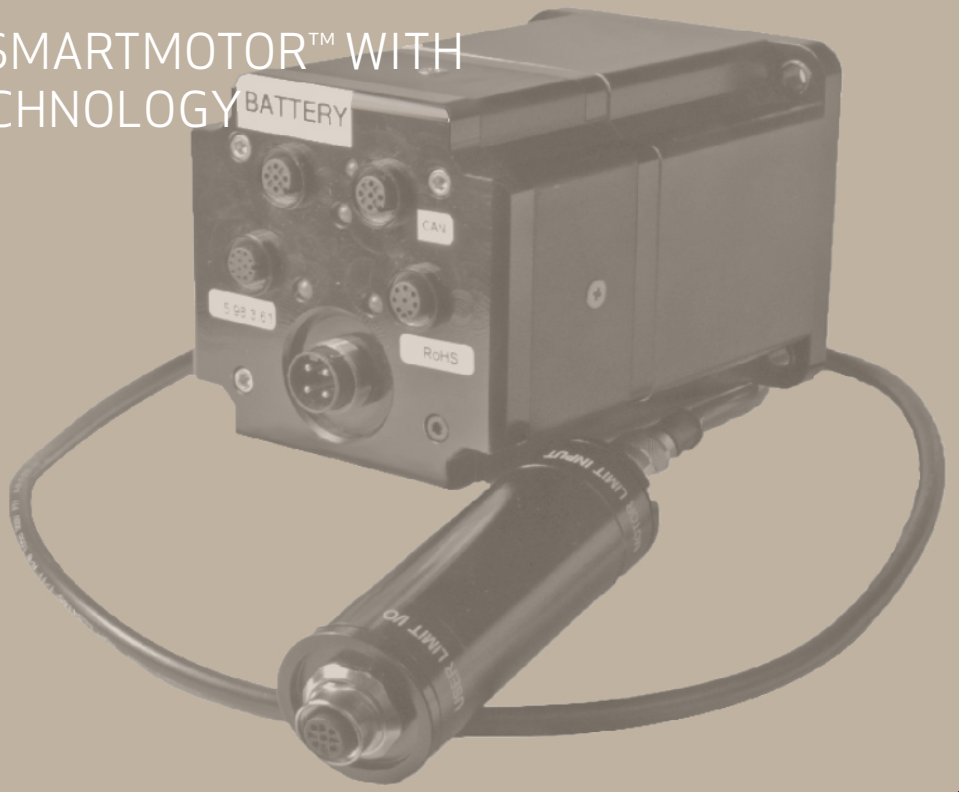
MULTITURN ABSOLUTE ENCODER OPTION FOR

FULLY INTEGRATED SERVO MOTORS

CLASS 5 M-STYLE SMARTMOTOR™ WITH COMBITRONIC™ TECHNOLOGY



Rev. D, May 2020

DESCRIBES THE INSTALLATION AND OPERATION OF THE MULTITURN ABSOLUTE ENCODER OPTION FOR THE CLASS 5 M-STYLE SMARTMOTOR™

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Moog Animatics Class 5 Multiturn Absolute Encoder Option Guide, Rev. D, PN: SC80100005-002.

Please let us know if you find any errors or omissions in this manual so that we can improve it for future readers. Such notifications should contain the words "Backup Battery" in the subject line and be sent by e-mail to: animatics_marcom@moog.com. Thank you in advance for your contribution.

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Table of Contents

Purpose

This document describes the features and operation of the Moog Animatics Multiturn Absolute Encoder option for the Class 5 M-style SmartMotor™. It also describes the installation and specifications for the backup battery.

CAUTION: The features and operation described in this guide require a Class 5 M-style SmartMotor that has been manufactured with the Multiturn Absolute Encoder option (-FB01 option). Do not attempt to attach a backup battery to a standard Class 5 M-style SmartMotor, as it will not work.

Class 5 M-style SmartMotors can be equipped with an optional, full-multiturn absolute encoder. This encoder option requires a backup battery that allows the motor to retain the absolute encoder position and allows continued multiturn position tracking when main power is removed from the motor. Together, these provide the benefits of no re-homing and minimized downtime when main power is removed due to an emergency stop, power outage or other cause.

M-Style SmartMotor with Multiturn Absolute Encoder Option

CAUTION: If the backup battery is disconnected from the SmartMotor or its charge is depleted after the main power is turned off, then the SmartMotor will lose the absolute location. For more details on the backup battery, see Backup Battery on page 14.

