



## ► *i-Drive* Series: Servo Drive with Integrated Positioning Control

The i-Drive is an intelligent, small, and powerful solution for a variety of applications.

The i-Drive is suitable for controlling permanent magnet brushless (synchronous) motors as well as squirrel cage induction motors. The graphical programming software supports both rotary and linear motor parameters.

i-Drive is the most cost-effective solution for high-performance applications. It is ideal for applications with small space requirements. The i-Drive can be used as a point-to-point controller for single axis positioning, based on a state-of-the-art DSP technology. With the i-Drive you will achieve superb dynamic performance in a compact and robust unit.

The i-Drive consists of integrated micro electronics protected from harsh thermal environment. It can be delivered with either a "cool plate" or compact fan unit.

The i-Drive supports a wide range of motor power (0.5 to 1.5 kW) and 115 single phase or 208/230 Vac single phase/three phase.

The i-Drive integrates all functions for fieldbus servo drive with position control.

### i-Drive

- Control via RS485, CAN open, digital or analog input
- 20 programmable index positions
- Time or event triggered
- Relative or absolute positioning
- Scalable control for positioning, velocity and torque
- Power range 0.25 - 1.5 kW
- Supply voltage 115 (1 Ø), 208/230 (1 Ø or 3 Ø)
- Feedback: Encoder (TTL or sin/cos), resolver
- Automatic shaft-position detection
- 5 digital inputs, 1 relay output
- 1 analog input, 1 analog output

1

#### User friendly Front Panel/LCD display

six function/programmable push buttons for entering all parameters and set points

4

#### PC based,

easy to use software for programming and operation simulation software for off line programming

1

4

2

#### Patented "Chip-on-Chip"

hybrid assembly allows for a higher power rating in a smaller package.

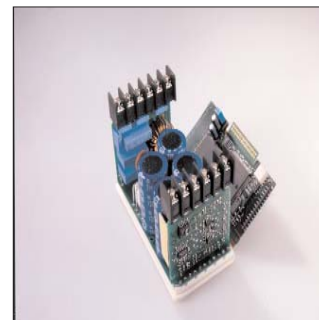
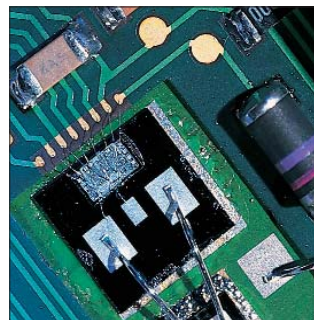
2

3

3

#### Optional "Cooling Module"

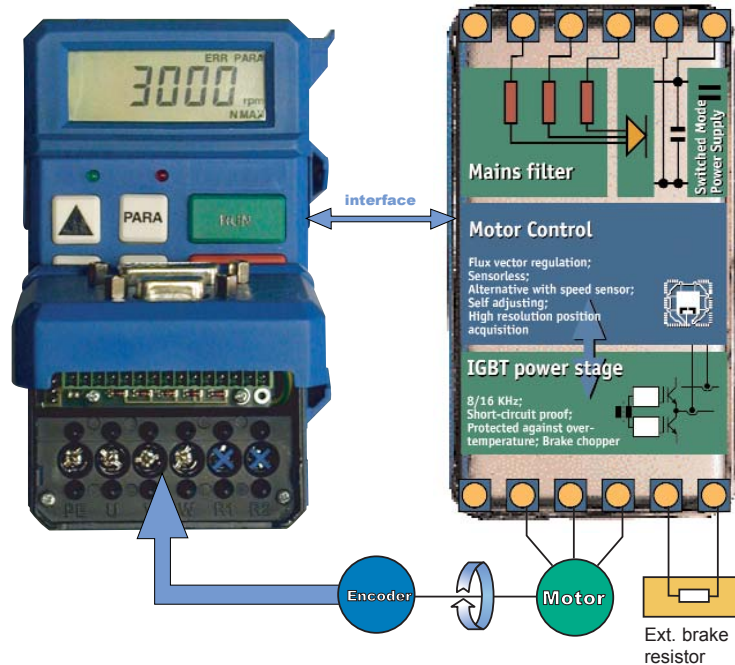
for harsh thermal environments or severe duty cycle operation





## User Interface

- ▶ RS 485 multidrop serial interface
- ▶ Connection for encoder
- ▶ Digital input terminals
- ▶ Digital-Analog interface
- ▶ Relay output
- ▶ Device variation with fieldbus communication
- ▶ CAN open bus compatible
- ▶ C301 V4.0 and 402 R1.2 fully implemented. Electronic data sheet per DSP306 V1.0 available for simple application programming
- ▶ UL & CE approved



## Back to Physics

- ▶ i-Drive is a vector control amplifier
- ▶ Torque build-up in less than 1 ms
- ▶ High dynamic response - current control with sample times as short as 125  $\mu$ s
- ▶ Power Output 0.25 - 1.5 kW
- ▶ Compact size - high power density

## For the engineer who wants more ...

- ▶ Variety of power ratings
- ▶ Integration tools for quick OEM set-up
- ▶ Different cooling systems
- ▶ Extensive range of accessories

***i-Drive has it!***

## Create the Connection Man-Machine - Machine-Man

Complex demanding technology on the inside, which is complimented by clear and simple operation on the outside. Do the test - after just a few minutes you will be able to work with your drive. Drive technology must be simple. i-Drive is therefore easy to install and set-up. Serial interfaces and expandibility to cater to practically all bus systems. This insures problem-free communication between machines.

## Robustness - Reliability

A special chip for protection against current surges, ground faults, short-circuits, power supply failures and over-temperatures, works together with the power components. The new Chip-On-Board / Chip-On-Chip technologies ensures excellent stability.

The vacuum encapsulated module is robust and vibration-proof.



# *i-Drive* Series: Patented Control Architecture

The i-Drive employs a unique, patented universal Field Oriented Vector Control technology. This control is suitable for all types of three-phase rotary and linear permanent magnet brushless motors (synchronous commutated) and squirrel cage induction (asynchronous) motors.

For synchronous brushless servo motor control, sinusoidal current commutation can be accomplished either via sensorless (Hall less) encoder commutation or digital Hall/encoder commutation for "no

motion" initialization. Hall based commutation very quickly switches to the higher resolution encoder to allow sinusoidal commutation. The encoder only commutation method utilizes a unique commutation angle initialization (pole finding) technique that results in only a quick minimovement of the motor/load. In both schemes, a resolver can be used instead of an encoder.

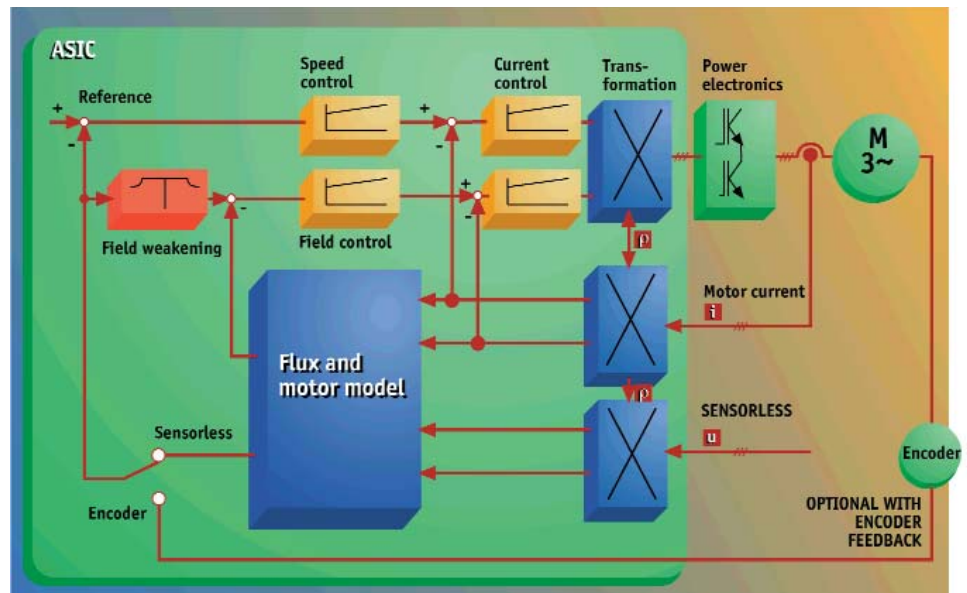
Asynchronous induction motors can be controlled in either sensor (encoder or resolver) or sensorless vector mode. The V/Hz control mode is used for initialization, parallel motor applications and traditional control if desired.

