, beginning on page 22 for further details.

ANTI-RESONANCE

Most step motors are prone to parametric instability or resonance when rotating at a rate of 4 to 15 revolutions (800 to 3000 full steps) per second. Called mid-band instability or resonance, this phenomenon appears as a torsional oscillation of 50 to 150 Hz while the motor is running in this speed range. The torsional oscillation has a tendency to increase in amplitude with time until it reaches a peak equal to the step angle of the motor. When this happens, the motor loses synchronization and stalls.

Generally the amplitude buildup takes from tens of cycles to hundreds of cycles to reach this level. Several seconds may elapse from the start of the oscillation until the motor actually stalls. Usually this is long enough to allow the motor to accelerate through this region. Continuous operation in this speed band is impossible.

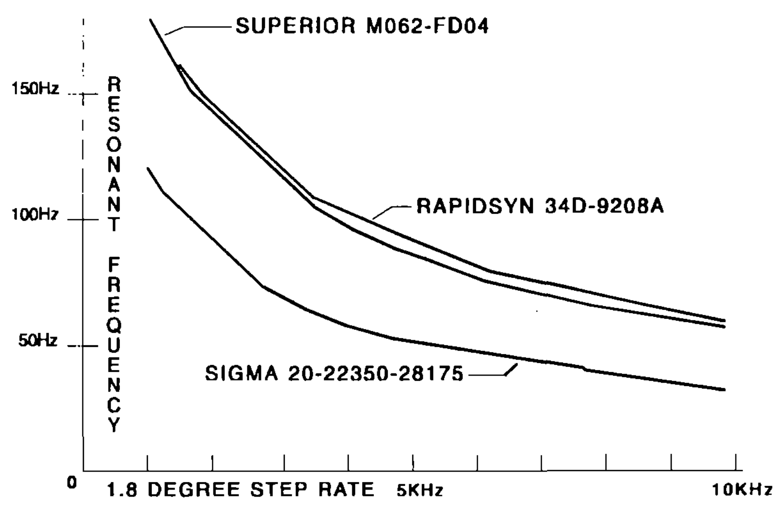


Figure 8 - Resonance

Above and below this range of speeds, the oscillation amplitude may not be sufficient to stall the motor but it is still present. The graph in Figure 8 shows the parametric resonance frequency versus motor step rate for three different step motors. In all three cases resonance breaks out at 1000-1400 (full) steps per second and is most severe at the higher torsional frequencies (lowest step rates).

Because any torsional oscillation implies the acceleration and deceleration of a mass, torque that otherwise would have been available for useful work is wasted to sustain this oscillation. The CN0165 incorporates a mid-band anti-resonance compensation circuit to close the loop on this instability and damp it out electronically. Since the motor will not sustain oscillation, torque previously wasted is now available to the application.

With anti-resonance circuitry the motor may be run continuously at speeds where de-synchronization would otherwise occur. The motor no longer exhibits 'forbidden' regions where continuous-operation cannot be sustained. And there is more torque available over the entire operating range of the drive.

The operation of the anti-resonance circuit is transparent to the user; no special provisions have to be taken to accommodate it.

TORQUE AND POWER

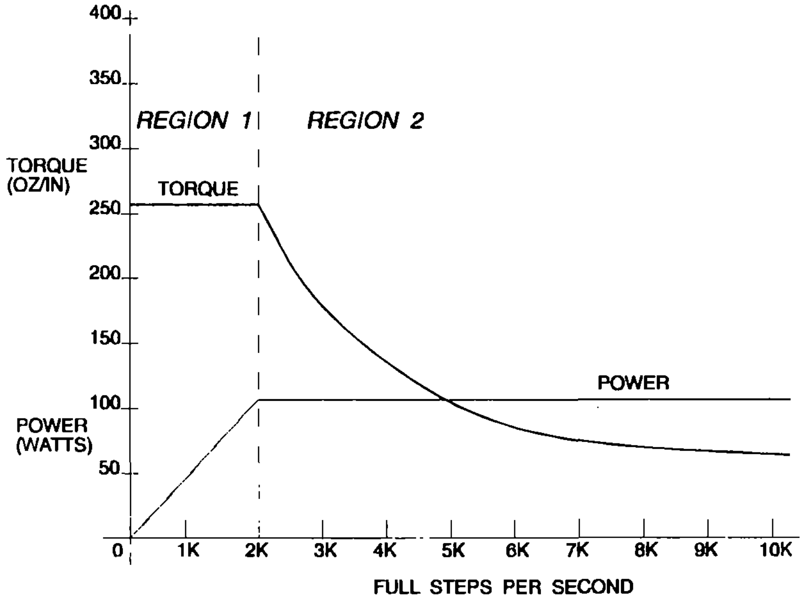


Figure 9 - Torque & Power vs. Speed

Step motor performance curves exhibit two distinct regions with respect to speed, as shown in Figure 9, page 17. In Region 1, from 0-2000 full steps/second, motor torque is constant with speed while motor shaft power is proportional to speed. In Region 2, from 2000 full steps/second to maximum speed, motor torque decreases as the inverse of the speed while motor shaft power remains constant.

The value of the current set resistor determines motor torque in Region 1. Motor torque is held constant by controlling the magnitude of the motor phase current. The step rate in Region 1 is low enough to permit motor phase current to reach the desired value. In Region 1 motor torque is nearly proportional to motor current and remains constant.

In Region 2 torque is no longer dependent on the value of the current set resistor. As the motor enters Region 2 torque begins to drop off as the inverse of the speed. Motor winding inductance limits the rate of current rise, and as speed increases, progressively less current can be forced into the windings. Because motor torque is proportional to phase current, and current (in Region 2) is proportional to the step period, torque decreases as the inverse of the step rate. Torque in Region 2 may be approximated with the equation:

$$T = \frac{kV}{f\sqrt{L}}$$

where:
T = torque
k = motor constant
V = power supply voltage
f = steps per second
L = motor inductance

Equation 7 - Motor torque

Power is the product of speed and torque. Power remains constant in Region 2 in an ideal step motor. In a real step motor there are speed related power losses (e.g., friction, magnetic losses, windage) that result in a slope to the power curve. The intersection of this slope and the speed axis determines the maximum speed of the motor.

THE CENTENT CN0165 DRIVE IS CAPABLE OF RUNNING STEP MOTORS AT SPEEDS HIGH ENOUGH TO CAUSE DAMAGE TO MOTOR SHAFT BEARINGS.

MOTOR WINDING CONFIGURATION

The customer has the option with 6 or 8 lead motors of connecting the windings in a high performance or a low performance configuration. High performance operation has twice the maximum motor power output of low performance operation. The speed to which constant torque is maintained is also doubled. This performance comes at the expense of greater motor and drive heating. The performance of a 6 lead motor will match that of an 8 lead motor in the same winding configuration, assuming the current ratings of the motors are the same.

PERFORMANCE

The low performance configuration is commonly called series operation or occasionally, in the case of 6 lead motors, full winding operation. The high performance configuration is commonly called parallel operation, or in the case of 6 lead motors, half winding operation. Further discussions in this manual of series or parallel operation refers to both 6 lead and 8 lead motors. A 4 lead motor is usually considered as parallel operation.

If a motor is used in the series configuration, the supply current will not exceed one third of the motor's rated per phase current. The current draw of a motor in the parallel configuration will not exceed two thirds of the motor's per phase current rating.

Motor torque is approximately proportional to motor current multiplied by the number of winding turns that carry the current. In series operation, twice the number of turns carry current as in parallel operation; thus only half the current is needed to generate a given level of torque. Unfortunately series operation also quadruples the effective winding inductance. In Region 2 (see Figure 9, page 17) motor power is proportional to the inverse of the square root of the winding inductance.

The effect of various winding currents on motor performance is illustrated in Figure 10, page 20. The data was acquired using a 4 amp per phase motor, driven from 1 to 6 amps in 1 amp increments.

Note that when the motor in Figure 10 is operated in excess of 4000 steps per second, the current set resistor value makes no difference in performance. What is significant is the reduction in low speed heating of the motor and drive evident at the lower current setting.

The effect of series versus parallel operation at low and high power supply voltages is illustrated in Figure 11, page 20. Note that series operation at 54 VDC yields performance virtually identical to parallel operation at 27 VDC.

Series configuration is preferred for Region 1 operation, and is suitable for Region 2 if the power available is sufficient. The benefits are lower motor and drive heating and lower power supply current requirements. For series operation the phase current level of the CN0165 is set to one-half the motor's nameplate phase current rating.

The parallel configuration doubles high speed torque. Motor phase currents are twice those in a series connected motor. This doubles power supply requirements and thus results in higher motor and drive temperatures. For parallel operation the phase current level of the CN0165 is set to the motor's nameplate phase current rating.

> Holding torque and low speed torque are the same in parallel and series configurations.

