



USB-SL MZ MEMS CONTROLLER



Last Revised: Dec. 2024

USER GUIDE

Mirrorcle Technologies, Inc.

Table of Contents

- Overview and Features
- Control & Connections of the Controller
- Various Ways of Control
- Terminal Commands
- Controller Cable Connections
- Connector Pinouts
- Embedded MEMS Driver
- The Development Kit

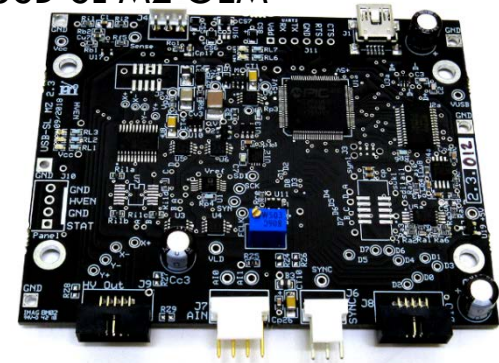
USB MEMS Controller – “USB-SL MZ”

- ❑ Mirrorcle-designed MEMS Controller with a fast Microchip PIC32MZ MCU
- ❑ Its main function is to interface with Mirrorcle software applications or user software based on Mirrorcle software APIs, receive and store prepared waveforms in a buffer, and run/output those waveforms in open loop mode to drive a MEMS Mirror or a Scan Module, and to optionally trigger or sync with peripherals.
- ❑ Compatible with Mirrorcle Software Suite 11.0 and newer
- ❑ Powered and controlled by USB, <750mW power consumption
- ❑ Digital Output connector with 8 digital outputs correlated with MEMS output
- ❑ Available as OEM Controller (provided as a PCBA with no housing or cables)

P/N: USB-SL MZ



P/N: USB-SL MZ OEM



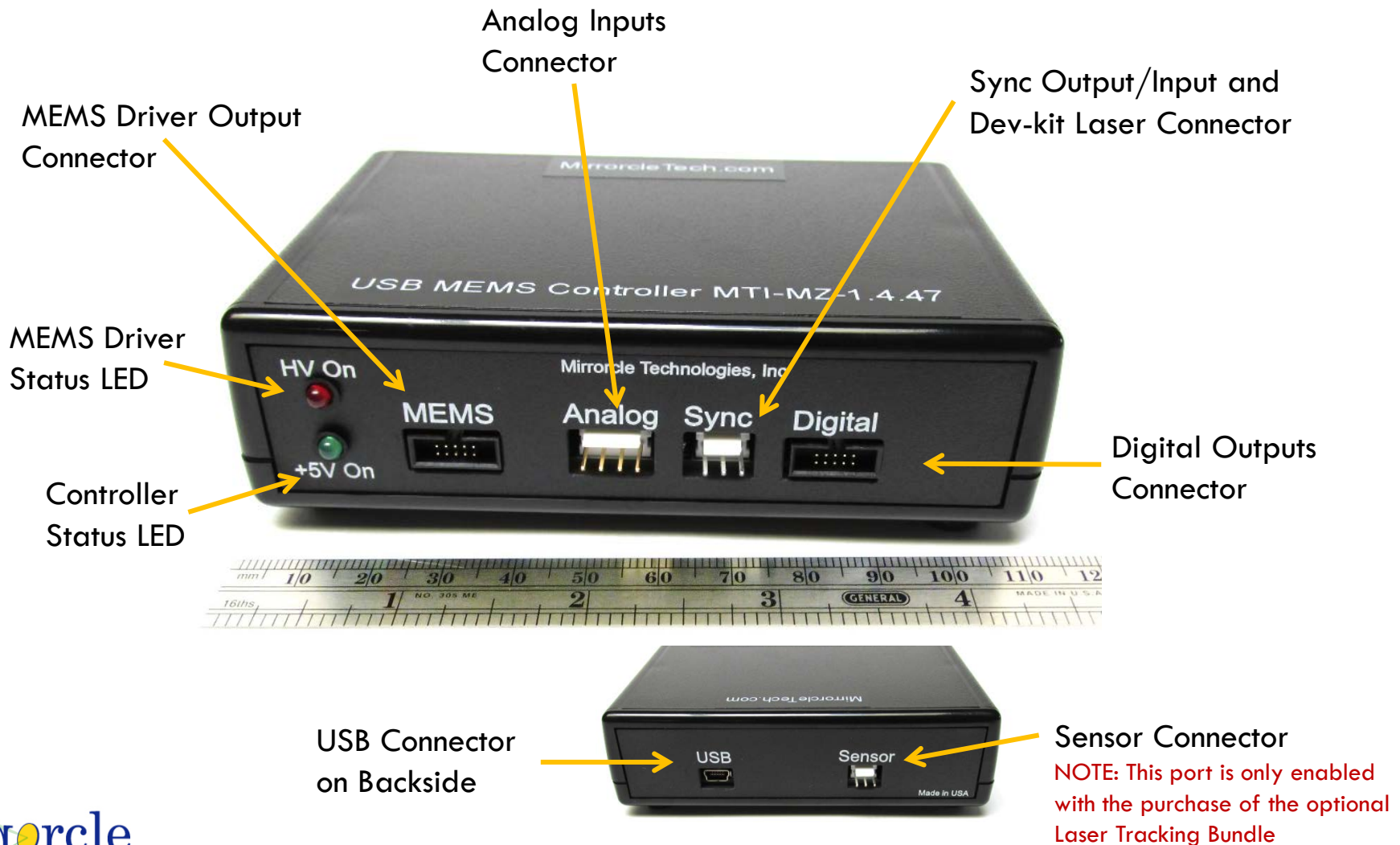
Boxed Dimensions: Approx. 80mm x 115mm x 30mm
Weight: Approx. 140g