Both motor types require sensor feedback for positioning mode.

### Universal Control Architecture

Field Oriented Vector Control architecture ensures that the optimal commutation and torque/force generating conditions are met throughout the dynamic range of the application.

Under vector control, the total drive output current is a



vector sum of the flux producing current ( $I_d$ ) and the torque/force producing current ( $I_q$ ).  $I_d$  is also referred to as the flux vector. For permanent magnet motors, the flux current vector (and slip) is set to zero, resulting in traditional PWM control of brushless commutated servomotors.

For induction motor control, the full vector control model is active. The flux/motor model section works together with the sensor/sensorless and field weakening control. The  $I_d$  and  $I_q$  vectors in the rotating reference frame are transformed into suitable three-phase PWM control signals.

### Closing the Loop

The i-Drive employs a cascade loop structure containing the current, speed and position loops. Direct command access to any loop is possible.

PM brushless servo motor control modes available:

- Current (torque/force) control
- Speed control
- Position control

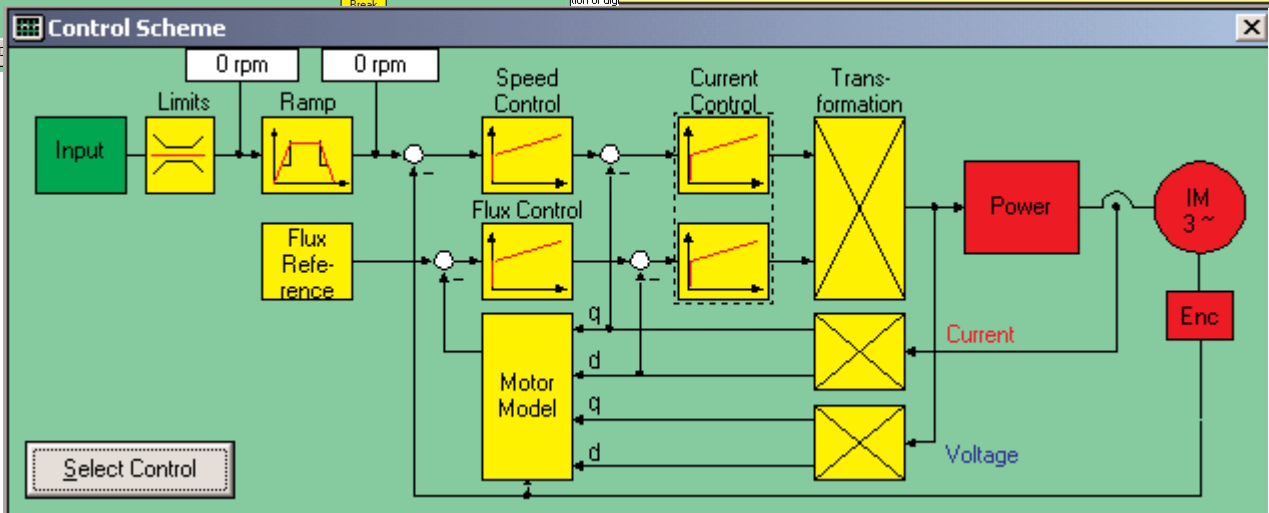
Position control requires a feedback device.

# i-Drive Series: Easy-to-Use Programming Software



Master Screen to monitor Total System

Displays I/O Status



Monitor status of the i-Drive and motor parameters at any time.

- Motor Set-up with units for
- induction motor
  - rotary brushless motor
  - linear brushless motor



# i-Drive Series

## Servo Drive Amplifier

### Performance Specifications

	Model BDS / BDN	115V, 1-Phase			208V/230V, 1-Phase			208V/230V, 3-Phase			
		021	031	071	022	032	072	023	033	073	
<b>Output</b>	<b>Size</b>	<b>1</b>	<b>1</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>	
	Power output (1)	kW	0.25	0.37	0.75	0.5	0.75	1.5	0.5	0.75	1.5
	Peak current RMS for 10 sec	amps	3.3	5.1	10	3.3	5.1	10	3.3	5.1	10
	Continuous current RMS	amps	2.2	3.4	6.7	2.2	3.4	6.7	2.2	3.4	6.7
	Output voltage (DC BUS)	Vdc	160			320			320		
	Switching frequency	KHz	8/16								
<b>Supply Power</b>	Voltage	Vac	115V / 208V / 230V (for all voltages $\pm$ 10%)								
	Frequency	Hz	50 to 60 or DC								
<b>General</b>	Control		Digital field orientation with position feedback. Suitable for asynchronous motors and synchronous servo-motors								
	Ramp time	s	0 to 300								
	Operational range		4 quadrant, integrated chopper circuit for external brake resistor								
	Speed control		Sine-wave encoder, incremental encoder or resolver (see page 193)								
	Messages		Over-current, over-voltage, over-temperature, further errors indicated by error codes								
	Cooling		Separate cooling module, alternative assembly on cold plate								
<b>Control section Inputs and Outputs</b>	Reference input	V ma	-10 +10; 0 to 10 0 to 20; 4 to 20 (with external resistor 500 ohms)								
	Analog input		1 input programmable								
	Analog output		1 output programmable; 0-10V								
	Digital inputs		5 inputs, programmable								
	Digital output		1 Relay 0.4 amps/ 125 Vac; 2 amps/30 Vdc								
	Standard interface		RS 485 serial interface (model BDS); CAN Open Bus (model BDN)								
	Control panel		6 buttons, illuminated LCD display, remote control via PC with Windows software								
<b>Environmental conditions</b>	Ambient temperature	°C	0 to +40								
	Storage temperature	°C	0 to +55								
	Relative humidity	%	5 to 85 non-condensing								
	Altitude	m	0 to 1,000 above sea level								
	RFI / EMC		EN55011 for construction in accordance with EMC regulations class A integrated in 1-Phase units (EN61800-3), 3-Phase optional class B optional (EN 55011)								
	Protection class	IP	IP 20								
<b>Mechanical</b>	<b>Dimensions:</b>		<b>Size 1</b>			<b>Size 2</b>					
	Without cooling module	WxHxD	80x150x118			150x150x118					
	With cooling module	mm	80x130x185			150x130x185					
	Weight without cooling module	kg	1.3			1.9					
	Weight with cooling module	kg	1.6			2.4					

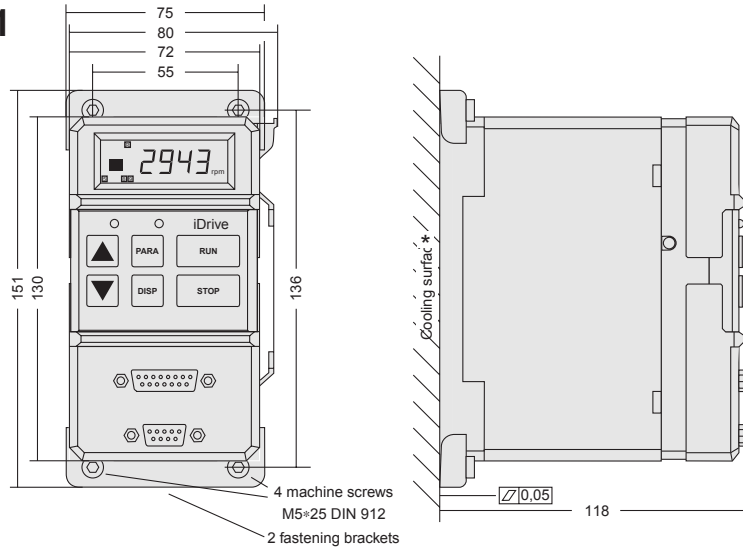
(1) Power Output is based on using the cooling module option.

