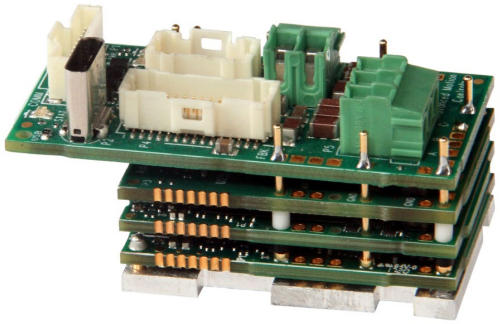
# FM060-1-EM

FlexPro® Series
**Product Status:** Active



## SPECIFICATIONS

| | |
|---|---|
| Current Peak | **2 A** |
| Current Continuous | **1 A** |
| DC Supply Voltage | **10 – 55 VDC** |
| Network Communication | **EtherCAT** |

The **FM060-1-EM** is a single-axis servo drive and integration board assembly for a FE060-1-EM FlexPro® series servo drive with IMPACT™ architecture. Connections to the controller, motor, power, and feedback are simplified through the standard connectors featured on the board.

The **FM060-1-EM** offers full tuning control of all servo loops and is designed to drive brushed and brushless servo motors, and closed loop stepper motors. The drive accepts a variety of external command signals, or can use the built-in Motion Engine, an internal motion controller used with Sequencing and Indexing commands. Programmable digital and analog I/O are included to enhance interfacing with external controllers and devices.

The **FM060-1-EM** utilizes EtherCAT® network communication using CANopen over EtherCAT (CoE) and is configured via USB. All drive and motor parameters are stored in non-volatile memory.

IMPACT™ (**I**ntegrated **M**otion **P**latform **A**nd **C**ontrol **T**echnology) combines exceptional processing capability and high-current components to create powerful, compact, feature-loaded servo solutions. IMPACT™ is used in all FlexPro® drives and is available in custom products as well.

