Hudson Motor User Manual

For Hudson motors purchased at Teknic.com

Rev. 1.26 August 26, 2021

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Introduction

What's in This Document

This document contains technical information on the Hudson family of brushless DC servo motors, including:

- Wiring information
- Mechanical drawings
- Application tips
- Specifications

Information on the Web

Please visit Teknic's website for more information on the Hudson family of brushless servo motors: https://www.teknic.com/products/hudson-motors/

What are Hudson Motors?

Hudson motors have been called (more or less correctly) all of the following:

- BLDC motors
- Three-phase, permanent magnet motors
- Synchronous, permanent magnet motors
- AC servomotors (AC because electronic commutation requires a sinusoidal current to produce constant torque, not to be confused with AC induction motors)
- DC servomotors (presumably to distinguish them from AC induction motors)
- 3-phase servomotors

Technically speaking, Hudson motors are:

Three-phase, synchronous, permanent magnet, brushless servo motors.

Definitions

"Servo Motor" refers to a motor that uses one or more feedback devices (encoder, Hall effect sensors, etc.) to control torque, velocity, and/or position in a closed loop manner.

"Brushless", aside from the obvious, means the motor requires a drive (amplifier) that supports electronic, non-contact commutation.

"Permanent Magnet" means that the motor has permanent magnets affixed to the rotor (brush motors typically have permanent magnets affixed to the stator).

"Synchronous" means that the rotational speed of the electromagnetic field is the same as (i.e. synchronous with) the speed of the rotor. There is no “slip” between them like there is with an AC induction motor.

“3-phase" means the motor has three separate stator windings connected together in a delta or wye configuration.

Safety and Safe Handling Information

General Precautionary Statement

Always follow appropriate safety precautions when installing and operating motion control devices. Automated equipment should be designed to prevent personnel from coming into contact with moving parts and electrical contacts that could potentially cause injury or death.

Read all cautions, warnings and notes before attempting to operate or service motion control devices. Follow all applicable codes and standards when using this equipment. Failure to use this equipment as described may impair or neutralize protections built into the product.

Symbols Used in this Manual

The following symbols and conventions are used on the equipment and in this manual.

Caution, risk of danger

Identifies information about practices or circumstances that can lead to equipment damage, personal injury, or loss of life.

Shock hazard

Identifies presence of hazardous electrical voltages and currents.

Protective earth terminal

Indicates points that must be connected to a reliable earth system for safety compliance. Protective earth connections should never be omitted.

Earth ground terminal

Frame or chassis terminal (shield)

Direct current

Note

Identifies information that is critical for successful application and understanding of the product.

Tip

Identifies additional information that may be helpful in supporting certain applications.

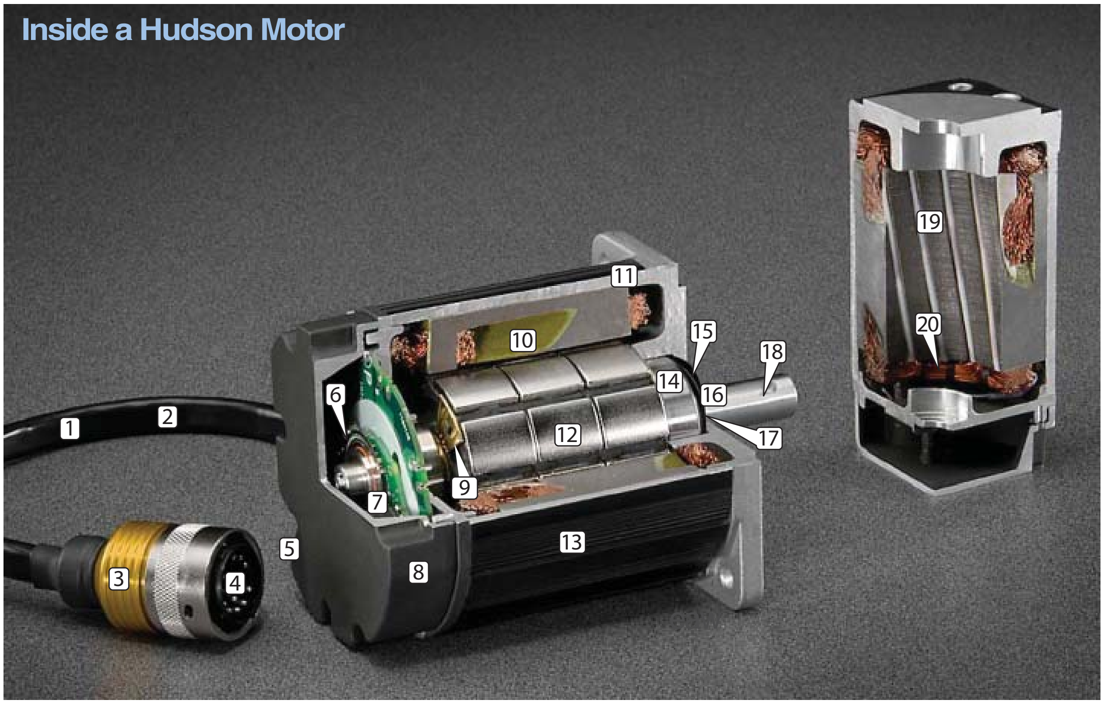
Safe Handling Practices

- **Do not hammer** pulleys, pinions, etc. onto the motor shaft.
- **Do not wrench or pry** pulleys, pinions, etc. off the motor shaft. When removing accessories use a gear puller that pushes on the center of the shaft (offsetting the applied force).
- **Do not exceed the axial force limit (see table below) when pulling on the shaft or bearing damage will occur.**
- **Do not pick up a Hudson motor by its pigtail.** Note: Maximum pigtail pull force is 7 lbs.
- Do not allow the Hudson pigtail to flex during routine operation. **The Hudson pigtail is not flex-rated.** Use cable ties or other means to immobilize the motor pigtail during operation.
- Do not install a Hudson motor such that pigtail is pulled taut (has a constant tension applied to it). Allow for some slack in the pigtail when securing the motor to your machine.
- When pushing an accessory onto the motor shaft, **do not exceed the axial force limit when pushing into the shaft (see table below).**

	Shaft Axial Force Limits, N (Lb.)			
	Pushing into shaft		***Pulling out of shaft***	
	NEMA 23	**NEMA 34**	**NEMA 23**	**NEMA 34**
Continuous, operating	90 (20.2)	115 (25.9)	22 (4.9)	32 (7.2)
Static, short term	224 (50.4)	360 (80.9)	112 (25.2)	135 (30.3)
Shock / Impact	45 (10.1)	68 (15.3)	45 (10.1)	68 (15.3)

ESD Warning: Hudson internal electronics are tolerant to a moderate amount of static discharge, but we recommend that you do not touch the bare pins on a Hudson motor connector unless you are working in a static-safe environment.