\* For Motor and Drive Selection calculations see page 197

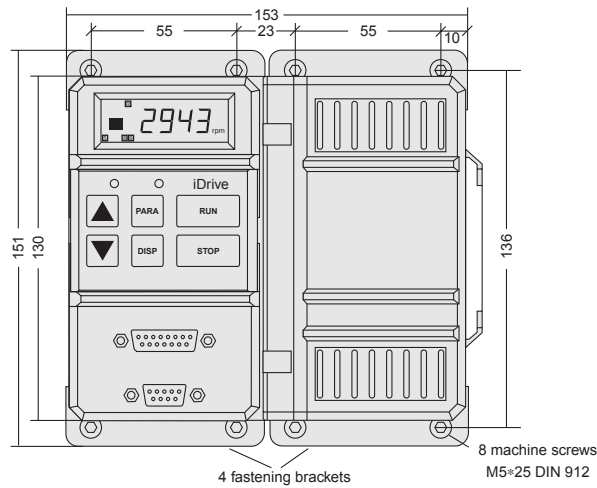


## Dimensions

### Size 1



### Size 2



\* *Cold Plate Mounting - The i-Drive may be mounted directly onto a cold plate using the supplied mounting brackets. In this case the cooling unit is not required. The temperature of the cold plate must not exceed 70° C for the maximum power loss.*

## Mounting of Unit with Cooling Module on DIN rails

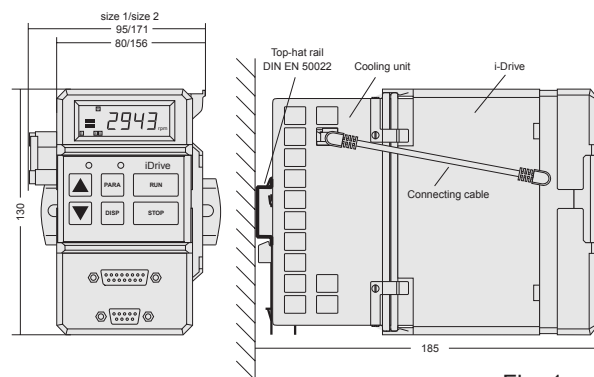
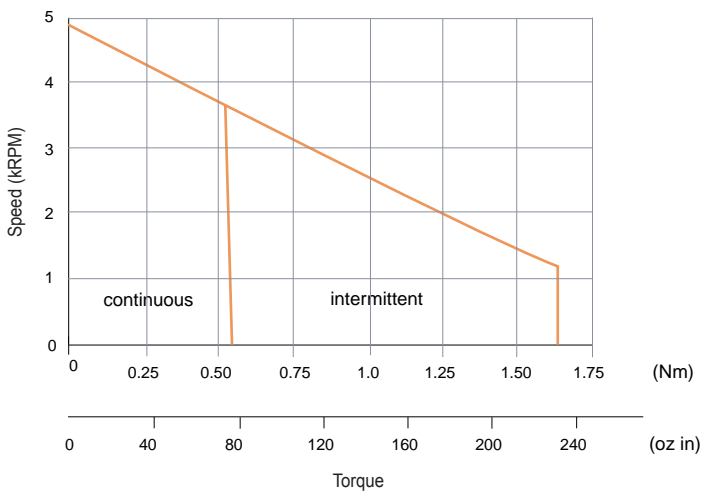


Fig. 1

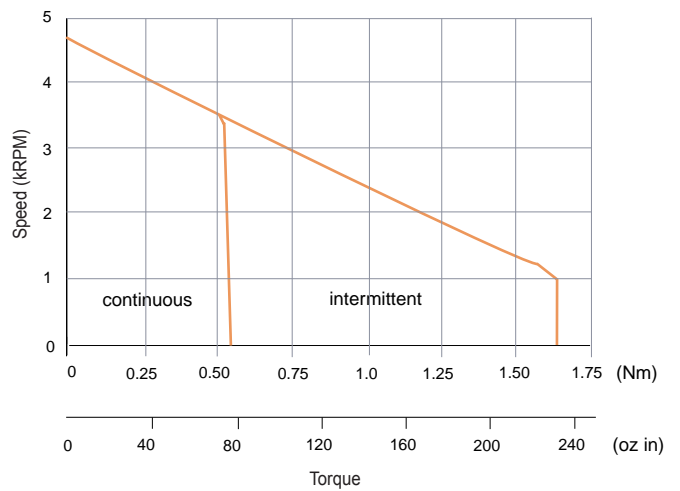


# *i-Drive* Series: Motor & Drive Speed / Torque Curves

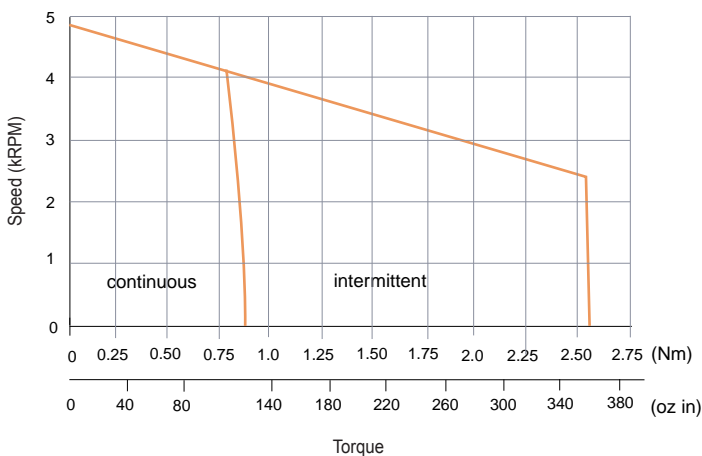
**IM60 Single Stack with BDS / BDN 071  
(winding C)**



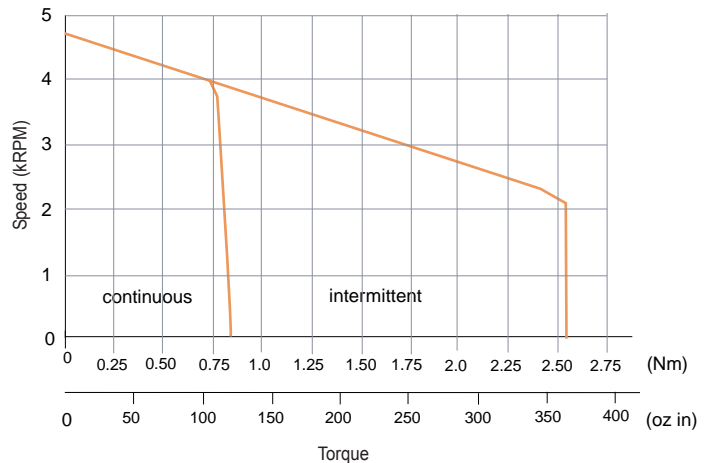
**IM60 Single Stack with BDS / BDN 022  
(winding D)**



**IM60 Double Stack with BDS / BDN 071  
(winding C)**



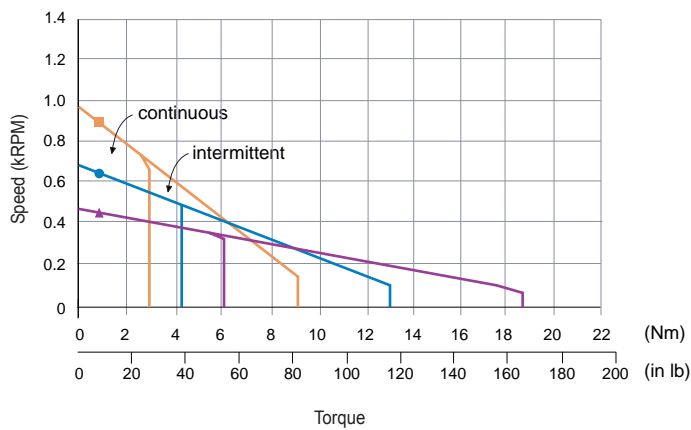
**IM60 Double Stack with BDS / BDN 032  
(winding D)**