Overview

The Multiturn Absolute Encoder option with backup battery provides non-volatile, multiturn absolute encoder features. In other words, the motor knows its position for multiple turns of the shaft and retains that information even when main power is removed (provided the backup battery remains connected and charged).

NOTE: The position retention time depends on the battery selected and its charge state. For more information, see Battery Life on page 16.

When main power is off, if the backup battery is disconnected or its charge is depleted, the motor defaults to the features of a single-turn absolute encoder only. If this occurs, before the motor can be operated after power up, the backup battery status bit must be reset (see Resetting the Status Bit on page 13). Then, in order to restore the non-volatile, multiturn absolute encoder features, the backup battery must be reconnected and charged (see Backup Battery on page 14).

Key Features

The following are the key features of the Multiturn Absolute Encoder option:

- **Resolution** of the encoder as reported by the RPA (report actual position) command is 8192 counts/revolution.
- **Position number space** (the range of reportable position) is 32 bits signed. The lower 13 bits are the position within one revolution; the upper 19 bits are the number of turns from the origin (524288 revolutions).
- **Speed** of the encoder system is up to 6000 RPM under either main or battery power. Power may transition from battery to main or main to battery while at this speed.

  NOTE: Speed is limited to 450 RPM within the first 30 msec of movement from shaft at rest.
- **Acceleration** up to 250 rev/(sec^2) can be tolerated when running on battery. This restriction does not apply when running on main power.
- **Quadrature output** is available when the main power is applied. This quadrature signal has a resolution of 2048 counts (post quadrature) per revolution. The ENCD(1) command must be issued to enable this output through the M-style SmartMotor encoder differential bus.
- **Internal encoder index capture** is supported from the encoder's index or an external index input.

System Requirements

CAUTION: The features and operation described in this guide require a Class 5 M-style SmartMotor that has been manufactured with the Multiturn Absolute Encoder option (-FB01 option). Do not attempt to attach a backup battery to a standard Class 5 M-style SmartMotor, as it will not work.

The Multiturn Absolute Encoder option requires the following items:

- Class 5 M-style (23 or 34 series) SmartMotor (-FB01 option) with firmware version 5.97.3.61 or later, or firmware version 5.98.3.61 or later
- Multiturn Absolute Encoder Backup Battery
- Backup Battery to SmartMotor cable
- (Optional) Flying Lead cable

NOTE: The above items, except flying lead cable, can be ordered as a "kit" option on the motor (-KFB01-XX). "-XX" represents the desired cable length, -01, -02 or -03 for 1, 2 or 3 meter cable, respectively. For example, SM23165MT-KFB01-02 = SM23165MT motor with Multiturn Absolute Encoder option, Backup Battery, and 2M battery cable.

Refer to the next section for the implementation steps. Also, refer to Backup Battery on page 14 for details on installing the backup battery.