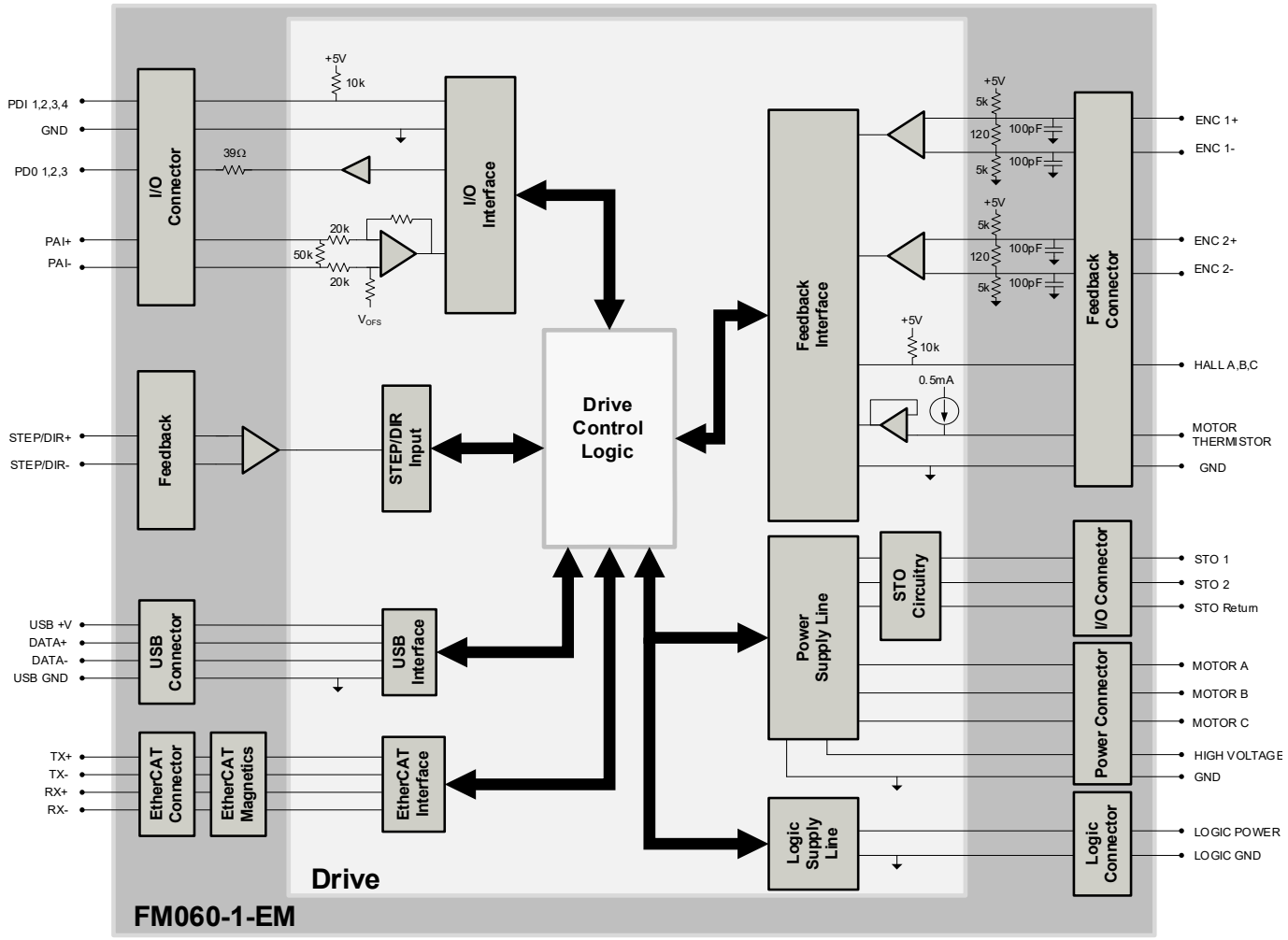
## FEATURES

- CoE – Based on DSP-402 Device Profile for Drives and Motion Control
- Synchronization using Distributed Clocks
- Position Cycle Times down to 100µs
- Four Quadrant Regenerative Operation
- Programmable Gain Settings
- PIDF Velocity Loop
- On-the-Fly Mode Switching
- On-the-Fly Gain Set Switching
- Compact Size, High Power Density
- Dedicated Safe Torque Off (STO) Inputs
- Bridge Status, Fault and Network Status LEDs
- Standard Connections for Easy Setup

| | | | | | |
|---|---|---|---|---|---|
| **Feedback Supported** | • Absolute Encoder<br>  ○ BiSS C-Mode<br>  ○ EnDat 2.2<br>• Incremental Encoder<br>• Hall Sensors<br>• Tachometer (±10V) | **Motors Supported** | • Three Phase<br>• Single Phase<br>• Stepper | **Modes of Operation** | • Profile Modes<br>• Cyclic Synchronous Modes<br>• Current<br>• Velocity<br>• Position |
| **Command Sources** | • Over the Network<br>• ±10V Analog<br>• Sequencing<br>• Indexing<br>• Jogging<br>• Step & Direction<br>• Encoder Following | **Inputs / Outputs** | • 4 Programmable Digital Inputs<br>• 3 Programmable Digital Outputs<br>• 1 Programmable Analog Input | **Agency Approvals** | • RoHS<br>• UL/cUL<br>• CE (LVD)<br>• CE Class A (EMC) |


*ADVANCED* Motion Controls · 3805 Calle Tecate, Camarillo, CA, 93012
ph# 805-389-1935 · fx# 805-389-1165 · www.a-m-c.com

