



Nidec-Avtron Makes the Most Reliable Encoders in the World

8901 E. PLEASANT VALLEY ROAD • INDEPENDENCE, OHIO 44131-5508  
**TELEPHONE:** (1) 216-642-1230 • **FAX:** (1) 216-642-6037  
**E-MAIL:** tachs@nidec-avtron.com • **WEB:** www.avtronencoders.com

# Encoder Instructions

## MODEL AV56S

4 1/2" C-FACE MOUNT  
 STAINLESS MODULAR

### DESCRIPTION

The Avtron AV56S is a modular, two piece incremental encoder (also known as a tachometer or rotary pulse generator). It provides a two phase, A Quad B frequency (pulse) output, with complements. The AV56S mounts on a 4.5" (NEMA 56C) Face.

The AV56S is manufactured from solid stainless steel, and the electronics are fully potted for protection. This makes it ideal for marine and other salt spray applications, as well as washdown with cleaners, pressurized water or other food applications. Note for highest environmental protection (IP) rating, select connector option "W", cable with grommet.

Because the AV56S is modular, there are no bearings or couplings required. This, combined with the latest magnetoresistive (MR) sensor technology, allows the AV56S to provide superior mechanical performance and increased reliability.

### Equipment Needed for Installation

Provided	Optional	Not Provided
AV56S Stator/Housing Socket Hd Cap Screw 3/8"-16 x 1.25" (4)	Extended Shaft Cover w/ Screws 6-32 x 0.31" (4) Lock Washers	Phillips Screwdriver Flat Blade Screwdriver 2mm Hex Wrench (T-Handle Style) 5/16" Hex Wrench
AV56S Rotor Socket Set Screw #M4 x 8mm (2) Thread locker (blue) Antiseize (copper)	Thru Shaft Cover w/ V-Ring Seal and Silicone Lubricant	

### AV56S PART NUMBERS AND AVAILABLE OPTIONS

Model	Housing Type	Shaft Size (Thru Shaft Rotor)	Cover Style	Line Driver	Single/Left Output (PPR)	Right Output (PPR)	Connector	Modifications
AV56S	1- Single Output	T0- Non-std. Shaft Size XX- None  Thru Shaft Rotor US Metric TA- 0.500 M2- 10mm TB- 0.625 MA- 11mm TC- 0.875 M3- 12mm TD- 0.938 MB- 14mm TE- 1.000 MC- 15mm TF- 1.125 MD- 16mm TG- 1.250 M4- 18mm TH- 1.375 ME- 19mm TT- 1.500 MF- 24mm TJ- 1.625 MG- 28mm TK- 1.750 MH- 30mm TL- 1.875 MT- 32mm TM- 2.000 MJ- 36mm TN- 2.125 MK- 38mm TQ- 2.250 ML- 42mm TP- 2.375 MM- 45mm TR- 2.500 MN- 48mm TS- 2.625 MP- 52mm TU- 2.875 MR- 55mm TW- 2.750* MS- 60mm TV- 3.000 MU- 65mm T4- 3.125 MV- 70mm T7- 3.188 MW- 75mm TZ- 3.250 MY- 80mm MZ- 85mm	E- Extended Shaft Cover F- Flat Cover T- Flat Thru-Hole Cover with Shaft Seal.	6- 5-24V in/out 8- 5-24 V in, 5-24 V out 9- 5-24V in, 5V out	0- Non- Y- 1024 std. Z- 1200 F- 60 3- 2000 G- 100 4- 2048 H- 120 5- 2500 A- 128 D- 4096 L- 240 8- 4800 N- 256 9- 5000 P- 300 E- 360 B- 480 Q- 500 R- 512 S- 600 V- 900 J- 960	X- None	P- 10 Pin EPIC Industrial w/ Plug G- 10 Pin Industrial w/ Plug (Northstar pinout) 1- 10 Pin Stainless Steel Epic w/Plug (Crimp connectors only) W- 3 Ft. Cable, Sealed R- Mini Twist Lock (Mini MS) w/ mating plug S- Mini Twist Lock (Mini MS) on 3' cable w/mating plug	000- No Modification 004- Add Housing Drain (single output only) 005- Super Magnetic Shielding 4xx- Special PPR Enter Ø in the PPR code(s), select the special option code below 9xx- Special Cable Length, xx=length in feet

### SPECIAL PPR OPTION CODES

OPTION CODE	LEFT PPR	RIGHT PPR
401	1270	None
402	150	None
403	50	None
405	16	None
406	6000	None
407	2800	None
408	1400	None
409	30	None

The AV56S output has six signals: (A, B) 90° out of phase, with complements (Ā, B̄). A marker pulse with complement (Z, Z̄) is also provided.

Output resolution on the AV56S is determined by the sensor only. Selection of the rotor is based only on the shaft mounting requirements (and not PPR).

**NOTE**  
**THIN-LINE III™ directly replaces THIN-LINE II™ and THIN-LINE™ models.**  
**THIN-LINE III models have Rev Code BA or later.**

**Special option 4xx selects an alternate PPR code definition.**  
**Example:**  
**PPR Code 0, Special Option Code 401 = 1270 PPR (Left), No Right Output.**

**INSTALLATION**

Installation and removal videos for the AV56S are available on Avtron's web site. Refer to the back page of these instructions for outline and mounting dimensions. The motor must comply with 1998 NEMA MG 1, section 4, for tolerances on diameters and runout for shafts and accessory faces. Axial float or endplay must be less than ±0.050" [±1.27mm].

In preparation for installing the AV56S encoder, it is first necessary to clean both the motor shaft and the mounting face. These surfaces must be inspected and any paint, burrs, or other surface imperfections removed.

Installation procedures should be performed only by qualified personnel. Safety precautions must be taken to ensure machinery cannot rotate and all sources of power are removed during installation.

**ROTOR INSTALLATION**

The motor shaft must project at least 0.63" from the motor face. For set screw rotors only: Apply anti-seize compound to the motor shaft. For all rotors: Slide the rotor onto the shaft with the marking "Motor side" facing in, (toward the motor face). The rotor centerline must match the sensor centerline. To accomplish this, use the rotor locating gauge (A28503) and slide the rotor onto the shaft until it is in the proper position as shown in Figure 1. If a guage is not available, use the stator housing alignment grooves as shown in Figure 3.

