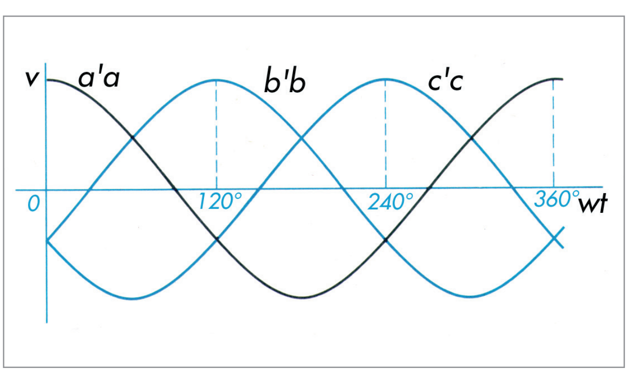
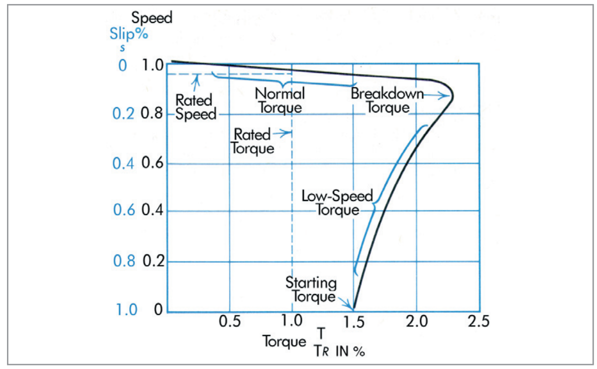
The motors use three phases of alternating current supplied to the stator to provide the speed and torque necessary for your motion control needs. These currents rise and fall in polarity much like an ocean wave. The waves circulate around the stator core at a frequency determined by the user and a drive such as our variable frequency AC Induction VFD-PCM Series. The rotor of the AC motor consists of multiple current paths (coils) integrated throughout an iron core. This rotor construction is typically known as a squirrel cage design. Reaction between stator and rotor coils result by transformer action across the stator/rotor air gap. The induction motor is essentially a transformer with a rotating secondary. The force that exists between primary and secondary coils in a transformer appears as useful torque in an induction motor. The rotor is pushed into rotation by the ensuing stator wave. The frequency of the waves establishes the maximum speed but it does not provide the torque necessary to run at that speed. The voltage and resulting current provide the actual power to do the work.

RPM = (120 x Hz)/Poles

The stator field rotates at a speed determined by the frequency and number of poles. The rotor always turns at a lower speed than the stator fields; if the rotor turned at a synchronous speed, there would be no change in flux linkage, no induced current, and no torque. The small difference in speed that produces flux cutting and motor action is called the slip.

Our VFD-PCM Series accepts either 115 VAC or 230 VAC input and provides respective 3 phase output for these motors. The PWM output gives us a high dynamic response for high performance use, a very wide speed range and smooth motor control through zero speed. The frequency range can be varied from 0 to 120 Hz with constant torque available up to 60 Hz, and constant horsepower available above 60 Hz. The drive features solid-state reversing with adjustable acceleration and deceleration. They also feature adjustable current limit, line starting and stopping,





min. and max. speed control, slip compensation, acceleration, torque boosting control, and many more features. Standard models are available to power induction motors up to 1.5 HP.

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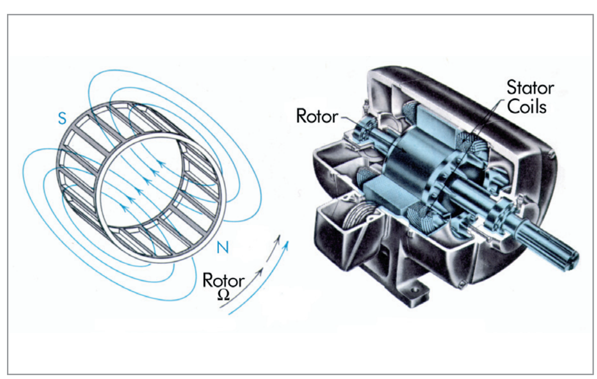
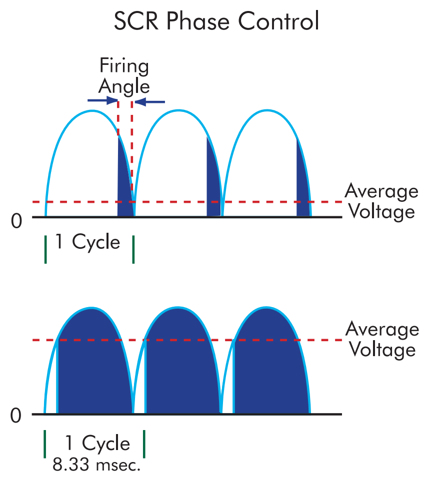
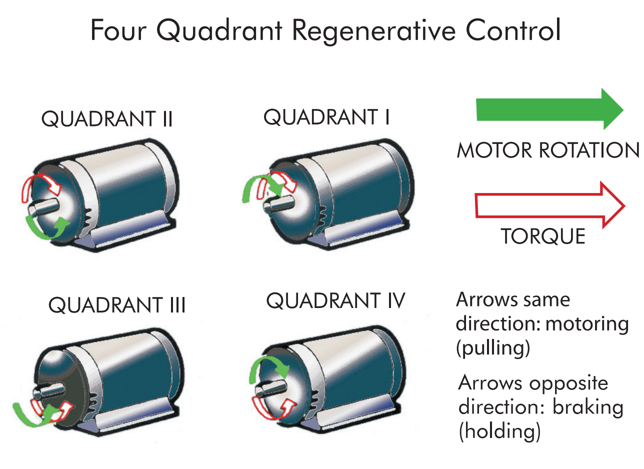
The key advantages of this motor design vs. the permanent magnet brush or permanent magnet BLDC motor line is simplicity, reliability, and durability. Positional feedback and high energy rare earth magnets are not necessary with this type of machine. Users may take advantage of standard power lines and wall outlets offering 115 VAC or 230 VAC. The complexity of these past machines did not come from the motor, but the control of that motor. Minarik has developed the ideal economical drive solution to this dilemma with the aforementioned VFD-PCM drive. This drive gives you complete control of three phase induction motors.