## BLOCK DIAGRAM




## INFORMATION ON APPROVALS AND COMPLIANCES

| | |
|---|---|
| c UL us | US and Canadian safety compliance with UL/IEC 61800-5-1, the industrial standard for adjustable speed electrical power drive systems. UL registered under file number E140173. Note that machine components compliant with UL are considered UL registered as opposed to UL listed as would be the case for commercial products. |
| CE | Compliant with European EMC Directive 2014/30/EU on Electromagnetic Compatibility (specifically EN 61000-6-4:2007/A1:2011 for Emissions, Class A and EN 61000-6-2:2005 for Immunity, Performance Criteria A). LVD requirements of Directive 2014/35/EU (specifically, EN 60204-1:2019, a Low Voltage Directive to protect users from electrical shock). |
| RoHS Compliant | The RoHS Directive restricts the use of certain substances including lead, mercury, cadmium, hexavalent chromium and halogenated flame retardants PBB and PBDE in electronic equipment. |

## SPECIFICATIONS

| Electrical Specifications | | |
|---|---|---|
| Description | Units | Value |
| Nominal DC Supply Input Range | VDC | 12 – 48 |
| DC Supply Input Range | VDC | 10 – 55 |
| DC Supply Undervoltage | VDC | 8 |
| DC Supply Overvoltage | VDC | 58 |
| Logic Supply Input Range (optional) | VDC | 10 – 55 |
| Safe Torque Off Voltage (Default) | VDC | 5 |
| Maximum Peak Current Output[1] | A (Arms) | 2 (1.4) |
| Maximum Continuous Current Output[2] | A (Arms) | 1 (1) |
| Bus Capacitance[3] | µF | 52.8 |
| Efficiency at Rated Power | % | 99 |
| Maximum Continuous Output Power | W | 54 |
| Maximum Power Dissipation at Continuous Current | W | 1 |
| Minimum Load Inductance (line-to-line)[4] | µH | 150 (@ 48VDC supply); 75 (@24VDC supply); 40 (@12VDC supply) |
| Switching Frequency | kHz | 20 |
| Maximum Output PWM Duty Cycle | % | 83 |
| **Control Specifications** | | |
| Description | Units | Value |
| Communication Interfaces[5] | - | EtherCAT® (USB for configuration) |
| Command Sources | - | ±10 V Analog, Over the Network, Sequencing, Indexing, Jogging, Step & Direction, Encoder Following |
| Feedback Supported | - | Absolute Encoder (BiSS C-Mode, EnDat 2.2), Incremental Encoder, Hall Sensors, Auxiliary Incremental Encoder, Tachometer (±10V) |
| Commutation Methods | - | Sinusoidal, Trapezoidal |
| Modes of Operation | - | Profile Modes, Cyclic Synchronous Modes, Current, Velocity, Position |
| Motors Supported[6] | - | Three Phase (Brushless Servo), Single Phase (Brushed Servo, Voice Coil, Inductive Load), Stepper (2- or 3-Phase Closed Loop) |
| Hardware Protection | - | 40+ Configurable Functions, Over Current, Over Temperature (Drive & Motor), Over Voltage, Short Circuit (Phase-Phase & Phase-Ground), Under Voltage |
| Programmable Digital Inputs/Outputs | - | 4/3 |
| Programmable Analog Inputs/Outputs | - | 1/0 |
| Primary I/O Logic Level | - | 5 VDC, not isolated |
| Current Loop Sample Time | µs | 50 |
| Velocity Loop Sample Time | µs | 100 |
| Position Loop Sample Time | µs | 100 |
| Maximum Encoder Frequency | MHz | 20 (5 pre-quadrature) |
| **Mechanical Specifications** | | |
| Description | Units | Value |
| Size (H x W x D) | mm (in) | 50.8 x 25.4 x 26.0 (2.00 x 1.00 x 1.03) |
| Weight | g (oz) | 36.9 (1.3) |
| Ambient Operating Temperature Range[7] | °C (°F) | 0 – 65 (32 – 149) |
| Storage Temperature Range | °C (°F) | -40 – 85 (-40 – 185) |
| Relative Humidity | - | 0-95%, non-condensing |
| P1 ETHERCAT COMMUNICATION CONNECTOR | - | 12-pin, 1.0mm spaced single row vertical header |
| P2 USB CONNECTOR | - | USB Type C, vertical entry |
| P3 IO and LOGIC CONNECTOR | - | 20-pin, 1.0mm spaced dual row vertical header |
| P4 FEEDBACK CONNECTOR | - | 30-pin, 1.0mm spaced dual row vertical header |
| P5 POWER CONNECTOR | - | 2-port, 3.5mm spaced vertical entry screw terminal |
| P6 MOTOR POWER CONNECTOR | - | 3-port, 3.5mm spaced vertical entry screw terminal |