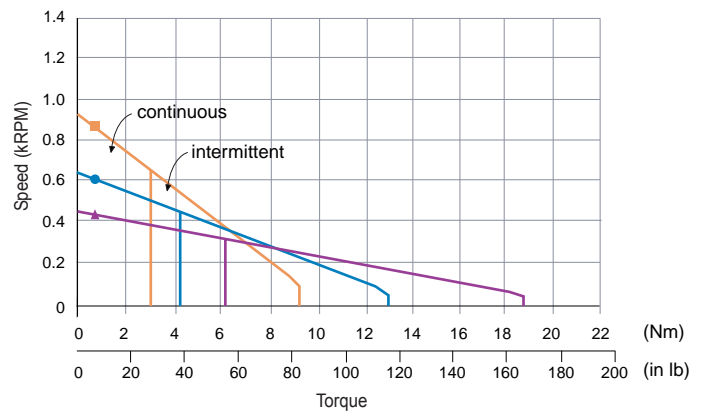
# *i-Drive* Series: Gearmotor & Drive Speed / Torque Curves



**GM60 Single Stack with BDS / BDN 071  
(winding C)**

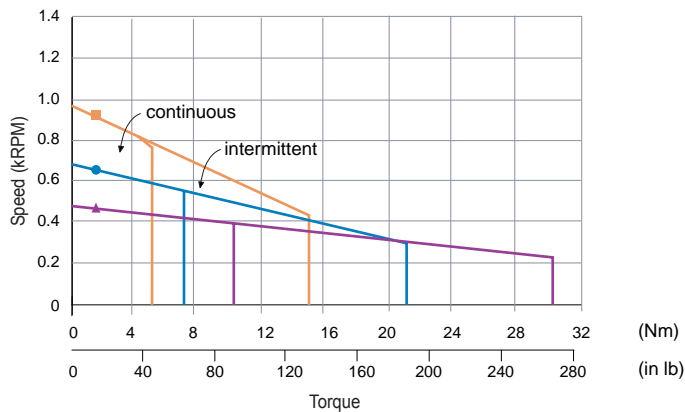


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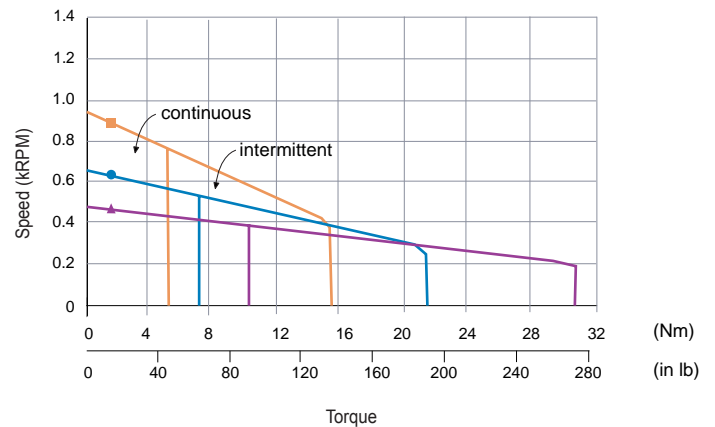


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**GM60 Double Stack with BDS / BDN 071  
(winding C)**



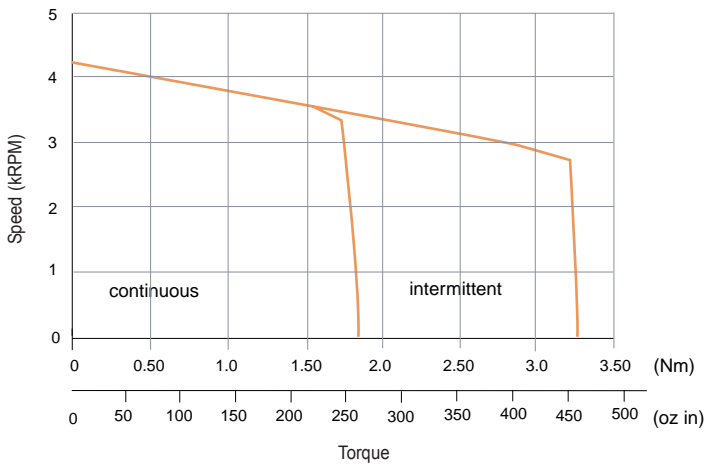
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(winding D)**



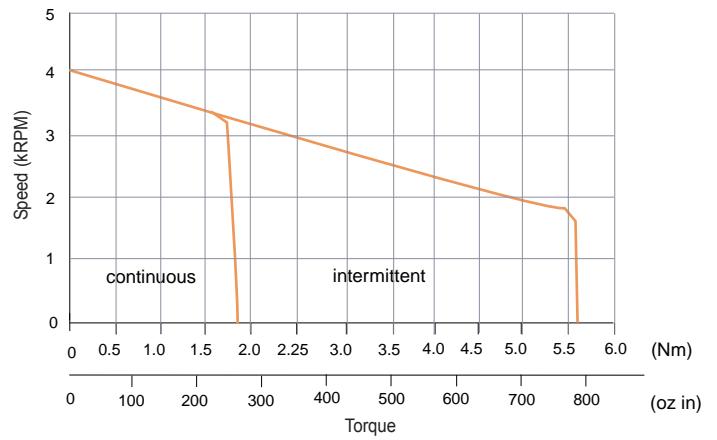


# *i-Drive* Series: Motor & Drive Speed / Torque Curves

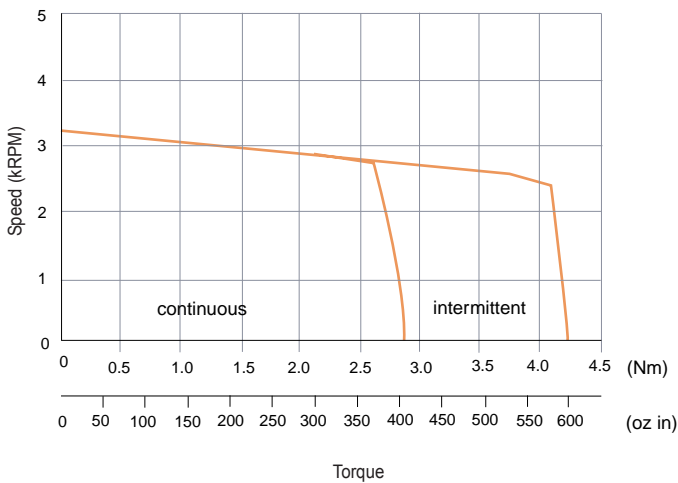
**IM90 Single Stack with BDS / BDN 071**  
(winding C)



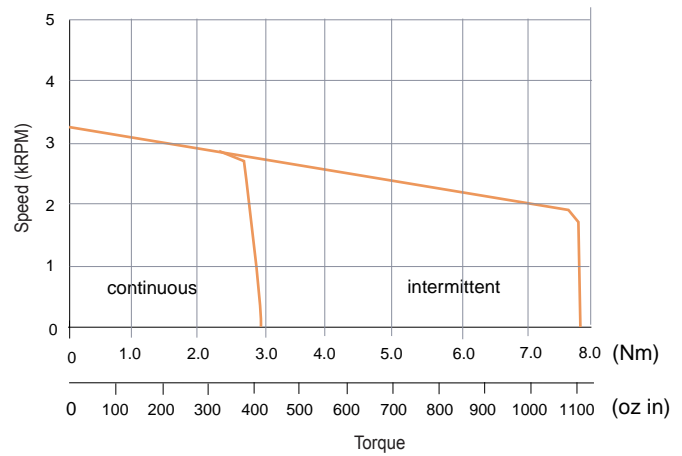
**IM90 Single Stack with BDS / BDN 072**  
(winding D)