OEM Dimensions: Approx.
87mm x 69mm x 20mm

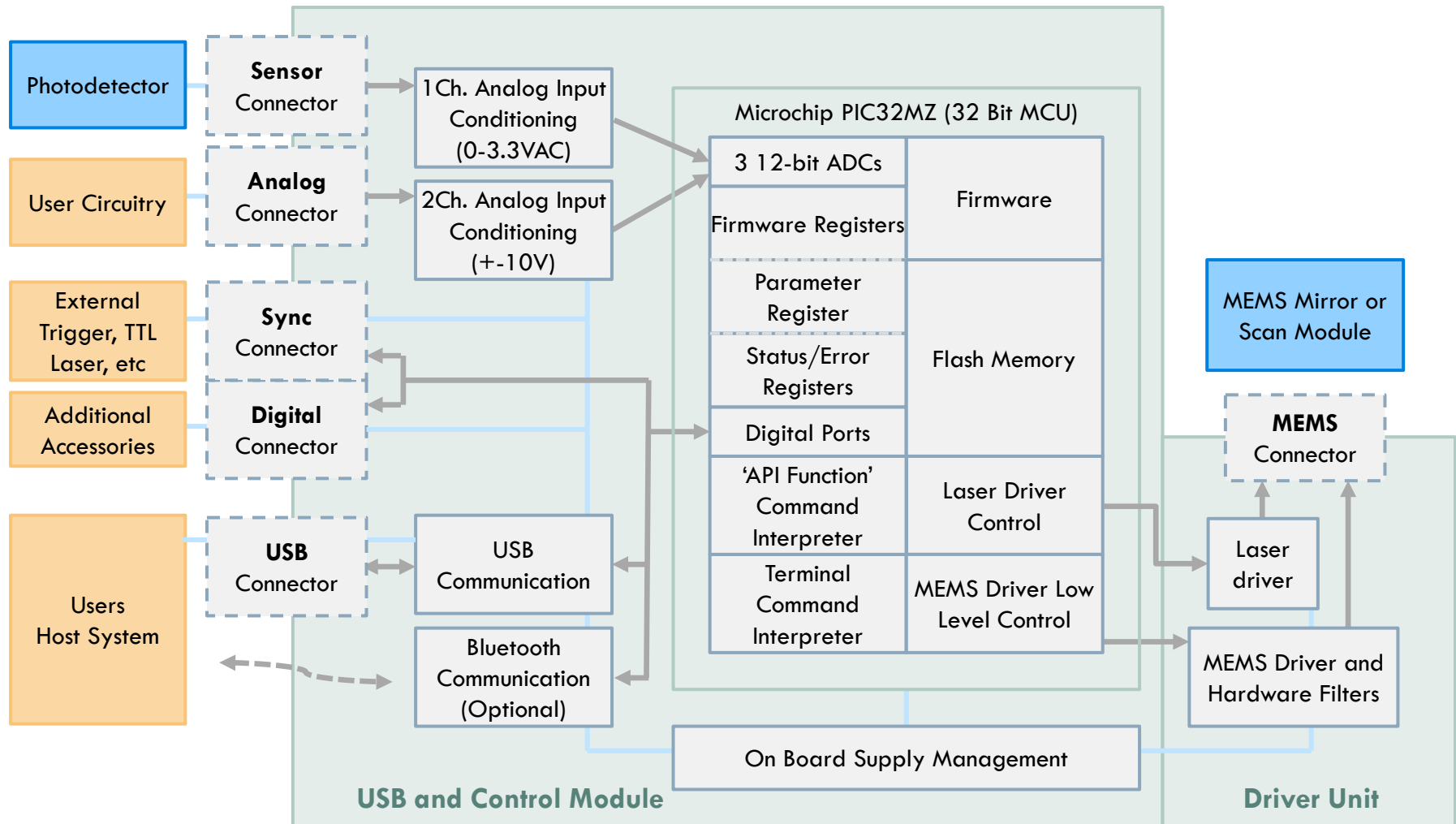
Features

- ❑ 4x (16-bit) Analog Outputs for X and Y axis control of MEMS mirrors
- ❑ Programmable hardware-based low-pass filters and protection circuitry to reduce the chances of device damage
 - ❑ Output bandwidth from 50Hz to 50kHz (governed by programmable filters)
- ❑ 8x Correlated Digital Outputs (3.3V) for controlling other components or systems
- ❑ Sample Rates up to 100,000 samples per second (100 kSPS)
- ❑ 500kB of Onboard RAM allows up to 100,000 samples to be stored
- ❑ 2x (12-bit) Analog Inputs with +/- 10V input range
- ❑ Flash Memory allows storage of settings and data for stand-alone operation (no PC)
- ❑ Sync Port for synchronization with additional Controllers or driving of laser peripherals
- ❑ USB Plug and Play support
- ❑ Separate analog input port for a laser tracking photosensor (with laser tracking bundle purchase)
- ❑ Wireless option (Add-On purchase) allows battery-run wireless operation over Bluetooth 16 bit outputs for X and Y axis control

Status LEDs & Connections

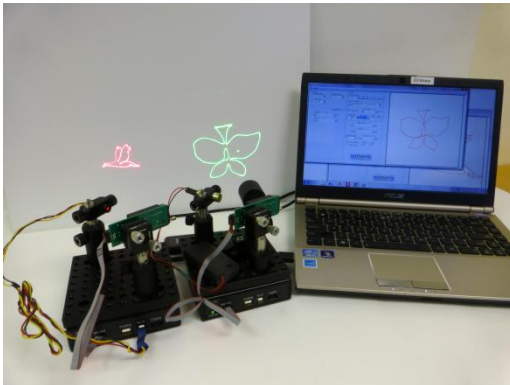
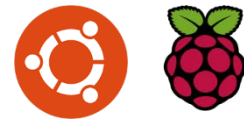


Block Diagram



Multi-Platform Compatibility

- Several ways of communicating with the USB-SL MZ Controller are available, whether by USB interface or by Bluetooth interface with a PC or an Android or Linux device.