**Notes**

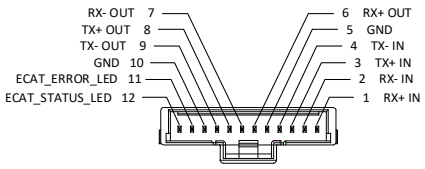
1. Capable of supplying drive rated peak current for 2 seconds with 5 second foldback to continuous value. Longer times are possible with lower current limits.
2. Continuous $A_{rms}$ value attainable when RMS Charge-Based Limiting is used.
3. Applications with a supply voltage higher than 30VDC require a minimum external decoupling capacitance of 470µF / 100V added across HV and POWER GND.
4. Lower inductance is acceptable for bus voltages well below maximum. Use external inductance to meet requirements.
5. EtherCAT® is a registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany.
6. Maximum motor speed for stepper motors is 600 RPM. Consult the hardware installation manual for 2-phase stepper wiring configuration.
7. Additional cooling and/or heatsink may be required to achieve rated performance.

## PIN FUNCTIONS

### P1 – EtherCAT Communication Connector

| Pin | Name | Description / Notes | I/O |
|---|---|---|---|
| 1 | RX+ IN | Receiver + (100Base-TX) | I |
| 2 | RX- IN | Receiver - (100Base-TX) | I |
| 3 | TX+ IN | Transmitter + (100Base-TX) | I |
| 4 | TX- IN | Transmitter - (100Base-TX) | I |
| 5 | GND | Ground | GND |
| 6 | RX+ OUT | Receiver + (100Base-TX) | O |
| 7 | RX- OUT | Receiver - (100Base-TX) | O |
| 8 | TX+ OUT | Transmitter + (100Base-TX) | O |
| 9 | TX- OUT | Transmitter - (100Base-TX) | O |
| 10 | GND | Ground | GND |
| 11 | ECAT_ERROR LED | Error Indicator for EtherCAT Network for optional external user LED connection. | O |
| 12 | ECAT_STATUS LED | Run State Indicator for EtherCAT Network for optional external user LED connection. | O |

| | |
|---|---|
| **Connector Information** | 12-pin, 1.0mm, spaced single row vertical header |
| **Mating Connector Details** | Molex: 5013301200 |
| **Mating Connector Included** | No |




### P2 – USB Connector

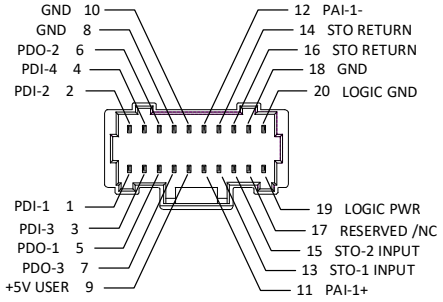
| Pin | Name | Description / Notes | I/O |
|---|---|---|---|

| | |
|---|---|
| **Connector Information** | USB Type C port |
| **Mating Connector Details** | Standard Type C USB connection cable |
| **Mating Connector Included** | No |