**IM90 Double Stack with BDS / BDN 071**  
(winding C)



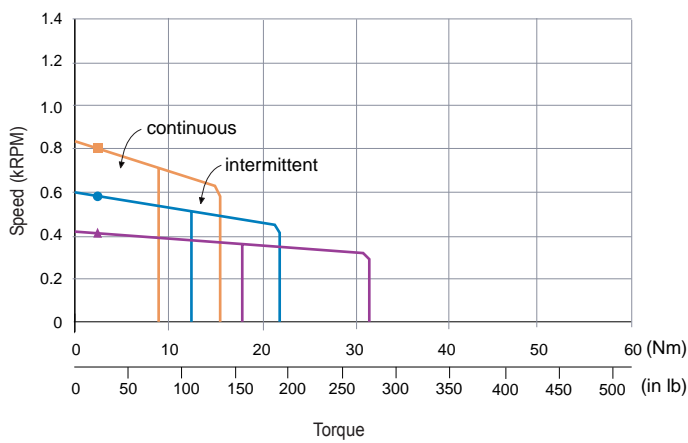
**IM90 Double Stack with BDS / BDN 072**  
(winding D)



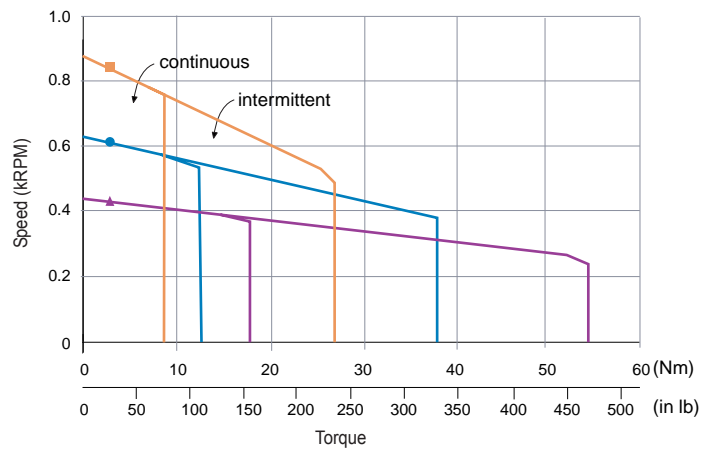
# *i-Drive* Series: Gearmotor & Drive Speed / Torque Curves



**GM90 Single Stack with BDS / BDN 071**  
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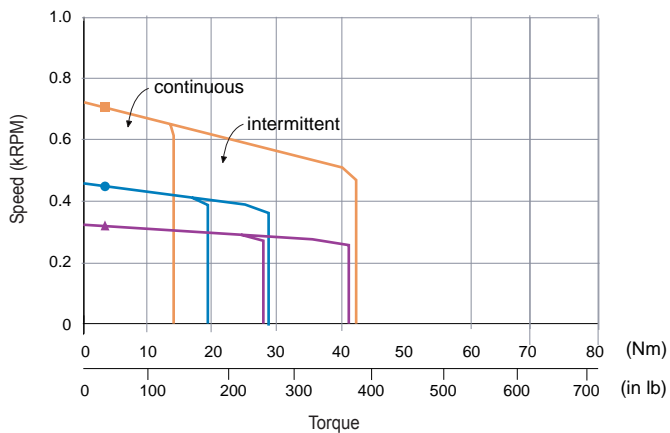


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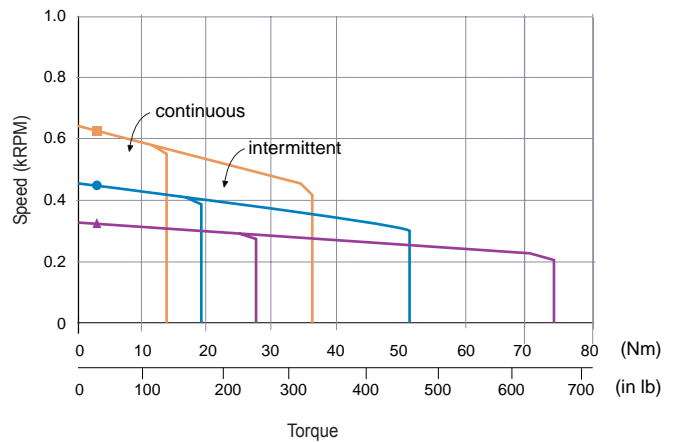


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**GM90 Double Stack with BDS / BDN 071**  
(winding C)



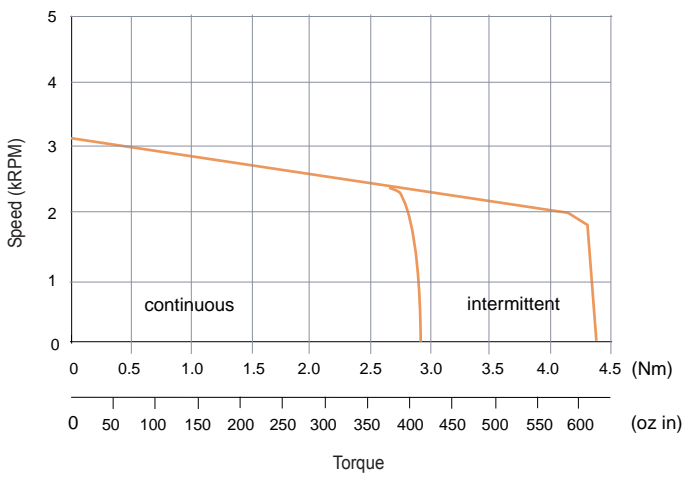
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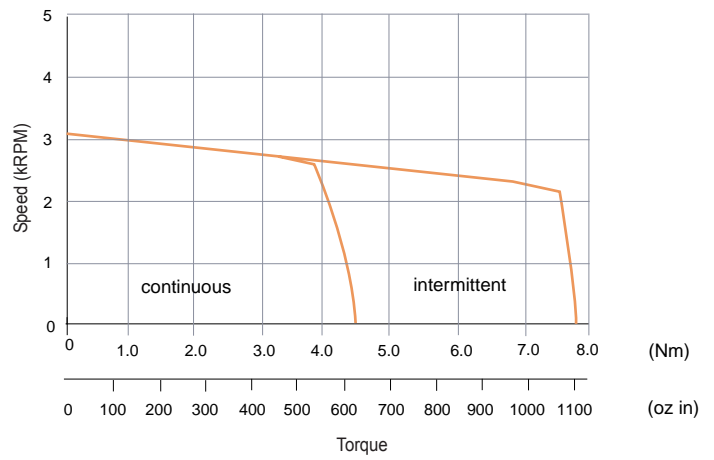


# ***i-Drive*** Series: Motor & Drive Speed / Torque Curves

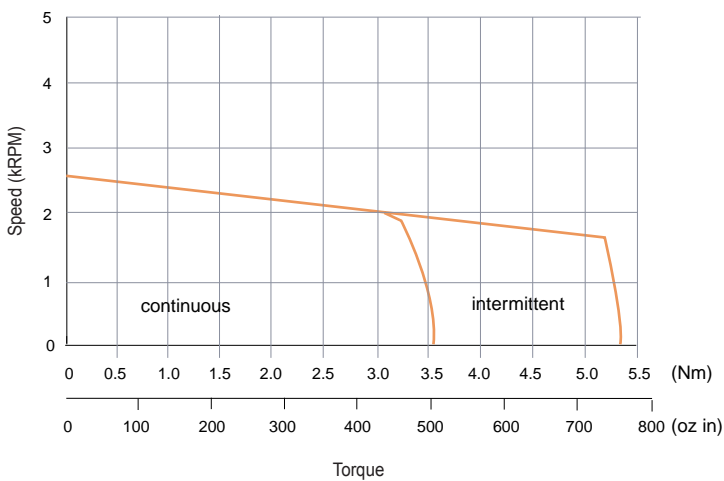
**IM115 Single Stack with BDS / BDN 071**  
(winding C)