Parts of a Hudson Motor



1. 16 inch pigtail eliminates costly motor cables in many applications.
2. Single cable, single connector pigtail results in neater, lower cost installations.
3. Two connector choices: lower cost automotive-style, and sealed, bayonet-style.
4. All Hudson motors come with connectors.
5. Zero-clearance pigtail allows bigger motors to fit into smaller spaces.
6. Shatter-proof encoder disk eliminates shock-induced failures.
7. Industry-standard encoder and commutation signals.
8. Low-profile encoder allows you to fit motors into tighter spaces.
9. Precision brass balancing tabs for smoother motion and less vibration.
10. Epoxy insulation layer allows the use of higher operating voltages.
11. Compression-fit aluminum stator housing channels heat out of the motor.
12. Sintered, nickel-plated, rare-earth magnets generate maximum power.
13. Architectural-quality, anodized finish will look great for years.
14. Oversized, permanently lubricated front bearing extends bearing life.
15. Long-stroke, wave spring imparts consistent bearing preload.
16. Optional high-performance shaft seal for more protection against dirt and dust.
17. Smooth, radiused transition from external shaft diameter results in a stronger shaft.
18. Feather keyway allows easy assembly (and the key can't work its way out).
19. Helically skewed stator laminations improve smoothness of motion.
20. Tightly formed and laced end-turns heat more evenly for higher reliability and longevity.

Hudson motor cutaway view

Interconnect and Wiring

This section discusses Hudson motor interconnect topics, including the following:

- Motor connector options
- Mating connector parts and pinout information

Motor Connector Options

Hudson motors are available in two connector options: **Molex MiniFit Jr.** (at left below) and **Souriau Trim-Trio**, free hanging (at right).

Hudson motor connector options

Molex Mini-Fit Jr. Connector

The Molex Mini-Fit Jr. connector provides a gas tight link with four points of contact. This low cost, rugged connector is rated at up to 10A continuous current per circuit, and 600V. The connector includes a positive locking mechanism, and fully isolated, low engagement-force terminals.

Use Molex Mini-Fit Jr. connectors when:

- Lower cost is required
- The operating environment is relatively clean and dry (typical dust/dirt is OK)
- Less than 10A of continuous current per phase is required

Souriau Trim-Trio Connector

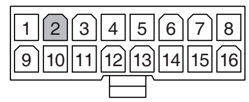
The Souriau Trim-Trio bayonet-style connector is a keyed, sealed, positively locking unit derived from the MIL-C 26482 specification.

Use Souriau Trim-Trio connectors when:

- The pollution level (at the connector) is higher (light spray, mists, fumes, chips, etc.)
- A water resistant seal (at the connector) is required
- Higher current-carrying capacity (> 10A continuous) is required

Connector Pinouts and Mating Parts

Molex Mini-Fit Jr. Pinout



WIRE ENTRY VIEW

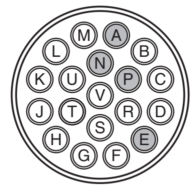
Pigtail Pinout Table (Molex, Minifit Jr.)

Pin#	AWG	Color	Signal Name	Notes
1	**16**	**TIN**	**P DRAIN**	**Drain wire for Phase Cable**
2	NO CONNECT			
3	26	GRN	COMM S-T	commutation (Hall) sensor
4	26	GRN/WHT	COMM R-S	commutation (Hall) sensor
5	26	GRY/WHT	COMM T-R	commutation (Hall) sensor
6	26	TIN	E DRAIN	drain wire for Logic Cable shield
7	26	BLK	GND	+5VDC ground (encoder/Hall board return)
8	26	BLU/WHT	ENC A~	encoder out (A~)
9	**16**	BLK *or* WHT/BLK	**PHASE R**	**MOTOR PHASE**
10	**16**	RED *or* WHT/RED	**PHASE S**	**MOTOR PHASE**
11	**16**	WHT	**PHASE T**	**MOTOR PHASE**
12	26	RED	+5VDC IN	+5VDC input (encoder/Hall board power)
13	26	BRN	ENC I	encoder out (index)
14	26	ORN	ENC B	encoder out (B)
15	26	BLU	ENC A	encoder out (A)
16	26	ORN/WHT	ENC B~	encoder out (B~)

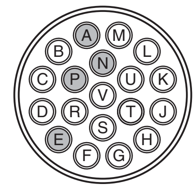
Mating Parts

Part Description	Mfg. / Part Number
Connector Housing, panel mount	Molex / 39-01-2166
Terminal, male, 24 AWG (logic signals)	Molex / 39-00-0049 (loose) -0048 (reel)
Terminal, male, 16 AWG (motor phases)	Molex / 39-00-0082 (loose) -0081 (reel)
Crimp tool, 22-28AWG	Molex / 11-01-0198
Crimp tool, 16AWG	Molex / 2002182200
Extraction Tool	Molex / 11-03-0044

Souriau Trim-Trio Pinout



Front View



Wire Entry View

Pigtail Pinout Table (Souriau, Trim Trio Connector)

Pin#	AWG	Color	Signal Name	Notes
A	NO CONNECT			
B	**16**	BLK *or* WHT/BLK	**PHASE R**	**MOTOR PHASE**
C	**16**	RED *or* WHT/RED	**PHASE S**	**MOTOR PHASE**
D	**16**	WHT	**PHASE T**	**MOTOR PHASE**
E	NO CONNECT			
F	26	ORN/WHT	ENC B~	encoder out (B~)
G	26	GRN	COMM S-T	commutation (Hall) sensor
H	26	GRN/WHT	COMM R-S	commutation (Hall) sensor
J	26	BLU	ENC A	encoder out (A)
K	26	BLU/WHT	ENC A~	encoder out (A~)
L	26	GRY/WHT	COMM T-R	commutation (Hall) sensor
M	26	TIN	E DRAIN	Drain wire for Logic Cable shield
N	NO CONNECT			
P	NO CONNECT			
R	**16**	**TIN**	**P DRAIN**	**Drain wire for Phase Cable**
S	26	BLK	GND	+5VDC return
T	26	RED	+5VDC IN	+5VDC input (encoder/hall power)
U	26	BRN	ENC I	encoder out (index)
V	26	ORN	ENC B	encoder out (B)

Mating Parts

Part Description	Mfg. / Part Number
Connector Housing, w/ flange (for free-hanging pigtail)	Souriau / UTG016-19S
Connector Housing, for panel-mount pigtail	Souriau / UTG616-19S
Terminal, female, 24 AWG (logic signals)	Souriau / SC24M1TK6
Terminal, female, 16 AWG (motor phases)	Souriau / RC16M23T
Backshell / Clamp	Souriau / UTG16AC

Servo Drive Selection

Drive Compatibility

Servo drives intended for use with a Hudson motor must have the capabilities listed below.