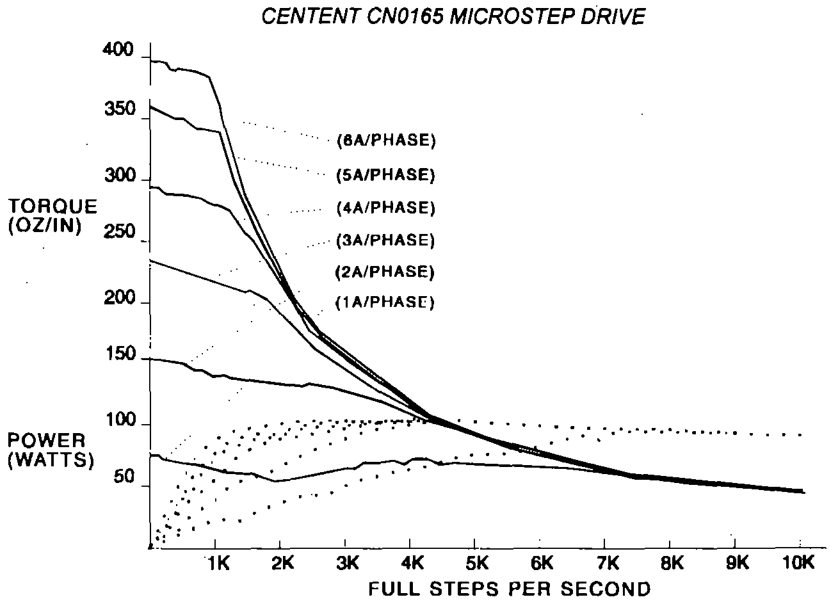


Figure 10 - Winding current vs. Torque

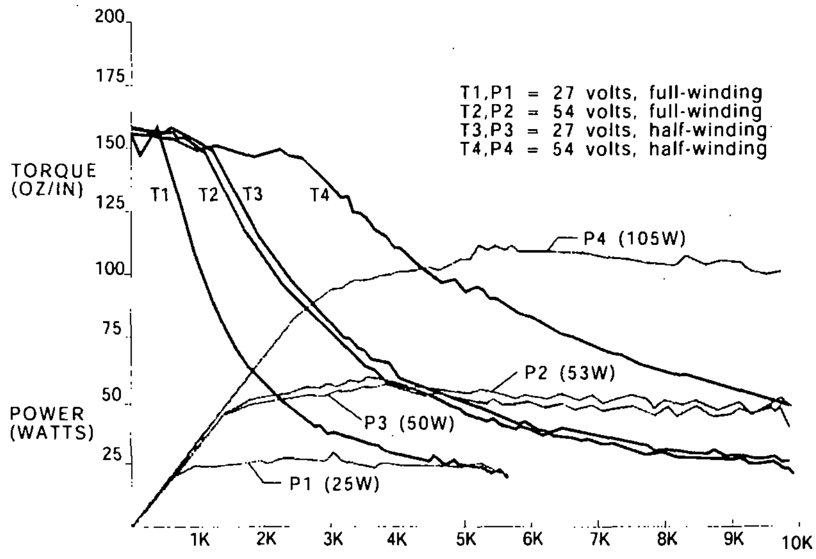


Figure 11 - Parallel vs. Serial operation

POWER SUPPLY VOLTAGE

The CN0165 step motor drive has a power supply range from 18 to 80 VDC. The magnitude of the power supply voltage affects the power a step motor generates in Region 2. See Figure 9 - Torque & Power vs. Speed on page 17. The speed to which constant torque is maintained is proportional to power supply voltage. Consequently maximum motor power is also proportional to the power supply voltage.

Increasing power supply voltage increases motor heating. Taking this into consideration, the power supply voltage should be just high enough to meet the application's power requirements and no higher. Excessively high supply voltage will result in unwanted motor and drive heating.

POWER SUPPLY CURRENT

Power supply current is determined by the load applied to the motor, the speed the motor is running and the value of the current set resistor. Normally, the power supply current for a series configured motor will not exceed one third of the rated per phase current of the motor. A parallel configured motor will require no more than two thirds of the rated per phase current.

The power supply current for a motor in the parallel configuration is shown in Figure 12. The solid line curve represents fully loaded motor operation. The dotted line curve represent the motor during unloaded operation.

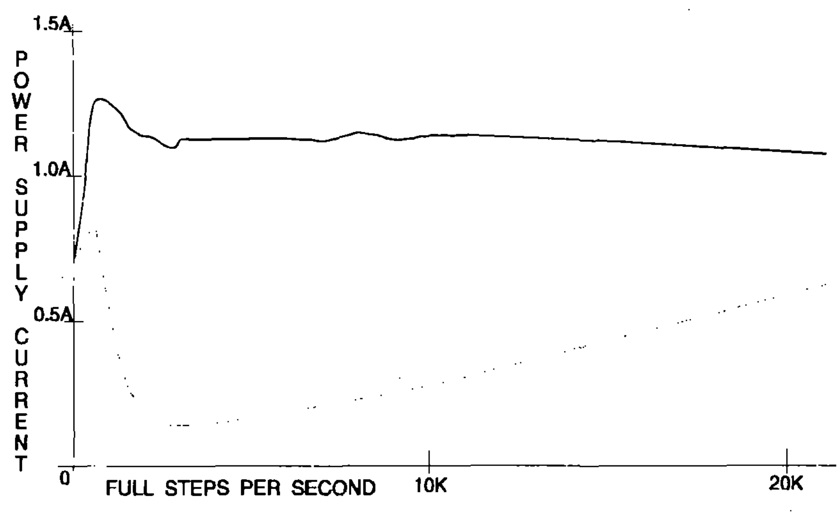


Figure 12 - Power supply current

MOTOR AND DRIVE HEATING

Motor and drive heating is equivalent to the difference between the electrical power input to the system and the motor's mechanical power output. The ratio of output to input power defines the system efficiency. The power losses that lower efficiency are dependent on motor speed, load and winding configuration, the power supply voltage, current set value, drive losses and other factors. The power losses in the drive are primarily resistive and easy to calculate. Each channel of the drive is equivalent to a 0.55 ohm resistor.

Motor drive current dissipation in Region 1 (Figure 9, page 17) is always considerably higher than in Region 2. In Region 1, motor phase currents, and therefore drive channel currents are sinusoidal. The peak amplitude is equal to the rated per phase current for parallel operation and half of that for serial operation. In Region 1, power dissipation may be calculated as follows.

$$R1_{Parallel}: \quad \omega = 0.55(I_\phi)^2$$

Equation 8 - Region 1 Current dissipation, Parallel operation

$$R1_{Series}: \omega = 0.55\left(\frac{I\phi}{2}\right)^2$$

Equation 9 - Region 1 Current dissipation, Series operation

Note that the power dissipation is four times higher for the parallel configuration. In Region 2 power dissipation may be calculated as follows.

$$R2_{Parallel}: \omega = 0.55\left(\frac{I\phi}{3}\right)^2$$

Equation 10 - Region 2 Current dissipation, Parallel operation

$$R2_{Series}: \omega = 0.55\left(\frac{I\phi}{6}\right)^2$$

Equation 11 - Region 2 Current dissipation, Series operation

Region 1 power dissipation is 4.5 times greater than Region 2 power dissipation. If the motor will spend most of its time stopped or in Region 1, use Region 1 power dissipation equations to determine the size of the heat sink. Utilizing the Standby Current Trimpot to lower power dissipation while the motor is idle will minimize heat sink requirements.

MOTOR TOLERANCES

Most step motors are specified as having a ±5% non-accumulative step tolerance. This implies that a 200 step per revolution motor will have an absolute accuracy of 1 part out of 2000. If the motor is run open-loop (as most step motors are) the user cannot expect to position a motor accurately at anything greater than a 10 microstep resolution. Using a higher microstep resolution, in an open-loop application, will contribute to motor smoothness but will not increase resolution.

MOTOR LOAD

Motor load is the most significant contributor to microstep positioning error. A step motor only generates torque when an error angle in rotor position exists. The relationship between rotor displacement angle and restoring torque for a typical motor is shown in Figure 13.

The function that relates error angle to torque is approximately sinusoidal. An error angle equal to one microstep occurs when the motor load equals the holding torque divided by the microstep resolution.

If the motor load is transient, the rotor error will decrease to a residual level upon removal of the transient load. This applies to the load induced by the acceleration and deceleration of the step motor during the course of a normal move.

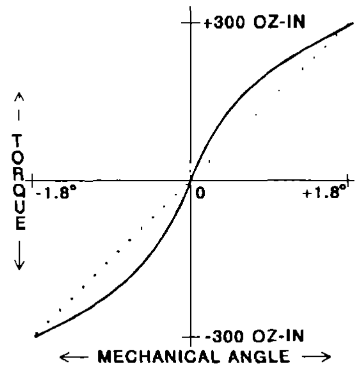


Figure 13 - Torque vs. rotor angle

MOTOR LINEARITY

Motor linearity is the relationship between the mechanical angle of shaft rotation and the electrical angle of the winding currents. In an ideal motor this is directly proportional; the application of sine-cosine currents produces uniform shaft rotation and equally spaced microsteps.

Real motors exhibit distortion as represented in Figure 14 - Motor linearity. The Offset Trimpot (see page 14) is provided to compensate for microstep size distortion. Varying the value of the current set resistor may also help trim the error.

Should these methods be inadequate, the motor winding currents may be distorted to compensate for the non-linearity. Centent can provide a 3rd Harmonic profile or generate a compensated profile for motors of a like model number or type. These custom profiles are 'programmed' into the customer's CN0165 as a Current Profile Option, as described in the next section.

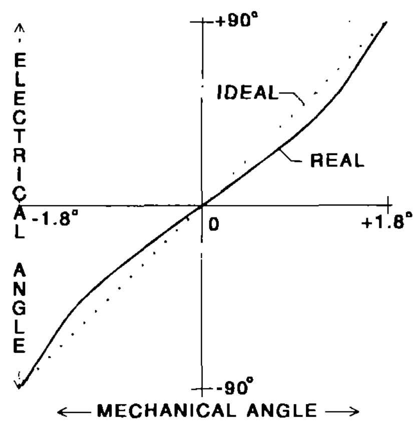


Figure 14 - Motor linearity

CURRENT PROFILE OPTION

The standard current profile for the CN0165 is the Sine-Cosine Profile. This is satisfactory for the vast majority of step motors and applications. Roughness, due to uneven microstep size, may be apparent at microstep resolutions of 16 or above. This distortion can be compensated by adjusting the Offset Trimpot (see page 14). The options described in this section apply to a very small percentage of applications and should not be specified unless required. The standard Sine-Cosine profile will provide the best performance for most motors and applications.