**SET SCREW ROTOR INSTALLATION**

Apply thread locker to the rotor set screw holes, preferably from the inside of the rotor bore before mounting. Tighten the rotor set screws to 15 in-lb [2 N-m] using the 2mm T-handle hex wrench.

**CAUTION**

**Use only a T-handle or torque hex wrench to tighten set screws; using a right angle wrench will not provide enough holding force, and the rotor may slip.**

**STATOR HOUSING INSTALLATION**

The stator housing is attached to the motor using four socket head cap screws (4) 3/8"-16, locating on a 5.88" bolt circle. Longer bolts (not included), are required for sandwich installation between a motor and a brake. Install the four mounting bolts using thread locker and torque to approximately 20-30 ft lbs [27 to 40 N-m] using the 5/16" T-handle hex wrench.

**VERIFY ROTOR LOCATION**

To ensure the rotor is properly located on the shaft: remove the back cover if factory-preinstalled, and verify that the outer face of the rotor is at the same depth as the alignment grooves, using a straight edge tool.

**SPECIFICATIONS**

**ELECTRICAL**

- A. Operating Power (Vin)
  - 1. Volts.....5-24 VDC
  - 2. Current .....80mA, each output, no load
- B. Output Format
  - 1. 2Ø & Comp .....A,Ā, B,B̄ (differential line driver)
  - 2. Marker .....1/Rev, Z,Z̄
- C. Signal Type .....Incremental, Square Wave, 50 ±10% Duty Cycle.
- D. Direction Sensing .....Ø A leads Ø B for CW rotation as viewed from the back of the tach looking at the non-drive end of the motor.
- E. Phase Sep. ....15% minimum
- F. Frequency Range .....@5V, @1m cable, 250 kHz Max  
 @24V, @300m cable, #8 output, 45 kHz Max
- G. PPR .....4-50000
- H. Line Driver Specs .....See table
- I. Connectors .....See connector options on page 1
- J. Integral LED Indicator ..GREEN: power on, unit ok. RED: alarm on  
 ORANGE: wiring fault

**MECHANICAL**

- A. Rotor Inertia:.....0.17-0.36 Oz. In. Sec.<sup>2</sup>
- B. Acceleration:.....5000 RPM/Sec. Max.
- C. Speed:.....5400 RPM Max.
- D. Weight:.....4-6 lbs [1.8-2.7kg].
- E. Sensor to Rotor
  - Air Gap (nominal):.....0.030" [0.76mm]
  - Tolerance: .....0.015" [0.38mm]
- F. Rotor Axial Tolerance.±0.050" [±1.27mm]

**ENVIRONMENTAL**

Solid stainless steel stator and rotor  
 Fully potted electronics, protected against oil and water spray  
 V-Ring seals provided on through shaft covers  
 Operating Temperature:.....-40 to 100°C, 0-100% condensing humidity\*  
 \*for IP67 applications, select connector option "W" (sealed cable)  
 Vibration: 18 g's  
 Shock: 1 meter drop test

**LINE DRIVER OPTIONS**

Electrical Specifications		LINE DRIVER OPTIONS			
		6	8	9	Units
Input Voltage		5-24	5-24	5-24	VDC
Nom Output Voltage		5-24	5-24	5	VDC
Line Driver		7272	Hx	7272	
Output Resistance Typ		13	75	13	ohms
Maximum Peak Current		1500	3000	1500	mA
Maximum Average Current		120	250	120	mA
Voh Typ		V <sub>IN</sub> -1	V <sub>IN</sub> -1	V <sub>IN</sub> -1	VDC
Vol Typ		0.5	0.2 @10mA current	0.5	VDC
Cable Drive Capacity		1000' @ 5V 500' @ 12V 200' @ 24V	1000'	1000'	feet
Protection	Reverse Voltage	yes	yes	yes	
	Short Circuit	yes	yes	yes	
	Transient	yes	yes	yes	
Alarm	+V(out)	Output voltage equal to input voltage.			
	Alarm*	Open collector, normally off, goes low on alarm, sink 100mA max, 50VDC max			
	LED	Green=power on, Red=Alarm, Orange=Wiring Error			
Marker		One per revolution. Pulse width approximately 1/128 of a revolution			

\*Alarm not available on connector option "G" (Northstar™ compatible pinout)

**CAUTION**

**Do not use silicone sealants or caulk of any kind on the motor or encoder face; these can cause misalignment or sensor scraping damage. The AV56S electronics are fully sealed; water may enter and leave the rotor area as needed. A drain hole option is available if frequent moisture buildup is expected.**

**COVER INSTALLATION**

Covers must not interfere with the motor shaft or rotor. The longest shaft that can be used without interfering is 0.69" [17.5mm] with a standard flat cover (Cover Style option "F") and 2.5" [63.5mm] with an extended "pie pan" cover (Cover Style option "E"). Through shaft covers with seals are available for other applications (Cover Style option "T").

**EXTENDED COVER MOUNT**

(Cover Style option "E")

The extended cover mounts to the encoder housing using quantity 4 #6-32 x 0.31" screws, lock washers, and thread locker.

**THRU SHAFT AND FLAT COVER INSTALLATION**

(Cover Style option "T" and "F")

The housing has a machined step in the outboard face to accept the cover and a recessed groove for the retaining ring. Insert the cover, line up ears on cover, smooth side facing out, fully into the machined step until it seats against shoulder. Using a spiral assembly method, install the retaining ring by first inserting the squared off end into the machined groove. Flex the ring and insert it into the groove walking it around the perimeter (A flat blade screwdriver can be used). Final position should have the ring fully seated into groove. Remove the cover by reversing above procedure, starting with the tang end.

