MSTEP-3

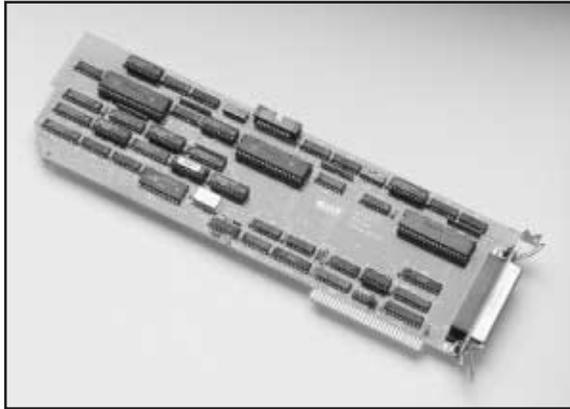**3-Axis, High-Speed ISA-Bus
Stepper Motor Controller**

Functional Description

Keithley's MSTEP-3 is a plug-in, 3-axis, stepper motor controller board for ISA-bus compatible PCs. Each independent stepper channel consists of a Sil-Walker PPMC-103C intelligent controller chip capable of executing a variety of motion control commands. The PPMC-103C contributes greatly to the boards simplicity of use. Keithley driver software further enhances the ease of stepper motor control by personal computer.

Once a command is loaded into the PPMC-103C controller chip, the host computer is no longer burdened by the execution of the particular motion but may monitor its status as needed. The associated stepper motor may be moved any number of steps up to 24 bits of resolution (0 to 16,777,215 steps) either with a controlled acceleration/deceleration profile or constant stepping rate. Associated with each motor are 5 limit switch inputs as well as a motor-enable input. The limit switches provide normal and emergency stop limits at both ends of travel, plus a home or reference point at any intermediate point. A normal stop is defined as a normal deceleration to rest without loss of the step count due to inertial effects. An emergency stop is a sudden stop that may lead to run on of the motor and hence loss of location from the step count. This would normally require recalibration by return to the reference or home point. The emergency stop amounts to an immediate cessation of step pulses regardless of what the motor is doing at the time. In addition to controlling the number of steps travelled by the motor (normal motion), the board executes the following commands:

Initialization	Determines initial parameters for each axis.
Move Normal	Moves the motor the desired number of steps with a controlled rate of acceleration/deceleration.
Move Constant	Rotates motor at constant speed for a specified number of steps.
Find Limit	Rotates motor to an outer limit switch.
Find High-Speed Limit	Rotates motor to a high-speed or inner-limit switch.
Find Base Point	Rotates motor to home or reference-limit switch.
Read Status	Read PPMC-103C controller status.
Decelerating Stop	Stops motor normally.
Emergency Stop	Instantly stops motor by removing drive pulses (may lead to loss of true location from step count).
Single Step	Single step or "jog" command.

All connections necessary for operation with Keithley accessories are made through the rear plate using a standard 50-pin connector. Keithley offers as options a stepper-motor driver (M3-DRIVE), a compatible power supply (M3-PWR-24), a popular type of stepper motor (STEP-MOT1), and a screw-terminal adapter (STA-50) that allows the MSTEP-3 to be connected to drivers other than the M3-DRIVE.