Supported Methods of Commutation (see section below for details)

- Six-Step (trapezoidal)
- Sine Wave
- Sine Wave with Vector Torque Control

All Hudson motors sold on the web have

- 5VDC differential encoder signals
- 5VDC, 120° optical commutation sensors (analogous to Hall effect sensors)
- 8 poles
- 4 electrical cycles per revolution

Supported Commutation Methods

Each Hudson motor has a precision optical encoder disk with 120º optical commutation sensors (analogous to Hall effect sensors). During assembly the disk is precisely locked into position such that the commutation tracks line up with the rotor in a known orientation.

Six-Step (Trapezoidal) Commutation

Note: Six-step commutation (aka "trapezoidal commutation") can be used with Hudson motors though it is generally not preferred for high precision, low speed applications due to higher torque ripple and lower operating efficiency. Six-step is often used in cost-sensitive, lower precision applications, and for high speed applications where the mechanical system and motor combine to have sufficient inertia to minimize the effect of torque ripple.

During six-step commutation, the servo drive interprets the rotating commutation sensor codes from the motor to determine relative rotor to stator position and uses this information to sequence and time the switching of current into the motor phases.

Step#	Commutation Sensor State 3 channels, 120º separation			Current Flow
1	1	0	1	From phase R to phase S
2	1	0	0	From phase R to phase T
3	1	1	0	From phase S to phase T
4	0	1	0	From phase S to phase R
5	0	1	1	From phase T to phase R
6	0	0	1	From phase T to phase S

During six-step commutation, current flows in only two phases at a time (the third phase is always off). Example: In Step #1 above, when the commutation sensors read binary (1 0 1) the drive sends current through Phases R and S, while Phase T remains off.

It is useful to understand that the commutation "code" changes state six times per electrical cycle[1], and thus provides a less precise fix on rotor position than a typical sine wave drive with encoder-based commutation. While this may be sufficient for less demanding motion applications, a high resolution feedback device—such as an encoder—is a better choice for high performance positioning tasks.

Pros and Cons of Six-Step Commutation

Pro: Lower cost of implementation (six-step drives may be cheaper)

Con: High torque ripple

Con: No torque control loop, though does have a current loop

Con: Lower torque efficiency (at high speeds)

Sine wave Commutation (Better)

Sine wave commutation is generally better suited to midrange applications where greater precision of control over position, velocity and/or current is required.

Most sine wave drives use the commutation sensors to initialize the commutation process. First, the commutation code is read from the motor to establish the initial rotor vs. stator position. Then the drive applies current to the motor windings to achieve the desired relationship between the permanent and electromagnetic fields. After this relationship is established, the electromagnetic vector is "locked" to the encoder position, and commutation continues based on encoder feedback (and not on the Halls).

Though more efficient than six-step drives, sine wave drives run open loop with respect to torque control. While the current in each motor phase is individually servo controlled, the actual torque produced at the shaft is not. In most sine wave drives, torque errors are only corrected indirectly—after they have resulted in velocity and position errors. This generally means sine wave drives operate with a wider positioning error band than sine wave drives with true vector torque control (see next topic).

Sine wave commutation with Vector Torque Control (Best)

Sine wave drives with Vector Torque Control (VTC) are often the drive of choice for high precision, high throughput positioning and contouring applications. A sine wave VTC drive is wired, and operates, in basically the same way as a sine wave drive without VTC. The key difference is how torque is controlled. While most sine wave drives servo control only the

[1] Note: Hudson motors are 8-pole motors that have four electrical cycles per mechanical revolution. This means that Hudson commutation sensors transition (6 states x 4 electrical cycles) 24 times per motor revolution.

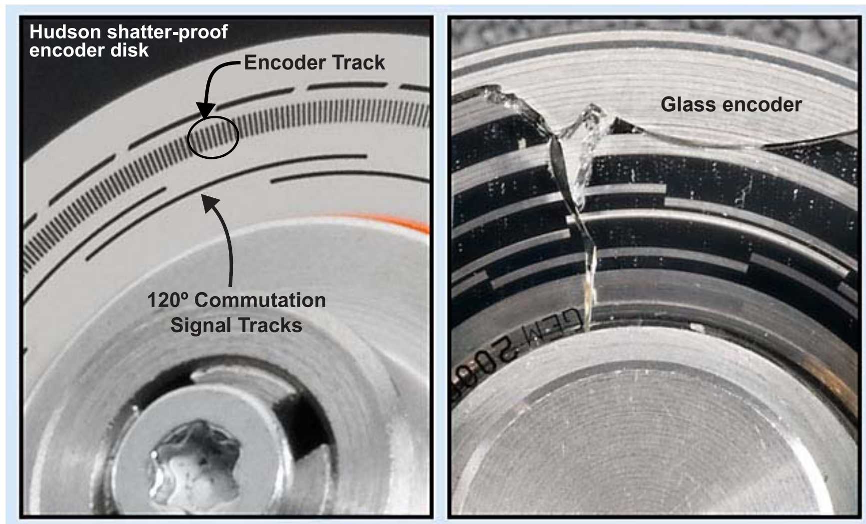
individual motor phase currents, VTC drives servo control the actual torque produced at the motor shaft.

The drive simultaneously takes calibrated current measurements from all motor phases, combines this data with information about rotor position, phase resistance, inductance and back-EMF, and then applies advanced vector mathematics to calculate the exact torque being produced at the shaft. This tight torque feedback loop allows for very rapid corrections in torque error, resulting in superior dynamic tracking performance.

Encoder and Commutation Signals

Hudson motors have differential encoder outputs and single-ended commutation (Hall) outputs.

Encoder and commutation tracks are optically read from the Hudson encoder disk and then translated to driven signals present at the motor connector.



At left is a Hudson encoder disk. At right is a glass encoder disk on a motor that was dropped on the floor.

Encoder & Commutation Board Power Requirements

Hudson motors require a 5VDC supply voltage to power the combined encoder & commutation sensor board.