The non-linear microstep size of a step motor can be offset by distorting the current profile to compensate for the mechanical characteristics of the motor. Two options are offered for step motors that cannot be adequately compensated or applications requiring exceptional smoothness.

The first option is the 3rd Harmonic profile. This provides improvement for step motor designs that exhibit distortions that are 3rd harmonic in nature. Centent Company will assist in evaluating a motor for this option.

The second option is the Compensated Current Profile. A specific model of step motor is run on a dynamometer to empirically generate the current profile necessary for even microstep size. This provides maximum smoothness and accuracy but will not work well with another model of step motor.

The CN0165 may be ordered with different current profiles in the same drive. The eight selections (see Option Header, page 13) may be any combination of current profiles and step resolutions, provided the step resolutions are all selected from the same column of the Resolution Options Table on page 13.

MOTOR SPEED-TORQUE CURVES

The following speed-torque and speed-power curves were plotted using a Centent CN0165 and various manufacturers' motors. Two sets of curves are plotted per motor. One set was taken with a 54 VDC power supply voltage, the other with a 27 VDC power supply voltage. The dynamometer's moment of inertia was adjusted to be equivalent to the motor's moment of inertia. The test data was collected at 100 points between zero and 10,000 full steps per second. The CN0165 was set to 10 microstep resolution and the motors configured for high performance (parallel) operation.

The data set for 27 volts DC power supply is also representative of a series configured motor run at 54 volts DC power supply. The solid line graph is the motor torque, measured in ounce/inches. The dotted line graph is the mechanical power output of the motor, measured in watts.

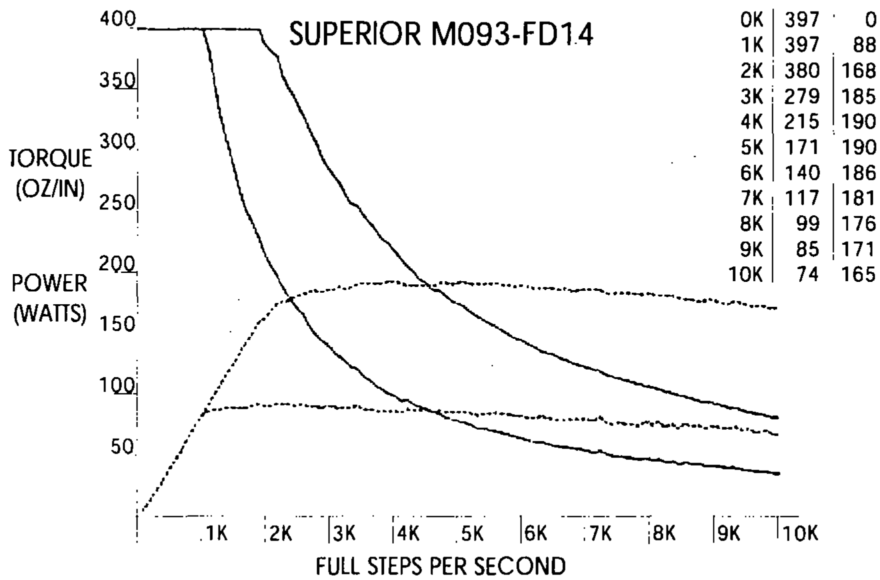


Figure 15 - SUPERIOR M093-FD14 Superior M093-FD14

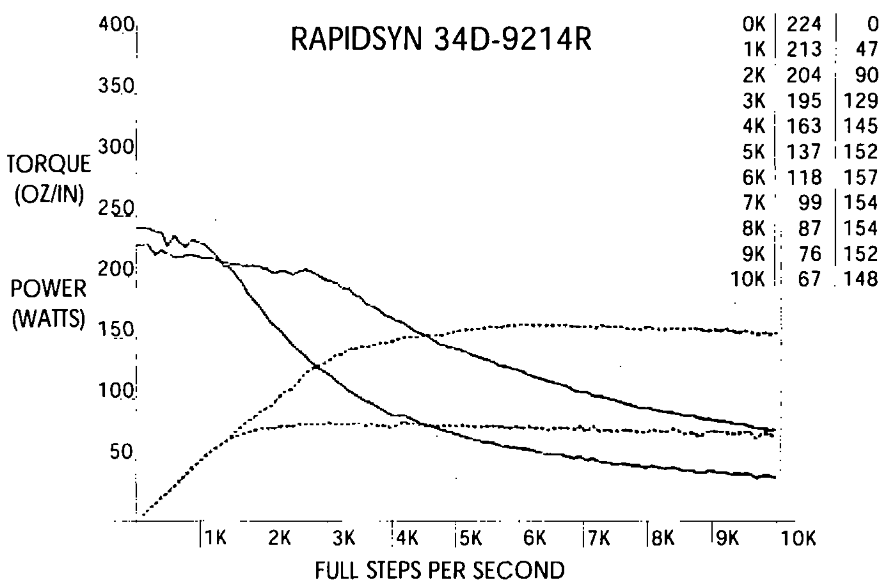


Figure 16 - RAPIDSYN 34D-9214R Rapidsyn 34D-9214R

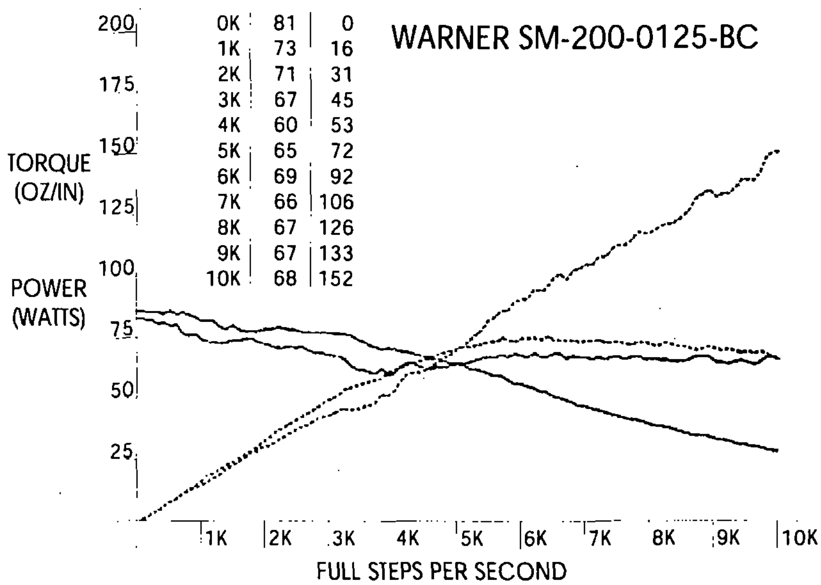


Figure 17 - WARNER SM-200-0125-BC

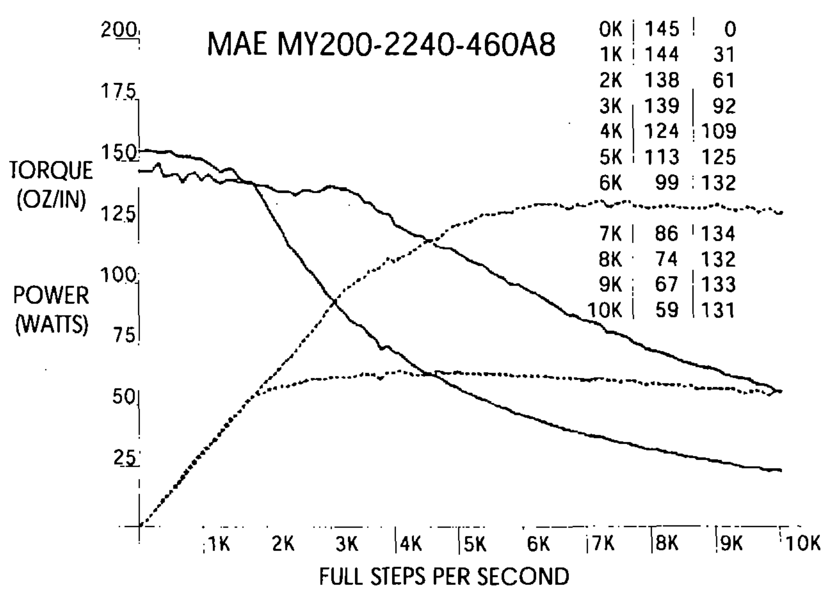
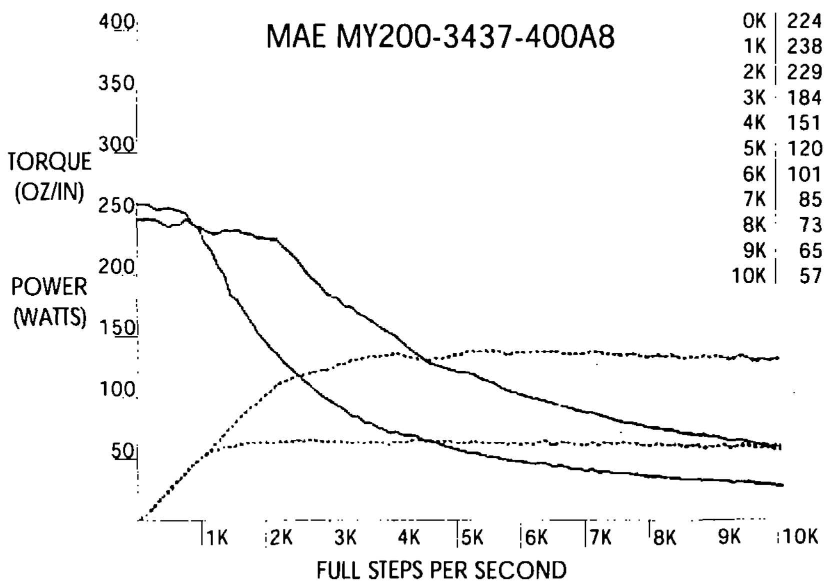
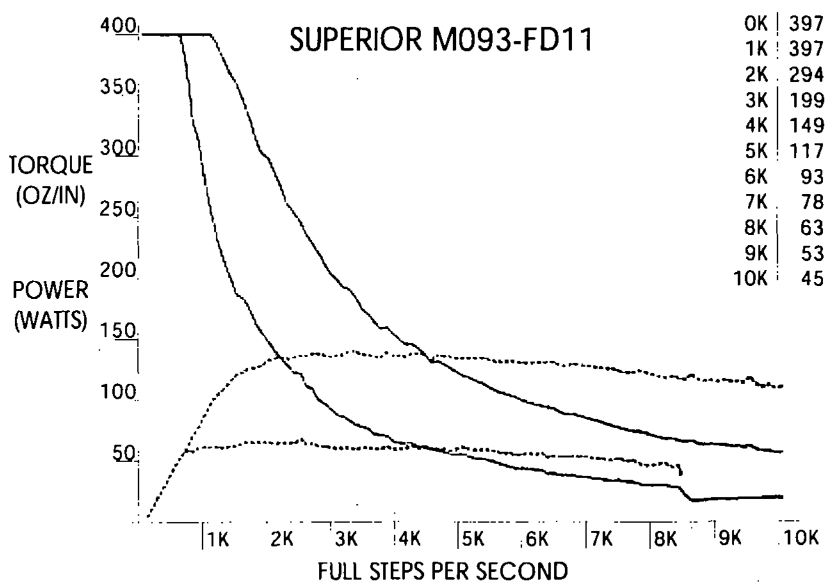