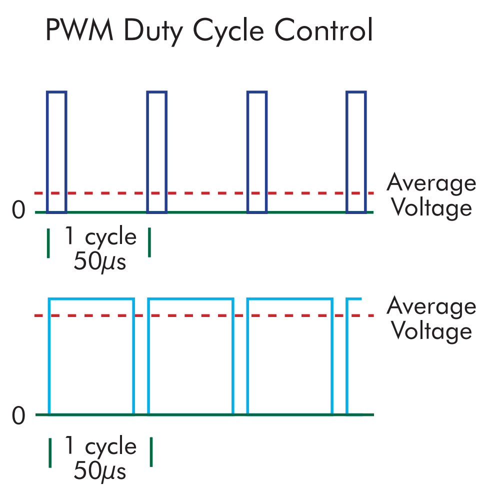


Regenerative drives have the ability to turn the mechanical energy required to brake a DC brushed motor back into electrical energy. They do this by electrically reversing or braking DC brushed motors at a user-defined rate. Therefore, there are no mechanical relays or resistors to wire or wear out. By controling torque in the opposite direction of speed, Regenerative drives can control overhauling loads caused by gravity or inertia. Minarik Drives' regenerative drives run on either SCR or PWM technology, giving you more options to choose from. Any application that requires reversing, braking, or the control of overhauling loads should use a Regenerative drive.





Silicon Controlled Rectified (SCR) drives are excellent for your everyday DC brushed applications. They have been very popular and are low cost. Typically, SCR drives have 60:1 speed ranges and form factors of 1.37 at base.



Pulse Width Modulated (PWM) drives perform as well as SCR drives in similar applications, with several more advantages. PWM drives add more flexibility to applications by being able to run on either AC or DC voltage. Their power devices switch at a rate over 120 times faster than SCR power devices, thus producing "cleaner" DC voltages. A "clean" voltage means your motor will run cooler and quieter over a wider speed range (100:1 compared to 60:1 of SCR drives). A cooler brushed DC motor will require longer maintenance periods between replacing the brushes. The higher switching frequency is above the audible range, so there is no hum from the motor. The wider speed range allows you to run the motor slower while maintaining control. Applications requiring cool, quiet, lower maintenance operation are perfect for PWM drives.

Speed range is usually defined as the ratio of maximum system speed to the minimum system speed. For example, if the maximum speed is 1,750 RPM, and the speed range is 100:1, the minimum speed will be 17.5 RPM. Using DC motors and drives as an example, let's analyze the three speed ranges listed below.

1) Motor speed range
2) Drive speed range
3) System speed range

1. Motor Speed Range

This is generally published as the fastest a motor can run trouble-free divided by the slowest it will run before it begins to "cog" (or "step"). Cogging occurs due to static friction in the motor, inefficiencies in a pre-mounted gearbox and/or spacing between the commutator slots of a DC brush motor. The fewer the number of slots, the sooner (or higher speed) the motor will "step".

Fan-cooled motors rely on the fan to stay below the maximum temperature of the motors. Often, a minimum fan speed is necessary, thus narrowing the motor speed range. Many motors can run at 1 1/2 to 2 times their rated speed. Their potential speed range may be artificially high.

2. Drive Speed Range

This is generally published as the maximum output voltage of the drive divided by the minimum output voltage of the drive. However, it should be published as the maximum output from the drive (where it can properly regulate motor speed), divided by the minimum output (when it can properly regulate motor speed).

The drive regulates motor speed by changing its output voltage in response to the motor load. More voltage will be applied when a motor begins to slow due to increased loading. Once the drive exceeds the maximum output voltage limit, it cannot output any additional voltage. At this point, the drive surpasses the speed range and fails to regulate properly.

The same concept holds true at minimum speed. The drive may be capable of running a motor, with "cogging," at 1 RPM. However, if the motor stalls when loaded, the drive speed range cannot be used at the lower end since the drive allowed the motor to stall.

3. System Speed Range

Those who specify a system, or end-users, are usually only concerned with the most important specification, the system speed range. However, the system speed range is a difficult specification to obtain from a catalog. Normal listings show motor speed range and drive speed range only; rarely will you find system speed range listed. We determine the system speed range by dividing the motor's speed at the maximum drive output voltage (with proper regulations) by the motor's minimum speed (before "cogging"). We combine only the motor and drive parameters that limit the system speed range. The maximum drive output is used because it is well below the maximum speed of the motor. The minimum speed of the motor is used because it is well above the minimum output of the drive (usually 2 to 3 volts are required to overcome the "dead zone" point of a motor).

Many things may affect the actual system speed range. Difficulties can arise when defining the minimum and maximum system speeds. For example, perhaps the bench tests and burn in were unidirectional. The way the brushes seat on the commutator could affect speed range in one direction. Ambient moisture might affect air gap fluxes of the commutator. Temperature changes in ambient air and/or the motor will affect magnetic field strength, thus affecting system speed range as well.

The most often overlooked culprit in narrowing the system speed range is the form factor of the drive output. The form factor from a drive worsens as motor speed reduces (lower output voltage) unless Minarik Drives PWM drives are used. This is a major concern when specifying motors, and deserves its own explanation (see form factor discussion on pg. 82).