Input voltage (at motor connector)	4.5-5.5VDC (6.0VDC absolute max.)
Current draw, loaded*	180mA @ 5VDC
Current draw, unloaded	125mA @ 5VDC

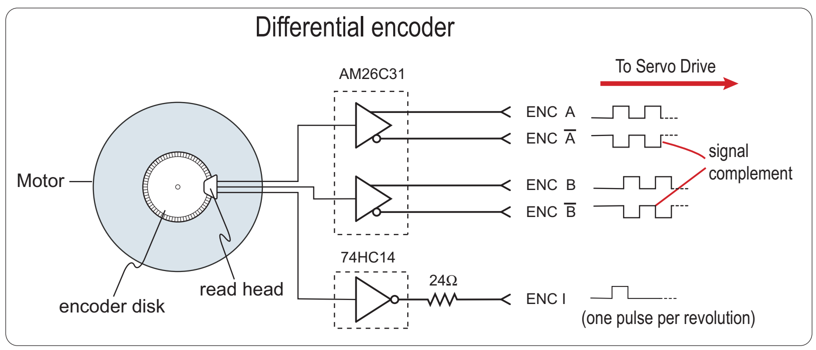
**This value is based on a 200 ohm test load.*

Encoder Signaling

Differential encoders on a Hudson motor have balanced, driven outputs intended to drive terminated, twisted pair transmission lines. Differential signals offer excellent common-mode noise immunity and support longer cable runs than single-ended signaling.

Technical Note

The differential encoder output is driven from an AM26C31 differential line driver optimized for 120Ω transmission lines. Refer to the AM26C31 data sheet for complete specifications.



Differential encoder output

Differential encoder signals provide excellent common mode noise immunity, especially over longer transmission ranges (up to 100 feet). In many applications, such as plasma cutting, differential encoder signals are superior to single-ended signals.

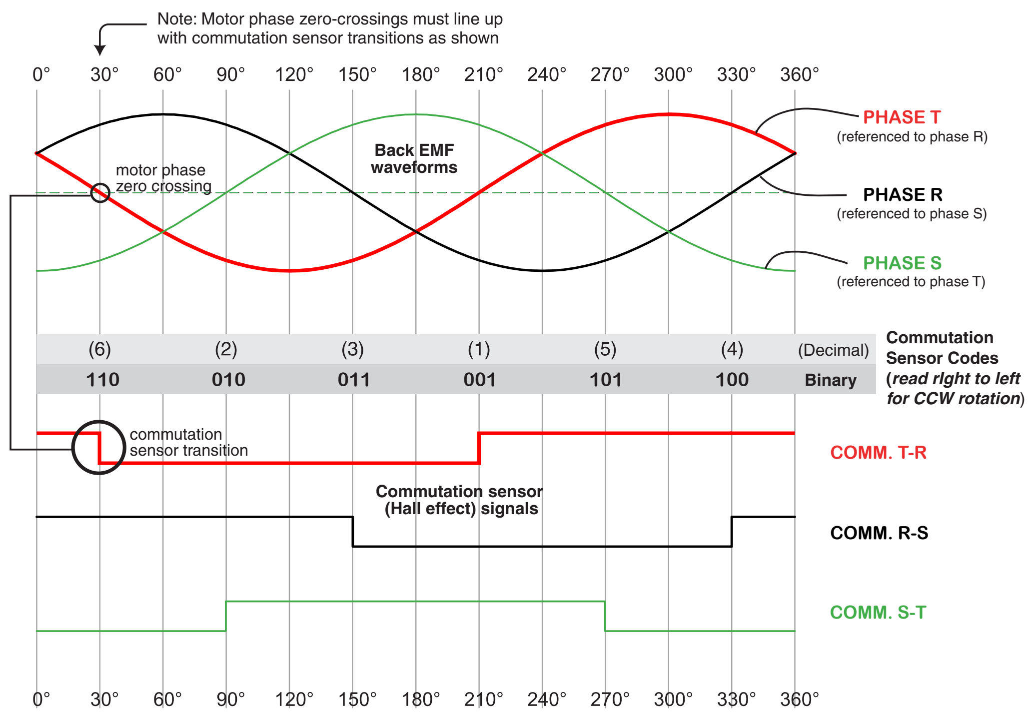
Commutation (Hall) Signaling

The optical commutation sensors are 5V TTL, totem pole driven outputs with 10mA maximum current.

Commutation Signal and Motor Phase Relationship

The diagram below illustrates the relationship between commutation (Hall) outputs and motor phases for properly wired Hudson motors. Refer to this diagram when wiring third-party servo drives to Hudson motors. When using the diagram below, bear in mind the following:

- The waveforms below apply to sine wave drives that can process 120° commutation sensor (Hall) signals and use encoder-based commutation.
- The drive must be wired to count *up* as the motor shaft is turned CCW (looking into the shaft).
- The commutation sequence shown in gray below **is read from right to left.** When spinning the shaft CCW, a properly wired motor should report commutation codes in the following sequence: 100, 101, 001, 011, 010, 110.



The above diagram shows the back-EMF waveforms you'd see if the motor shaft was spun counterclockwise (looking into the shaft) with an oscilloscope probe attached to the phase of interest and the ground clip attached to the reference phase. The lower part of the diagram shows how the commutation signals would appear on an oscilloscope when probed signal to ground.

The motor is phased correctly when the zero-crossings of motor phases line up with the transition points of the commutation sensor signals as shown in the previous illustration.

Wiring Hudson Motors To Third-Party Drives

When wiring a Hudson to a third-party drive, start with a motor that is wired to show positive encoder counts when spun CCW (viewed looking into the motor shaft). If this is not the case, swap encoder signals A and A~ (for differential encoders).

Important: the motor phases must align with their associated commutation signal as follows (refer to phase diagram on previous page):

- Phase T and Comm. T-R
- Phase R and Comm. R-S
- Phase S and Comm. S-T

Note: Within the motion control industry, there is no standardized convention for the labeling of encoder signals, motor phases or commutation (Hall) signals. ***Consult the servo drive manufacturer for questions regarding the wiring of encoder outputs, commutation (Hall) outputs and motor phases.***

Hudson Motor FAQ

Q: Are Hudson Motors UL or CE certified?

A: Yes, both.

Q: How are Hudson Motors tested?

A: Each Hudson motor is rigorously tested before shipment. The tests include:

- 100% HASS tested (Highly Accelerated Stress Screening)
- Mechanical compliance tests
- Encoder integrity test
- Commutation sensor accuracy test
- Full electrical compliance test
- Full functional test

Q: What type of servo drives will work with a Hudson Motor?

A: Hudson servo motors are 3-phase, synchronous, permanent magnet, brushless, servo motors with an incremental encoder that outputs standard differential encoder signals and standard 120º optical commutation (Hall) sensor signals. Hudson BLDC motors will work with the following drive types:

- Six-step (trapezoidal)
- Sine wave
- Sine wave with vector torque control

Q: Which connector should I use?