Steps for Implementation

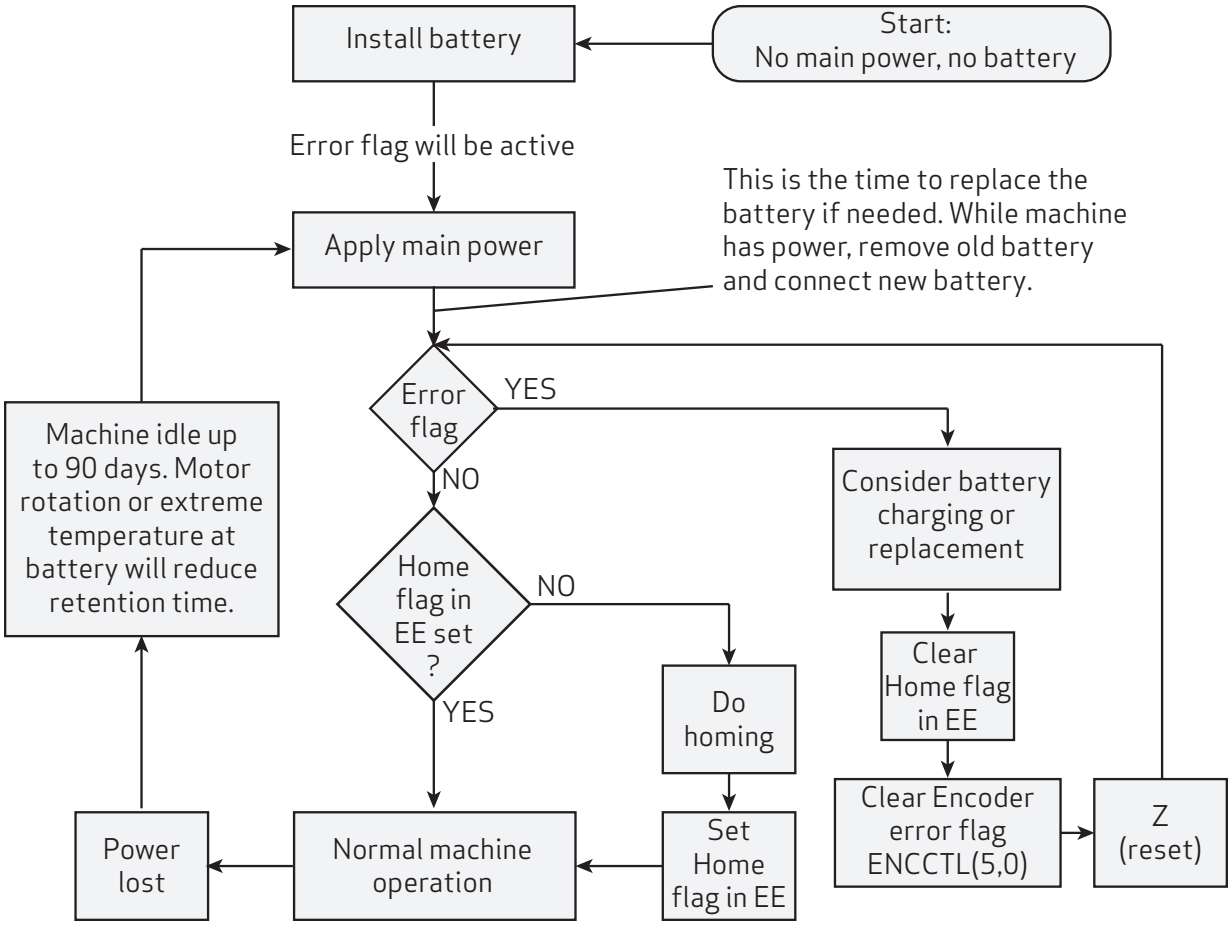
The following are the steps for implementing the Multiturn Absolute Encoder option (also, see Operation Flow Chart (with Battery) on page 7):

1. Install a SmartMotor that has the Multiturn Absolute Encoder option.
2. Connect and charge the backup battery. For details, see Backup Battery on page 14.
3. Review the Operations Flow Chart to understand the operation of the SmartMotor when equipped with the Multiturn Absolute Encoder option and backup battery. For details, see Operation Flow Chart (with Battery) on page 7.
4. Use the SmartMotor commands to initialize and operate the Multiturn Absolute Encoder option. For details, see Commands on page 9.
5. When needed (if the backup battery is removed or loses its charge), use the reset status bit. For details, see Resetting the Status Bit on page 13.

Operation Flow Chart (with Battery)

The following flow chart shows the operation of the SmartMotor when equipped with the Multiturn Absolute Encoder option and backup battery.