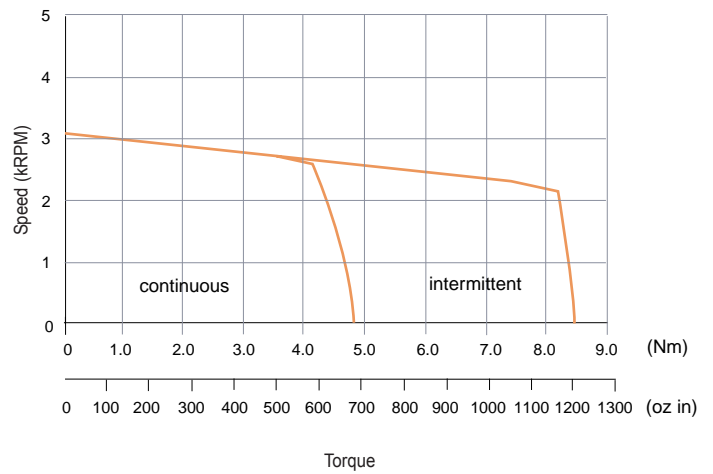
**IM115 Single Stack with BDS / BDN 072**  
(winding D)



**IM115 Double Stack with BDS / BDN 071**  
(winding C)



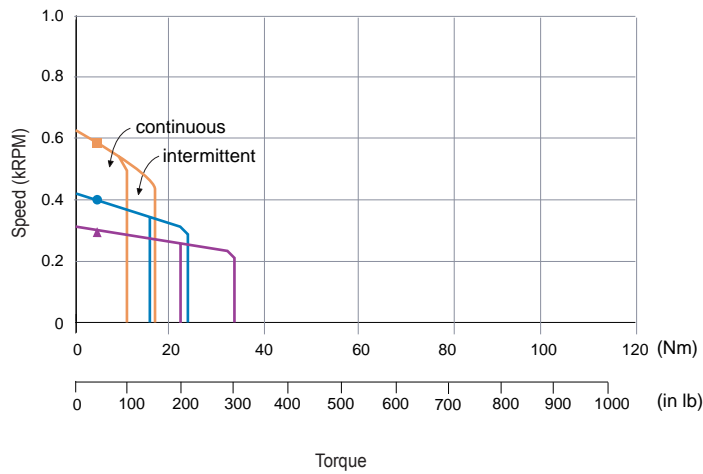
**IM115 Double Stack with BDS / BDN 072**  
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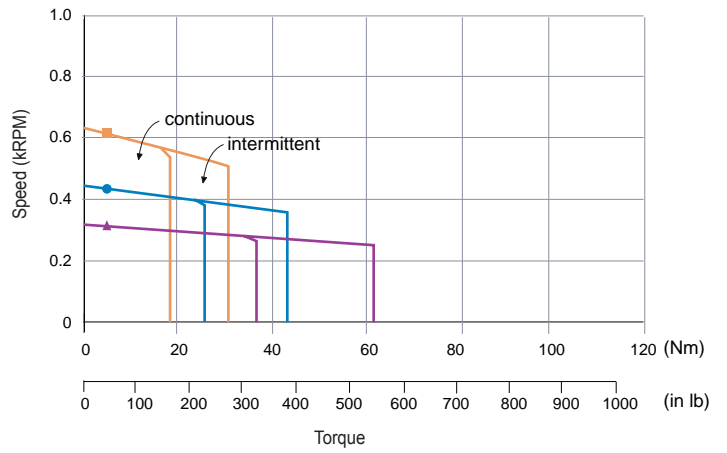
# *i-Drive* Series: Gearmotor & Drive Speed / Torque Curves



**GM115 Single Stack with BDS / BDN 071  
(winding C)**

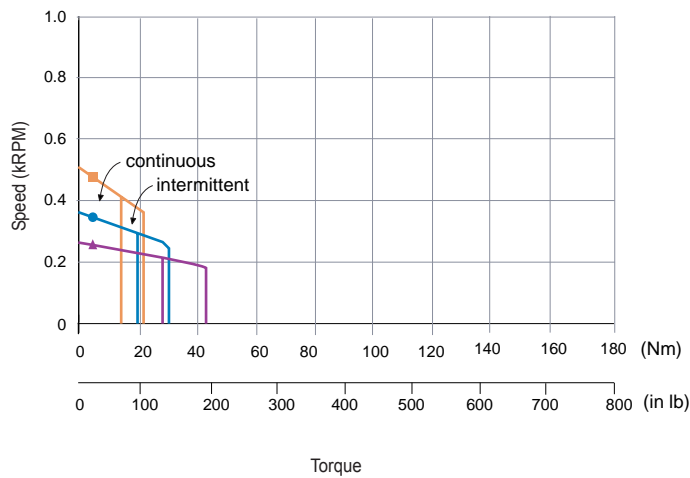


**GM115 Single Stack with BDS / BDN 072  
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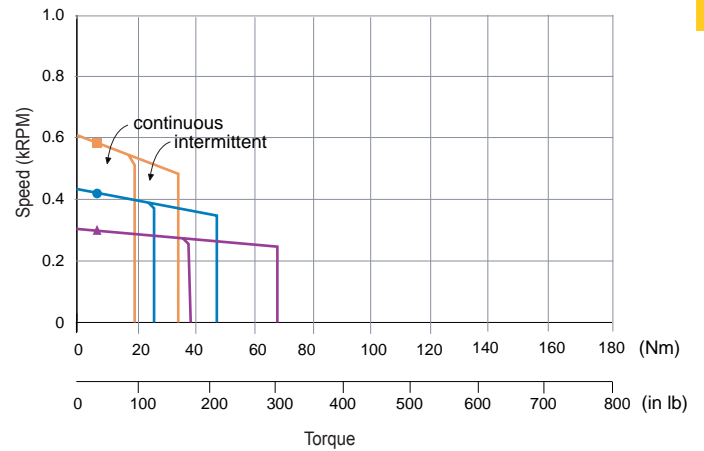


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**GM115 Double Stack with BDS / BDN 071  
(winding C)**



**GM115 Double Stack with BDS / BDN 072  
(winding D)**





# i-Drive Series: Servo Drive Accessories



**12602005**  
Cooling Module  
Size 1



**12602006**  
Cooling Module  
Size 2



**12602007** Filter Class B, 115/230V, 1 Phase  
**12602008** Filter Class A, 115/230V, 3 Phase  
**12602009** Filter Class B, 115/230V, 3 Phase



**12602010**  
**12602011**  
Regen Resistor



**12602004**  
Manual Set-Up  
Box



**12602002-1** **12602002-8**  
**12602002-2** **12602002-16**  
**12602002-4**  
Hall/Encoder Interface <sup>(1)</sup>

**12602003**  
Resolver  
Interface



**10963096**  
Sensor Cable 3m



**10963093**  
Power Cable 3m



**10963018** Linear / Rotary  
**10963204** Luge LM  
Power Cable 3m



**10963137** Linear / Rotary  
**10963201** Luge LM  
Sensor Cable 3m



**12602001** Linear / Rotary  
Y-Cable Generic  
Controller to i-Drive



**12602000** i-Drive Com Kit \*  
\*includes items listed below

**12602012** win+ i-Drive CD  
**12602013** RS232 Cable  
**12602014** RS485-232 Converter

## Velocity Capability

### Linear motion

Encoder Resolution (A Quad B) ( $\mu\text{m}/\text{count}$ )	Maximum Velocity	
	(m/sec)	(in/sec)
0.1	0.072	2.84
0.2	0.144	5.68
0.5	0.36	14.16
1.0	0.72	28.32
5.0	3.6	141.6

### Rotary motion

Encoder Resolution (Lines Per Rev)	Maximum Speed RPM (Max)
2,000	5,400
1,000	10,800

(1) Module is used for Hall Effect start-up commutation, as well as for frequency dividing of the input encoder signals to the i-Drive (max input frequency limited to 180Khz).  
**Note that an encoder is still required for sinusoidal commutation performed by i-drive.** Choose part number of module with the appropriate divisor 1, 2, 4, 8, or 16 based on application needs to limit the encoder input frequency to 180 KHz based on the maximum speed of the application.