Consult Minarik Drives' factory engineers for assistance in selecting a motor and drive that will meet your system's speed range requirements. Typically, Minarik Drives specifies SCR drives for a 60 to 1 speed range and DC brush PWM drives are either 80 or 100 to 1 speed range.

REGULATION

We define the speed regulation of a DC brush-type motor as the drive's ability to hold a desired set speed as the load seen by the motor changes. Speed Regulation is measured as a percentage of base speed, not set speed. For example, a 1% regulation on a 1750 RPM motor means the speed may fluctuate ±17.5 RPM from no load to full load.

Once the motor sees a load in excess of its rating, the drive may go into "current limit" to protect the motor. Until then, we want the drive to regulate speed. The amount of regulation required depends on the application; users set its value by calibrating the IR COMP trimpot on the drive.

Applications requiring tight regulation might be:

a) Cut-to-length

b) Leader-follower (involving multiple axes)

c) Winding applications

d) Printing, marking, labeling, and gluing (requires a high level of accuracy)

Applications where precise speed regulation may not be as critical:

a) High-speed braking and reversing applications (like index tables, palletizers, strapping, cranes, hoists, lifts)

b) Applications where simply moving from point A to point B is sufficient

c) Applications where an operator uses visual feedback (eyesight) to make speed adjustments

CURRENT LIMIT

Motors can handle currents in excess of their rated values for short periods of time. However, if operation outside of rated values occurs for an excessive duration of time, armature and brush life are reduced, and eventually permanent motor damage will occur. Minarik drives generally possess a current limit (or torque limit) trimpot adjustment that allows users to limit the amount of current drawn by a motor. Consequently, users can limit the torque delivered to the load from a motor.

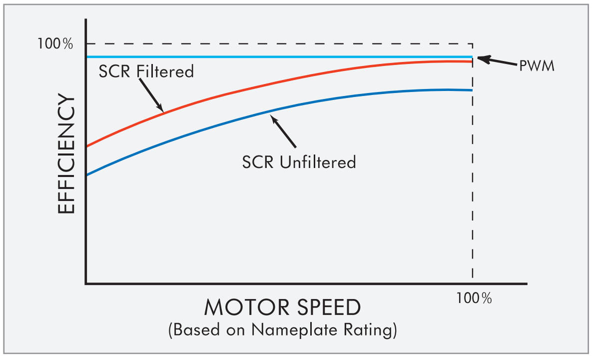
Note: This adjustment is designed to limit steady state overloads and may not limit very fast changing (impulse) type loads.

EFFICIENCY

Efficiency is usually described as $\eta =$ (power output ÷ power input) x 100% .

System efficiency corresponds inversely with power consumption from the power company. Higher system efficiencies consume less electricity than lower system efficiencies. They also correspond, though not linearly, with system life. Primarily, we are concerned with the efficiencies of the motor, drive and system.

When a device cannot convert all of the input power into work, the excess energy is wasted as heat and sometimes, noise. Usually, one must know the efficiency of the motor and drive only for a calculation of heat dissipation; for example, when sizing an enclosure for a drive. Another example might be the sizing of a cooling fan for a non-ventilated motor. The greatest contributing factor to motor and system efficiency is form factor. The graph below describes typical system efficiencies using Minarik drives.



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DEADBAND

Some Minarik Drives regenerative drives contain the deadband feature for applications requiring the ability to adjust the time that elapses between current reversals. Adjustments to the deadband trimpot will alter the degree to which a motor resists changes in shaft position at zero speed. It performs this function by applying a small AC voltage to the motor armature.

MINIMUM (MIN) & MAXIMUM (MAX) SPEED

These application specific settings are present on most drives as a convenience to users. The minimum speed trimpot (MIN Speed) allows one to adjust output voltage to the motor when the reference to the drive is at a minimum. The reference may be 0 volts input with a 0-10 VDC signal, or with the main speed potentiometer turned fully counter clockwise. If the application requires the motor to continue rotating, even with a zero reference input, rotate the MIN speed trimpot clockwise to the desired minimum speed. The minimum speed is important in applications such as conveyor ovens, where stopping the motor could damage the product in the machine.

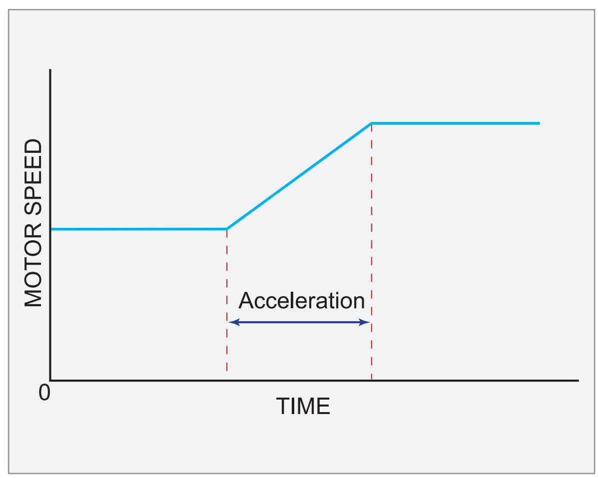
The maximum speed setting (MAX Speed) determines the fastest motor speed allowable when the main speed pot (or reference voltage) is at 100%. With this adjustment, we can overspeed the motor slightly, or we can limit the speed below the motor's maximum speed rating. The MAX speed trimpot is especially useful when we cannot obtain the exact motor for our desired speed. Simply use one that can go faster, and reduce the maximum speed setting during calibration.