**V-RING INSTALLATION FOR THRU SHAFT COVERS**

(Cover Style option "T")

For thru shaft covers, verify that the shaft passes completely through the hole in the cover. Apply a small amount of silicone lubricant to the cover plate around the thru shaft hole. The V-Ring seal should compress axially when it is pressed against the clean, smooth face of the cover plate. See Figure 4 for proper installation and V-Ring compression.

**WIRING**

**CAUTION**

**Be sure to remove power before wiring the encoder. Be sure to ground the cable shield: It can be connected to case ground at the encoder, or grounded as the receiving device, but should not be grounded on both ends. See note below for Danaher/Northstar wiring.**

Refer to the wiring diagrams for specific information on each option. The AV56S can be wired for single phase or two phase, either with or without complements, with or without markers. For bidirectional operation, Phase A channel leads phase B channel for clockwise shaft rotation as viewed from the anti-drive or accessory end of the motor (AV56S mounting end).

**NOTE**

**Wiring option "G" provides a pinout compatible with Northstar™ encoders, with a cable shield connection on pin 10. Note that this option does not ground the shield; Avtron still recommends grounding the shield at the drive end of the cable for all wiring options.**

**CORRECTIVE ACTION FOR PHASE REVERSAL**

- 1) Remove Power.
- 2) Exchange wires on cable, either at encoder cable end, or at speed controller end (but not both).
  - a) Single Ended 2 Phase Wiring (see wiring diagram) Exchange A and B at the use end of the wires.

- b) Differential 2 Phase Wiring (see wiring diagram) Exchange either A with  $\bar{A}$  in the phase A pair OR B with  $\bar{B}$  in the phase B pair but NOT both.
- 3) Apply Power.
- 4) Verify encoder feedback is correct, using hand rotation of shaft, or jog mode of the speed controller.

Interconnecting cables specified in the wire selection chart are based on typical applications. Physical properties of cable such as abrasion, temperature, tensile strength, solvents, etc., are dictated by the specific application. General electrical requirements are: stranded copper, 22 through 16 AWG (Industrial EPIC connector type options can use 14 AWG), each wire pair individually shielded with braid or foil with drain wire, 0.05 uf of maximum total mutual or direct capacitance, outer sheath insulator. See specifications for maximum cable length. Stranded 22 AWG wire should not be used for cable runs greater than 61 meters. If 22 AWG is used with EPIC type connector options the wire ends should be tinned.

**FAULT-CHECK**

After power-up and the rotor position is checked by the sensor, the Fault-Check LED will turn GREEN.

If the adaptive electronics reach their adjustment limit for any reason, the Fault-Check alarm and LED will notify the drive and operator of an impending failure. The LED will turn RED if the Adaptive Electronics reach their adjustment limit. This output occurs before an actual failure, allowing steps to be taken to replace the unit before it causes unscheduled downtime. Fault-Check annunciation is available as an "alarm" output through the connector and as an integral LED.

**TROUBLESHOOTING**

If the drive indicates a loss of encoder/tach fault and the fault-check LED is not illuminated, check the encoder power supply. If power is present, check polarity; one indicator of reversed power supply is that all outputs will be high at the same time. If the drive indicates encoder fault, but the LED shows GREEN, then check the wiring between the drive and the encoder. If the wiring appears correct and

CONNECTOR SPARE PARTS						
STYLE	OPTION CODE	ENCODER SIDE		CABLE SIDE PLUG		
Industrial EPIC on Encoder	P,G	315233	Base	315937	Hood	Conn1-02
		315229	Terminal	315936	Terminal	
Industrial EPIC w/ Adapter Block	Q			401112	Adapter	
Stainless Steel EPIC on Encoder	1	316400	Base	316401	Hood	
		47016	Terminal	477015	Terminal	
Industrial EPIC on 3' Cable	Z	315232	Surface	315937	Hood	Conn1-02
		315229	Terminal	315936	Terminal	
		471819	Bushing	401112	Adapter	
Mini-MS Twist Lock	R, S	315296	Base	316110	Plug	
10 pin MS on cable	Y	314383	In-Line	315932	Plug	Conn1-01
				411216	Cable Bushings	
				411217		
				411218		
				411219		

in good shape, test the wiring by replacing the AV56. If the new unit shows GREEN, and the drive still shows encoder loss/tach fault, then the wiring is faulty and should be repaired or replaced.

#### If the alarm output and/or LED indicate a fault (RED):

1. Remove the rear cover, and use the built-in gauge to check the location of the rotor (see Figure 1). Ensure the label marked "This side out".
2. Remove the AV56 from the motor. Clean the housing mounting surface for the AV56 housing. Ensure the AV56 is directly mounted on the motor, with no sealant, gasketing, or other materials, and is firmly bolted in place.

#### If the alarm output and/or LED indicate a fault (RED)

On a properly mounted AV56 and the rotor is properly located, replace the AV56.

An oscilloscope can also be used to verify proper output of the THIN-LINE III encoder at the encoder connector itself and at the drive/controller cabinet. If the outputs show large variations in the signals at steady speed (jitter or "accordion effect", see figure 5), check rotor position. If the rotor position is correct, the motor or shaft may be highly magnetized. Replace any magnetized material nearby with non-magnetic material (aluminum, stainless) (especially shafts). For GE CD frame motors and similar styles, Avtron offers non-magnetic stub shafts. If variations persist, consider replacing the encoder with super-shielded models, option -005, or use retrofit shielding kits AVSKxxx yy z, where xxx=model (ex: 56S), yy=rotor (ex: CB), and z=cover (ex: F).

#### If the alarm output and/or LED indicate a wiring fault (ORANGE):

Remove all output wires/connections (A,A',B,B',Z,Z'). The LED should turn GREEN. If the LED does not turn GREEN, the encoder is not receiving enough voltage at +V to properly operate. Correct input voltage problem at power supply or cabling.

If the LED turns GREEN once all outputs are disconnected, reconnect each output, one at a time, monitoring for ORANGE LED. For partial/resistive short circuits, the LED may take a few minutes to turn ORANGE. To speed the troubleshooting process, if possible, spin the encoder while replacing individual output connections. This will make the ORANGE LED condition occur faster. Once the shorted output(s) are located, correct the shorting condition, and the encoder LED should remain GREEN.