FEATURES

- **3-axis stepper control**
- **3, 4, or 5 phase motors**
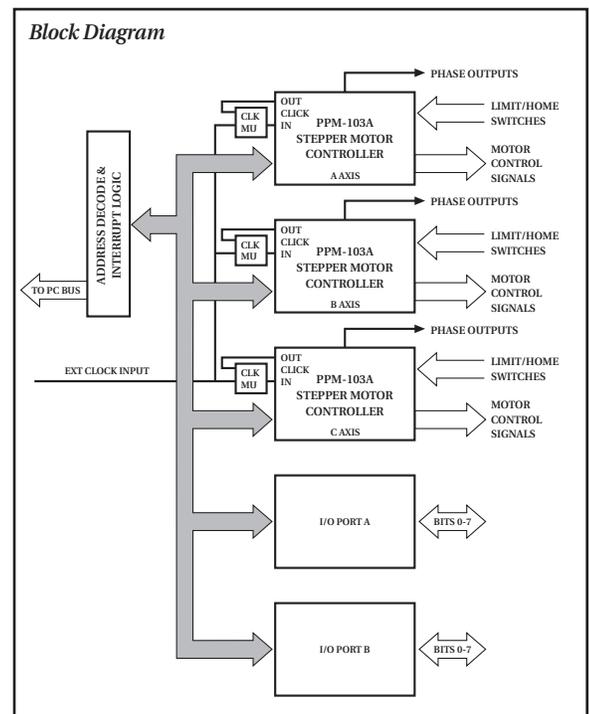- **Up to 16,666 pulses per second**
- **Software included**
- **Two 8-bit I/O ports**

APPLICATIONS

- **X-Y table control**
- **High-speed motor control**
- **Robotics**
- **Mechanical positioning control**

Block Diagram

MSTEP-3

Each stepper channel provides two different types of outputs. One is a counter-clockwise/clockwise (Direction) signal plus a pulse-train output corresponding to the number of steps to be moved. This is suitable for driving the M3-DRIVE as well as a wide variety of standard stepper motor translators available from most stepper motor manufacturers. The other set of signals consists of 5-phase outputs used to drive power transistors to switch the stepper motor windings directly. The 5 phase signals interface via the P2 connector on the top edge of the board. The number of outputs enabled and the stepping sequence are controlled by the initialization command and can be matched to 3-, 4-, or 5-phase motors.

The M3-DRIVE sets up quickly to drive most small to medium size (i.e., 1–2A/phase) stepper motors directly. This is a bipolar-chopper type of driver which provides better efficiency and often better torque at high speeds than R/L drives. If you desire to interface with an R/L driver, the necessary signals are accessible on the MSTEP-3 either through connector J1 at the rear of the card or connector P2 on the top edge of the card.

The step rate is controlled by the clock frequency. The PPMC-103C chip has an internal clock of 25kHz. This clock has a programmable divider that can divide it by any number in the range of 13–255 (20–255 if not in turbo mode) giving corresponding step rates from 98 to 1923pps. This range is often adequate, but you also have the option of selecting an external clock. There are two possible sources for this external clock. One is an onboard 800kHz crystal controlled clock, and the other is a user supplied clock. Whichever source is selected is in turn passed through an 8254 clock divider before being fed to the PPMC-103C. The division ratio for the 8254 must be selected so that with the chosen clock source, the input to the PPMC-103C is less than 267kHz. This allows step rates as high as 16,666pps or as slow as 1 per 20 seconds.

Software

The accompanying utility software simplifies the use of the MSTEP-3 and saves a lot of programming time. The standard Call Mode Driver is designed to be used from Interpreted Basic, Compiled Basic, or QuickBASIC. The Calls are a collection of functions accessed from your BASIC program through a single-line CALL statement. The various modes of the call routine select all of the functions of the board, format and error check data and perform frequently used sequences of instructions.

Example Program

A comprehensive demonstration program is provided. This is excellent both as a programming example and a way of getting the "feel" of the PPMC motion commands and driver software features.

PCF-M3

The PCF-M3 software package provides functionality similar to the BASIC drivers, but provides the calls for Pascal, C, and FORTRAN languages. The PCF-M3 also includes the assembly source code for the driver. Please refer to Keithley's website to order this software package.

Accessories

Several accessories for the MSTEP-3 are available.