# *i-Drive* Series: How to Order



## How to Order

Order Numbering Example: **B D S 0 2 1 E 1 1 2**

### MODEL STYLE

**S**= Standard Interface  
**N**= CAN Interface

### CURRENT/VOLTAGE RATING

115VAC, 1Ø	208/230VAC, 1Ø	208/230VAC, 3Ø
021= 2.2 A	022= 2.2 A	023= 2.2 A
031= 3.4 A	032= 3.4 A	033= 3.4 A
071= 6.7 A	072= 6.7 A	073= 6.7 A

### FEEDBACK

**E**= Encoder  
**H**= Hall / Encoder (1)  
**R**= Resolver (1)

### COOLING MODULE

**1**= None  
**2**= Size 1  
**3**= Size 2 (2)

### CE FILTER

**1**= See Note 4  
**2**= Class B - 1 Phase (external)  
**3**= Class A - 3 Phase (external)  
**4**= Class B - 3 Phase (external)  
**5**= No Filter - 3 Phase Only

### REGEN RESISTOR (3)

**1**= None  
**2**= Yes

Class A per EN 61800-3 Specifications  
Class B per EN 55011 Specifications

### Notes:

- (1) Plug-in module in the sensor connector  
(2) Model numbers 071, 072, & 073 requires mandatory factory supplied cooling units.  
Please make the choice of cooling unit by inserting "3" in the ordering number scheme.

### (3) Regen resistor

Model	Resistance	Maximum current	Continuous Power	Peak power	Part Number
BD_021, 022, 023	150 Ω	2.7 A	100 W	1.0 kW	12602010
BD_031, 032, 033	150 Ω	2.7 A	100 W	1.0 kW	12602010
BD_071, 072, 073	100 Ω	4.0 A	100 W	1.6 kW	12602011

- (4) Single Phase drives includes internal Class A Filter.

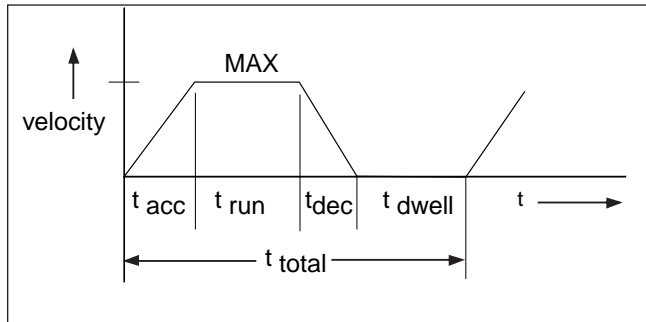
Bayside's *i-Drive* Brushless Digital Drive / Control are supported by a worldwide network of offices and local distributors. Call **1-800-305-4555** for application engineering assistance or for the name of your local distributor. Information can also be obtained at [www.baysidemotion.com](http://www.baysidemotion.com).



# ► Bayside Motor and Drive Selection

Selection of the proper motor and amplifier for a particular system depends on a number of inter related parameters. Among these are:

- Maximum ambient temperature
- Continuous torque requirements
- Peak torque requirements
- Maximum speed
- Duty cycle
- Available amplifier bus voltage



## Load / Output Cycle Analysis

In all cases, the load requirement (torque, velocity, acc/dec, inertia) must be reflected back to the motor shaft, either directly or through the transmission device such as a gearhead (ratio) or lead screw (pitch).

## The Velocity Profile

A starting point is to estimate the worst case velocity profile for the system, i.e. a plot of velocity vs. time showing maximum accelerations and velocities that are expected. This typically is a trapezoidal profile.

In cases where the profile consists of a series of non-equal moves, a worst-case estimate is usually sufficient. An exact calculation is rarely needed, since using the worst profile will assure proper operation and add a certain level of safety factor.

In this profile, the acc/dec is:  $\frac{\text{Max velocity}}{t_{\text{acc}}}$  or  $\frac{\text{Max Velocity}}{t_{\text{dec}}}$

The total distance moved is:  
 $(\frac{1}{2}) (t_{\text{acc}}) (\text{Max velocity}) + (t_{\text{run}}) (\text{Max velocity}) + (\frac{1}{2}) (t_{\text{dec}}) (\text{Max velocity})$

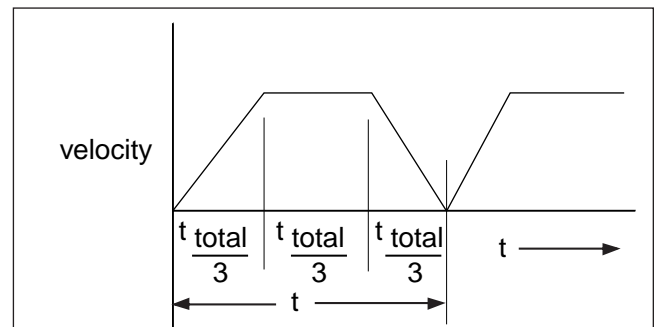
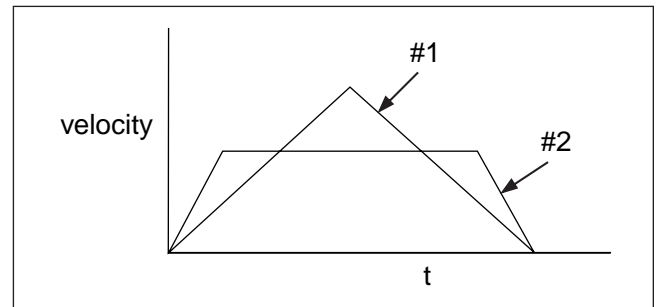
For a fixed distance, there is a trade-off between  $t_{\text{acc}}$ ,  $t_{\text{dec}}$ ,  $t_{\text{run}}$  and velocity.

The following shows two profiles which will provide the same motion displacement

Profile #1 will have the larger maximum velocity, but the lowest acceleration. Profile #2 has higher acceleration and lower maximum velocity.

In addition, profile #2 operates at a constant velocity for a certain portion of the profile.

If such a constant velocity is required to be a certain value for a certain time or distance, then this will be the gating parameter and in turn determine the acc and dec



If initially a profile is not known, a good starting point is the so-called "1/3, 1/3, 1/3" profile, in which  $t_{\text{acc}} = t_{\text{dec}} = t_{\text{run}}$  and  $t_{\text{dwell}} = 0$

This profile will provide an initial set of parameters which can be analyzed and modified to achieve required performance.

## Torques

Since a motor has a continuous and peak torque rating, both of these required by the application must be evaluated in order to select the proper motor.

Continuous torque rating is determined under specific thermal conditions. Typically, it is the torque available with the motor winding at 155°C in a 23°C ambient, mounted to a pseudo standard test plate.  
 (see section 5.3)

Under these conditions, the external housing temperature can easily reach 70°C, especially for small motors.

If this is objectionable, then even if the motor meets all the operational requirements, a larger size motor may be required.

The peak torque (or accelerate torque) is determined by:

$$T_{\text{acc/dec}} = J a \pm T_L$$

where  $J a$  = Inertia x acceleration

$T_L$  = various load torques (bearing friction, gravity effect, etc).

Note that during acc,  $T_L$  opposes  $T_{\text{acc}}$  and during dec,  $T_L$  aids  $T_{\text{dec}}$

This is especially important in vertical lead screw or linear motor applications in which the gravity effect can greatly increase the “UP” acc and “DOWN” dec torques or forces.

The run torque is simply:  $T_{\text{run}} = \pm T_L$

The RMS torque, which must be less than the motor continuous torque rating is:

$$T_{\text{RMS}} = \sqrt{\frac{T_{\text{acc}}^2 t_{\text{acc}} + T_{\text{run}}^2 t_{\text{run}} + T_{\text{dec}}^2 t_{\text{dec}}}{t_{\text{total}}}}$$

## Velocity / Core Loss

The maximum velocity is required to determine:

- ▶ Suitability of operating with a gearhead or lead screw
- ▶ Motor core losses contributing to motor temperature rise.
- ▶ The voltage constant ( $K_E$ ) of the motor.