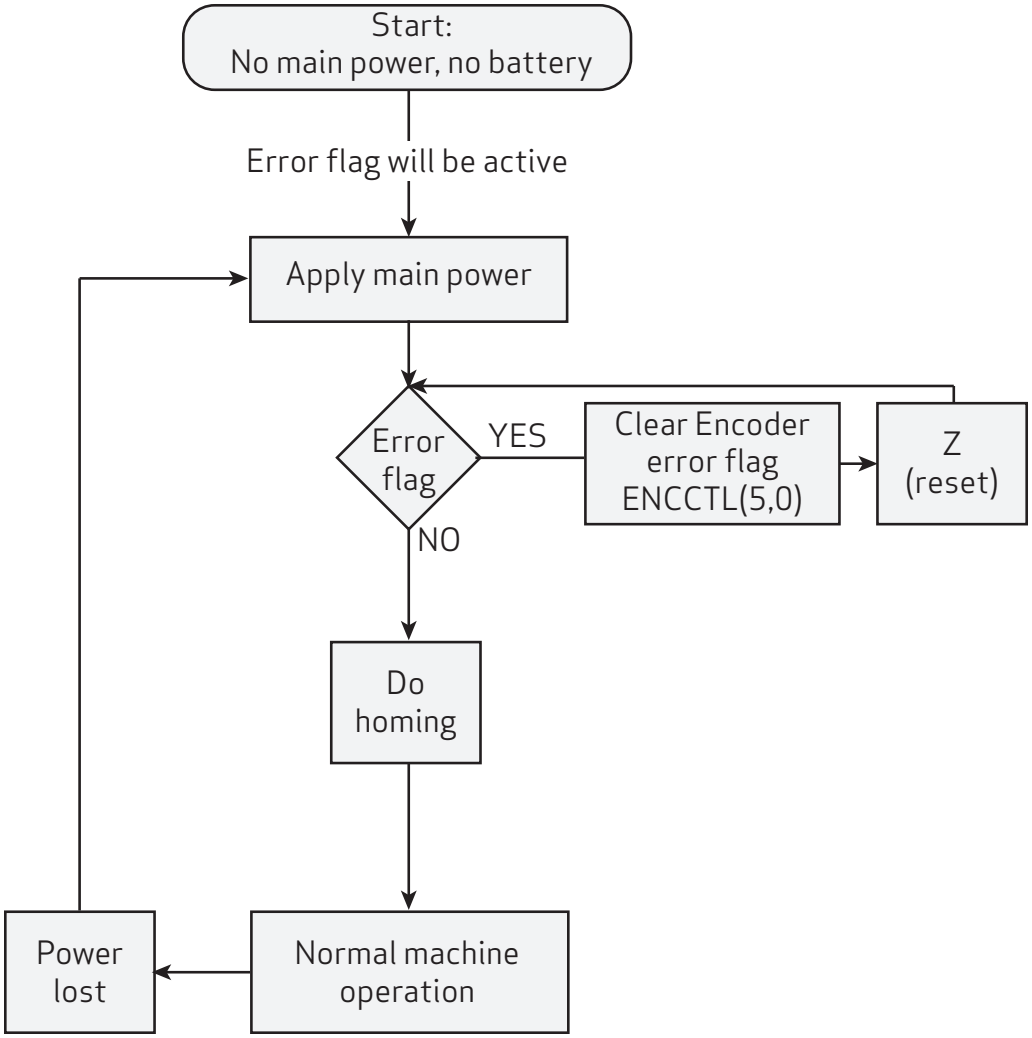
CAUTION: If main power is off and the battery is removed or its charge is depleted, the multiturn absolute position will be lost. For single-turn absolute encoder operation with no battery, see Operation Flow Chart (without Battery) on page 8.



Operation Flow Chart (without Battery)

The following flow chart shows the operation of the SmartMotor when equipped with the Multiturn Absolute Encoder option but without the backup battery. For multiturn absolute encoder operation with the backup battery, see Operation Flow Chart (with Battery) on page 7.

NOTE: With no battery, the absolute encoder operates as a single-turn absolute encoder only.



Commands

This section describes the commands that are available for SmartMotors equipped with the Multiturn Absolute Encoder option. Also, see Example Program (with Battery) on page 10, which shows several of these commands used within a SmartMotor program.

Differential Encoder Bus

ENCD(0) sets the encoder bus port as an input (default at power up).

ENCD(1) sets the encoder bus port as an output.

Absolute Encoder Control

CAUTION: Use of the O= or OSH= command will confuse the absolute position information. Therefore, do not use these commands. Instead, use the ENCCTL command (described in this section).

ENCCTL(0,x) sets the absolute position to x, offset is nonvolatile and maintained in the SmartMotor's EEPROM memory. At power-up, the motor's firmware will adjust absolute position with offset.

0 is the command; x is the desired position at the time the instruction is executed and is a signed 32-bit integer.

NOTE: Because offsets include multiturn information, this is not recommended for use with single-turn operation.

ENCCTL(-1,x) removes the effect of the ENCCTL(0,x) command — the PA offset is then set as shipped from factory.

x can be any value.

ENCCTL(5,x) resets the error flags.

x can be any value.

Follow this with a Z (soft reset) command.

ENCCTL(6,x) reports the encoder firmware version to the terminal.

x=0: report lowest byte (minor rev).

x=1: report mid byte (major rev).

x=2: report high byte (firmware type).