If the LED is OFF, but power is being applied to the encoder, check the output voltage level at A, A', B, B'. If all outputs are ON ( $\approx +V$ ), the connections to +V and COM are reversed. Swap connections between +V and COM; the LED should turn GREEN.

#### NOTE:

**Do not use rotors from THIN-LINE I (M56, M56S, M67, M85, M115) with THIN-LINE III. This will cause incorrect PPR output, but the Encoder LED will remain green.**

## Encoder Removal

The stator housing can be removed by loosening and removing the socket head cap screws.

#### Set Screw Rotor Removal

Disengage the (2) set screws by turning them counterclockwise until removed from the rotor. Retain the set screws. Remove the rotor by hand by pulling it away from the motor. If the rotor will not move, do NOT use a gear puller, and do not use a heat gun. Instead, pry the rotor away from the motor gently, being careful to only pry against the rotor metal hub and not the magnetic outer strip.

FIGURE 5

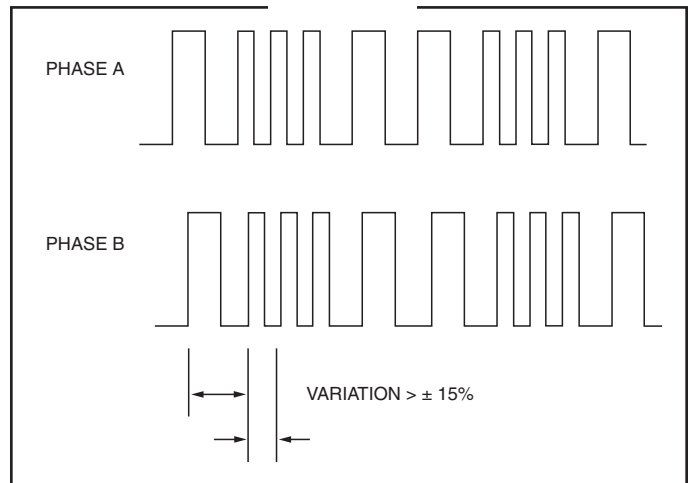


FIGURE 1

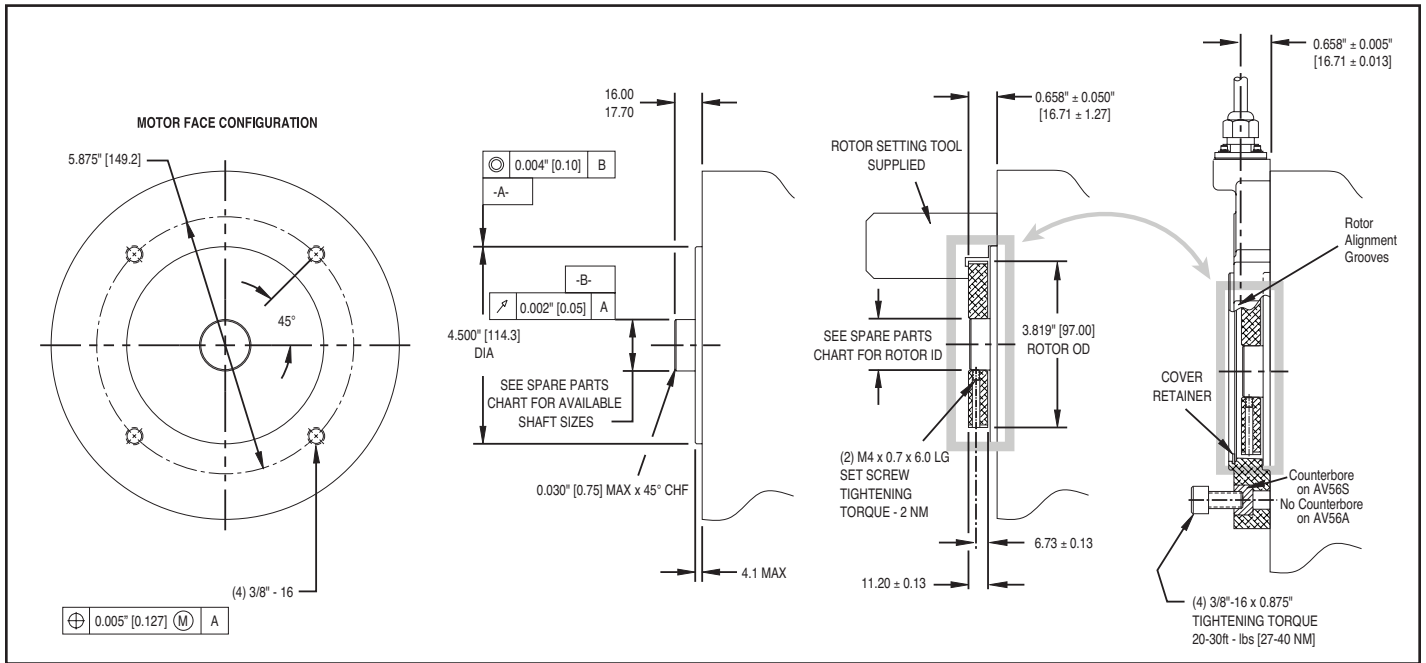


FIGURE 3

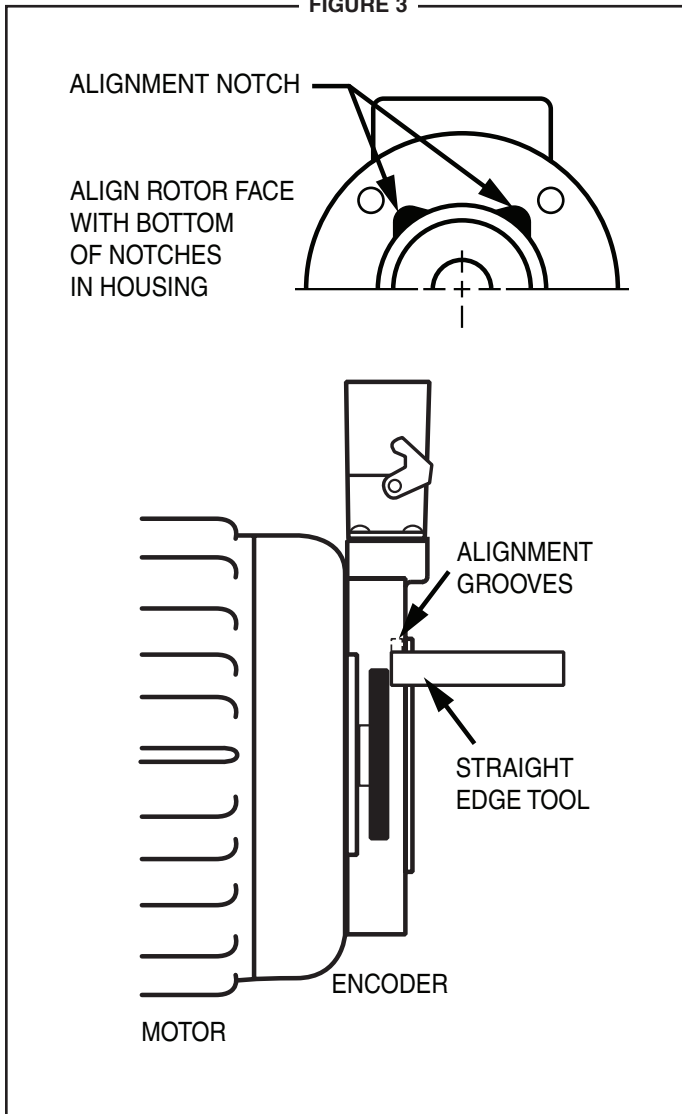
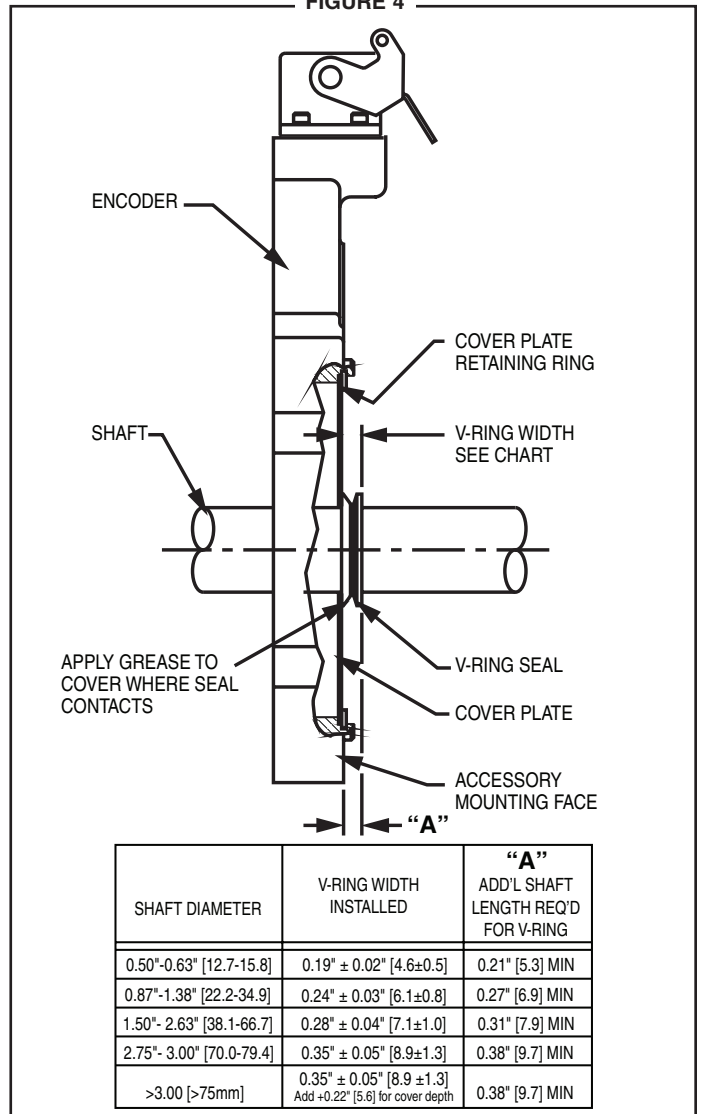