Figure 18 - MAE MY200-2240-460A8 MAE MY200-2240-460A8



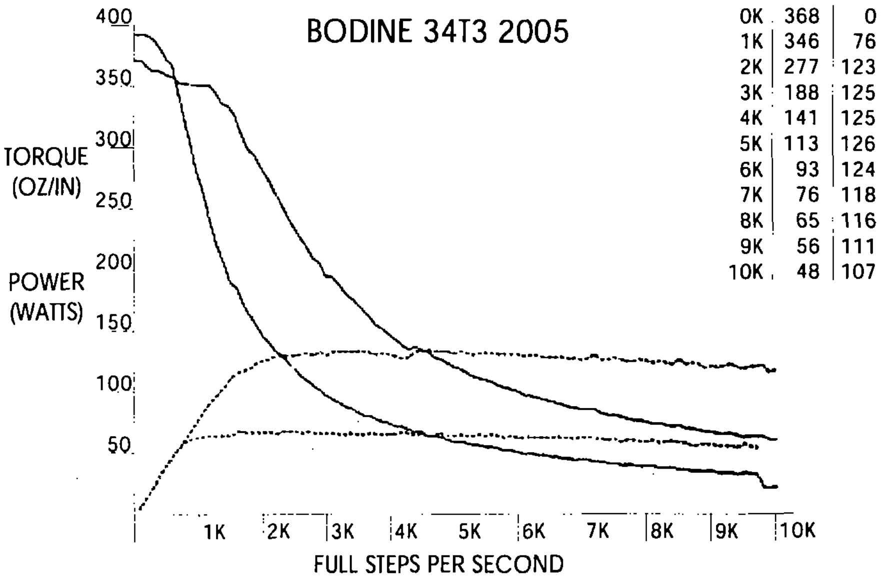
0K	224	0
1K	238	52
2K	229	101
3K	184	122
4K	151	134
5K	120	133
6K	101	134
7K	85	133
8K	73	129
9K	65	130
10K	57	127

Figure 19 - MAE MY200-3437-400A8 MAE MY200-3437-400A8



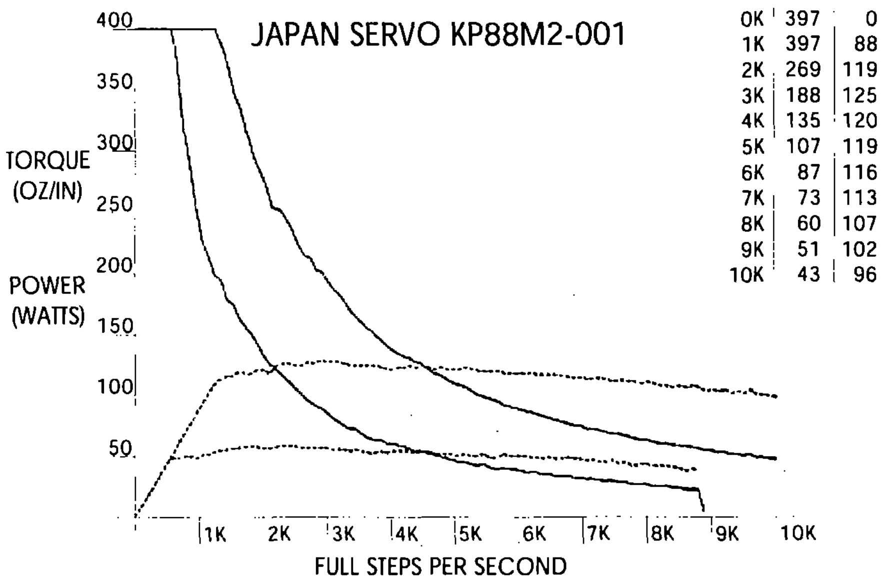
0K	397	0
1K	397	88
2K	294	130
3K	199	132
4K	149	132
5K	117	129
6K	93	124
7K	78	120
8K	63	113
9K	53	105
10K	45	100