USB-SL MZ - Various Ways to Control

APIs in several languages



- Comprehensive APIs for generation of content (MEMS positions and correlated digital outputs), for control and streaming of the content, reading of analog inputs, synchronization with additional Controllers or peripherals, tracking, etc.
 - C++ SDK (Windows and Linux)
 - LabVIEW and Matlab SDKs
 - Python SDK (with Add-On purchase)
 - Java (Android) SDK (with Add-On purchase)
- Easy-to-use GUI and Console Applications such as MirrorcleDraw, MirrorcleLinearRaster, MirrorcleTrack, for various platforms (previous slide)

Serial Terminal Commands

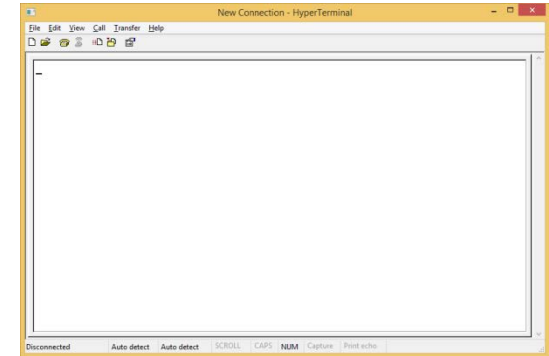
- Serial port terminal commands are available for more basic MEMS mirror control without the use of the Windows, Android, Linux APIs.

USB Supply, Status LEDs & Wireless Option

- Please Note that the power supply (+5VDC) and fast communication is handled via the USB interface. To ensure proper operation, use the provided USB cable directly plugged into the PC instead of a USB hub (too long or not conforming cables could cause malfunction).
- Ensure proper USB or battery power supply. The USB voltage level has to be in spec (at least 4.7 V). If a USB port or a battery does not provide adequate supply, the Mirrorcle MEMS Controller card may respond to software commands but may not fully enable the MEMS Driver.
- The green status LED will light up after approx. 4 seconds when the device is ready. It will flash during communication. The red LED indicates the enabled MEMS output on Controller.
- With the optional Wireless Add-On, Bluetooth is used to communicate with the Mirrorcle MEMS Controller with almost all Android devices by using the powerful Android SDK. When used in wireless mode, power should be supplied to the USB input port from either a computer's USB port or a 5VDC battery.
- For communicating with SoCs e.g. Arduino or Raspberry Pi, its possible to change the USRAT/Bluetooth interface baudrate of the processor between 115200 and 921600 Baud.

How to use Terminal Mode

- Please consider this mode is dedicated for experienced users only.
- Install Terminal Application (e.g. HyperTerminal, PuTTY)
- Connect the terminal application to the proper COM port.
- Enable/unlock the UART/terminal mode by entering '\$MTI\$'.
- Switch on displaying your commands (ECHO) by 'MTI+EO\n\r'.
- Ensure proper hardware settings from their representative datasheets with 'MTI+SetVbias 70\n\r', 'MTI+SetVdifferenceMax 100\n\r', and 'MTI+SetHardwareFilterBw 300\n\r'.
- Enable the MEMS Mirror driver with 'MTI+EnableDevice\n\r'.
- Manipulate the output by steering the mirror: 'MTI+GotoDevicePosition 0.45 -1.00 255\n\r'.
- Before quitting the terminal application, disable the MEMS driver by 'MTI+DisableDevice\n\r' and exit/lock the terminal/UART mode by the 'MTI+Exit\n\r' command.
- Please note that there are also short commands available.
- Type MTI+? For a complete list of available terminal commands.



Terminal Communication Table

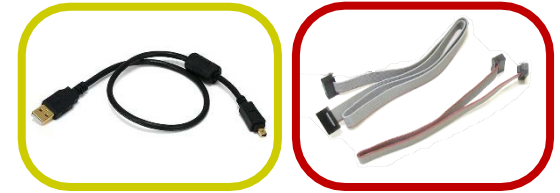
Prefix	Command	Suffix (Return)	Short Command	Description	Reply	Reply Suffix	Example Terminal Input
	\$MTI\$	\n or \r		Enter Terminal Command Mode	MTI-Device [name] Ready in command mode	\n	\$MTI\$\n
MTI+	Exit	\n or \r	EX	Exit Terminal Command Mode	MTI-Device Exit command mode	\n	MTI+EX\n
MTI+	EnableDevice	\n or \r	EN	Enable MEMS Driver	MTI-OK	\n	MTI+EN\n
MTI+	DisableDevice	\n or \r	DI	Disable MEMS Driver	MTI-OK	\n	MTI+DI\n
MTI+	EnableDigitalOutput	\n or \r	ED	Enable Digital Output	MTI-OK	\n	MTI+ED\n
MTI+	DisableDigitalOutput	\n or \r	DD	Disable Digital Output	MTI-OK	\n	MTI+DD\n
MTI+	EnableModulation	\n or \r	EM	Enable Modulation for PD measurement	MTI-OK	\n	MTI+EM\n
MTI+	DisableModulation	\n or \r	DM	Enable Modulation for PD measurement	MTI-OK	\n	MTI+DM\n
MTI+	GoToDevicePosition	\n or \r	GT	Mirror XY Position and Digital output M, Send 3 values: float float byte	MTI-OK	\n	MTI+GT 0.5 -.22 13\n
MTI+	GetAnalogInputValue	\n or \r	GA	Replies with AI0 and AI1 values as floats, samples of both analog input channels	MTI-AI0:float AI1:float	\n	MTI+GA\n
MTI+	GetPhotoDetectorValue	\n or \r	PD	Not implemented in this Controller	MTI-AI0:float	\n	MTI+PD\n
MTI+	EchoOn	\n or \r	EO	Echo mode on (displays keyboard input)	MTI-OK	\n	MTI+EO\n
MTI+	EchoOff	\n or \r	EF	Echo mode off	MTI-OK	\n	MTI+EF\n
MTI+	DisableConfirm	\n or \r	DC	Disable confirm reply after commands (only MTI-OK)	MTI-OK	\n	MTI+DC\n
MTI+	EnableConfirm	\n or \r	EC	Enable confirm reply after commands	MTI-OK	\n	MTI+EC\n
MTI+	SetVdifferenceMax	\n or \r	VD	Sets Maximum Voltage Difference, number between 0-200	MTI-OK	\n	MTI+VD 80\n
MTI+	SetHardwareFilterBw	\n or \r	BW	Set Hardware Filter, number between 50-50000	MTI-OK	\n	MTI+BW 200\n
MTI+	SetVbias	\n or \r	VB	Set Bias Voltage, number between 0-100	MTI-OK	\n	MTI+VB 70\n
MTI+	SetSyncMode	\n or \r	SM	Set SyncMode, number between 0-6	MTI-OK	\n	MTI+SM 2\n
MTI+	GetDeviceParams	\n or \r	GP	Get device parameters	MTI-[list of device parameters]	\n	MTI+GP\n
MTI+	Help	\n or \r	?	Lists all terminal commands	MTI-[list of all commands]	\n	MTI+?\n
				Description	Error Replies		
				Previous command was invalid	MTI-ERR InvalidCommand		
				Previous send data was invalid	MTI-ERR InvalidCommandData		

