PC not included

TEGAM, INC.
MODEL 9070
MEMS DRIVER SYSTEM

Instruction Manual

P/N 810046-CD
Publication Date: August 2005
REV. B

NOTE: This user's manual was as current as possible when this product was manufactured. However, products are constantly being updated and improved. Because of this, some differences may occur between the descriptions in this manual and the product received. Please refer to www.tegam.com for future updates of this manual.

9070 System Specifications

Refer to equipment instruction manuals for more details.

9070 Basic System Components		
2 - Model 2414A-GS Arbitrary Waveform Generator with GPIB and Sequencer options 1 - Model 2375, four-channel MEMS Driver Amplifier with high voltage cables 1 - 200022 - Super μDriver Software.		
System Configuration		
Number of Channels: Output Signal Connector: Output Signal Monitor: Output Event Signals Splitter Bypass	4 each, High-Voltage Outputs 4 each, BNC-HV Front Panel 4 each, 1 per channel Sync 1 (Front Panel), Sync 3, 4 (Rear Panel) 1 set per Generator ON/OFF Switch (Front Panel)	
Electrical Specifications		
Description Voltage Range Voltage Adjustment Voltage Stability Voltage Tracking Sine Distortion Frequency Range Current Output	**MEMS Driver Amplifier Output** +0 to +170 V peak ±0.1 V ≤ 0.1% per 24 hours 50 mV rms ≤0.1% DC to 5 kHz 20 mA per phase or total of 20 mA	
Note: External current limiting series resistors are recommended to protect MEMS devices.		
Computer Interface		
GPIB: IEEE 488.2-1987		
Programmable Parameters		
Frequency: Controlled by Super μDriver Normal Mode-Sample Clock 20 MS/s max Amplitude: 100% of Specified Range with 0.1% resolution Output: On or Off Waveform: Standard, User-Defined, and Sequence		
Waveform Creation Tools		
Software: Operating System: Computer Requirement: Interface Card:	Super μDriver by Sandia National Labs Windows 95, 98, ME, 2000 Pentium 166 MHz or better with 16 MB RAM space National Instruments® AT_GPIB/TNT Card (or equivalent)	
Environmental		
Operating Temperature: Specified Accuracy: Storage Temperature: Humidity Range:	32°F to 104°F (0°C to +40°C), ambient 73.4°F ± 5.4°F (+23°C ± 3°C) -4°F to 140°F (-20°C to +60°C) 80% RH	
General		
Mains:	100/120/220/240 VAC, +5% -10%; 48 ~ 63 Hz	
	2414A-GS	**2375**
Power Rating: Dimensions (H x W x L): Weight (approximate):	55 VA; 45 W max 4.51" x 10.14" x 11.81" 10 lbs (4.5 kg)	6 VA' 50 W max 4.51" x 10.14" x 11.81" 12 lbs (5.1 kg)
Options & Accessories		
200020A - WaveWorks Pro+ Wave creation software. (Optional) 2301 MEMS Adapter w/ High Voltage Cables 200022 - Super μDriver Software (optional) 740949 - BNC-HV Coaxial Cables CBL-3102 - BNC Output cables 1583-3 – 3 ft. GPIB Cable 1583-6 – 6 ft. GPIB Cable 740532 – Single Unit Rack Mount Kit for 2414A-GS& 2375 NI AT-GPIB/TNT – Plug-and-Play GPIB Interface Card		

Unpacking & Inspection:

Each 9070 MEMS Driver System is put through a series of electrical and mechanical inspections before shipment to the customer. Upon receipt of your system, unpack all of the items from the shipping carton/s and inspect for any damage that may have occurred during transit. Report any damaged items to the shipping agent. Retain and use the original packing material for reshipment if necessary. Upon Receipt, inspect the carton(s) for the following items:

Standard Supplied Items:

1 - Model 9070 User's Manual CD, P/N 810046-CD
1 - Model 2375 Four Channel MEMS Driver Amplifier
    Included Accessories
    1 - CD Users Manual P/N810045-CD
    4 - High Voltage BNC Output Cables P/N 740949
2 – Model 2414A-GS Arbitrary Waveform Generators (AWG) with GPIB and Sequencer Options
    Included Accessories
    1 - CD Users Manual P/N 810008-CD
1 - Sandia National Labs, Super μDriver Software CD, P/N200022 (includes user's manual on CD)