Figure 20 - SUPERIOR M093-FD11 Superior M093-FD11



0K	368	0
1K	346	76
2K	277	123
3K	188	125
4K	141	125
5K	113	126
6K	93	124
7K	76	118
8K	65	116
9K	56	111
10K	48	107

Figure 21 - BODINE 34T3 2005



0K	397	0
1K	397	88
2K	269	119
3K	188	125
4K	135	120
5K	107	119
6K	87	116
7K	73	113
8K	60	107
9K	51	102
10K	43	96

Figure 22 - JAPAN SERVO KP88M2-001 Japan Servo KP88M2-001

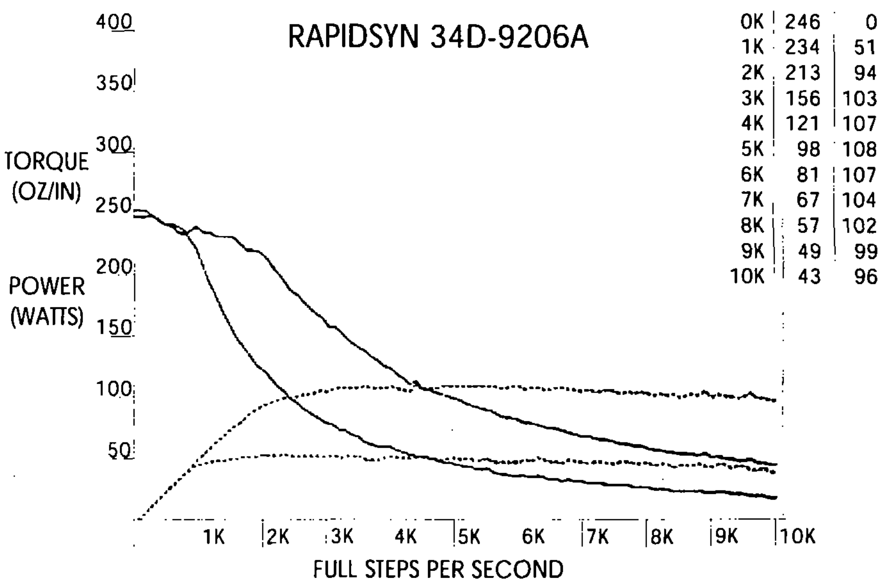


Figure 23 - RAPIDSYN 34D-9206A Rapidsyn 34D-9206A

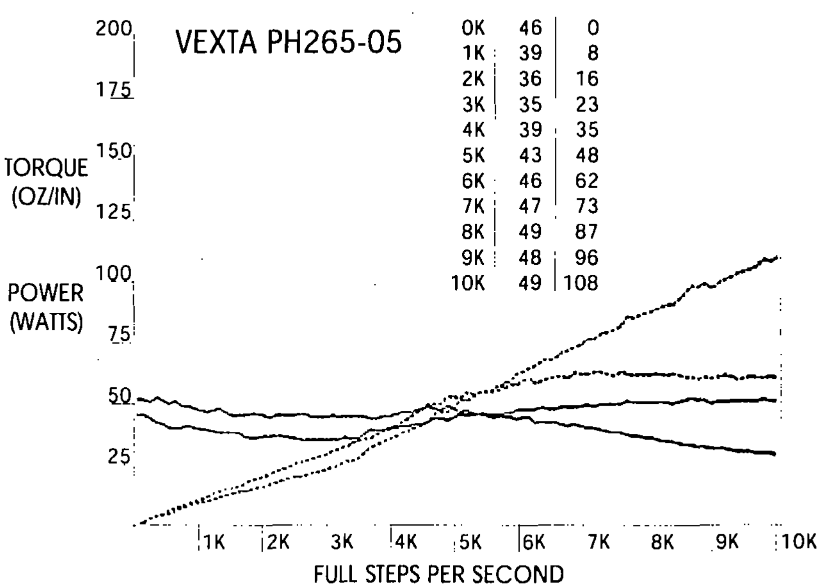
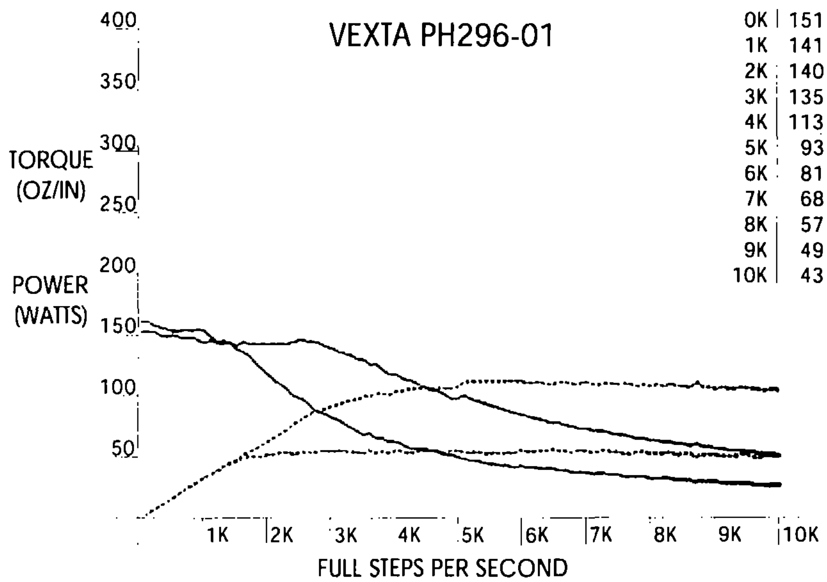
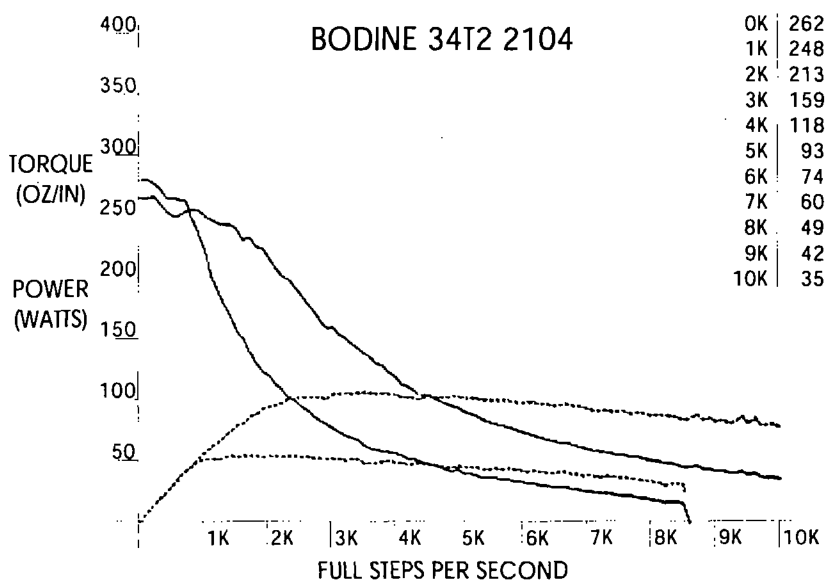


Figure 24 - VEXTA PH265-05 Vexta PH265-05



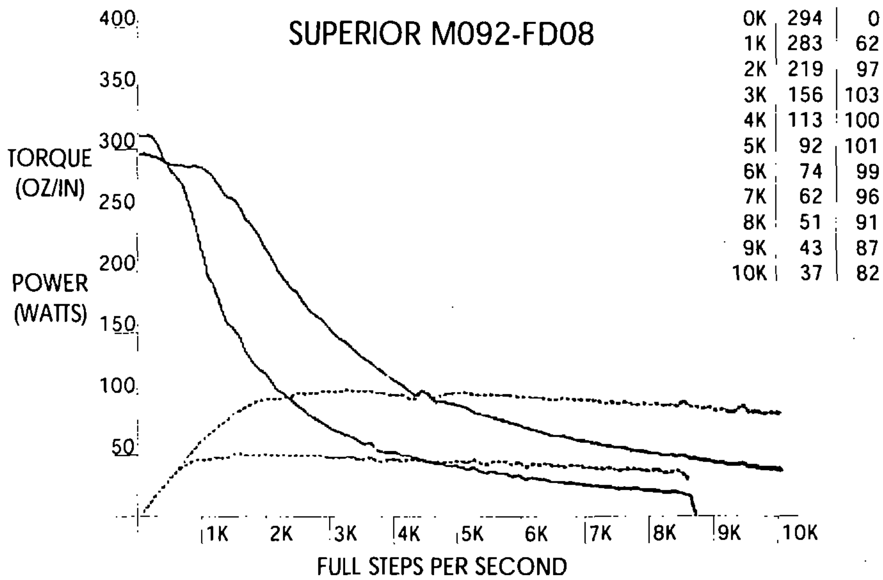
0K	151	0
1K	141	31
2K	140	62
3K	135	90
4K	113	100
5K	93	103
6K	81	107
7K	68	106
8K	57	102
9K	49	99
10K	43	96

Figure 25 - VEXTA PH296-01 Vexta PH296-01



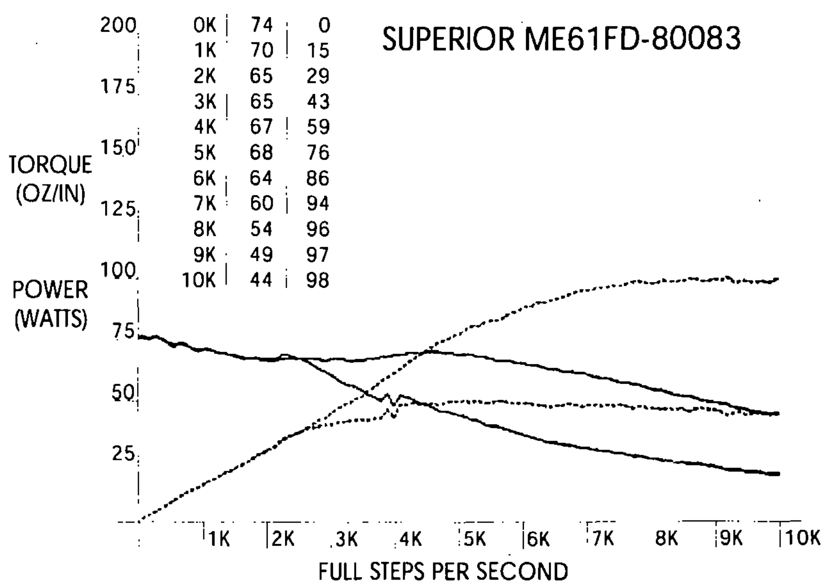
0K	262	0
1K	248	54
2K	213	94
3K	159	105
4K	118	105
5K	93	103
6K	74	99
7K	60	94
8K	49	88
9K	42	83
10K	35	79