FIGURE 4



<b>Thinline III Spare Parts (AV56S Only)</b>				
<b>SAE/USA Sizes</b>				
<b>Shaft Size</b>	<b>Option Code</b>	<b>Rotor AV56S</b>	<b>Tru-Shaft Covers</b>	
		<b>Set Screw Stainless Rotor</b>	<b>AV56S Cover Kit</b>	<b>Seal Only</b>
.500/.4995	TA	AVTR2-TA	A36521-TA	471960
.625/.6245	TB	AVTR2-TB	A36521-TB	471877
.875/.8745	TC	AVTR2-TC	A36521-TC	471963
.9375/.9370	TD	AVTR2-TD	A36521-TD	471963
1.000/.9995	TE	AVTR2-TE	A36521-TE	471964
1.125/1.1245	TF	AVTR2-TF	A36521-TF	471965
1.250/1.2495	TG	AVTR2-TG	A36521-TG	471359
1.375/1.3745	TH	AVTR2-TH	A36521-TH	471952
1.500/1.4995	TT	AVTR2-TT	A36521-TT	471969
1.625/1.6245	TJ	AVTR2-TJ	A36521-TJ	471969
1.750/1.7495	TK	AVTR2-TK	A36521-TK	471970
1.875/1.8745	TL	AVTR2-TL	A36521-TL	471970
2.000/1.9995	TM	AVTR2-TM	A36521-TM	471971
2.125/2.1245	TN	AVTR2-TN	A36521-TN	471972
2.250/2.2495	TQ	AVTR2-TQ	A36521-TQ	471972
2.375/2.3745	TP	AVTR2-TP	A36521-TP	471953
2.500/2.4995	TR	AVTR2-TR	A36521-TR	471954
2.625/2.6245	TS	AVTR2-TS	A36521-TS	471954
2.875/2.8745	TU	AVTR2-TU	A36521-TU	471956
3.000/2.9995	TV	AVTR2-TV	A36521-TV	471956
3.1250/3.1245	T4	AVTR2-T4	A36737-T4	471957
3.1875/3.1870	T7	AVTR2-T7	A36737-T7	471957