### P3 – I/O and Logic Connector

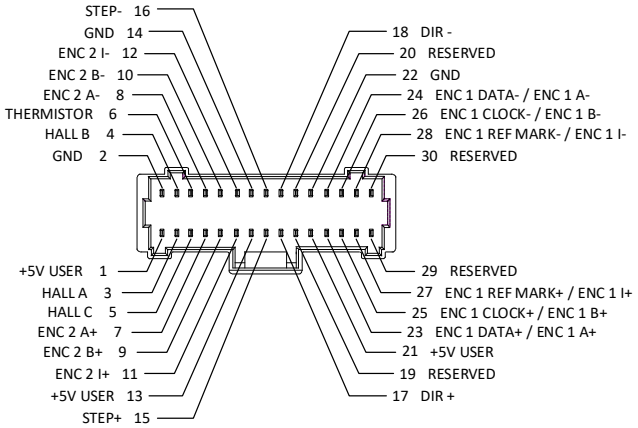
| Pin | Name | Description / Notes | I/O |
|---|---|---|---|
| 1 | PDI-1 | General Purpose Programmable Digital Input | I |
| 2 | PDI-2 | General Purpose Programmable Digital Input | I |
| 3 | PDI-3 | General Purpose Programmable Digital Input | I |
| 4 | PDI-4 | General Purpose Programmable Digital Input | I |
| 5 | PDO-1 | General Purpose Programmable Digital Output (TTL/8mA) | O |
| 6 | PDO-2 | General Purpose Programmable Digital Output (TTL/8mA) | O |
| 7 | PDO-3 | General Purpose Programmable Digital Output (TTL/8mA) | O |
| 8 | GND | Ground. | GND |
| 9 | +5V USER | +5V Supply Output. Short-circuit protected.<br>(300ma total load capacity shared between P3-9, P4-1, P4-13, and P4-21) | O |
| 10 | GND | Ground. | GND |
| 11 | PAI-1+ | General Purpose Differential Programmable Analog Input or Reference Signal Input. | I |
| 12 | PAI-1- | ±10VDC Range (12-bit Resolution) | I |
| 13 | STO-1 INPUT | Safe Torque Off – Input 1 | I |
| 14 | STO RETURN | Safe Torque Off Return | STORET |
| 15 | STO-2 INPUT | Safe Torque Off – Input 2 | I |
| 16 | STO RETURN | Safe Torque Off Return | STORET |
| 17 | RESERVED / NC | Reserved. | - |
| 18 | GND | Ground. | GND |
| 19 | LOGIC PWR | Logic Supply Input (10 – 55VDC) (optional). When using a separate logic power supply, turn on the logic supply first before turning on the main power supply. | I |
| 20 | LOGIC GND | Ground | GND |

| | |
|---|---|
| **Connector Information** | 20-pin, 1.0mm spaced dual row vertical header |
| **Mating Connector Details** | Molex: 5011892010 |
| **Mating Connector Included** | No |