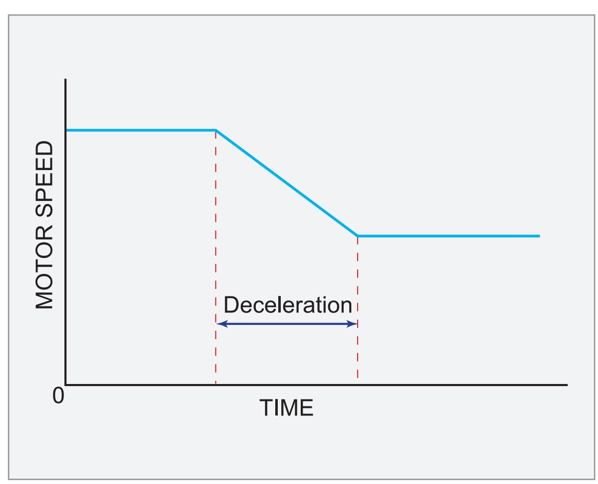
ADJUSTABLE ACCELERATION & DECELERATION

These settings are often referred to as soft start and soft stop. They are useful in applications that require the motor to ramp up to set speed, and ramp down to a slower speed; a filling machine conveyor is a good example. Here we don't want liquid in the containers to spill because of abrupt changes in speed. These trimpots are also useful in applications using an undersized motor due to space constraints (centrifuges for example). A very slow acceleration helps to avoid going into current limit as the motor accelerates to set speed.

Turning the acceleration or deceleration trimpot clockwise will lengthen the time it takes for the speed change to occur.

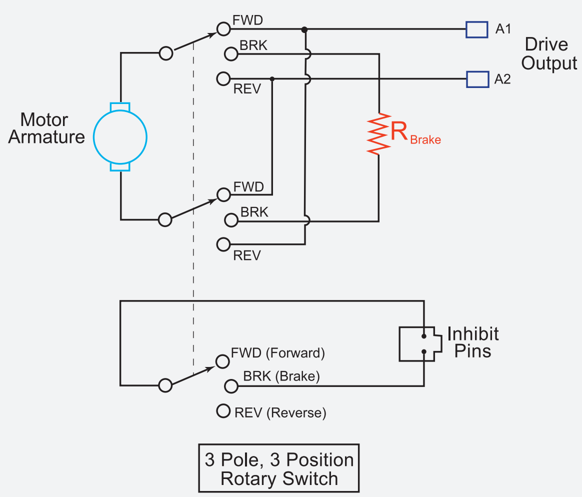
Single quadrant drives can not stop the motor any faster than a coast. If quick stopping is needed then use a regenerative drive.





DYNAMIC BRAKING

Minarik Drives always recommends regenerative drives when applications require fast, contactorless braking and reversing. Even when reversing is not fast or frequent, regenerative drives may still be the most long term economical solution. However, certain situations may call for another method known as dynamic braking and reversing. This method uses a relay or switch rated for motor current, and a properly sized resistor. The brake resistor converts the energy of the load into thermal energy in the brake resistor. A smaller Ohm rating of the resistor means faster stopping. Minarik Drives recommends starting with a 40 Ohm, 40 Watt resistor. It is always recommended that the armature be disconnected only when the drive's output voltage is zero.



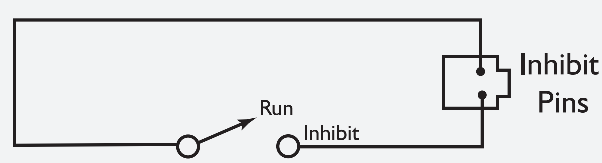
Note: It is critical that the drive's output voltage is 0 VDC before reversing or braking. If using two relays in place of the above drawing, the motor relay should have a "delay on the make" and the inhibit relay should have a "delay on the break".

INHIBIT

Depending on the application, users may want to ramp their motor down slowly (decelerate), while others may need to stop more quickly. For rapid or frequent motor stopping capability, most applications require regenerative drives. However, typical Minarik Drives drives contain inhibit circuitry. Inhibiting a drive causes the output voltage to fall to zero or to a level determined by the minimum speed trimpot.

Inhibiting occurs by closing a switch on most drives, and opening a switch on others. Inhibiting single-quadrant drives simply reduces the drive output to zero (or a calibrated minimum voltage) which allows the motor and its load to coast. The drive applies no braking torque, rather the system friction provides the retarding forces. Inhibit bypasses the decel setting for "coast-to-stop". Opening the inhibit switch allows the motor to accelerate smoothly to its set speed.

In four-quadrant (regenerative) drives, shorting the inhibit terminals will regeneratively brake the motor. It bypasses both the minimum speed and the deceleration settings for rapid braking determined by the torque trimpot setting. Depending on the drive wiring scheme, users can regeneratively brake a motor (following the deceleration setting) to a stop, decelerate the motor to minimum speed, or coast the motor to a stop (without removing power) by shorting the INHIBIT-RUN terminals.



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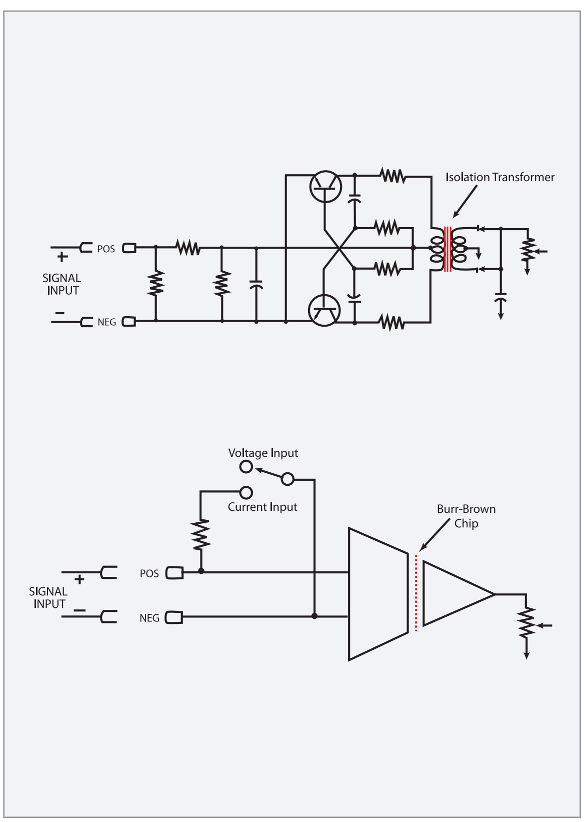
ISOLATION

Motor windings are simply coils of wire separated by insulating material. Only the base and outside of the motor is touching "earth ground." The drives use one of the wires coming from these motor coils as "common". Common is the point in the control circuit from which all other internal voltages are referenced. This part of the motor coil is the drive's zero reference.