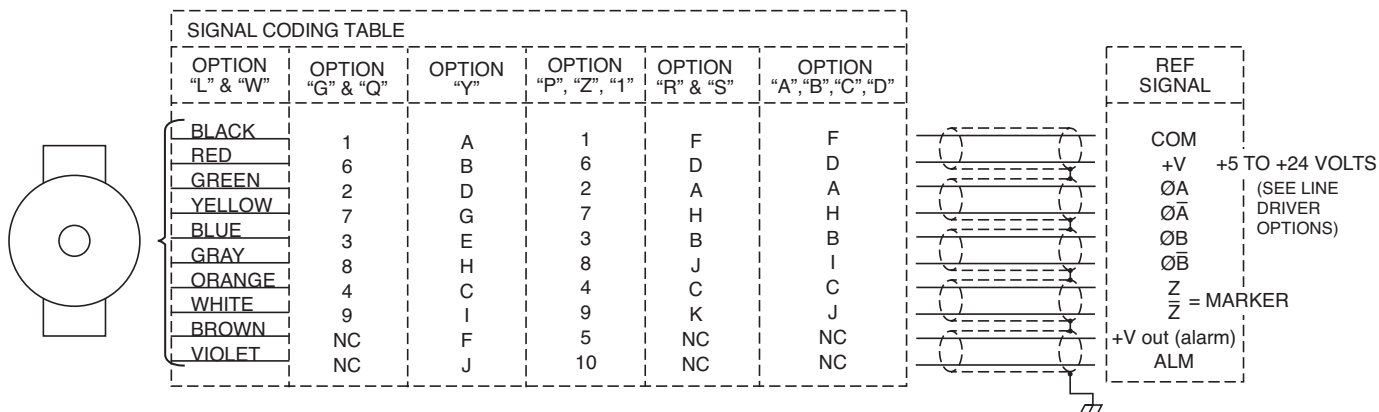
<b>Extended and Flat Cover Plates</b>			
<b>Shaft Size</b>	<b>Model</b>	<b>Extended Shaft Cover Kit</b>	<b>Flat Cover Kit</b>
Any	AV56S	A36526	A37298

<b>Thinline III Spare Parts (AV56S)</b>				
<b>Metric Sizes</b>				
<b>Shaft Size</b>	<b>AV56S Rotor</b>		<b>Thru-Shaft Covers</b>	
	<b>Option Code</b>	<b>Set Screw</b>	<b>AV56S Cover Kit</b>	<b>Seal Only</b>
10mm	M2	AVTR2-M2	A36522-M2	471959
11mm	MA	AVTR2-MA	A36522-MA	471959
12mm	M3	AVTR2-M3	A36522-M3	471960
14mm	MB	AVTR2-MB	A36522-MB	471961
15mm	MC	AVTR2-MC	A36522-MC	471961
16mm	MD	AVTR2-MD	A36522-MD	471877
18mm	M4	AVTR2-M4	A36522-M4	471962
19mm	ME	AVTR2-ME	A36522-ME	471951
24mm	MF	AVTR2-MF	A36522-MF	471964
28mm	MG	AVTR2-MG	A36522-MG	471965
30mm	MH	AVTR2-MH	A36522-MH	471966
32mm	MT	AVTR2-MT	A36522-MT	471359
36mm	MJ	AVTR2-MJ	A36522-MJ	471968
38mm	MK	AVTR2-MK	A36522-MK	471969
42mm	ML	AVTR2-ML	A36522-ML	471969
45mm	MM	AVTR2-MM	A36522-MM	471970
48mm	MN	AVTR2-MN	A36522-MN	471971
52mm	MP	AVTR2-MP	A36522-MP	471971
55mm	MR	AVTR2-MR	A36522-MR	471972
60mm	MS	AVTR2-MS	A36522-MS	471953
65mm	MU	AVTR2-MU	A36522-MU	471954
70mm	MV	AVTR2-MV	A36522-MV	471955
75mm	MW	AVTR2-MW	A36522-MW	471956
80mm	MY	AVTR2-MY	A36737-MY	471957
85mm	MZ	AVTR2-MZ	A36737-MZ	471958

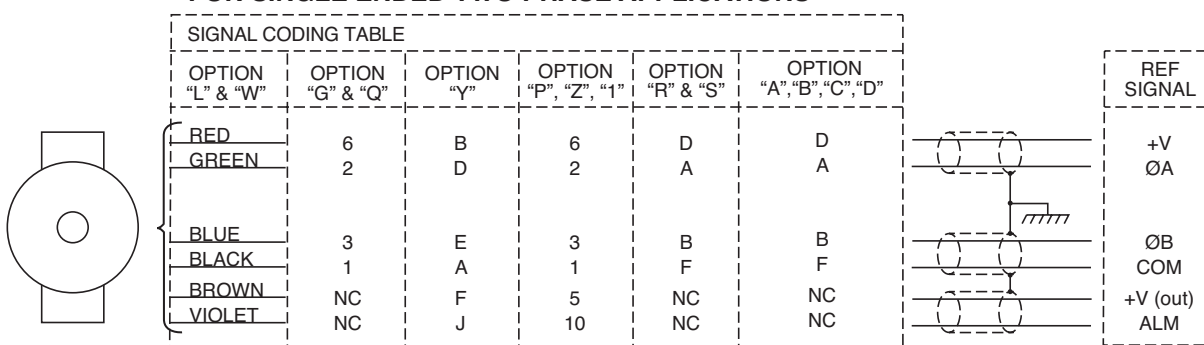
<b>Extended and Flat Cover Plates</b>			
<b>Shaft Size</b>	<b>Model</b>	<b>Extended Shaft Cover Kit</b>	<b>Flat Cover Kit</b>
Any	AV56S	A36526	A37298