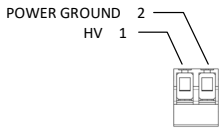
| P4 – Feedback Connector | | | | |
|---|---|---|---|---|
| Pin | Absolute Encoder | Incremental Encoder | Description / Notes | I/O |
| 1 | +5V USER | +5V USER | +5V Supply Output. Short-circuit protected.<br>(300ma total load capacity shared between P3-9, P4-1, P4-13, and P4-21) | O |
| 2 | GND | GND | Ground. | GND |
| 3 | HALL A | HALL A | Single-ended Commutation Sensor Inputs. | I |
| 4 | HALL B | HALL B | | I |
| 5 | HALL C | HALL C | | I |
| 6 | THERMISTOR | THERMISTOR | Motor Thermal Protection. | I |
| 7 | ENC 2 A+ | ENC 2 A+ | Differential Incremental Encoder A. | I |
| 8 | ENC 2 A- | ENC 2 A- | | I |
| 9 | ENC 2 B+ | ENC 2 B+ | Differential Incremental Encoder B. | I |
| 10 | ENC 2 B- | ENC 2 B- | | I |
| 11 | ENC 2 I+ | ENC 2 I+ | Differential Incremental Encoder Index. | I |
| 12 | ENC 2 I- | ENC 2 I- | | I |
| 13 | +5V USER | +5V USER | +5V Supply Output. Short-circuit protected.<br>(300ma total load capacity shared between P3-9, P4-1, P4-13, and P4-21) | O |
| 14 | GND | GND | Ground. | GND |
| 15 | STEP + | STEP + | Differential Step Input. | I |
| 16 | STEP - | STEP - | | I |
| 17 | DIR + | DIR + | Differential Direction Input. | I |
| 18 | DIR - | DIR - | | I |
| 19 | RESERVED | RESERVED | Reserved. | - |
| 20 | RESERVED | RESERVED | | - |
| 21 | +5V USER | +5V USER | +5V Supply Output. Short-circuit protected.<br>(300ma total load capacity shared between P3-9, P4-1, P4-13, and P4-21) | O |
| 22 | GND | GND | Ground. | GND |
| 23 | ENC 1 DATA+ | ENC 1 A+ | Differential Data Line for Absolute Encoders (BiSS: SLO+/-) or Differential Incremental Encoder A. | I |
| 24 | ENC 1 DATA- | ENC 1 A- | | I |
| 25 | ENC 1 CLOCK+ | ENC 1 B+ | Differential Clock Line for Absolute Encoders (BiSS: MA+/-) or Differential Incremental Encoder B. | I |
| 26 | ENC 1 CLOCK- | ENC 1 B- | | I |
| 27 | ENC 1 REF MARK+ | ENC 1 I+ | Differential Reference Mark for Absolute Encoders (Leave open for BiSS and EnDat 2.2)<br>or<br>Differential Incremental Encoder Index. | I |
| 28 | ENC 1 REF MARK- | ENC 1 I- | | I |
| 29 | RESERVED | RESERVED | Reserved. | - |
| 30 | RESERVED | RESERVED | Reserved. | - |

| | |
|---|---|
| **Connector Information** | 30-pin, 1.0mm spaced dual row vertical header |
| **Mating Connector Details** | Molex: 5011893010 |
| **Mating Connector Included** | No |



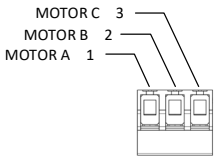
| P5 - Power Connector | | | |
|---|---|---|---|
| Pin | Name | Description / Notes | I/O |
| 1 | HV | DC Supply Input. Applications with a supply voltage higher than 30VDC require a minimum external decoupling capacitance of 470µF / 100V added across HV and POWER GND. | I |
| 2 | POWER GND | Ground. | GND |

| | |
|---|---|
| **Connector Information** | 2-port 3.5mm spaced vertical entry screw terminal |
| **Mating Connector Details** | N/A |
| **Mating Connector Included** | N/A |




| P6 – Motor Power Connector | | | |
|---|---|---|---|
| Pin | Name | Description / Notes | I/O |
| 1 | MOTOR A | Motor Phase A. | O |
| 2 | MOTOR B | Motor Phase B. | O |
| 3 | MOTOR C | Motor Phase C. | O |

| | |
|---|---|
| **Connector Information** | 3-port 3.5mm spaced vertical entry screw terminal |
| **Mating Connector Details** | N/A |
| **Mating Connector Included** | N/A |



## BOARD CONFIGURATION

### Status LED Functions

| LED | Description |
|---|---|
| STAT | Indicates drive power bridge status. GREEN when DC bus power is applied and the drive is enabled. RED when the drive is in a fault state. |
| LOGIC PWR | Indicates that logic power is available to the drive. GREEN when logic power is available. |