Common and earth ground are at a high voltage potential from each other, typically equal to the line voltage. If we plugged a drive into a 115 VAC line socket, and measured the voltage from the drive's common to earth ground, we would see about 115 VAC. We say the drive floats above ground since these two points have a very large potential difference.

Often control signals from an external source (such as a PLC or transducer) are referenced to earth ground. If we set a grounded 0-10 VDC analog signal to 0 VDC, and measure from that point to earth ground, we would see "0 VDC". An attempt to connect this source directly into the drive would result in catastrophic failure of the signal source and/or the drive. Therefore, we must use a device that provides good electrical isolation between these two points. An isolation device takes the incoming voltage from the signal source, and makes an "image" of this voltage, but isolated, for the drive to use as the reference. The output voltage is isolated from the ground and safe to wire to the drive.



There are two basic methods of isolation used by Minarik Drives:

1. ISOLATION TRANSFORMERS

Minarik Drives uses a simple push-pull transistor pair to transform an external DC signal into square-wave AC. Since transformers can only transmit AC, the DC signal from the remote source must be "sampled" into AC. Then, the signal goes through a 1:1 isolation transformer; subsequently, a bridge rectifier converts it back into DC. This method is 2 to 3 times more linear than an opto-coupled device, but voltage drops still exist across the transistors and diode bridge. Our USIM-8 isolation module, and PCM20000 and PCMXP drives use this method.

2. INTERNALLY ISOLATED OP-AMP

This is Minarik Drives' most reliable method of isolation. The Integrated Circuit (IC) uses a uniquely isolated op-amp, with feedback for excellent linearity. It is 300 times more linear than the opto-coupler and has better isolation than the other devices. More complex, the op-amp requires support circuitry to run. Minarik Drives provides separate isolation modules to use with any motor drive, or with isolation directly integrated into a drive. Minarik Drives' PCM4 isolation module, PCM adder card, RG5500U, MM300, and MM-PCM among many other drives use this method.

SIZING AN ENCLOSURE

There are numerous issues to consider when sizing an enclosure for a drive: motor nameplate rating, type of material, style and appearance, environment, and internal volume of the drive. Two things affect the internal volume; first, the amount of depth for safe clearance of components mounted inside of the enclosure; second, the amount of volume necessary to dissipate the heat generated by the drive. We either dissipate heat through a heatsinking device (similar to an aluminum back plane), or by letting it flow out to the “ambient” air. If there is sufficient aluminum in the enclosure’s back plane, then the internal volume may be smaller.

However, if using a plastic or steel enclosure, where little or no backplane exists to dissipate heat from the drive, then you will need to use forced air ventilation, or a larger volume inside the enclosure to dissipate the heat into the “ambient” air.

Most enclosure manufacturers use computers to quickly answer your questions and recommend the correct size enclosure for your drive.

DEPTH

All Minarik Drives’ SCR drives require at least 1” of clearance at the top point of the drive. Filtered PWM drives (due to bus capacitors) require at least 2” clearance from the top. When mounting anything into the lid, remember to make accommodations in the depth behind the lid for components like switches and potentiometers.

HEAT DISSIPATION

Unfiltered SCR drives are typically 96% efficient, while filtered PWM drives are typically 94% efficient. We calculate the heat dissipation by multiplying the power output to the motor measured in watts (1 HP motor at full load = 746 watts) by the inefficiency of the drive (0.04 for SCR drives or 0.06 for PWM drives).

ENCLOSURE STANDARDS

for non-hazardous locations

Standard NEMA (IEC)*	Indoors	Outdoors	Accidental bodily contact	Falling dirt	Dust, lint, fibers (non-volatile)	Windblown dust	Falling liquid, light splash	Indirect hosedown & heavy splash	Rain, snow & sleet	Oil or coolant seepage	Oil or coolant spray & splash	Corrosion Resistant
NEMA 1 (IP10)	x		x	x								
NEMA 3 (IP54)	x	x	x	x	x		x			x	x	
NEMA 4 (IP56)	x	x	x	x	x	x	x	x	x			
NEMA 4X (IP56)	x	x	x	x	x	x	x	x	x			x
NEMA 12 (IP52)	x		x	x	x		x					
NEMA 13 (IP54)	x		x	x	x		x			x	x	

*The IEC equivalents listed in this column are approxiamate. NEMA types meet or exceed the test requirements for the associated IEC classifications.

1st DIGIT	Protection against foreign objects	2nd DIGIT	Portection against moisture
0	Not protected	0	Not protected
1	Protected against objects > 50 mm	1	Protected against dipping water
2	Protected against objects > 12 mm	2	Protected against dripping water when tilted up to 15N
3	Protected against objects > 2.5 mm	3	Protected against spraying water
4	Protected against objects > 1.0 mm	4	Protected against splashing water
5	Dust protected	5	Protected against water jets
6	Dust tight	6	Protected against heavy seas
	-----------------	7	Protection against the effects of immersion
	-----------------	8	Protection against submersion

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FORM FACTOR

Form factor is a figure that indicates how much the current departs from pure DC. Mathematically, form factor is the quotient of RMS current and average (AVG) current:

$$\frac{\text{RMS Current (AC)}}{\text{AVG Current (DC)}}$$

Unity form factor represents pure DC. Values greater than one indicate increasing departure from pure DC. The practical effects of larger form factor input into a motor include increased heating, decreased brush life, and diminished motor and system efficiency. The form factor rating of a motor defines the maximum form factor for which the stated motor ratings apply. The output form factor of the drive should never exceed the form factor rating of the motor.