# WIRING DIAGRAMS

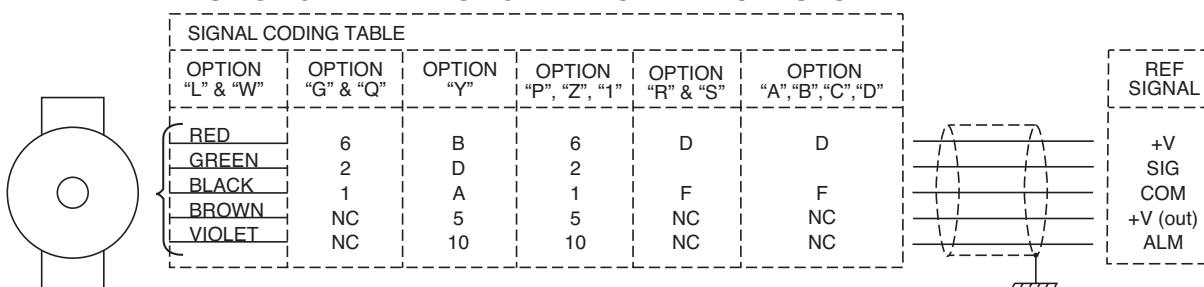
## FOR DIFFERENTIAL APPLICATIONS



## FOR SINGLE ENDED TWO PHASE APPLICATIONS



## FOR SINGLE ENDED SINGLE PHASE APPLICATIONS



**TYPICAL WIRE SELECTION CHART**  
for 18 AWG, multiple pair, individually shielded

	BELDEN	ALPHA
2 PAIR	9368	5620B1802
3 PAIR	9773 or 9369	6445
4 PAIR	9388	6444
3 CONDUCTOR	9365	5640B1801

For option "W", unused outputs must be insulated to prevent accidental contact.



# THIN-LINE III™

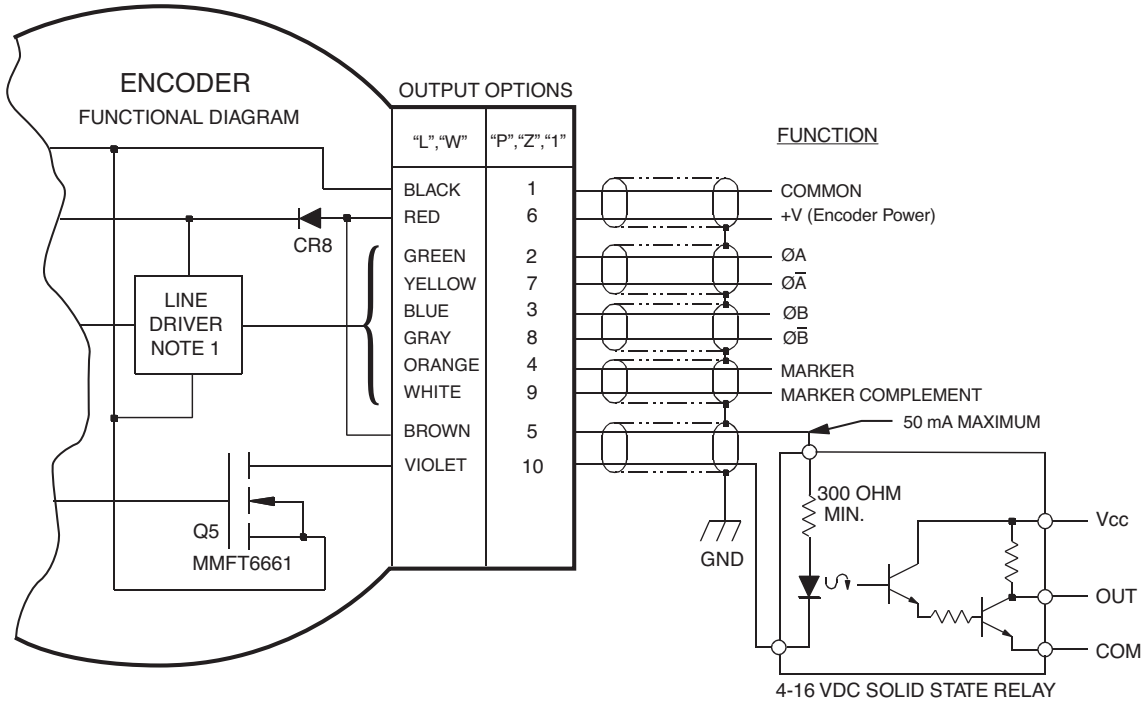
## Application Examples

Applies to all AV56S models, except, wiring options "G", "Q", "R", and "S".