Additional Required Hardware:

1 **-** Computer capable of supporting a GPIB (IEEE 488.2) card and/or RS-232 interface
2 – GPIB Cables for 2414A-GS communications

Optional Items:

1 – WaveWorks Pro+, Wave Creation Software CD, P/N200020A (Includes user's manual on CD)
1 - National Instruments' AT-GPIB/TNT (Plug-and-Play) card with software
1 – MEMS Adapter

Safety Information & Precautions:

The following safety information applies to both operation and service personnel. Safety precautions and warnings may be found throughout this instruction manual and the equipment. These warnings may be in the form of a symbol or a written statement. Below is a summary of these precautions.

Terms in This Manual:
CAUTION statements identify conditions or practices that could result in damage to the equipment or other property.

WARNING statements apply conditions or practices that could result in personal injury or loss of life.

Terms as Marked on Equipment:
CAUTION indicates a personal injury hazard not immediately accessible as one reads the marking, or a hazard to property including the equipment itself.

DANGER indicates a personal injury hazard immediately accessible as one reads the marking.

Symbols
As Marked in This Manual:

	This symbol denotes where precautionary information may be found.

As Marked on the Equipment:

	Attention – Please refer to the instruction manual.
	Danger – High or hazardous Voltage
	Earth Ground Terminal
I	On
O	Off
	Chassis Terminal
	Alternating Current

Grounding the Equipment
These products are grounded through the grounding conductor of the power cords.
WARNING: To avoid electrical shock or other potential safety hazards, plug the power cords into a properly wired receptacle before using this instrument. The proper grounding of this instrument is essential for safety and optimizing instrument operation.

Danger Arising from Loss of Ground
If any connection to ground is lost or compromised, a floating potential could develop in any of the instruments. Under these conditions all accessible parts, including insulating parts such as keypads and buttons could develop a hazardous voltage and put the user at risk.

Use the Proper Fuses
To avoid fire hazard, use only the correct fuse types as specified for the AC power supplies in each of the component's manuals. Please note that the fuse rating for 100/120-volt operation is different than the rating for 200/240-volt operation.

A blown fuse usually indicates a problem with the instrument. Refer fuse replacement to qualified service personnel.

Do Not Use in Explosive Environments
WARNING: The 9070 (or any of its components) is not designed for operation in explosive environments.

Do not Operate Without Covers
WARNING: All components of the 9070 system should be operated with all panels and covers in place. Operation with missing panels or covers could result in personal injury.

Outputs 1~4 of model 2375, have the potential to deliver high voltage and the necessary precautions should be taken. Refer to the 2375 owner's manual for more information.

FOR QUALIFIED SERVICE PERSONNEL ONLY

⚠ Servicing Safety Summary:

Do Not Service Alone
Do not perform service or adjustment on any of these products unless another person, capable of rendering first aid, is present.

Use Care When Servicing with Power On
Dangerous voltages may exist at several points in this product. To avoid personal injury or damage to this equipment, avoid touching exposed connections or components while the power is on. Assure that the power is off when removing panels, soldering, or replacing components.

Power Source
This product is intended to connect to a power source that will not apply more than 252V RMS between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Power & Fuse Settings

⚠

CAUTION: DO NOT POWER ANY OF THE INSTRUMENTS before verifying that the proper supply voltage settings have been made. Line voltage settings for 110 VAC or 220 VAC should be specified at the time of order placement and checked upon receipt of product.

Important Safety Information:

The chassis of the 2375 is grounded. The input & output shields of the 2414A-GS, generators are floating. Use caution when making or breaking connections and NEVER disconnect or make connections while the instruments are powered up.

WARNING: DO NOT MODIFIY any configurations or connections from their original state otherwise safe operation of this equipment may be compromised.

WARNING: Always remember to shut off the power and wait at least 5 minutes before disconnecting or connecting any cables or connections to or from the 9070 system. This warning also applies to any instruments having an electrical connection of any kind to the Model 9070. This includes the signal source, load, and all ground and shield connections. Ignoring this warning could result in electric shock or death.