*Please note: MTI-OK reply can be disabled by DisableConfirm command

Controller Cable Connections

Controller sales typically include:

- One high quality shielded USB-A to Mini-B 2.0 cable with a ferrite core filter
- One 12" long 10-pin 1.27mm pitch ribbon cable for MEMS output
 - Digikey P/N: SAM8219-ND (12" version)
 - The controller is designed and tuned for MEMS Mirror driving only by this cable type, with a maximum length of 12".
 - Any longer cable starts to degrade MEMS driver output signals.
 - In some cases, Mirrorcle can provide an engineering service in modifying the controller to drive a special customer cable.
- One 6" long 10-pin 1.27mm pitch ribbon cable for Digital output
 - Digikey P/N: SAM8218-ND (6" version)



Analog, Sync, and Sensor Port cables are not included. Those ports mate with following connectors based on their 0.1" pitch – alternatively jumper wires (1568-1513-ND) e.g. can be used:

- Analog Input Connector
 - Header Digikey P/N: A106219-ND
 - Mating Socket Digikey P/N: A30988-ND
- Synchronization & Sensor Connectors
 - Header Digikey P/N: A19451-ND
 - Mating Socket Digikey P/N: A30987-ND

Analog Inputs Connector Pinout



- 2x Analog Input Channels
 - Voltage Range: -10 V to +10 V
 - ADC Resolution: 12-Bit
 - AI0, AI1 Input Impedance is approx. 36k Ω
 - Sample Rate: up to 100ksps (API sample rate setting)
 - Optional: +3.3V output on Pin 1 can supply some simple external circuits - pin is usually left open / floating when not in use

Analog Connector: 4 - Pin Header		
J7-Pin	Name	Description
1	+3.3V	+3.3V Output , limited to 25mA (Do not input 3.3V. Output Pin for Optional Customer Use)
2	AI0	Analog Input Channel 0
3	AI1	Analog Input Channel 1
4	Gnd	Ground



Header Digikey P/N: A106219-ND

Mating Socket Digikey P/N: A30988-ND

Synchronization Connector Pinout



- The Synchronization port controls accessories e.g. Laser, Camera, etc.
 - ▣ **The SYNC pin is compatible with 3.3V CMOS and TTL Voltage levels**
 - ▣ Sync -pin can be set via software as an output to provide start trigger or sample clock, or to copy digital output DOut0.
 - ▣ Sync-pin can be set via software as an input to receive external sample clock, frame trigger, or start trigger.
 - ▣ The SYNC pin is limited to sourcing / sinking 3mA of current – depending on it's operating mode of output or input.
- The default setting for this pin is a direct copy of DOut0.
- Optional: +3.3V output on Pin 1 can supply some simple external circuits - pin is usually left open / floating when not in use

Sync Connector: 3 - Pin Header		
J6-Pin	Name	Description
1	+3.3V	+3.3VDC Output, 70mA (Do not input 3.3V. Output Pin for Optional Customer Use)
2	SYNC	Pin Function set with MTISync Parameter
3	Gnd	Ground



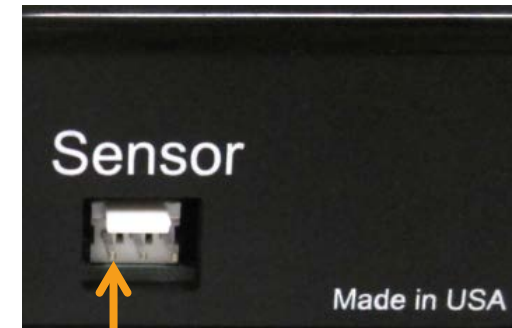
Header Digikey P/N: A19451-ND

Mating Socket Digikey P/N: A30987-ND

Sensor Connector Pinout



- This port is only enabled with the purchase of the Laser Tracking Bundle.
- The Sensor port powers the tracking bundle photosensor.
- The middle pin receives analog voltage from the [Mirrorcle \(Tracking\) Photosensor](#) which is amplified in the Controller before being processed by the MCU.
- This port's middle pin should receive [AC-coupled signals](#), and has a bandwidth of 1kHz up to 100kHz, to filter out ambient light in a room.
- AI2 Input Impedance is approx. infinite, capacitively coupled input.



Sync Connector: 3 - Pin Header		
J6-Pin	Name	Description
1	+5VDC	+5VDC Output (Do not input 5V. Output Pin for Optional Customer Use)
2	AI2	Tracking Sensor Input
3	Gnd	Ground

Header Digikey P/N: A19451-ND

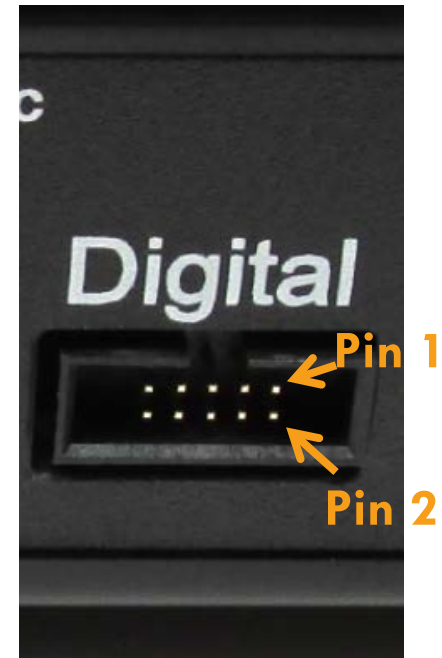
Mating Socket Digikey P/N: A30987-ND

Digital Output Connector Pinout



- The Digital Output connector has 8 digital outputs that are synchronous with the MEMS Driver sample output. The digital lines are typically used to trigger accessories like cameras, lasers, etc., at specified times within a certain waveform).
 - Pins DOut0 – DOut7 can source 3mA of current per channel, 3.3V CMOS
- Each waveform data sample includes X, Y, and M. M is the byte (0-255) that sets the digital outputs DOut0 through DOut7