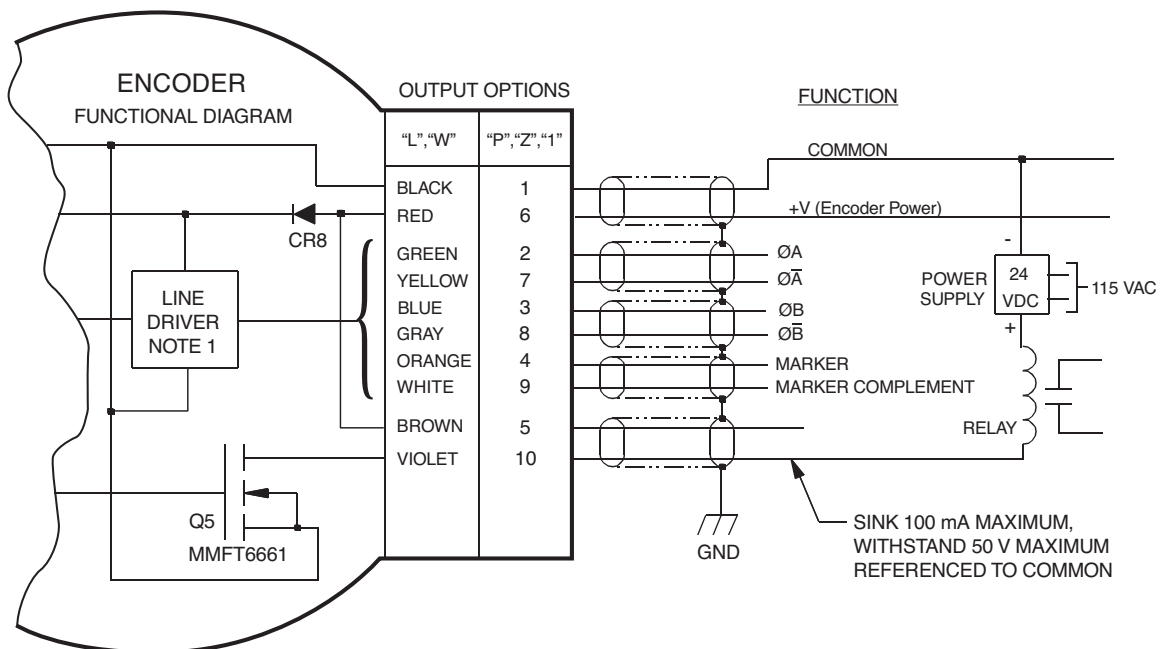
### ALARM OUTPUT CONNECTION

Avtron THIN-LINE III encoders provide an alarm signal if maintenance is required under specific circumstances. An alarm LED indicator is also available. Green indicates power on, red indicates alarm on. Following are application examples provided to help install the alarm output.

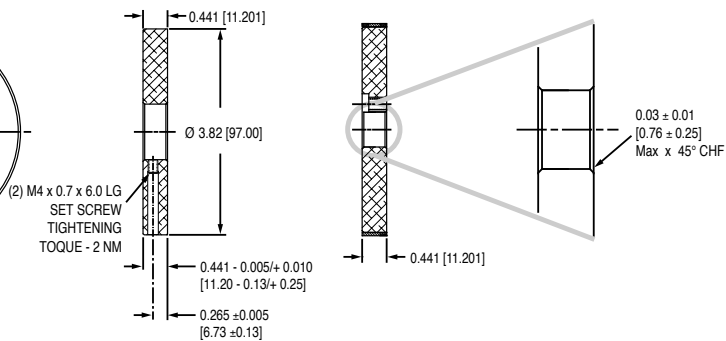
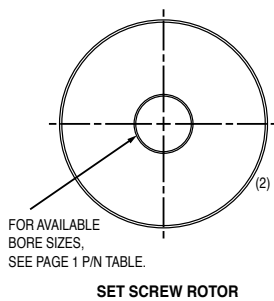
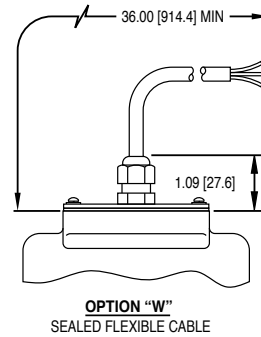
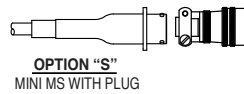
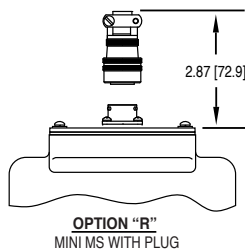
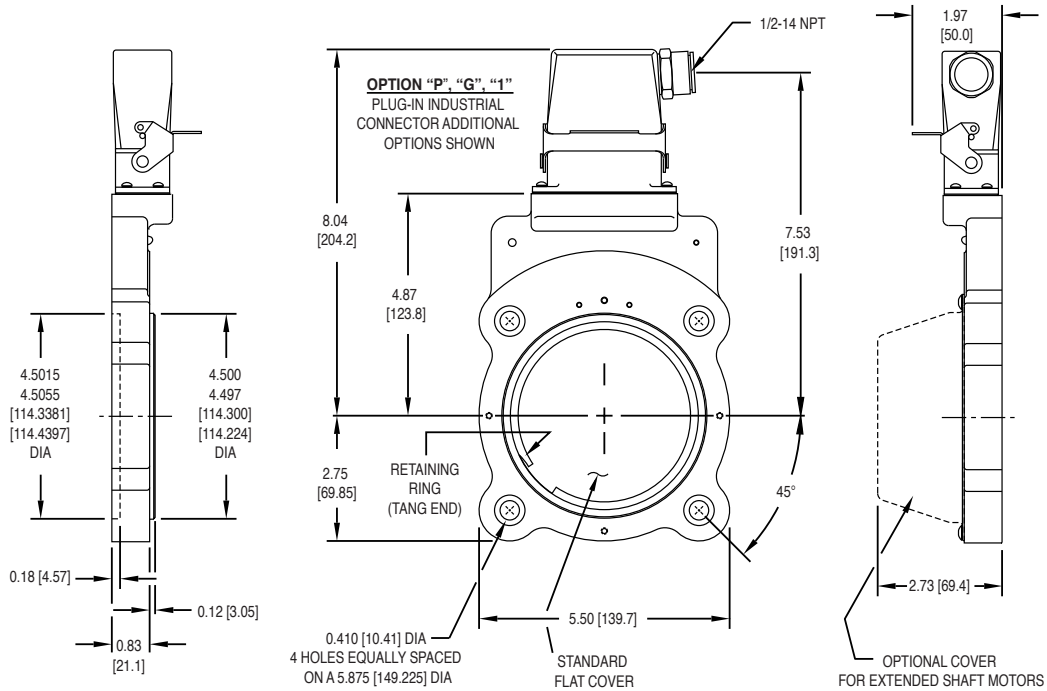
Example 1. Alarm output using +V(OUT). +V(OUT) is equal to +V, the encoder power supply.



Example 2. Alarm Output Using Separate 24 VDC Power Supply and Relay.



# OUTLINE DRAWING



3 - DIMENSIONS IN INCHES [MILLIMETERS]  
 2 - ALL DIMENSIONS ARE APPROXIMATE  
 1 - WEIGHT: 4-6 LBS [1.8-2.7KG].  
 NOTES:



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CE  
 Features and specifications subject to change without notice.  
 Avtron standard warranty applies. All dimensions are in millimeters approx.

REV: 03-22-17