A: A Hudson motor can be fitted with either a Molex MiniFit Jr. or Souriau Trim-Trio connector.

For most applications, the **Molex MiniFit Jr.** connector is a good choice. Use this type of connector in relatively clean, dry environments (general dust is OK), and when 10 amps or less motor phase current will be applied.

Consider using **Souriau Trim-Trio** connectors where the connector may be subject to water spray, mist or fumes, or when more than 10 amps per phase may be present. Note: Trim-Trio connectors have a longer lead time.

Q: Which motor winding option should I pick?

A: Hudson motors are available in **Series** or **Parallel** winding configurations. Select the winding that best matches your torque and speed requirements. Torque-speed graphs are available in the Hudson motor section of our website.

Q: Do I need the optional motor shaft seal?

A: For extra protection beyond the standard double-sealed ball bearings, an optional dynamic shaft seal is available. The seal is appropriate when the motor face (side with the shaft comes out) will be exposed to potentially damaging particulate matter generated during machine operations.

Note: The shaft seal option is *not available for 1/4" shaft NEMA 23 motors*.

Q: How do I tune a Hudson motor?

A: Please consult the servo drive manufacturer for wiring and tuning instructions.

Tip: Hudson servo motors have relatively fast electrical time constants. As a result, they respond very rapidly to changes in winding current which allows the motor to follow dynamic commands very quickly. If less aggressive servo response is required for an application, it may be advisable to reduce the drive's current or torque loop gains.

Q: How can I change a motor's "sense of direction"?

A: Some drives may include firmware or software controls that allow you to reverse motor shaft direction by changing a setting. Consult the servo drive manufacturer for more information.

In some scenarios, you may need to reverse the motor's sense of positive and negative motion by modifying the motor cable. Assuming you have a properly operating motor, *except* that direction of rotation is reversed from what you desire, swapping the following signals will change the direction of rotation:

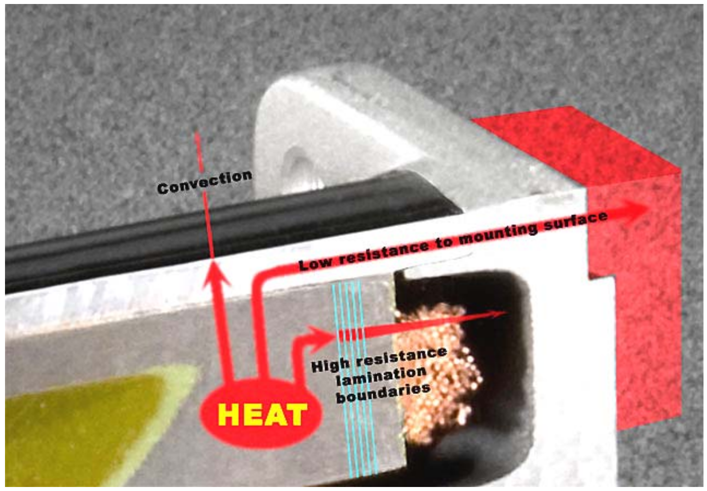
Motors with Differential Encoders

- Swap Phase S with Phase T
- Swap Comm R-S with Comm T-R
- Swap Enc A with Enc A~

Note: Make wiring changes at the motor extension cable and *not at the motor's pigtail connector*. This generally saves time, money, and preserves the motor warranty.

Q: Why is the motor warm during operation?

A: Hudson motors have thermal overload protection and high-temperature winding insulation (specifically class H). They can get quite hot to the touch (up to 80 degrees C) when operating close to their continuous torque rating. Hudson motors have a tight fitting, cylindrical aluminum housing that surrounds the stator to provide a low-resistance path for heat to flow out of the motor. Improved heat flow out of the motor increases continuous power output and improves long term reliability.



In exposed-lamination motors (i.e., motors with no true housing) axial heat flow from motor to mounting surface is impeded by the many oxide-coated interfaces between the steel laminations. To make matters worse, silicon steel [laminations] have about 6 times the thermal resistance of aluminum, which makes exposed-lamination motors good insulators (i.e., good at holding in heat) but poor radiators.

Q: Where can I find 3D drawings of Hudson motors?

A: 3D files for Hudson motors can be found at:
https://www.teknic.com/downloads/?download=4&hudson=0#hudson_1

Appendix A: Hudson Part Number Key

Example

3411P-LN-08D

M-□□□□□-□□-□□□

NEMA Frame Size: 23, 34

Stack Length: 1-4

Indicates the number of magnet sets (stacks) on the rotor.

Winding/Magnetic Structure: 1-3

Indicates winding design. Different designs offer different torque-speed /power characteristics

Electrical Interface

Indicates the pigtail connector and winding type.

- **P**: Molex MiniFit-Jr, 16 pos. pigtail, free-hanging, parallel winding
- **S**: Molex MiniFit-Jr, 16 pos. pigtail, free-hanging, series winding
- **C**: Souriau Trim-Trio, sealed pigtail, free-hanging, parallel winding
- **E**: Souriau Trim-Trio, sealed pigtail, free-hanging, series winding

Shaft Diameter

- **L**: Standard dia. NEMA 23 = 0.375”, NEMA 34 = 0.500”, with keyway[1]
- **Q**: 1/4” (0.250”) dia., round shaft *available on M-231x, and M-232x models only,* no keyway

Sealing[2]

- **N**: IP41
- **S**: Optional Shaft Seal[3]

Encoder Density

Encoder counts per revolution (post-quadrature)

- **02**: 2,000 counts/rev.
- **04**: 4,000 counts/rev.
- **08**: 8,000 counts/rev.
- **16**: 16,000 counts/rev.

Encoder Type

All motors use precision, electroformed disks.

- **D**: Differential

1: Dimensions of keyway are 12x3mm (NEMA 23) and 20x5mm (NEMA 34). Key not included.
2: IPC rating dependent upon the combination of electrical interface and sealing option.
3: Not available with 0.250” shaft.