DOut Connector: 10 - Pin Header		
J8-Pin	Name	Description
1	+3.3V	+3.3V Output, limited to 25mA* (Do not input 3.3V. Output Pin for Optional Customer Use)
2	GND	Ground
3	DOut0	Digital Output Pin DOut0
4	DOut1	Digital Output Pin DOut1
5	DOut2	Digital Output Pin DOut2
6	DOut3	Digital Output Pin DOut3
7	DOut4	Digital Output Pin DOut4
8	DOut5	Digital Output Pin DOut5
9	DOut6	Digital Output Pin DOut6
10	DOut7	Digital Output Pin DOut7



Header Digikey P/N: 1175-1628-ND

Mating Cable Digikey P/N: SAM8219-ND

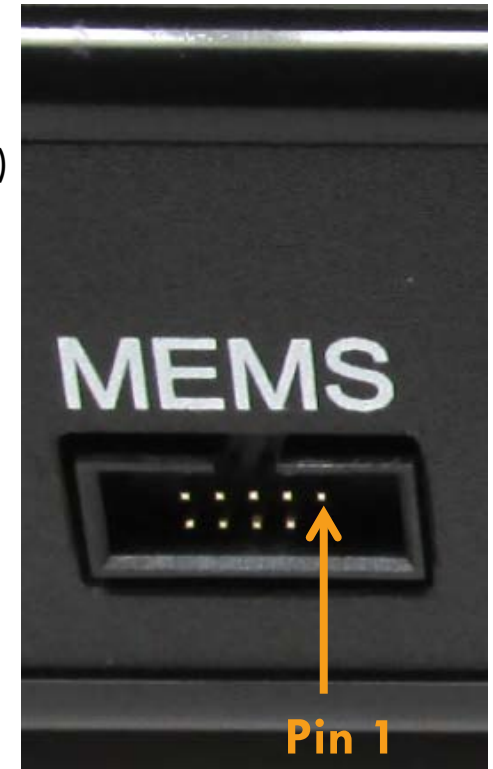
*Optional: +3.3V output on Pin 1 can supply some simple external circuits - pin is usually left open / floating when not in use

MEMS Output Connector Pinout



- 4x High Voltage Analog Output Channels
 - Voltage Range: 0V to 200V
 - DAC Resolution: 16-Bit
 - Sample Rate: up to 100ksps (API sample rate setting)
 - Do not probe header for MEMS output voltages, it can cause shorts and damage the driver. (see later pages, Breakout PCBA)

MEMS Connector: 10-Pin Header		
J5-Pin	Name	Description
1	HV_A (X+)	MEMS Channel X+
2	GND	Ground
3	HV_B (X-)	MEMS Channel X-
4	GND	Ground
5	HV_C (Y-)	MEMS Channel Y-
6	GND	Ground
7	HV_D (Y+)	MEMS Channel Y+
8	GND	Ground
9	LD+	Laser Diode (Anode)*
10	LD-	Laser Diode (Cathode)*



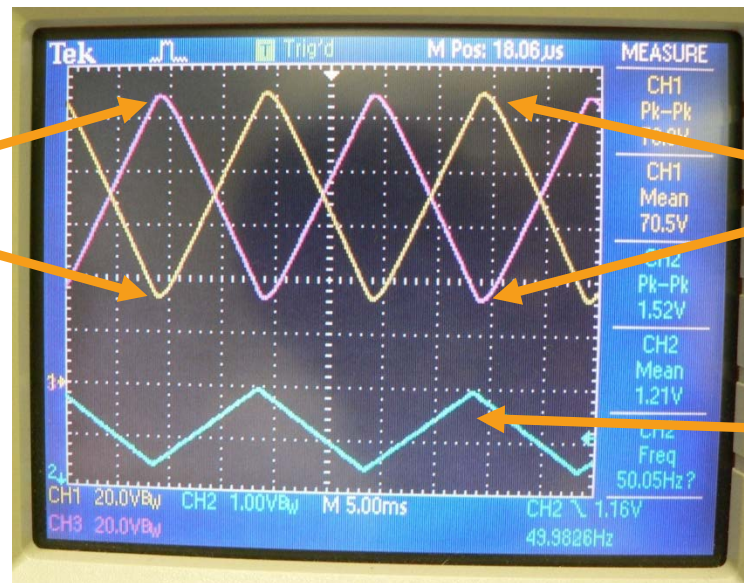
Header Digikey P/N: 1175-1628-ND

Mating Cable Digikey P/N: SAM8219-ND

Embedded MEMS Driver

- Embedded, sophisticated MEMS driver generates biased differential quad (BDQ) channel high voltage control signals
- Driver Bandwidth is governed by hardware filters set in software – settings from 50Hz to 50kHz are accepted.
- Output Voltage Range (each channel): 0V - 200V
- BDQ driving provides linearization and smooth driving of MEMS mirrors over all four quadrants (bi-directional on both axes).
- See [Application Note AN017](#) regarding the “BDQ” driving methodology