An unfiltered SCR drive output is not a fully rectified sine wave at maximum speed. Form factors of approximately 1.37 are typical for an unfiltered SCR drive operating at full speed. At lower speeds, the form factor of the armature output increases. The published form factor rating of an SCR drive indicates only its best (lowest) form factor value.

The form factor of PWM drives does not exceed 1.05, nor does it deteriorate as speed reduces. The form factor rating of PWM drives is valid over the entire speed range, which accounts for the larger speed range of PWM drives. The low form factor can be a substantial system advantage over SCR drives in terms of efficiency of operation and lower maintenance costs.

CALIBRATION REVIEW

The following section reviews calibration of most single quadrant drives. Four quadrant drives use similar calibration techniques, but for two directions.

MIN SPD

The MIN SPD setting determines the motor speed when the speed adjust potentiometer is turned full CCW. It is factory set to zero speed.

Use the following procedure to set MIN SPD:
1. Set the speed adjust potentiometer full CCW.
2. Adjust the MIN SPD trimpot until the motor has stopped (for zero speed setting), or is running at the desired minimum speed.

MAX SPD

The MAX SPD setting determines the motor speed when the speed adjust potentiometer is turned full CW. It is factory set for maximum rated voltage.

Use the following procedure to set MAX SPD:
1. Set the speed adjust potentiometer full CW.
2. Adjust the MAX SPD trimpot until the motor is running at the desired maximum speed.

TORQUE (CURRENT LIMIT)

The TORQUE setting determines the maximum torque for accelerating and driving the motor.

Use the following procedure to set TORQUE:
1. With power disconnected from the drive, connect a DC ammeter in series with the armature.
2. Set the TORQUE trimpot to minimum (full CCW)
3. Set the speed adjust potentiometer to maximum speed (full CW).
4. Carefully lock the motor armature. Be sure that the motor is firmly mounted.
5. Apply line power. The motor should be stopped.
6. Adjust the TORQUE trimpot CW slowly until the

CALIBRATION REVIEW

armature current is 150% of motor rated armature current.

7. Turn the speed adjust potentiometer CCW until the motor stops.
8. Remove the line power.
9. Remove the stall from the motor.
10. Remove the ammeter in series with the motor armature if it is no longer needed.

IR COMP

The IR COMP trimpot setting determines the degree to which motor speed is held constant as the motor load changes.

Use the following procedure to recaliabrated the IR COMP setting:

1. Turn the IR COMP trimpot to full CCW.
2. Set the speed adjust potentiometer until the motor runs at midspeed without load (for example, 900 RPM for an 1800 RPM motor). A hand held tachometer may be used to measure motor speed.
3. Load the motor armature to its full load armature current rating. The motor should slow down.
4. While keeping the load on the motor, rotate the IR COMP trimpot CW until the motor runs at the speed measured in step 2. If the motor does not maintain set speed as the load changes, gradually rotate the IR COMP trimpot CW. If the motor oscillates (over compensation), the IR COMP trimpot may be set too high (CW). Turn the IR COMP trimpot CCW to stabilize the motor speed.
5. Unload the motor.

ACCEL

The ACCEL setting determines the time the motor takes to ramp to a higher speed. See User Manual for approximate acceleration times. ACCEL is factory set for the fastest acceleration time (full CCW).

Use the following procedure to set acceleration time:

CALIBRATION REVIEW

1. Set the speed adjust potentiometer full CCW. The motor should run at a minimum speed.
2. Turn the speed adjust potentiometer to full CW and measure the time it takes for the motor to go from minimum to maximum speed.
3. If the time measured in step 2 is not the desired acceleration time, turn the ACCEL trimpot CW for a slower accelertion time, or CCW for a faster acceleration time. Repeat steps 1 through 3 until acceleration time is correct.

DECEL

The DECEL setting determines the time the motor takes to ramp to a lower speed. See User Manual for approximate deceleration times. DECEL is factory set for the fastest deceleration time (full CCW).

Use the following procedure to set the deceleration time:

1. Set the speed adjust potentiometer full CW. The motor should run at maximum speed.
2. Turn the speed adjust potentiometer to full CCW and measure the time it takes the motor to go from maximum to minimum speed.
3. If the time measured in step 2 is not the desired deceleration time, turn the DECEL trimpot CW for a slower deceleration time, or CCW for a faster deceleration time. Repeat steps 1 through 3 until the deceleration time is correct.

Acceleration/Deceleration The time rate of change in velocity; acceleration refers to an increase in velocity, while deceleration refers to a decrease in velocity. Generally expressed as radians/sec/sec. Board-mounted trimmer potentiometers let users adjust the time it takes for the motor to reach set speed.

Actuator A device that converts various forms of energy, when given an input, to rotating or linear mechanical motion such as a motor.

Air-Gap The area between the rotating and stationary members of an electric motor.

Alternating Current (AC) Electrical current flow, usually generated by the utilities at 60 Hz, which continuously reverses direction in the middle of its cycle. Mathematically, it follows a sine wave; it travels from zero, then reaches a maximum in one direction, decreases to zero, then reverses to reach a maximum in the opposite direction.

Ambient Temperature The temperature of the medium, usually air, around a device such as a motor or drive.

Ampere (AMP) The standard unit of electrical current, or rate of electron flow. A closed-loop electrical circuit with one volt of potential difference across one Ohm of resistance causes one ampere of current to flow.