Example Program (with Battery)

Status word 6, bit 12 indicates if a failure occurs in the encoder. A typical reason would be if the battery was disconnected or depleted while main power was removed. Users should check the state of this bit. The following example program provides a method for checking and clearing the status bit. Also, refer to Resetting the Status Bit on page 13.

NOTE: The status bit will be set initially when installing a battery and powering up for the first time. The user is responsible for clearing this bit. Refer to the following example.

NOTE: The backup battery is required for multiturn absolute position retention through power cycles.

```
' Variables used:
' x
' EEPROM byte locations 0-3

IF B(6,12)==1
    ' Encoder has logged an error,
    ' or has not been cleared for the first time.
    ' This is a good indication that the system should find
    ' the home position.
    GOSUB(12)    ' Clear the 'homed' flag in EEPROM to mark homing as invalid.
    ENCCTL(5,0)  ' Clear the encoder error. It is important to clear
                 ' the 'homed' flag before this.
    WAIT=100     ' Give the ENCCTL command time to function.
    Z            ' Reset the motor so that the encoder will boot cleanly
                 ' without the error.
ENDIF

GOSUB(13)       ' Get homing flag into variable x.
IF x!=1         ' Test if homing is valid.
    GOSUB(10)   ' Homing flag shows 'not homed' - do homing.
ENDIF

WHILE 1
    ' Do main loop.
LOOP

END

C10 ' Homing routine:
    ' Code for homing routine here...
    ' << Add code here to find home position >>
    ' DO NOT use O= or OSH= type offset commands.
    ' These commands are volatile and will not
    ' be remembered when the system is power cycled.
    ' Use the ENCCTL mechanism to save an offset value.
    ' For example:
    x=1000 ' When at the home position, we want to declare that as
           ' position 1000.
           ' This is completely dependent on the user's desire for
```

```
            ' this application.
    ENCCTL(0,x) ' While at the home position, set the desired value
                ' of that home position.
    GOSUB(11)   ' Set a flag in EEPROM to show that homing was completed.
RETURN

C11  ' Set a flag in the user EEPROM to indicate when homing is complete.
    x=1
    EPTR=0
    VST(x,1)
RETURN

C12 ' Clear a flag in the user EEPROM to void the 'homing complete' status.
    x=-1
    EPTR=0
    VST(x,1)
RETURN

C13 ' Get a flag from the user EEPROM.  If x==1, then homing was
    ' completed previously.
    EPTR=0
    VLD(x,1)
RETURN
```

Example Program (without Battery)

Status word 6, bit 12 indicates if a failure occurs in the encoder. This would occur if the battery was disconnected or depleted while main power was removed.

The following example program provides a method for checking and clearing the status bit, and operating the SmartMotor as a single-turn absolute encoder only. Also, refer to Resetting the Status Bit on page 13.

```
' Encoder system with NO BATTERY,
' SINGLE-TURN position only!
IF B(6,12)==1
    ' Encoder must be cleared since there is no battery.
    ENCCTL(5,0) ' Clear the encoder error.
    WAIT=100    ' Give the ENCCTL command time to function.
    Z           ' Reset the motor so that the encoder will
                ' boot cleanly without the error.
ENDIF
GOSUB(10)   ' Do homing.
WHILE 1
            ' Do main loop.
LOOP
END
C10         ' Homing routine:
            ' Code for homing routine here...
            ' << Add code here to find home position >>
    O=1000  ' While at the home position,
            ' set the desired value of that home position.
RETURN
```