### Communication Status LED Functions

| LED | Description | |
|---|---|---|
| LINK/ACT IN/OUT | Green – On | Valid Link - No Activity |
| | Green – Flickering | Valid Link - Network Activity |
| | Off | Invalid Link |
| ETHERCAT STATUS | Green – On | The device is in the state OPERATIONAL |
| | Green – Blinking (2.5Hz – 200ms on and 200ms off) | The device is in the state PRE-OPERATIONAL |
| | Green – Single Flash (200ms flash followed by 1000ms off) | The device is in state SAFE-OPERATIONAL |
| | Green – Flickering (10Hz – 50ms on and 50ms off) | The device is booting and has not yet entered the INIT state<br>or<br>The device is in state BOOTSTRAP<br>or<br>Firmware download operation in progress |
| | Off | The device is in state INIT |
| ERROR | Red – On | A PDI Watchdog timeout has occurred.<br>Example: Application controller is not responding anymore. |
| | Red – Blinking (2.5Hz – 200ms on and 200ms off) | General Configuration Error.<br>Example: State change commanded by master is impossible due to register or object settings. |
| | Red – Flickering (10Hz – 50ms on and 50ms off) | Booting Error was detected. INIT state reached, but parameter "Change" in the AL status register is set to 0x01:change/error<br>Example: Checksum Error in Flash Memory. |
| | Red – Single Flash (200ms flash followed by 1000ms off) | The slave device application has changed the EtherCAT state autonomously: Parameter "Change" in the AL status register is set to 0x01:change/error.<br>Example: Synchronization error; device enters SAFE-OPERATIONAL automatically |
| | Red – Double Flash (Two 200ms flashes separated by 200ms off, followed by 1000ms off) | An application Watchdog timeout has occurred.<br>Example: Sync Manager Watchdog timeout. |

### Address Selection

The drive Station Alias is set via the EtherCAT network or with the setup software. Note that drives on an EtherCAT network will be given an address automatically based on proximity to the host.