Appendix B: NEMA 23 Specifications

SPECIFICATIONS

GENERAL	Insulation Rating:	Class H, 180°C
	Motor Poles:	8
	Standard Shaft Diameter:	0.375 in., 9.5 mm
	Motor Pigtail Type:	Space saving, single-exit, DualShield™
	Motor Pigtail Length:	16 in ± 1 in., 406.4 mm ± 25.4 mm.
	RoHS:	RoHS Compliant
ENVIRONMENTAL	Shock:	2.0 G
	Vibration:	0.5 G
	Max External Deceleration:	250,000 rad/s^2
	Max Case Temperature:	85°C
	Max Winding Temperature:	155°C
	Ambient Temperature:	-40°C to +70°C*
	Humidity, non-condensing:	0-95%
	Operating Conditions:	No direct fluid wash-down or submerged use
ENCODER	Type:	Floating optical disk; differential signals
	Resolution(s):	2000, 4000, 8000, 16000 quadrature counts per revolution
	Current Draw, Loaded:	180mA @ 5VDC, all signals loaded with 200Ω load
	Current Draw, Unloaded:	125mA @ 5VDC
COMMUTATION	Commutation Type:	120° spaced, optical commutation (Hall) sensors
MECHANICAL LOADING	Bearing Type:	Oversized, single-row, deep groove, radial with non-contacting lubrication seals.
	Bearing Life vs. Load:	Depending on the specific motor model, typical bearing life is approximately 3.2 x10^9 to 5.0 x10^9 revolutions (based on 5 lb axial and 25 lb radial loads, centered 1.0 inch from front bearing surface).
	Max. pigtail push/pull force	7 lbs.
	Shaft Axial Force Limits:	See chart on page 7.
WARRANTY		3½ years

**The RMS torque limit on certain motors is derated for operation in ambient temperatures above +40 degrees C. Contact Teknic for derating assistance.*

INDIVIDUAL SPECIFICATIONS

Model	2311	2311	2321	2321	2331	2331	2341	2341
Interface (connector & winding combo)	S/E	P/C	S/E	P/C	S/E	P/C	S/E	P/C
Resistance, phase to phase, [ohms]	2.76	0.69	2.46	0.62	2.42	0.61	2.98	0.75
Inductance, phase to phase, [mH]	2.93	0.733	3.66	0.92	3.55	0.89	4.59	1.15
Electrical time constant, [mS]	1.06	1.06	1.49	1.49	1.47	1.47	1.54	1.54
Back EMF (Ke), [Vpeak/kRPM]	13.27	6.64	23.29	11.65	27.31	13.65	36.4	18.2
Motor constant (Kt), [oz-in/amp] p-p	16.74	8.37	28.4	14.2	35.82	17.91	47.8	23.9
Continuous torque [oz-in][1,2]	60	60	116	116	145	145	186	186
Weight [oz, g]	22.1, 626		32.8, 929		44.2, 1253		54.1, 1533	

1: Typical, varies by application – contact your sales engineer for application specific rating.
2: The Molex Mini-Fit Jr. connector (option S and E) limits the continuous current to 10A RMS.
For more continuous current use the C or E option (Souriau Trim-Trio connectors).

Appendix C: NEMA 34 Specifications

SPECIFICATIONS		
GENERAL	Insulation Rating:	Class H, 180°C
	Motor Poles:	8
	Standard Shaft Diameter:	0.500 in., 12.7 mm
	Motor Pigtail Type:	Space saving, single-exit, DualShield™
	Motor Pigtail Length:	16 in ± 1 in., 406.4 mm ± 25.4 mm.
	RoHS:	RoHS Compliant
ENVIRONMENTAL	Shock:	2.0 G
	Vibration:	0.5 G
	Max External Deceleration:	250,000 rad/s²
	Max Case Temperature:	85°C
	Max Winding Temperature:	155°C
	Ambient Temperature:	-40°C to +70°C*
	Humidity, non-condensing:	0-95%
	Operating Conditions:	No direct fluid wash-down or submerged use
ENCODER	Type:	Floating optical disk; differential signals
	Resolution(s):	2000, 4000, 8000, 16000 quadrature counts per revolution
	Current Draw, Loaded:	180mA @ 5VDC, all signals loaded with 200Ω load
	Current Draw, Unloaded:	125mA @ 5VDC
COMMUTATION	Commutation Type:	120° spaced, optical commutation (Hall) sensors
MECHANICAL LOADING	Bearing Type:	Oversized, single-row, deep groove, radial with non-contacting lubrication seals.
	Bearing Life vs. Load:	Depending on the specific motor model, typical bearing life is approximately 2.4 x10⁹ to 5.0 x10⁹ revolutions (based on 10 lb axial and 50 lb radial loads, centered 1.0 inch from front bearing surface).
	Max. pigtail push/pull force	7 lbs.
	Shaft Axial Force Limits:	See chart on page 7.
WARRANTY	3½ years	

**The RMS torque limit on certain motors is derated for operation in ambient temperatures above +40 degrees C. Contact Teknic for derating assistance.*

INDIVIDUAL SPECIFICATIONS

Model	3411	3411	3421	3421	3422	3422	3422	3432	3432	3432	3441	3441	3441
Interface (connector & winding combo)	S/E	P/C	S/E	P/C	S/E	P	C	S/E	P	C	S/E	P	C
Resistance, phase to phase, [ohms]	3	0.75	2..500	0.624	1.65	0.413	0.413	2.183	0.546	0.546	2.637	0.659	0.659
Inductance, phase to phase, [mH]	3.9	0.975	4.791	1.198	3.18	0.795	0.795	5.058	1.265	1.265	6.64	1.66	1.66
Electrical Time Constant, [mS]	1.3	1.3	1.92	1.92	1.9	1.92	1.92	2.32	2.32	2.32	2.52	2.52	2.52
Back EMF (Ke), [Vpeak/kRPM]	29.36	14.69	46.99	23.49	38.91	19.46	19.46	58.43	29.22	29.22	77.9	38.95	38.95
Motor constant (Kt), [oz-in/amp] p-p	38.32	19.16	63.12	31.6	51.52	25.76	25.76	80.6	40.3	40.3	106.5	53.2	53.2
Continuous Torque [oz-in][1,2]	150	150	289	289	289	223	289	377	349	392	479	461	479
Weight [oz, g]	49.6, 1406		73.6, 2087					99.2, 2812			121.6, 3447		

1: Typical, varies by application – contact your sales engineer for application specific rating.

2: The Molex Mini-Fit Jr. connector (option S and E) limits the continuous current to 10A RMS.
For more continuous torque use the C or E electrical interface option (Souriau Trim-Trio connectors).