Resetting the Status Bit

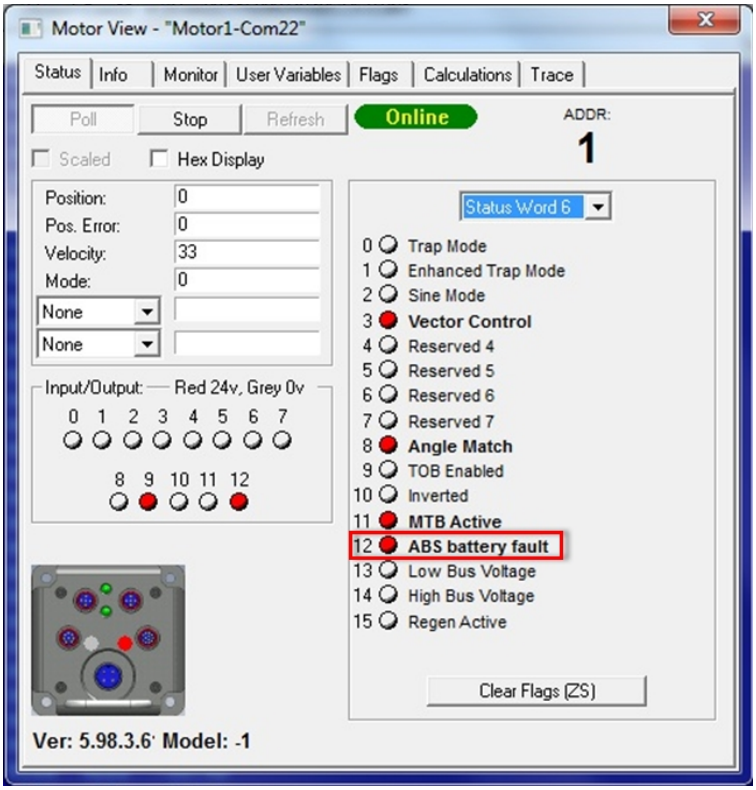
This section describes the procedure for resetting the status bit for the Multiturn Absolute Encoder backup battery. The status bit is checked on power up and activates if the backup battery has been removed or has lost its charge (see Operation Flow Chart (with Battery) on page 7.

While the motor is powered, clearing the status bit once allows the motor to operate normally. However, if main power is off and the battery is removed or loses its charge, the fault will reoccur at the next power-up.

NOTE: While the motor is on main power, the battery can be disconnected (i.e., for replacement) without causing a battery fault. This allows you to change the battery without losing the multiturn absolute location.

To reset the status bit:

1. Use the SMI software to select and connect to the SmartMotor. For details, see the *Class 5 SmartMotor™ Installation and Startup Guide* or the SMI software online help.
2. Open the Motor View tool and select "Status Word 6". You will see an error on status bit 12 (ABS battery fault), as shown in the following figure.



3. Clear the error by issuing the command ENCCTL(5,0) from the SMI software, followed by a Z (soft reset) command. For more information on related commands, see Commands on page 9.

The motor is now ready for operation. For operation and programming information, see the *SmartMotor™ Developer's Guide*.

Backup Battery

The Multiturn Absolute Encoder option requires a backup battery that allows the motor to retain the absolute encoder position and allows continued multiturn position tracking when main power is removed from the motor.

CAUTION: If the battery is disconnected from the SmartMotor or its charge is depleted after the main power is turned off, then the SmartMotor will lose the absolute location.

Multiturn Absolute Encoder Backup Battery

Installation

This section describes the required equipment/materials and installation procedure for the backup battery.

Required Equipment/Materials

This procedure requires the following items:

- Class 5 M-style SmartMotor with the Multiturn Absolute Encoder option
- Multiturn Absolute Encoder Backup Battery, PN: CBLIP-BAT1
- Backup Battery to SmartMotor cable, PN: CBLIP-LIM-EXT-XX (where XX is cable length from 1M to 3M)
- (Optional) Flying Lead cable, PN: CBLIP-LIM-FL

NOTE: The above items, except flying lead cable, can be ordered as a "kit" option on the motor (-KFB01-XX). "-XX" represents the desired cable length, -01, -02 or -03 for 1, 2 or 3 meter cable, respectively. For example, SM23165MT-KFB01-02 = SM23165MT motor with Multiturn Absolute Encoder option, Backup Battery, and 2M battery cable.

Procedure

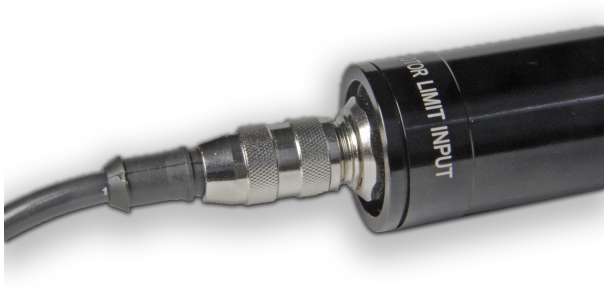
The following steps describe the procedure for installing the backup battery and clearing the battery status bit in the motor. Also, refer to the Operation Flow Chart (with Battery) on page 7.