Armature The armature is the rotating member of an electric motor. In brush-type DC motors, it consists of the main current carrying windings (conductors). The commutator switches the power supply to the armature windings to generate a magnetic field.

Back-Emf Also known as counter emf (cemf), it is the voltage produced across motor windings, due to the winding turns being cut by a magnetic field, during rotation of the motor. The back-emf is directly proportional to rotor velocity and opposite in polarity to the applied voltage. This static voltage arises from the generator action in a motor, even if the motor windings are not energized.

Backlash In a mechanical system, backlash is the relative motion between two devices, connected by a coupler, gear, screw, etc.

Bridge Rectifier A section of the DC drive that converts the AC power supply into a DC source.

Brushes The current conducting material, usually carbon or graphite, which rests directly on the commutator of brush-type DC motor. They transmit current from the power supply to the armature.

Capacitor A device which holds electrical charge for a period of time, prevents the flow of direct current and allows the flow of alternating current. These components serve as filters in DC drives to provide a “cleaner” DC signal to the motor.

Chassis Open construction of a drive for mounting within a customer’s existing enclosure or control console.

Choke A filter device consisting of an inductor and a resistor. Although more expensive than a typical RC filter, they exhibit better performance.

Closed-loop A system that uses feedback information to regulate the output response. The output feeds back to a controller for comparison to the input command; any difference results in a corresponding change in the input command. Thus, the accuracy increases.

Cogging Cogging refers to shaft rotation occurring in jerks or increments rather than smooth continuous motion. The non-uniform (“jerky”) rotation results from the armature’s propensity to certain discrete angular positions. The interaction of the armature coils entering and leaving magnetic fields, produced by the field coils or permanent magnets, causes speed changes. The armature tends to speed up and slow down as it cuts through the fields during rotation. Cogging is very apparent at low speeds, and determines a motor’s speed range.

Commutator A device mounted on the armature shaft and consisting of a number of wedge shaped copper segments arranged around the shaft. These segments are insulated from the shaft and from each other. The motor brushes ride on the periphery of the commutator, and electrically connect and switch the armature coils to the power source.

Conductor Any material, such as copper or aluminum, which offers little resistance to the flow of electric current.

Current Limit (Torque Limit) This feature permits the operator to adjust the maximum current the motor can draw. This, in effect, limits the maximum torque the motor will produce.

Dynamic Braking A way of quickly stopping a motor by disconnecting the power source. The rotating motor then becomes a generator. When connected to a resistor, the energy of rotation is then dissipated as heat in the resistor.

Duty Cycle The ratio of operating time versus total cycle time of a motor. A motor has a continuous duty rating if it continues to operate for an indefinite amount of time and its normal operating temperature remains within the temperature limits of its insulation system. A motor has an intermittent duty rating if it never reaches a steady temperature, but is allowed to cool between operations.

Enclosure A description of the motor or drive housing. The selected enclosure depends on the application’s environment and heat generated by the device.

Encoder A feedback device that translated mechanical motion into an electronic signal or combination of signals (pulses).

Field Motor field windings provide the magnetic field, located in the stator of DC shunt-wound motor, which interacts with the armature field to produce torque. PM motors use magnets, instead of windings, to produce the stator field.

Filter An electrical device used to suppress electrical noise, or to improve the DC output to a DC motor.

Flyback Diode This is a super fast recovery diode that snubs current and voltage spikes as a result of the fast transients that occur when IGBT, and MOSFETS are turned on and off quickly.

Form Factor Form factor indicates how much AC component resides in the DC output from DC drives. Represented mathematically as the ratio of a signal’s root-mean square current value to its average current value. Any form factor value greater than one means that some of the current produces heat instead of torque.

Four-quadrant This term refers to a drive’s ability to control the velocity and torque of a motor in either direction of rotation. The direction of torque can be in the opposite direction of the velocity for applications requiring braking or deceleration. Single-quadrant drives, on the other hand, only produce torque and velocity in the same direction of rotation.

Frequency Frequency refers to how often a complete cycle occurs in a unit of time. Frequency is usually measured in cycles per second, or Hertz, where 1 cycle/second equals 1 Hz. The standard AC power supply in the USA is 60 Hz, while 50 Hz remains common in many other countries of the world.

Friction The resistance to motion between surfaces.

Fuse A device connected to an electrical circuit designed to melt and open the circuit in the event of excess current flow.

Gearhead A mechanical device that converts speed and torque to values required by the application. Output torque increases, and output speed decreases proportionally to the gear ratio.

Generator A machine that converts mechanical energy into electric energy.

Hall Effect Sensor These feedback devices, commonly used in brushless motors, provide information for the amplifier to electronically commutate the motor. The sensors generate commutation signals by sensing the position of a magnetized wheel on the rotor.

Horsepower The rate at which work is performed. It equals the speed multiplied by torque, and a constant, depending on the units selected.

Inductance A property of an electric circuit that represents its ability to resist changes in current flow.

Inertia A function of the mass and shape of an object. The inertia represents the property of an object that resists a change in motion. An object’s inertia increases directly with an increase in the object’s mass; also, increasing inertia loads require more force to accelerate and decelerate them.

Inverter (Variable Frequency Drives) AC drive that varies the frequency and voltage applied to an AC motor to vary motor speed.

IR Compensation It varies the amount of voltage to the armature in response to current (load) changes. It is adjustable via a board mounted trimmer potentiometer.

Isolated Gate Bipolar Transistor (IGBT) A power transistor with a gate similar to the base of BJT. The difference is that the gate is electrically insulated from the collector-emitter circuit. This allows high voltages and currents to be conducted.

Jogging This feature provides a means of momentarily moving the motor at a different speed (normally slower) from the normal operating speed. Operators access this function using a separate control input.