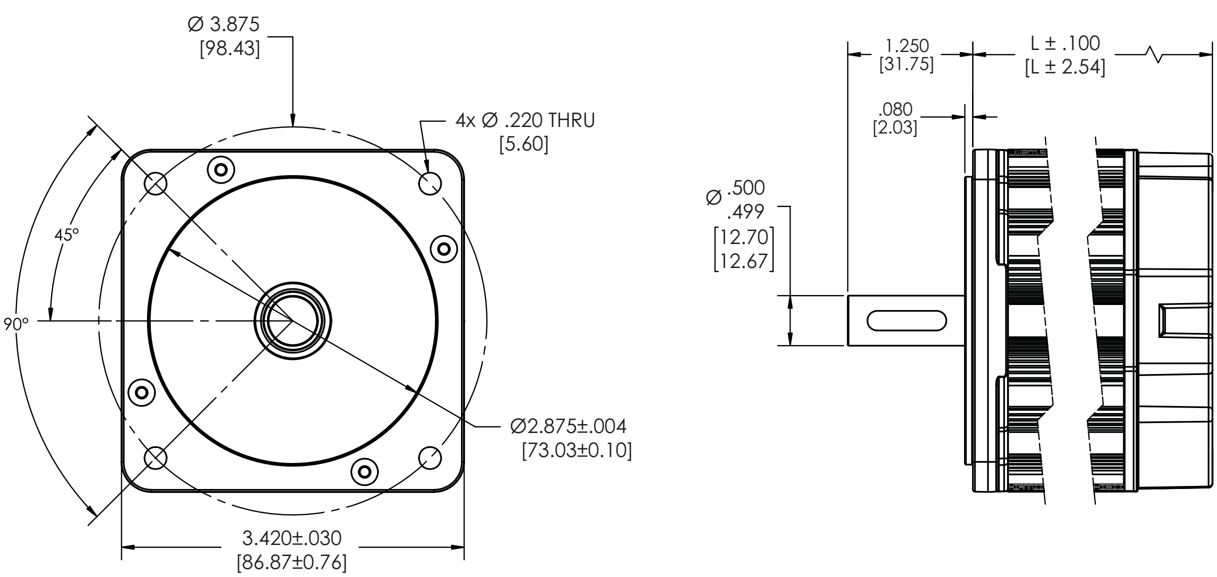
Appendix D: Motor Dimensions

Hudson Motor 3D Models

3D Models of Hudson motors are available at Teknic.com. ***Note:*** *you may be asked to log in or register to access to these files.*

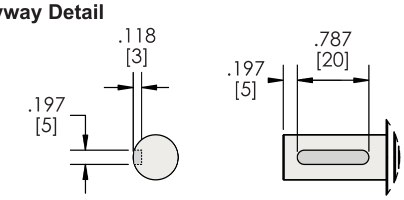
https://www.teknic.com/downloads/?download=4&hudson=0#hudson_1

NEMA 34 Series Dimensions



Note: Shaft key not included
(Available through McMaster-Carr)
Part Number: 96717A181
Description: Metric shaft key
Dimensions: 5mm x 5mm x 20mm

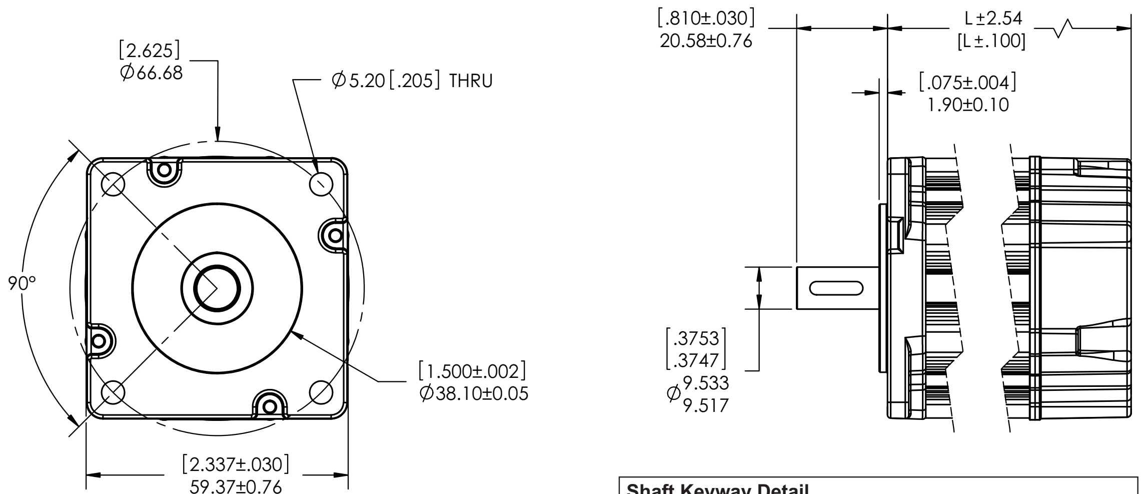
Shaft Keyway Detail

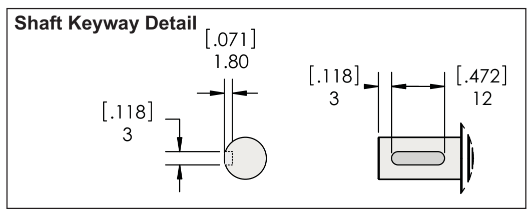


Model	Motor Body Length (L)	
M-341x	70.37 mm	2.77 in.
M-342x	89.19 mm	3.51 in.
M-343x	108.19 mm	4.29 in.
M-344x	127.37 mm	5.01 in.

NEMA 23 Series Dimensions

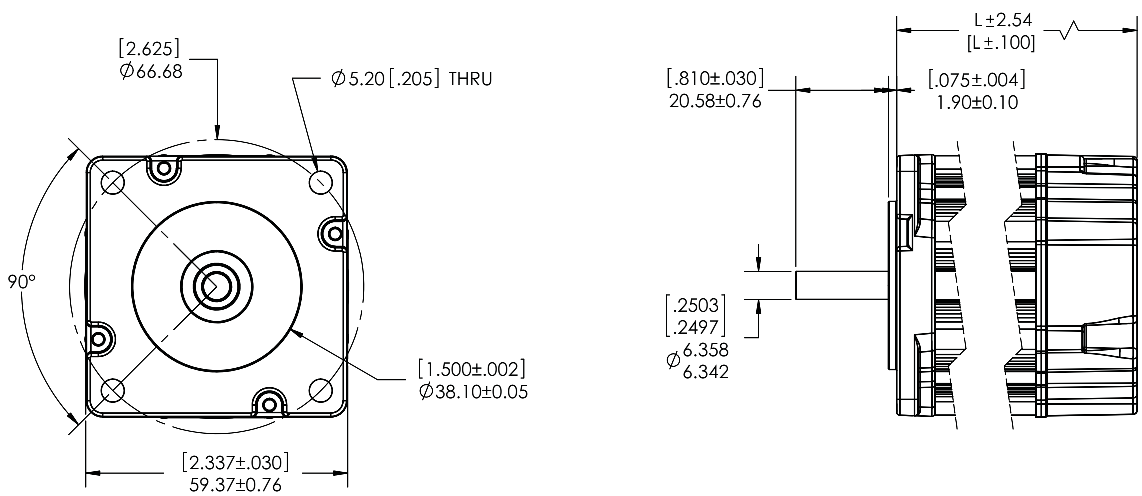
3/8" shaft option





Note: Shaft key not included
(Available through McMaster-Carr)
Part Number: 96717A086
Description: Metric shaft key
Dimensions: 3mm x 3mm x 10mm

1/4" shaft option



Model	Motor Body Length (L)	
M-231x	70.94 mm	2.79 in.
M-232x	89.92 mm	3.54 in.
M-233x	108.97 mm	4.29 in.
M-234x	128.02 mm	5.04 in.