Physical Connections

CAUTION: M-style connectors must be finger tightened only! DO NOT use a wrench or other tool. Doing so can cause overtightening of the connection, which may damage the connector and will void the warranty.

This section describes how to physically connect the battery cylinder to the SmartMotor.

1. Locate the items in the equipment/materials list (see the previous section).
2. Attach the cable's female connector (see Backup Battery to Motor Cables on page 17) to the end of the battery cylinder labeled "Motor Limit Input".



3. Attach the cable's male connector (see Backup Battery to Motor Cables on page 17) to the motor connector labeled "BATTERY" (see the following figure).

NOTE: Only connect it to the upper-left receptacle on the back (connector end) of the motor. There is a "BATTERY" label above that receptacle.

4. Make all remaining motor connections as you would for a standard M-style motor. For details, see the *Class 5 SmartMotor™ Installation and Startup Guide*.
5. Optionally, the remaining connector on the battery housing can be used for I/O. In this case, attach the "flying lead" cable, PN: CBLIP-LIM-FL.

NOTE: Because an external battery is required to retain the absolute position, I/O port 10 is not available.

6. Make sure all connections are secure (finger tightened only).
7. After attaching the power cable and communication cable, apply power to the motor. For details, see the *Class 5 SmartMotor™ Installation and Startup Guide*.

CAUTION: A new battery (as shipped or from a stocking shelf) may take *at least* 4 hours to charge before it is restored to its rated retention time for the Absolute Encoder position.

Battery Life

CAUTION: If the motor is being rotated continuously while on battery power, this will significantly reduce the length of time before the battery becomes depleted.

Assuming a full charge and operation with an ambient temperature of 25 degrees C, the battery depletion rate depends on the amount the motor is being rotated: No motion (0 RPM) = 90 days; continuous motion (motor shaft is continuously rotating) = 7 days. (Number of days are approximate.)

CAUTION: Increasing the battery temperature to 50 degrees C will reduce these specifications by approximately 30%.

There is a status bit available to indicate if battery voltage has failed. For details, see Resetting the Status Bit on page 13.

NOTE: As the battery ages, its life (charge retention time) will diminish.

Battery Specifications

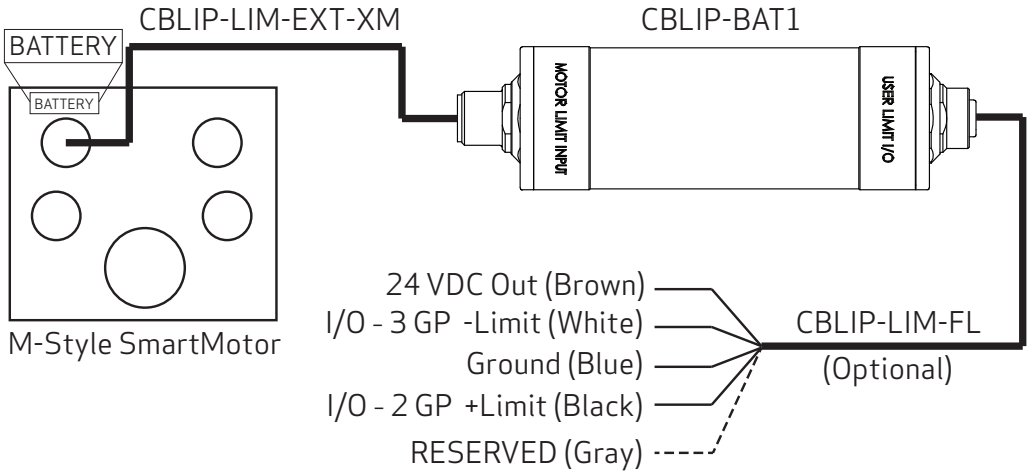
This section describes the specifications for the backup battery.

- **Part number:** CBLIP-BAT1
- **Temperature range:** 0 to 60 degrees C operating environment
- **Chemistry:** Rechargeable nickel-metal hydride (NiMH)
- **Physical structure:** Three stacked cells for 3.6 VDC
- **Maximum charge voltage:** 4.2 VDC (from SmartMotor)
- **Battery life (charge retention time):** No motion (0 RPM) = 90 days; continuous motion (motor shaft is continuously rotating) = 7 days (assumes an ambient temperature of 25 degrees C; see Battery Life on page 16 for more details)
- **Time to full charge:** Requires *at least* 4 hours (from SmartMotor)

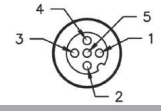
CAUTION: A new battery (as shipped or from a stocking shelf) may take *at least* 4 hours to reach a fully charged state. Therefore, do not remove main power before the battery is fully charged.