Load A term used to describe work require from a motor to drive equipment attached at the shaft. Usually defined in units of horsepower, or torque at a certain speed.

MOSFET A Metal-Oxide-Semiconductor-Field-Effect-Transistor is similar to standard field-effect transistors. MOSFETs can be a N or P type. They will or will not conduct from source to drain unless a voltage is applied to the gate of the MOSFET. They have turn-on and turn-off capability, as well as fast reaction times.

NEMA The acronym stands for the National Electrical Manufacturers Association. The agency provides specification standards for motors and drives.

Noise (EMI/RFI) Electrical disturbances that interfere with proper transmission of electrical signals. Noise can have adverse effects on system performance.

Non-volatile Memory A memory storage system that maintains information during the loss of power.

Ohm Unit of electrical resistance of a circuit in which a potential difference of one volt produces a current of one ampere.

Open-Collector An output signal, provided by a transistor, where the "open-collector output" acts like a switch closure to ground when activated.

Open-Loop A system that does not use feedback information to regulate performance.

Phase Lock Loop (PLL) Used for error correction, PLL refers to an external digital controller that monitors digital feedback proportional to velocity. It compares that to a known number of counts that should be seen within a specified time frame, and calculates error based on its feedback. Minarik Drives uses Phase Lock Loop on digital front-ends such as the DLC Series.

PLC A programmable logic controller (PLC) uses programmed logic instructions to control banks of inputs and outputs which interface timed switch actuation to external electro-mechanical devices.

Plugging A method to provide quick stopping or reversing of a motor by applying partial or full reverse voltage on the motor terminals during operation. Not recommended for DC systems since the life of the motor and drive reduces. Permanent damage may result.

Poles The magnetic poles in an electric motor that result from connection and placement of the windings in the motor. Besides poles created by electricity, permanent magnets mounted in specific areas are poles with a constant orientation.

Potentiometer (Pot) A passive device (variable resistor) used to vary voltage between a minimum and maximum level. The standard speed pot is a 300° or single-turn. Operators control the speed of a motor from the potentiometer connected to a drive. Also, board-mounted trimmer pots allow users to make calibrations.

Proportional-Integral-Derivative The act of recognizing a velocity or position error in a system, and applying correction (or voltage change) to the system amplifier, thereby changing the motor's speed or altering position. PID refers to a group of gain parameters that tune or optimize the response of a closed-loop system.

1. Proportional: This feedback loop compares error and adds an equal amount of reference beyond the original. For example: with a 20% error, the loop applies 20% more than the original reference.

2. Integral: This loop examines the average error over a number of samples, and makes the correction associated with it. For example: with a 20% error reading in one window and 10% error in another, the integral loop may apply 15% error correction in the third window based on average of previous readings.

3. Derivative: This loop reads instantaneous change in error, as opposed to the error itself. It analyzes how an error differs from a previous error and adjusts accordingly. PID combines all three loops resulting in an extremely accurate form of digital error correction. Each loop checks and balances the other to assure the right amount of error correction. Lead-Lag is similar to PI in correcting error through known error and average error. The difference is that this can over or under compensate, based on a trend or assumption of what is assumed will occur in the next error. The error correction can lead or lag the actual error.

Rated Values The rated value of a parameter (voltage, temp, etc.) is the maximum value that the parameter can reach in an electric device operating continuously without undue degradation, loss of its basic properties, or safety hazards.

Regenerative Regenerative drives, often used interchangeably with four quadrant drives, applies to the regeneration of energy from the motor and drive, back to the power source. A motor generates when the load forces the motor to go faster than the drive has set. Four quadrant drives can prevent motors from over speeding. A four quadrant drive is regenerative when it puts the generated energy back into the source, like a battery or the AC line. Also, the energy could be dumped across a dynamic brake resistor or a dump resistor, as is the case in a non-regenerative, four quadrant drive.

Relay These electronic components control other devices in a circuit. A set of contacts, the switching mechanism, open or close when the relay's magnetic coil becomes energized.

Resistance The opposition to current flow through a conductor in a closed circuit.

Rotor The rotating assembly of a motor. Usually includes a shaft, fan and rotor core.

Silicon Controlled Rectifier (SCR) Also known as a thyristor, a SCR is basically a diode with an extra junction tied to a third leg, known as the gate between the cathode and anode. SCRs prevent current flow in either direction until the gate receives a voltage signal. After receiving this trigger signal, the SCR then becomes a diode. It remains on, regardless of what happens at the gate, until the zero crossing, at which point current ceases to flow.

Servo A system consisting of an amplifier, actuator, and feedback element. Servos tend to control one or combination of the following variables: position, velocity and torque.

Speed Regulation Defined as the deviation in motor speed from No Load to Full Load; usually expressed as a percentage of base speed. Feedback devices, like a tachometer or digital closed loop control, provide increased regulation.

Stator The stationary part of a motor. A PM DC motor holds its magnets in the stator.

Surge Suppressors These devices, like a metal oxide varistor (MOV), suppress voltage transients that can occur on the AC line.

Tachometer Feedback A tachometer (tach) generates a voltage proportional to speed. Tachs provide a closed-loop system with excellent speed regulation.

Torque A rotational force equal to an equivalent linear force applied at a right angle to a radius of r.

Torque-to-Inertia Ratio The rated motor torque divided by its rotor inertia. Helps determine a motor's ability to accelerate loads.

Transformer A passive device that raises or lowers AC voltage by induction.

TTL (Transistor-Transistor Logic) A popular family of integrated circuit devices that operate from logic level voltages, 5 to 12 VDC.

Voltage Voltage is electric pressure. A volt is a unit of electromotive force which causes 1 Amp of current to flow through a 1 Ohm resistor.

Watts The power required to maintain one ampere of current at a pressure of one volt when the two components are in phase with each other. A unit of horsepower is equal to 746 watts.