Figure 26 - BODINE 34T2 2104



0K	294	0
1K	283	62
2K	219	97
3K	156	103
4K	113	100
5K	92	101
6K	74	99
7K	62	96
8K	51	91
9K	43	87
10K	37	82

Figure 27 - SUPERIOR M092-FD08 Superior M092-FD08



0K	74	0
1K	70	15
2K	65	29
3K	65	43
4K	67	59
5K	68	76
6K	64	86
7K	60	94
8K	54	96
9K	49	97
10K	44	98

Figure 28 - SUPERIOR ME61FD-80083 Superior ME61FD-80083

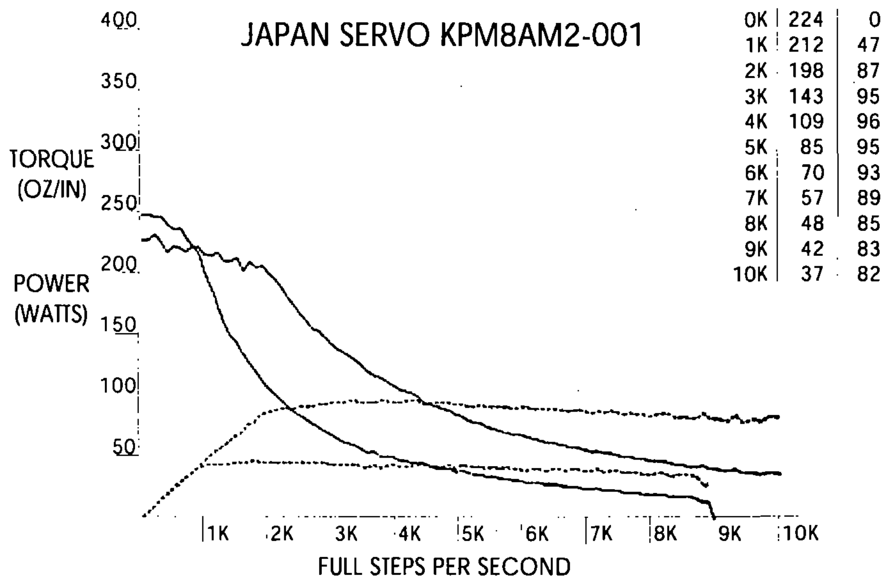


Figure 29 - JAPAN SERVO KPM8AM2-001 Japan Servo KPM8AM2-001

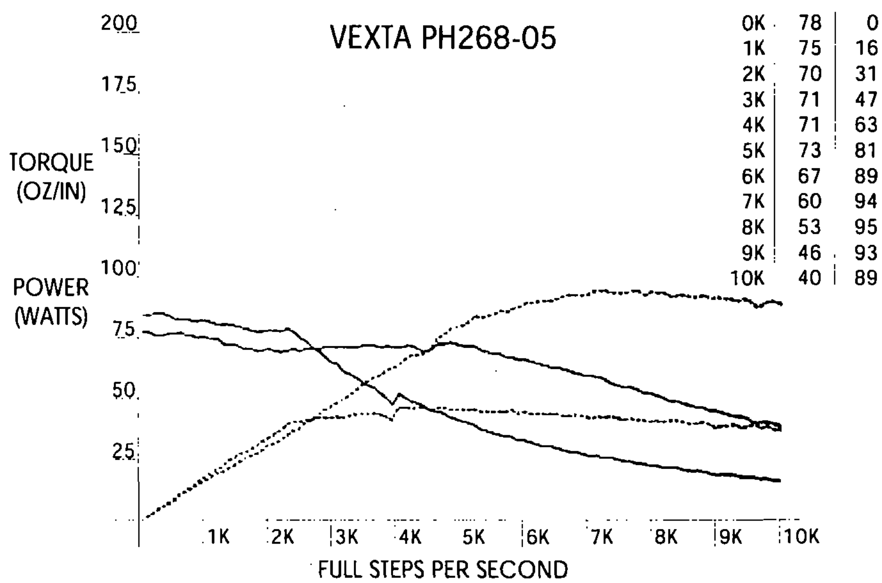
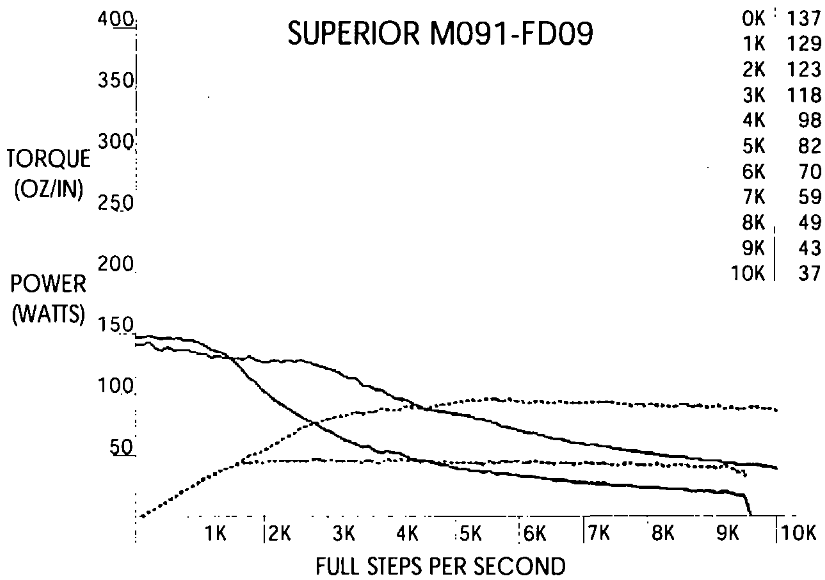
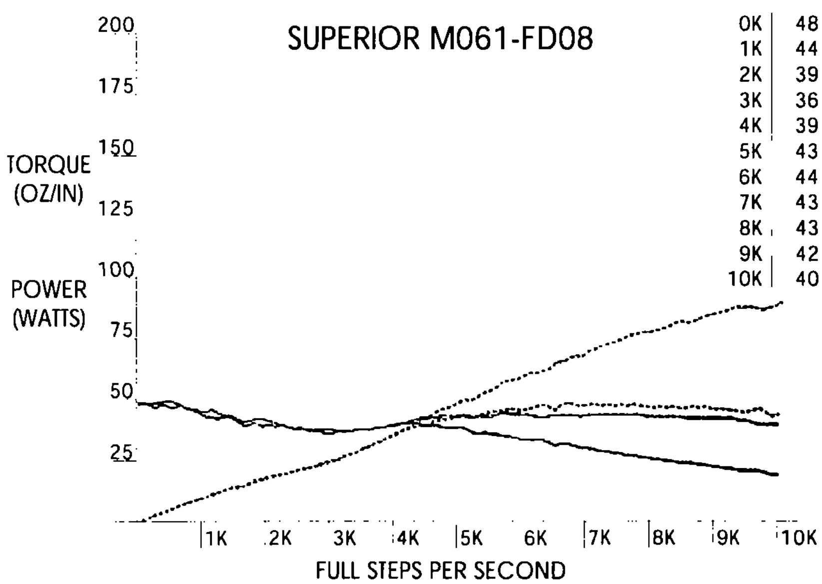