HV_B is high
HV_A is low
Mirror rotates in
X- direction



HV_A is high
HV_B is low
Mirror rotates in
X+ direction

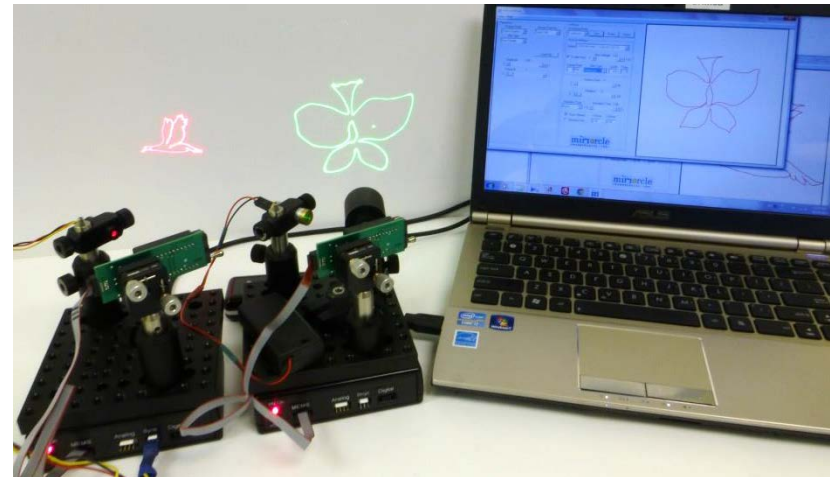
Resulting Mirror
X-axis Tilt

On-board Hardware Filter

- The MEMS Driver portion of the USB-SL MZ MEMS Controller features on-board (hardware) lowpass filters with cutoff frequencies which can be controlled via the Mirrorcle API by the *HardwareFilterBw* device parameter.
 - The LPFs are of switched capacitor type – they re-sample the waveform with a clock (FCLK) = $\text{HardwareFilterBw} * 60$.
- These hardware filters are typically set to a recommended cutoff frequency for easy and safe driving of MEMS Mirrors without concern about angle overshooting and oscillations. The rule of thumb for such safe driving is to set *HardwareFilterBw* at $f_{\text{res}}/2.5$ (based on device resonant frequency).
- The drive signal is therefore sampled twice – by the DAC and by the LPFs.
 - The hardware filter clock (FCLK) is often the lower sampling rate in the final output waveform. This often surprises users when checking waveforms by oscilloscope.
- To reduce any adverse effects of the two sampling clocks mixing, it is often helpful to match $\text{HardwareFilterBw} * 60$ and *SampleRate* as an integer ratio
 - For example, consider a device with 200 Hz recommended LPF cutoff. The corresponding FCLK is $200 * 60 = 12$ kHz. Good sample rate choices would be 24 kHz, 48 kHz, and 96 kHz.

Mirrorcle's Development Kit Enables Fast Setups

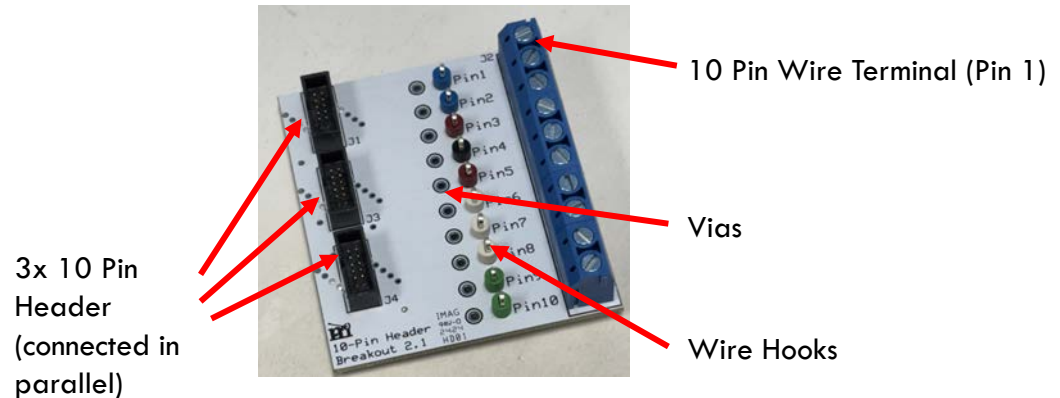
- ❑ Mirrorcle Technologies MEMS Mirror Development Kit allows a user to quickly and efficiently gain familiarity with all aspects of these devices and their various possible uses.
- ❑ It enables safe operation of the devices with specifically developed software and MEMS driver solutions which include several levels of protection for the MEMS devices.
- ❑ Display a variety of vector graphics as well as animations at arbitrary refresh rates.
- ❑ Mirrors can be operated in point-to-point (quasi-static), resonant or hybrid modes.
- ❑ The system is highly adaptable to projection on various surfaces and in a variety of applications.



[https://www.mirrorcletech.com/pdf/Mirrorcle MEMS Mirror Development Kit - Overview.pdf](https://www.mirrorcletech.com/pdf/Mirrorcle%20MEMS%20Mirror%20Development%20Kit%20-%20Overview.pdf)

Development Kits Include a Breakout PCBA

- The breakout PCBA (P/N: BRK-DRIVER-5.x) is offered with a purchase of Development Kit or Mirrorcle MEMS Driver.



- User can connect the breakout board to either MEMS driver output or Digital outputs connectors to monitor both.



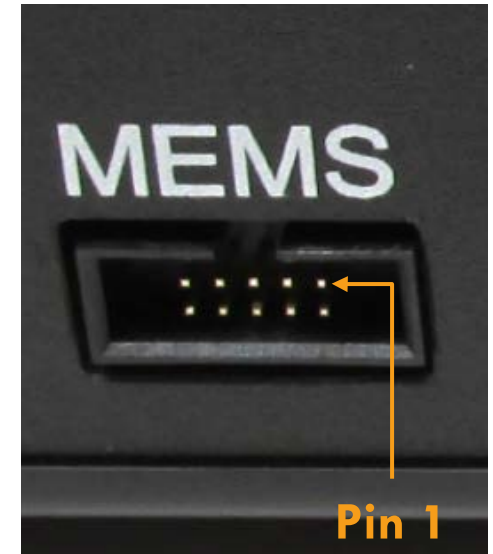
MEMS Output Connector Pinout



- The MEMS connector on the MEMS Controller has 4 high voltage outputs that drive a MEMS Mirror and two low voltage (current) outputs that drive an optional laser diode.
- Users can utilize BRK-DRIVER-5.x PCBA to breakout the 10 pins of the MEMS connector and more easily monitor MEMS driving waveforms in debug/development cases. Recommended setup for testing of new waveforms (by o-scope) before plugging in MEMS Mirror. Connect with 10-pin ribbon cable to J1, J3, or J4.