Drawings

Backup Battery Wiring Diagram



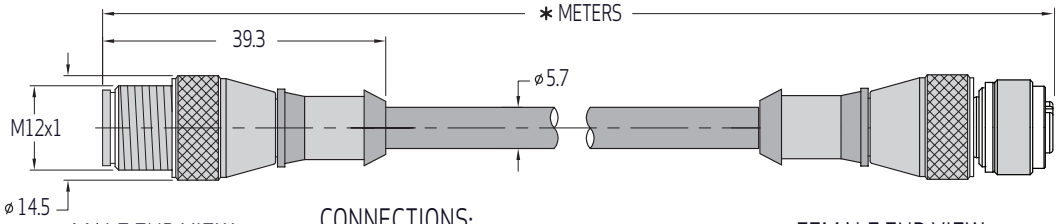
PIN	24V I/O Connector	Specifications:	Notes:	P4
1	+24Volts Out		From Control Pwr In	M12, 5-PIN FEMALE END VIEW
2	I/O – 3 GP -Limit	150mAmps Max	Configurable	
3	Ground	Common Ground	Unisolated	
4	I/O – 2 GP +Limit	150mAmps Max	Configurable	
5	RESERVED – USED FOR BATTERY			



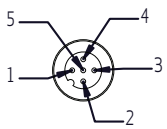
Backup Battery to Motor Cables

CBLIP series cables have sealed M12 threaded connectors, gold-plated brass pins, maximum 4.0A 250V, and foil shield with black PVC jacket.

Part Number	Description	Length*
CBLIP-LIM-EXT-1M	Limit Bus Extension Cable	1 meter
CBLIP-LIM-EXT-2M	Limit Bus Extension Cable	2 meters
CBLIP-LIM-EXT-3M	Limit Bus Extension Cable	3 meters



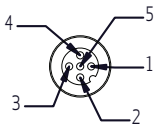
MALE END VIEW:



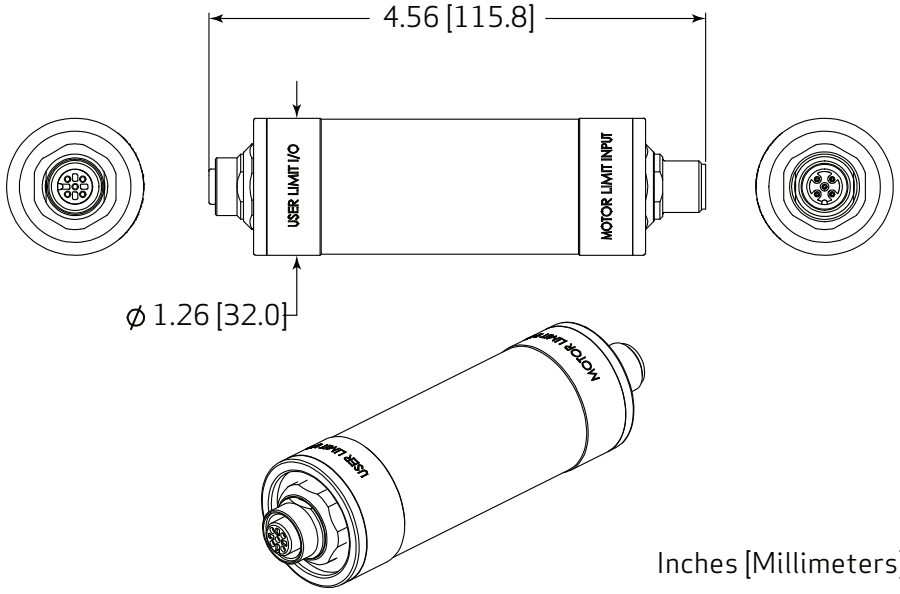
CONNECTIONS:

PIN #	NAME	COLOR
1	+ 24V OUT	BROWN
2	-LIMIT IN	WHITE
3	GROUND	BLUE
4	+LIMIT IN	BLACK
5	RESERVED	GRAY

FEMALE END VIEW:



Backup Battery Cylinder



Inches [Millimeters]

NOTES

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