## Ratio Limitations

Gearheads and lead screws have maximum input velocity limitations, typically 3,000 to 6,000 RPM, depending on size, length, diameter, etc.

Exceeding these limits will affect performance, life, and stability. If initial system analysis shows velocity requirements exceeding these limits, the load requirement must be reviewed to bring them into compliance.

## Core Losses

Velocity dependent losses in the motor stator contribute to temperature rise and should be considered, especially for high speed applications where core losses can actually exceed the copper winding losses created by the load.

Core losses at any speed are:  $P_N = P_{1000} N^{1.5}$  watts

Where  $P_{1000}$  is the core loss at 1,000 RPM and  $P_N$  is the core loss at any speed  $N$ .

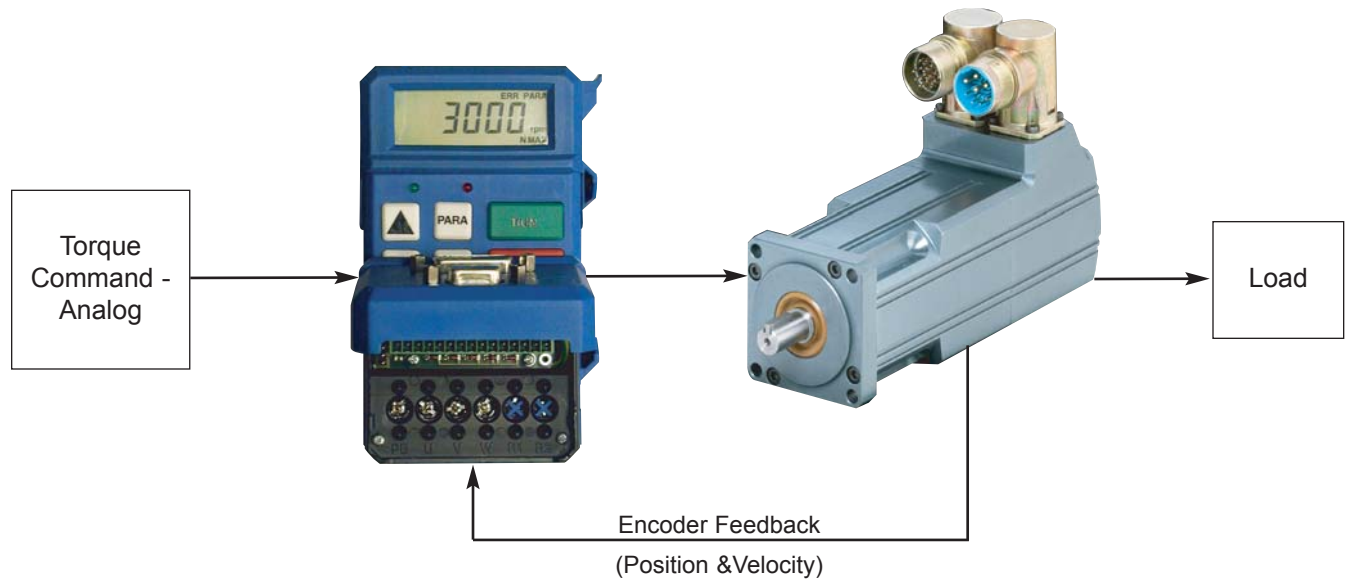
Although the core losses are zero at 0 velocity and maximum at maximum speed, using their maximum value for the whole profile is simple and adds some safety margin.

## Voltage Constant

The voltage constant required is determined by the maximum velocity and the amplifier bus voltage that is being considered. Line voltage tolerance, amplifier losses, and IR drops also affect  $K_E$  selection.

## Thermal Resistance

A thermal resistance is specified for each motor, which determines the temperature rise above ambient that will be experienced by the motor stator when mounted on a vertical test plate in still air.



## Terms for Sinusoidal Operation:

$I_{peak}$	=	Peak (Acceleration) current in Amps RMS
$I_{RMS}$	=	Continuous Current in Amps RMS
$K_E$	=	BEMF Voltage Constant in $V_{PKL\_L}/kRPM$
$K_T$	=	Torque Constant in torque units/ Amp RMS
$R_{25}$	=	Stator Resistance Cold (Line-to-line in ohms)
1.5	=	Multiplier to create stator resistance Hot (@155 °C)
$N$	=	Speed in kRPM
$L$	=	Stator Inductance Line-to-line in mH
$P_c$	=	Core Loss in watts @ 1,000 RPM
$P$	=	Total motor power dissipation in watts
$p$	=	Pole Count
$\theta$	=	Thermal Resistance in °C/watt

# Sinusoidal Drive Control Selection

Conversion factors for six step vs. sinusoidal commutation:

Unless the motor specifications or units indicate otherwise, Bayside motors are rated based on six step commutation.

To accurately apply the sinusoidal formulas, the following conversion is required if the motor's torque constant is specified for six step:

$$K_{TSINE} \text{ (torque/ARMS)} = 1.22 \times K_T \text{ six step (torque/Amp)}$$

After the required sinusoidal I<sub>peak</sub> and I<sub>RMS</sub> is calculated, a comparison can be made to six step motor ratings after the following conversions:

$$I_C \text{ six step (amps)} = 1.22 \times I_{RMS \text{ sine}}$$

$$I_P \text{ six step (amps)} = 1.22 \times I_{\text{peak sine}}$$

$$\text{Note: } K_E \text{ sine} = K_E \text{ six step (Vpk L-L/kRPM)}$$

## 11 Step Procedure

**1** Analyze the system performance requirements and reflect all parameters back to the motor shaft.

**2** Select a motor whose continuous torque and peak torque ratings are equal to or greater than the required RMS and peak torque of the application.

**3** Decide on a bus voltage and calculate a preliminary  $K_E$  as follows: 
$$K_E = \frac{\text{Ebus} \times 0.9 - 10}{\text{Max velocity (KRPM)}}$$

where:  $\text{Ebus} \times 0.9 - 10$  = bus voltage at low line  
= overhead for amplifier

**4** Select a motor or winding whose  $K_E$  is equal to or less than the above value.

**5** Note the  $K_T$ , resistance (R), inductance (L), core loss factor ( $P_C$ ), thermal resistance ( $\theta$ ) and pole count (p) of the selected motor.

**6** Calculate the peak current as: 
$$I_{\text{peak}} = \frac{T_{\text{acc}}}{K_{TSINE}}$$

**7** Calculate the RMS current as: 
$$I_{RMS} = \frac{T_{RMS}}{K_{TSINE}}$$

**8** Calculate power dissipation as: 
$$P = [3(I_{RMS}^2 \times 0.5 \times R_{25} \times 1.5) + (P_C N^{1.5})]$$

**9** Calculate winding temperature as:

$$t_{\text{wdg}} = (\theta_{\text{wdg}} - \text{amb}) \times P + t_{\text{amb}}$$

If  $t_{\text{wdg}} > 155^\circ\text{C}$  select a larger motor

**10** Calculate required drive DC bus voltage as:

$$E_{\text{input}} = \sqrt{[(1.4 \times I_{\text{peak}} \times R_{25} \times 1.5) + (K_E N)]^2 + \left(1.4 \times I_{\text{peak}} \times \frac{\pi N p L}{60}\right)^2}$$

if  $E_{\text{input}} > E_{\text{bus}} \times 0.9 - 10$ , select a winding with a lower  $K_E$ .

**11** Select a drive as follows:

- ▶ Required bus voltage
- ▶ Required continuous current
- ▶ Required peak current
- ▶ Required input power

### MOTOR / AMPLIFIERS SELECTION PROCESS IS COMPLETE !

Application Guides

1. The lowest total dissipation is achieved when the I<sup>2</sup>R copper losses equal the core losses.
2. The highest efficiency is achieved when  $K_E$  is the highest value obtainable consistent with meeting all requirements.