MEMS Connector: 10-Pin Header		
J5-Pin	Name	Description
1	HV_A (X+)	MEMS Channel X+
2	GND	Ground
3	HV_B (X-)	MEMS Channel X-
4	GND	Ground
5	HV_C (Y-)	MEMS Channel Y-
6	GND	Ground
7	HV_D (Y+)	MEMS Channel Y+
8	GND	Ground
9	LD+	Laser Diode (Anode)
10	LD-	Laser Diode (Cathode)

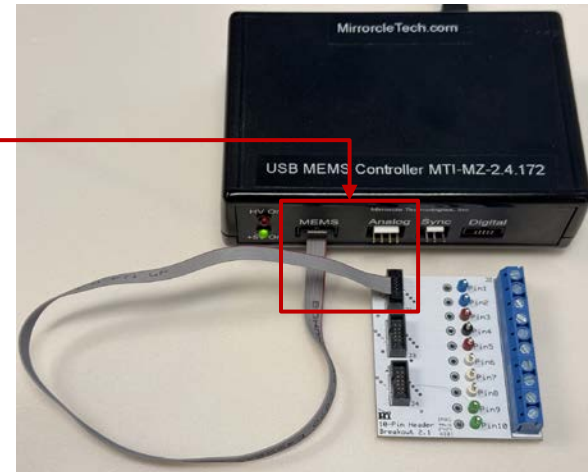


Header Digikey P/N: 1175-1628-ND

Mating Cable Digikey P/N: SAM8219-ND

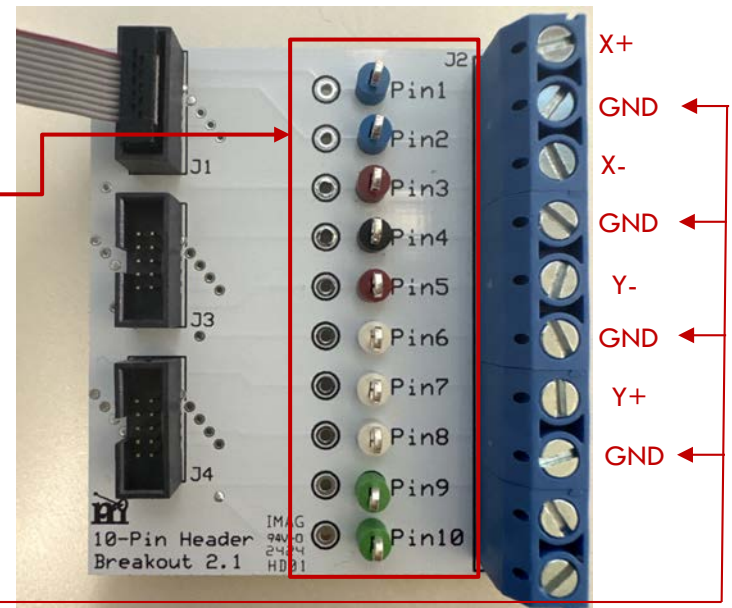
Check MEMS Output (MEMS Not Connected)