M3-DRIVE. This is a power driver which, with the addition of a power supply such as the M3-PWR-24, allows the MSTEP-3 to control a stepper motor requiring from 1 to 2 Amps per phase. Screw terminals allow easy connections to M3-PWR-24, the motor, and limit or home switches, as well as one of the two general purpose I/O ports of the MSTEP-3. Up to three M3-DRIVEs can be connected to each MSTEP-3. The MSTEP-3 is connected to the axis A M3-DRIVE, the Axis A unit is connected to the Axis B unit, and the Axis B unit to the Axis C unit. The M3-DRIVE is built upon the Superior Electric 230-TH stepper motor drive module. The 230-TH is a stepper driver capable of driving a four-phase stepper motor with

Configuration Guide

MSTEP-3

M3-DRIVE,
M3-PWR-24/115
and STEP-MOT1
Accessories
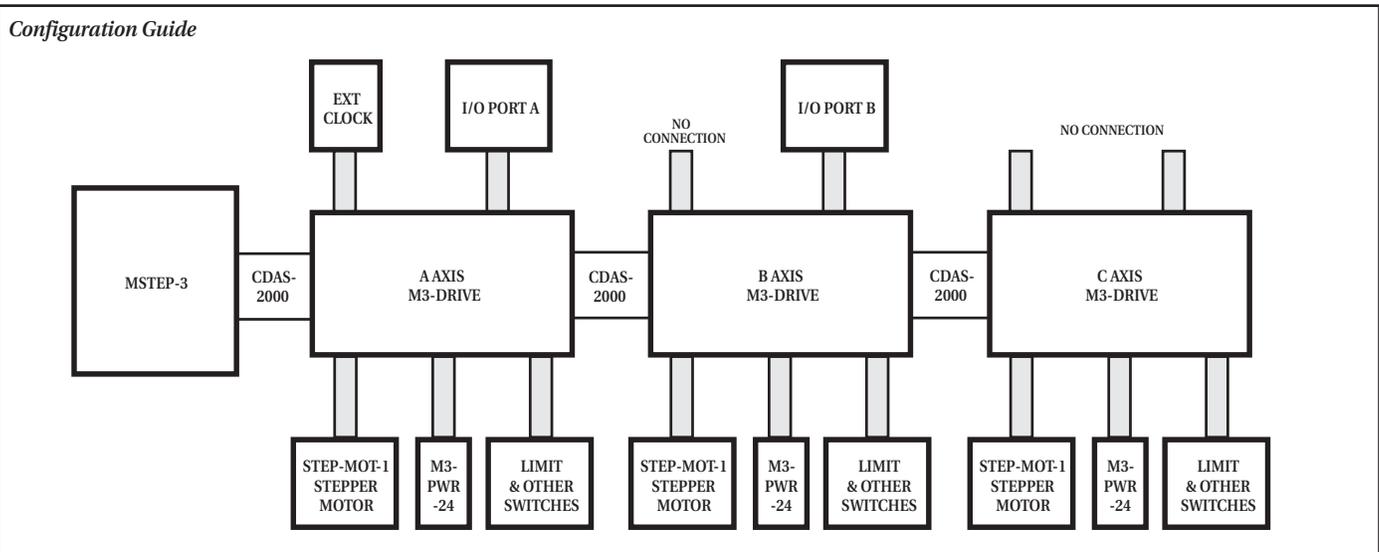
winding currents ranging from 1 to 2 Amps per phase. It accepts the pulse and direction inputs from the MSTEP-3 to produce either full (200 steps per revolution) or half (400 steps per revolution) step motion from the motor.

M3-PWR-24. The M3-PWR-24 supply is capable of powering one M3-DRIVE connected to a 1-to-2-per-phase motor.

Other power supplies can be used. Note that when a phase is turned off, the 230-TH dumps the energy from the motor's collapsing magnetic field back into the power supply. The power supply should therefore have a sufficiently large output capacitor to absorb this charge and prevent damaging voltage spikes. The M3-DRIVE includes a 4700µF, 50V capacitor to meet this requirement (this is important when powering the unit from a regulated power supply, since regulated supplies often have very little output capacitance). An isolation diode in the M3-DRIVE allows several M3-DRIVEs to use a common power supply.

CDAS-2000. This cable connects the Axis A M3-DRIVE to the MSTEP-3, or the Axis B M3-DRIVE to the Axis A output, or the Axis C M3-DRIVE to the Axis B output.

STA-50. This is a screw terminal accessory recommended if the M3-DRIVE is not being used.