Figure 30 - VEXTA PH268-05 Vexta PH268-05



0K	137	0
1K	129	28
2K	123	54
3K	118	78
4K	98	87
5K	82	91
6K	70	93
7K	59	91
8K	49	88
9K	43	87
10K	37	82

Figure 31 - SUPERIOR M091-FD09 Superior M091-FD09



0K	48	0
1K	44	9
2K	39	17
3K	36	24
4K	39	35
5K	43	48
6K	44	59
7K	43	67
8K	43	77
9K	42	85
10K	40	89

Figure 32 - SUPERIOR M061-FD08 Superior M061-FD08

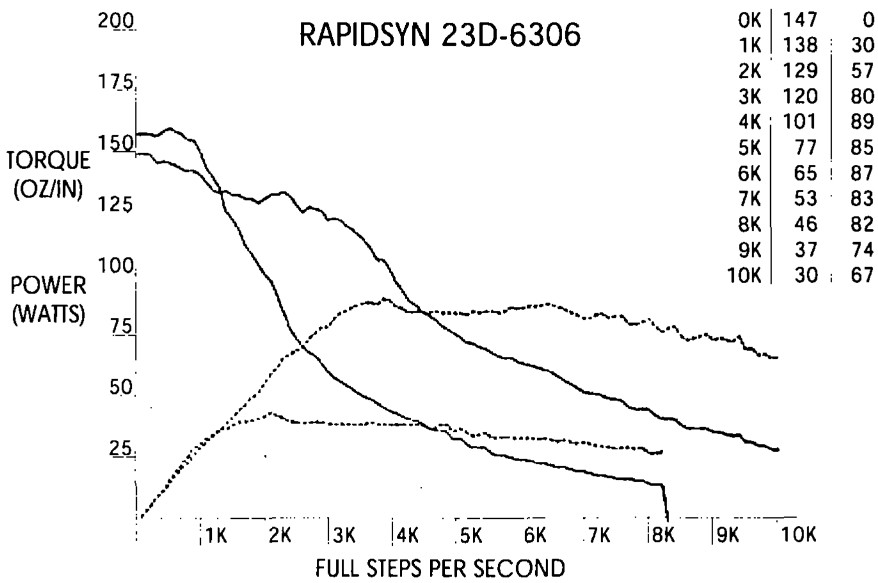


Figure 33 - RAPIDSYN 23D-6306 Rapidsyn 23D-6306

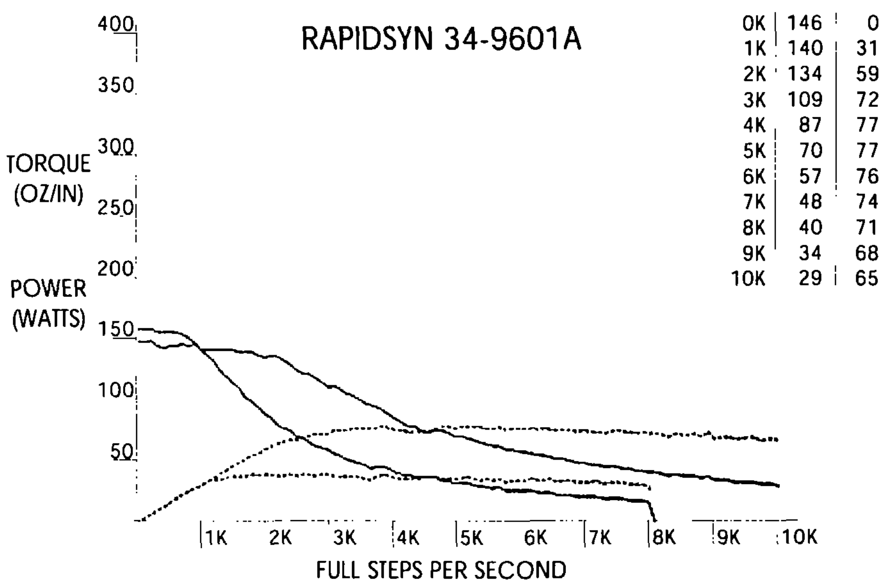


Figure 34 - RAPIDSYN 34-9601A Rapidsyn 34-9601A

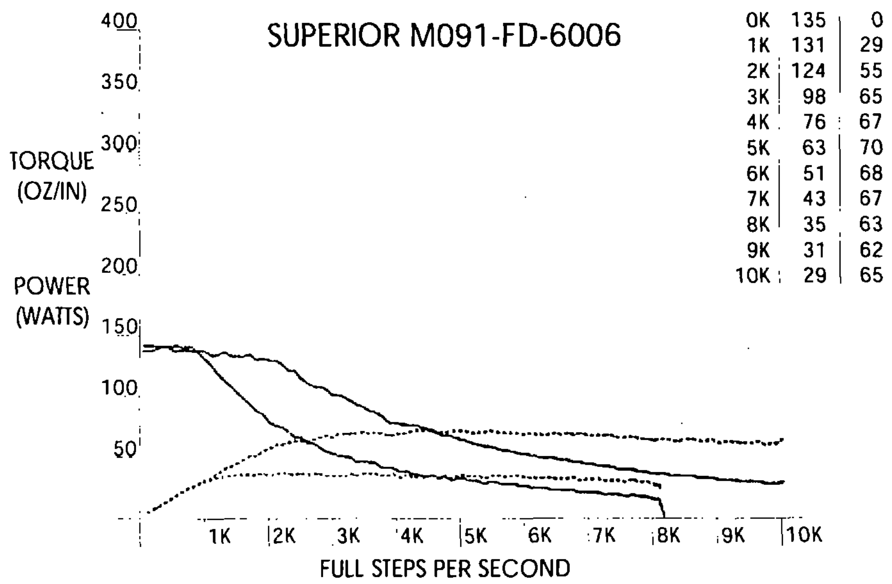


Figure 35 - SUPERIOR M091-FD-6006 Superior M091-FD-6006

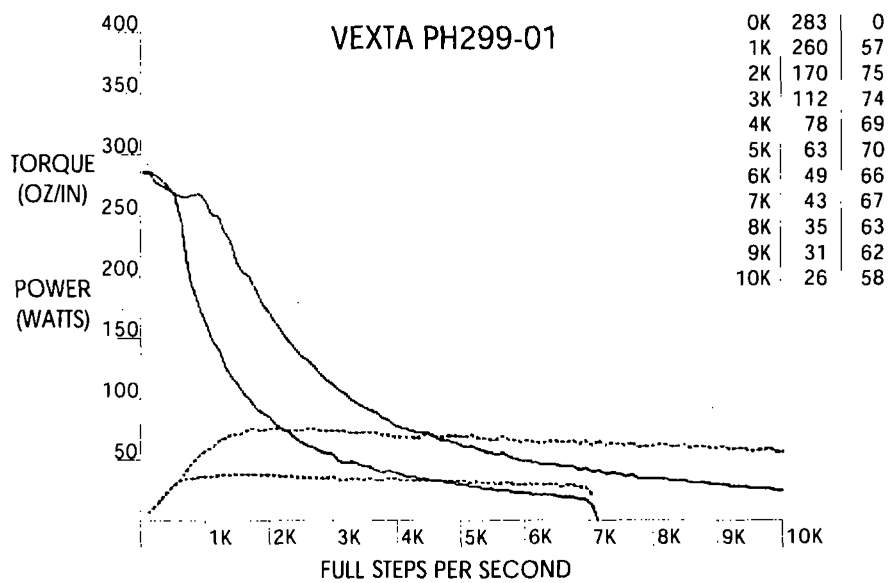
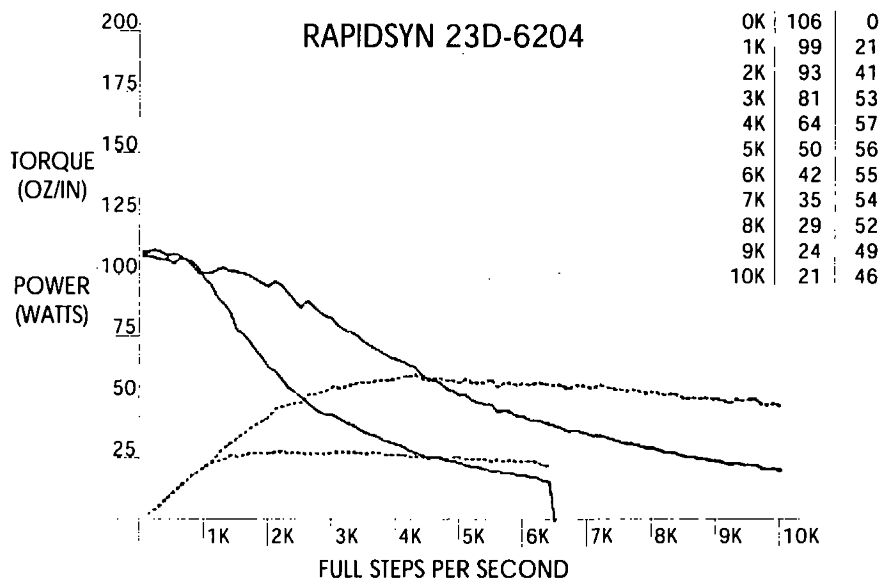
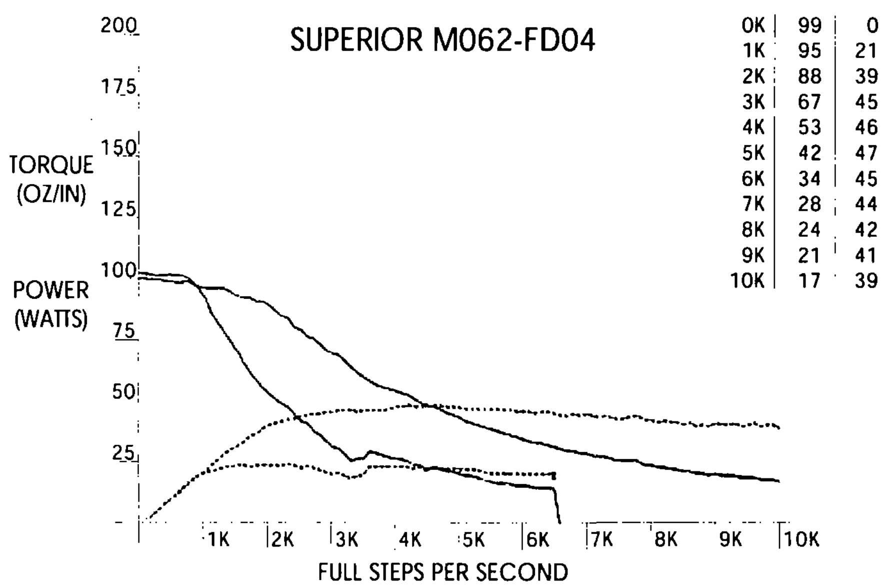


Figure 36 - VEXTA PH299-01 Vexta PH299-01



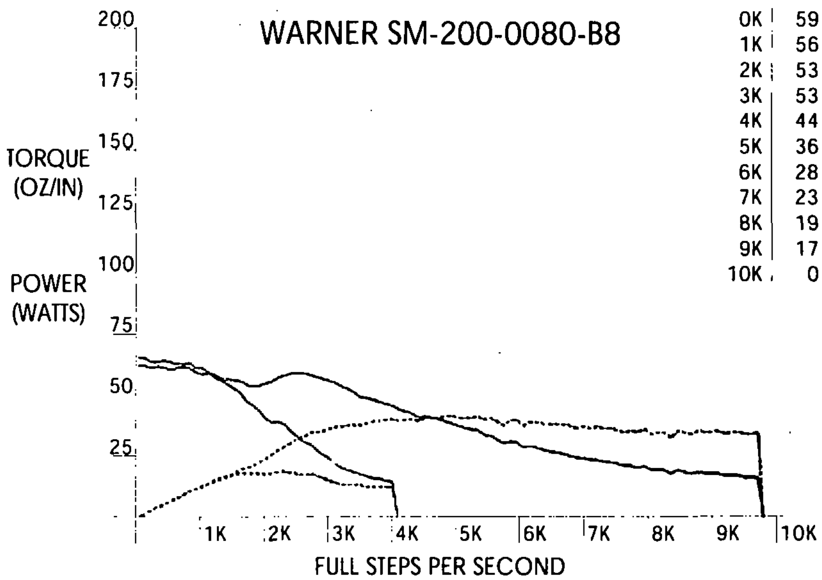
0K	106	0
1K	99	21
2K	93	41
3K	81	53
4K	64	57
5K	50	56
6K	42	55
7K	35	54
8K	29	52
9K	24	49
10K	21	46

Figure 37 - RAPIDSYN 23D-6204 Rapidsyn 23D-6204



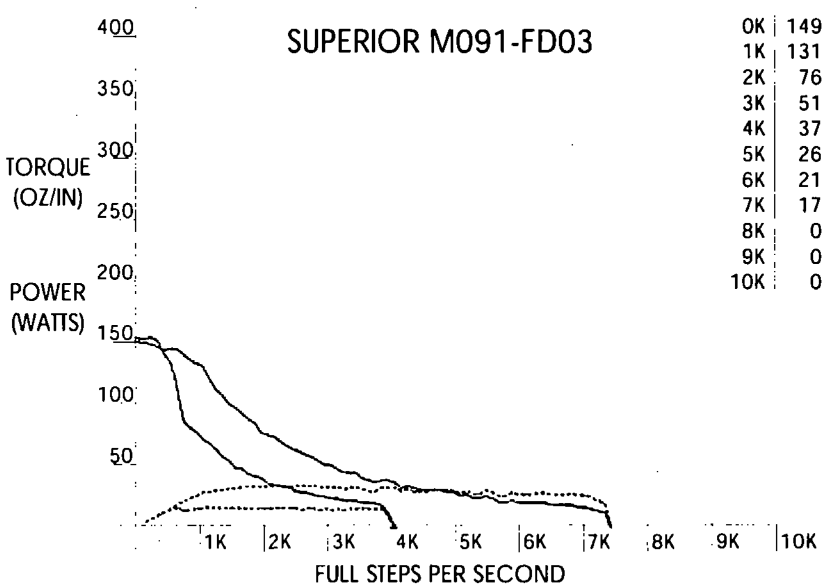
0K	99	0
1K	95	21
2K	88	39
3K	67	45
4K	53	46
5K	42	47
6K	34	45
7K	28	44
8K	24	42
9K	21	41
10K	17	39