Appendix E: Motor Extension Cables

HDSN-CABLE-120 (Sold by Teknic)

This cable, available at Teknic.com, https://www.teknic.com/hdsn-cable-120/ connects a Hudson brushless servo motor *(with Molex connector option only)* to any compatible servo drive.

This 10 foot cable comes with a mating Molex connector on the drive end (instead of "flying leads") to allow us to electrically test every cable before it ships.

Tip: Most users cut off the unneeded connector to wire the cable to their specific motor drive, but, if you happen to need a motor extension cable longer than 10 feet, you can leave this connector on and daisy-chain 2 or 3 of these cables end-to-end.

Do not modify the motor pigtail in order to connect it directly to your drive. **Modifications to the motor pigtail itself void the motor warranty** and the 90-day return policy on Fast-ship motors.

Example Motor Cable Drawings (Flex-rated)

Follow the links below to view or download motor cable drawings for Molex or Souriau connectors (these drawings flex-rated cable stock. The drawings include pinouts, part numbers, and fabrication/test instructions for user's who want to make their own custom motor cables.

https://www.teknic.com/files/downloads/hudson-souriau_cable.pdf

https://www.teknic.com/files/downloads/hudson-molex_cable.pdf

Golden Rules for Motor Cable Construction

1. Use low capacitance, shielded twisted pair cable for the encoder and commutation (Hall) signals.
2. **IMPORTANT**: Do not ground the encoder cable shield to the motor case.
3. Don't run the motor's commutation (Hall) or encoder signals through the motor phase cable at any point. Use two cables, one for low voltage signals and one for motor phases.
4. Use 16AWG or larger shielded cable for motor phases.
5. Motor phase leads should be kept as short as possible where they exit the cable shield, preferably under 2".
6. The motor phase cable shield termination should be kept short at both ends, preferably under 2".
7. **The motor phase cable shield must not come in contact with the encoder cable shield at any point outside of the servo drive. Failure to isolate these shields properly will result in electrical noise problems on the encoder signals. Insulate any exposed shield wires to prevent shields from touching.**

Cable Making Guidelines

The following guidelines are provided help minimize cable design, fabrication, and application errors.

General Recommendations

1. The pitfalls of hand crimping tools

Hand crimping tools, when properly selected and used by a skilled operator, make good crimp connections. However, since these tools are expensive, typically $200 - $400 each, technicians don't always have the wide variety required to make proper crimps on all of the terminal types and wire sizes they encounter.

Unfortunately, it's easy to use the wrong tool and not realize it, or even more likely, to use the wrong tool and think it's "probably OK". Hand crimp tools can be awkward to use and often require practice and a certain "feel" to achieve consistent, high quality results. In addition, hand tools generally don't have built-in quality assurance features.

In certain instances, you may need to make a hand crimped cable, for example, when you're in a hurry for a custom length cable. If you do:

- **Be sure that you have the exact hand tool and die that the terminal manufacturer recommends–for each terminal**
- Perform a visual inspection of each terminated wire to ensure that the insulation is properly captured in the strain relief closure and the bare wire is captured in the conductor closure.
- always perform a "pull test" on each wire connection before inserting it into the connector housing. If a wire can be pulled out of the terminal with a few pounds of force, the crimp was faulty.

Note: Each type of crimp terminal requires a specific handset and die. Failure to use the proper tool, die, terminal, or wire for the job will likely result in poor quality terminations and premature cable failure.

2. Verify that your cable shop has all of the proper tools and equipment

Use a cable shop that has automated presses for wire termination and make sure they have the proper applicator "heads" (dies) for the exact terminals used. (If they don't, consider buying applicator heads for them). It's strongly preferred that they have presses with automatic "crimp height" checking as this in-process check is the main measure of termination quality. Making this 100% check without requiring human intervention is a key advantage. If they don't have these automatic crimp-height-checking presses, make sure their general procedures include checking the crimp height on first articles and periodically during a run of cables. Avoid patronizing cable shops that use hand tools only.

3. Specify 100% electrical testing of all cables

Specify that cables and harnesses be 100% electrically tested, preferably with resistance tests. The cable shop should have automated equipment by CableScan, DynaLab, CheckSum, or other vendors for this purpose. The initial fixturing cost for 100% electrical testing is typically low, ranging from $0-$200 per different cable assembly.

4. Be certain that all terminals are properly specified

Check all your terminal specifications carefully. Research all of your drawings and make certain that the terminals specified can accept the necessary wire gauges. Also, look carefully at the insulation diameter range supported by each terminal. If the insulation diameter range on the terminal is incorrect for the wire used, the individual wire strain relief will be compromised and this can lead to premature terminal failure. Make certain that the plating between mating terminals is the same. Using gold is great, but not if you are mating with tin. Always mate gold plated terminals with gold plated terminals, and tin with tin to avoid galvanic corrosion.

5. Prepare complete, pictorial drawings

Create drawings that are pictorial in nature (i.e. visually representative of the subject). Include fabrication details such as jacket strip lengths, shield termination details, cable tie locations, marking details, etc. The more call-outs, detail views, and exploded views, the better. Visual communication is critical here. Don’t leave the details to the cable shop as "best practices" vary widely from shop to shop. Include the complete BOM (Bill of Materials) right on the drawing. Finally, make the end-to-end cable length easy to modify. This may help reduce future drawing effort if you need similar cables of varying length at some point down the road.

Molex "Good Crimps" Guide on the Web

Good quality cables *can* be made with hand tools, provided that the terminal manufacturer’s guidelines are closely followed. A good resource on this topic is the Molex document ***“Good Crimps and How to Recognize Them”*** at: **http://www.molex.com/tnotes/crimp.html**

This document describes the main parts of a Molex Mini-Fit Jr. crimp terminal, how to identify good and bad crimps, and best practices for cable makers.

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