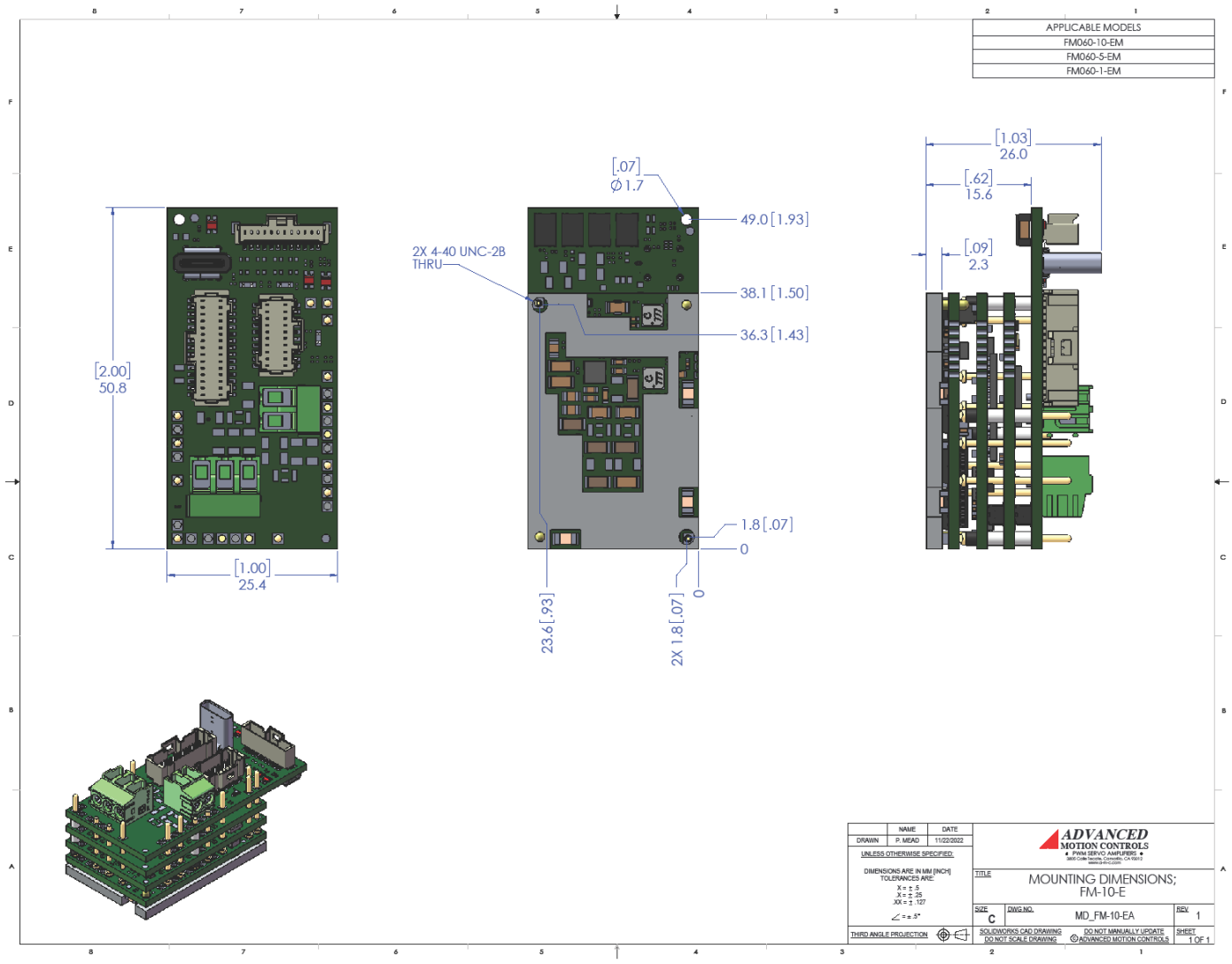
### Safe Torque Off (STO) Inputs

The Safe Torque Off (STO) inputs are dedicated +5VDC sinking single-ended inputs. For applications not using STO functionality, disabling of the STO feature is required for proper drive operation. STO may be disabled by following the STO Disable wiring instructions as given in the hardware installation manual.

### Mating Connector Kit

Mating connector housing and crimp contacts can be ordered as a kit using *ADVANCED* Motion Controls' part number KC-MC1XFM01. This includes mating connector housing and crimp style contacts for the Communication, I/O and Logic, and Feedback connectors. The recommended tool for crimping the contacts is Molex PN: 63819-1500 (not included with the kit). Pre-crimped leads (Molex PN: 797581018) are also available for purchase from many inline component vendors.

## MOUNTING DIMENSIONS



## PART NUMBERING AND CUSTOMIZATION INFORMATION

F M 060 – 1 – E M

**Drive Series**
- **F** FlexPro®

**Environment**
- **X** EXtended Environment

**Form Factor**
- **E** FlexPro® Embedded
- **D** FlexPro® E (W/ Development board)
- **M** FlexPro® Machine Mount

**Maximum DC Bus Voltage**
- **060** 60 VDC
- **100** 100 VDC

**Feedback**
- **M** Multi Encoder (BiSS, 5V Incremental)

**Network Communication**
- **E** EtherCAT
- **C** CANopen
- **R** RS485/232
- **IP** Ethernet/IP

**Continuous Current**
- **1** 1A
- **5** 5A
- **10** 10A
- **25** 25A
- **50** 50A
- **60C** 60A (continuous only, no peak)
- **100** 100A

*ADVANCED* Motion Controls also has the capability to promptly develop and deliver specified products for OEMs with volume requests. Our Applications and Engineering Departments will work closely with your design team through all stages of development in order to provide the best servo drive solution for your system. Equipped with on-site manufacturing for quick-turn customs capabilities, *ADVANCED* Motion Controls utilizes our years of engineering and manufacturing expertise to decrease your costs and time-to-market while increasing system quality and reliability.

### Examples of Customized Products

- Optimized Footprint
- Private Label Software
- OEM Specified Connectors
- No Outer Case
- Increased Current Resolution
- Increased Temperature Range
- Custom Control Interface
- Integrated System I/O
- Tailored Project File
- Silkscreen Branding
- Optimized Base Plate
- Increased Current Limits
- Increased Voltage Range
- Conformal Coating
- Multi-Axis Configurations
- Reduced Profile Size and Weight

Feel free to contact us for further information and details!

### Available Accessories

*ADVANCED* Motion Controls offers a variety of accessories designed to facilitate drive integration into a servo system. Visit www.a-m-c.com to see which accessories will assist with your application design and implementation.