STEP-MOT1. The STEP-MOT1 is a stepper motor compatible with the MSTEP-3 and the M3-DRIVE.

SPECIFICATIONS

STEPPER CHANNELS: 3 (individually programmable).
MAXIMUM STEP COUNT: 16,777,215.
MAXIMUM STEP RATE: 16,666pps.
ACCELERATION/DECELERATION: Automatic trapezoidal ramping, programmable start, run & ramping rates.
LIMIT SWITCH INPUTS: 5 per channel (Stop & Emergency Stop in both directions and base point) active low or high, open collector, TTL or mechanical switch to ground.
TRANSLATOR DRIVE: CCW/CW and 20µs pulse.
PHASE DRIVES: TTL compatible signals for 3, 4 or 5 phase motor windings.
PHASE DRIVE LOGIC POLARITY: Programmable.
PHASE DRIVE SEQUENCE: Programmable full or half step
POWER CHOPPING AT STANDSTILL: Programmable (reduces motor heating).
LOGIC OUTPUTS: All outputs TTL compatible.
0.4V max output low voltage.
2.4V min output high voltage.
PHASE DRIVE: 7.8mA sink current @ 0.4V.
–7.8mA source current @ 4.3V.
PULSE, DIRECTION: 31.2mA sink current at 0.4V.
–31.2mA source current at 4.3V.
LOGIC INPUTS: All inputs TTL/CMOS compatible.
0.8V max input low voltage.
2.0V min input high voltage.
PULLUPS: All inputs have internal 10k pullups to +5V.

POWER REQUIREMENTS
+5V: 385mA typ., 500mA max.
+12V: Not used.

ENVIRONMENTAL
OPERATING TEMP RANGE: 0 to 50°C.
STORAGE TEMP RANGE: –20 to 70°C.
HUMIDITY: 95% non-condensing.
WEIGHT: 8oz (230g).
DIMENSIONS: 13.3in L × 4.25in H × 0.75in (33.8cm × 10.8cm × 1.9cm).

SPECIFICATIONS M3-DRIVE
MAXIMUM MOTOR VOLTAGE: 36V.
MAXIMUM WINDING CURRENT: 2A.
DRIVER TYPE: Bipolar chopping.
MAXIMUM STEP RATE: 10,000 steps per second, depending on motor and load.

SPECIFICATIONS STEP-MOT1

ELECTRICAL
NOMINAL DC VOLTS: 5.0V.
WINDING RESISTANCE: 5.0Ω at 25°C.
RATED CURRENT: 1.0A per winding.
WINDING INDUCTANCE: 0.4mH.
WINDING TYPE: 4-phase, 6-lead unipolar.
TIME FOR SINGLE STEP: 2.5ms with 24VDC drive.

MECHANICAL
STEP ANGLE: 1.8 degrees full step (200 steps per revolution).
ANGLE ACCURACY: 5%.
HOLDING TORQUE: 53oz–in min (2 windings energized).
RESIDUAL TORQUE: 1.25oz–in min.
ROTOR INERTIA: 0.04lb–in².
TORQUE/INERTIA RATIO: 32,000 typ.
SHAFT DIAMETER: 0.25 inch.
RADIAL LOAD: 15lb max.
AXIAL LOAD: 25lb max.
WEIGHT: 20oz.

ORDER	DESCRIPTION
MSTEP-3	Three Axis, High Speed Stepper Controller with software on 3.5 inch disks
OPTIONS	
M3-DRIVE	Power driver for MSTEP-3
M3-PWR-24/115	Power supply for M3-DRIVE (24VDC out, 115VAC in)
M3-PWR-24/230	Power supply for M3-DRIVE (24VDC out, 230VAC in)
STEP-MOT1	Stepper motor
STA-50	Screw terminal accessory board
CDAS-2000	Interconnecting Cable (2ft)
PCF-M3	Pascal, C, FORTRAN drivers for MSTEP-3 (can only be ordered from Keithley's website, www.keithley.com.)
MS-MSTEP-3	Additional Hardware and Software Manual and Basic Software