- Connect MEMS driver output on controller to one of the 10-pin headers

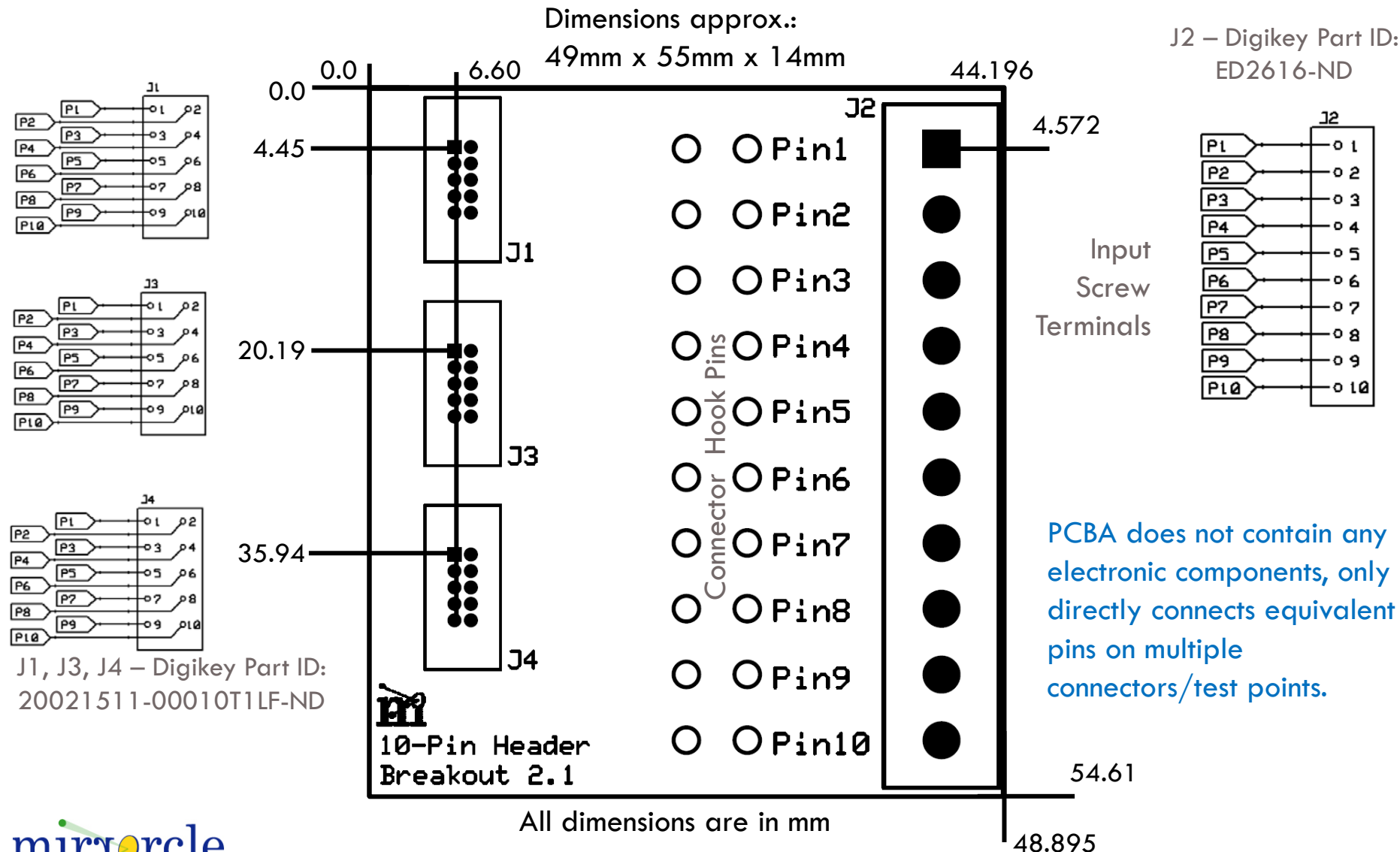


Example:

- Probe Pins 1 and 5 using O-Scope to check X+ and Y- channels waveform
- O-Scope ground can connect to breakout board using pins 2, 4, 6, or 8

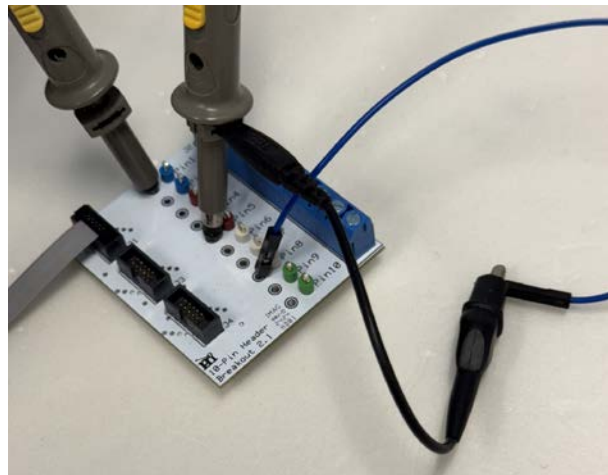
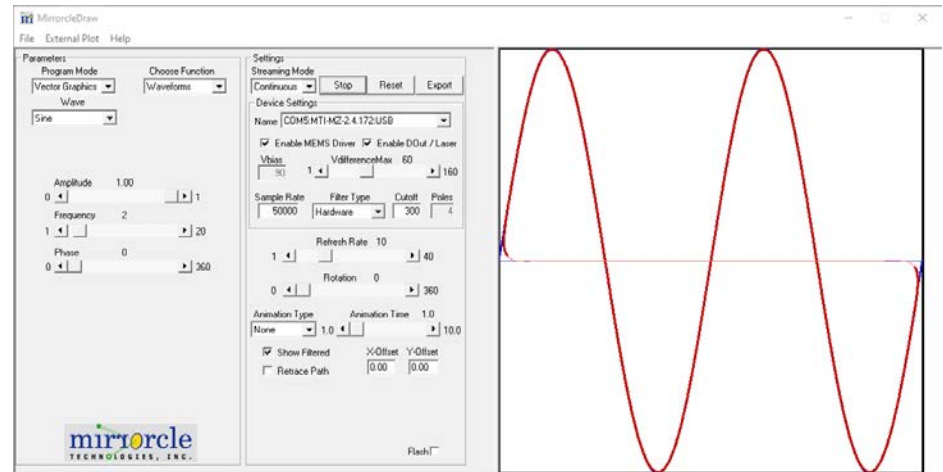


BRK-DRIVER-5.x: Dimensions and Connections

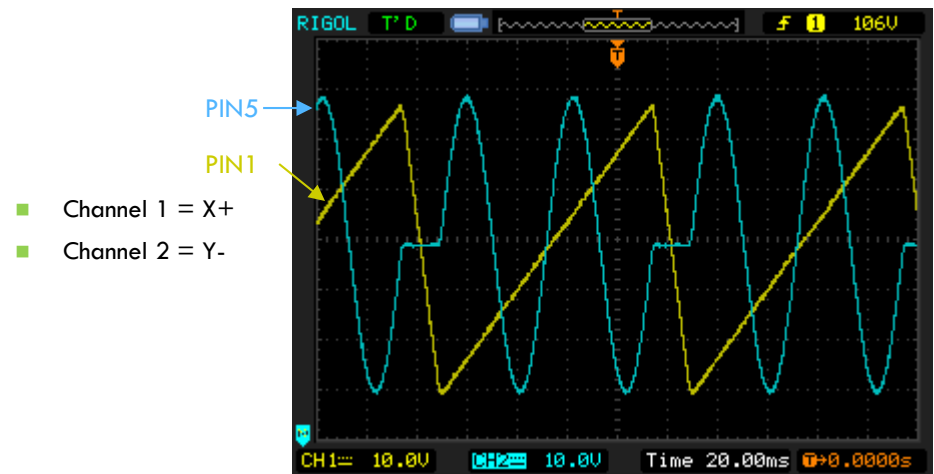


Example of testing MEMS Output (MEMS Not Connected)

- Specification of waveform data that is being sent to the controller.



Breakout board Setup



Oscilloscope waveform data projection

Example of testing MEMS Output (MEMS Connected)

- Connect MEMS driver output on controller and MEMS Mirrors (or Scan Module) to the 10-pin headers
- The MEMS mirror (or Scan Module) will project the data that is being sent to the controller.



- To ensure consistent performance and prevent any potential issues, make sure the ribbon cable length does not exceed 6 inches.
 - For further info on MEMS Controller and Driver output cable length please refer to application note 12:
 - [AN012 - MEMS Controller and Driver Output Cable Length](#)

Thank you for Choosing



That's it! Thank you for reading through this guide.

If you have any further questions or suggestions please email us:

support@mirrorcletech.com