Figure 38 - SUPERIOR M062-FD04 Superior M062-FD04



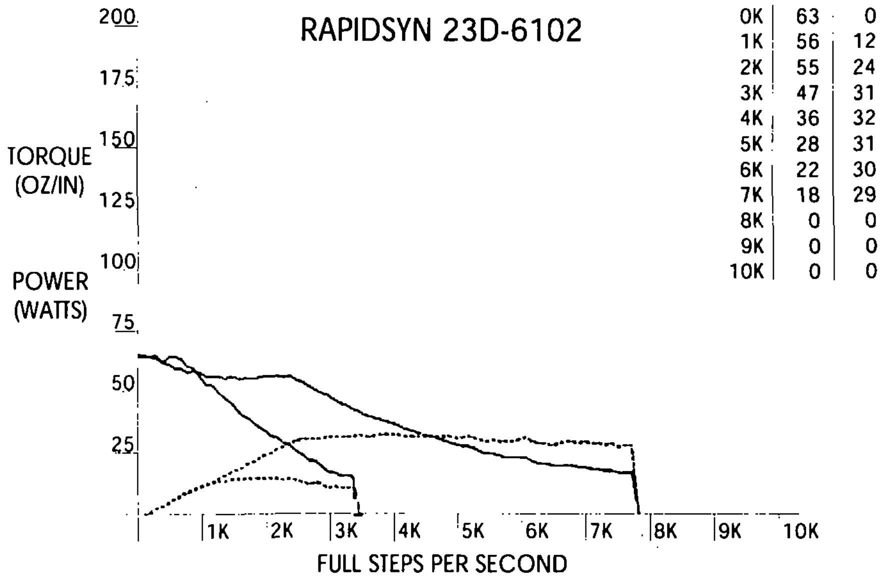
0K	59	0
1K	56	12
2K	53	23
3K	53	35
4K	44	39
5K	36	40
6K	28	37
7K	23	36
8K	19	34
9K	17	34
10K	0	0

Figure 39 - WARNER SM-200-0080-B8 Warner SM-200-0080-B8



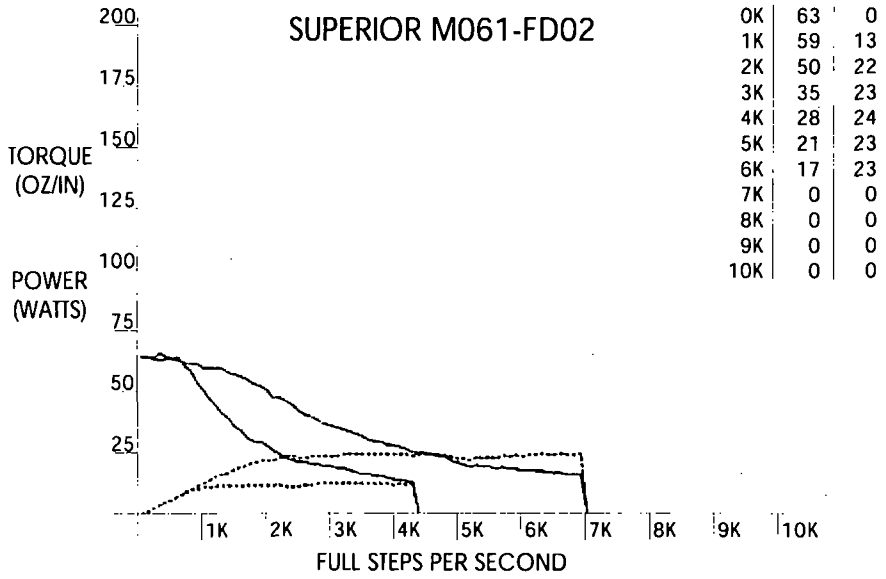
0K	149	0
1K	131	29
2K	76	33
3K	51	34
4K	37	33
5K	26	29
6K	21	29
7K	17	26
8K	0	0
9K	0	0
10K	0	0

Figure 40 - SUPERIOR M091-FD03 Superior M091-FD03



0K	63	0
1K	56	12
2K	55	24
3K	47	31
4K	36	32
5K	28	31
6K	22	30
7K	18	29
8K	0	0
9K	0	0
10K	0	0

Figure 41 - RAPIDSYN 23D-6102 Rapidsyn 23D-6102



0K	63	0
1K	59	13
2K	50	22
3K	35	23
4K	28	24
5K	21	23
6K	17	23
7K	0	0
8K	0	0
9K	0	0
10K	0	0

Figure 42 - SUPERIOR M061-FD02 Superior M061-FD02

CENTENT CN0165 MICROSTEP DRIVE

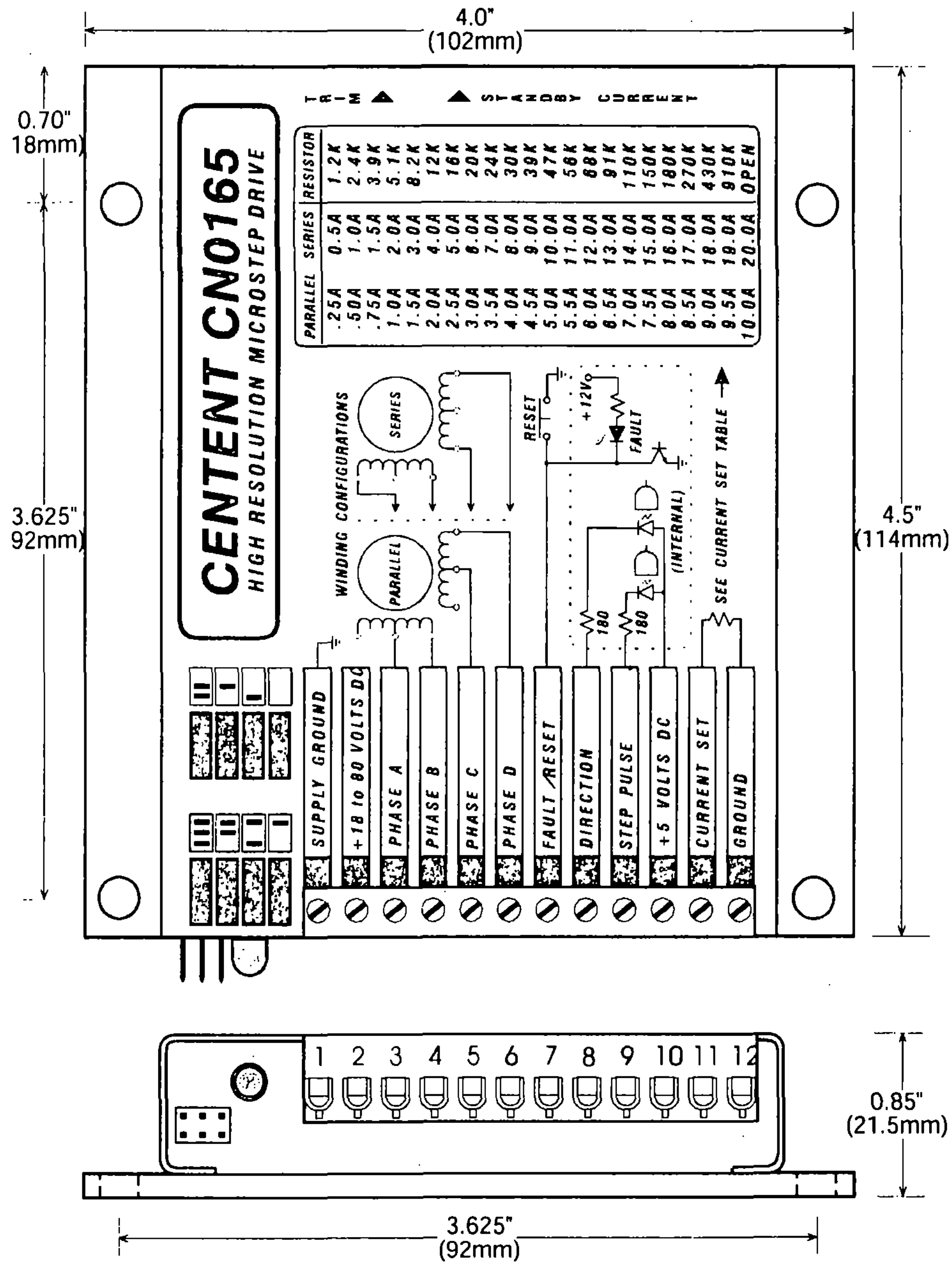


Figure 43 - CN0165

CN0165 SPECIFICATION			
	MIN	MAX	UNITS
ELECTRICAL			
Resolution	1	256	µStep
Supply voltage	18	80	VDC
Current (no motor)	50	60	mA
Motor phase current	0.1	10	A
Motor phase inductance	0.5	--	mH
Step Pulse Input			
Logic '1' voltage	1.8	5.0	VDC
Logic '0' current	3	20	mA
Pulse width 'high'	500	--	nSec
Pulse width 'low'	500	--	nSec
Rise time	--	--	--
Fall time	--	--	--
Frequency	--	1.0	MHz
Direction Input			
Logic '1' voltage	1.8	5.0	VDC
Logic '0' current	3	20	mA
ENVIRONMENTAL			
Operating temperature	-20	+75	°C
	-4	+167	°F
Humidity	0	100	%
Shock	--	100	G
MECHANICAL			
Weight	17	19	oz.
	482	539	gram
Mounting screw size	6	8	#
Size (L x W x H)	4.75 × 4 × .85		in.
	121 × 102 × 21.5		mm
Mounting hole centers	3.625 × 3.625		in.
	92 × 92		mm

Table 7 - Specification

STandard $550.