WARNING: Replace damaged output cables immediately. Otherwise, severe injury or death could result from electric shock.

System Overview

The TEGAM 9070 MEMS Driver System is a fully integrated solution providing accurate control for electrostatic actuator-driven engines. Each application requires unique waveforms and a system to convert these arbitrary waveforms into electrostatic voltages suitable to meet drive requirements.

The TEGAM 9070 MEMS Driver System is an updated equivalent to the former Pragmatic 9014 MEMS Driver System. The TEGAM 9070 meets or exceeds all performance criteria of the former Pragmatic 9014. However, there is one exception. The special connector for the National Instruments AT-AO-10 Analog Output Board has been omitted from the 2375, high voltage amplifier.

A typical 9070 system uses a computer and Sandia's Super μDriver software to define the waveforms needed to satisfy the load and speed requirements. These waveforms are loaded into the memory of two or more arbitrary waveform generators, along with dynamic time sequence information, which describes the time profile of the operating MEMS device. These waveforms are then conditioned and amplified to energize the actuators and obtain the specified motion. The computer provides the facility to start, stop or change the operation of the MEMS device.

Component Installation

It is recommended that each of the accessories be installed and checked sequentially before advancing to the next item. The following process assumes GPIB (IEEE-488.2) installation.

A. National Instruments' AT-GPIB/TNT (Plug-and-Play) card
   1. Take the National Instruments' AT-GPIB/TNT (Plug-and-Play) card and plug it into the available slot.
   2. Next, connect a GPIB cable to each of the TEGAM 2414A-GS AWGs.
   3. Load the software in accordance with the instructions and verify that both TEGAM 2414A-GS AWGs can be accessed and can respond to a few basic commands.

B. Super μDriver Software, or WaveWorks Pro+ (optional)
   1. Install the Super μDriver software into your computer.
   2. Verify functionality by using the Getting Started Manual.
      The two 2414A-GS AWGs have already been connected using the GPIB cables in A.2. above. Using the Driver Name, "TEGAM 2414A," will expedite getting started. Verify the performance of the software as outlined.

C. Install User's Manuals for all System Components
   1. Store the user's manuals for each of the system's components on your PC hard drive for future reference. User's manuals for the following should be saved:
      a. Model 9070, "Instruction Manual"
      b. 2375 Amplifier, "Instruction Manual"
      c. Sandia's Super μDriver "Reference Manual" and "Getting Started" manual.
      d. 2414A-GS "Operation Manual"

This completes component installation and the next step is to properly interconnect all the components to enable operation of the complete system.

System Connection:

Note the ***CAUTIONS*** in the following component installation section.
Component Interconnection

CAUTION

The MEMS Amplifier high voltage OUTPUT is capable of +170 volts dc. The signal is a potential shock hazard and extreme caution must be exercised in the use of this amplifier.

Carefully read Step 5 before proceeding so you can become acquainted with the required precautions in managing the MEMS Amplifier OUTPUT.

1. Interconnection of the computer and the two 2414A-GS AWGs were previously accomplished in the Component Installation section. Both AWGs are connected to the GPIB port of the computer.

2. Front panel sketches of the TEGAM 2414A-GS AWG and the 2375 MEMS Amplifier are shown. The MEMS Amplifier chassis is illustrated with the AWGs.

3. To complete the system interconnections, the two 2414A-GS AWGs must be set up in the MASTER/SLAVE configuration. This requires connecting the Sync Trig Out of the MASTER to the Trig In of the SLAVE and interconnecting the Clock In/Out of both instruments. Other instrument configuration conditions must be met but these are controlled by Super µDriver.

4. Connect the OUTPUT of each 2414A-GS AWG to the appropriate INPUT on the 2375 MEMS Amplifier. The diagram (see figure 2.1) shows the connection using two 2414A-GS AWGs, using Channels 1 and 3 having the Splitter engaged, which rectifies the driver waveforms, and presenting these signals to the proper amplifier channel.

DANGER *CAUTION* DANGER

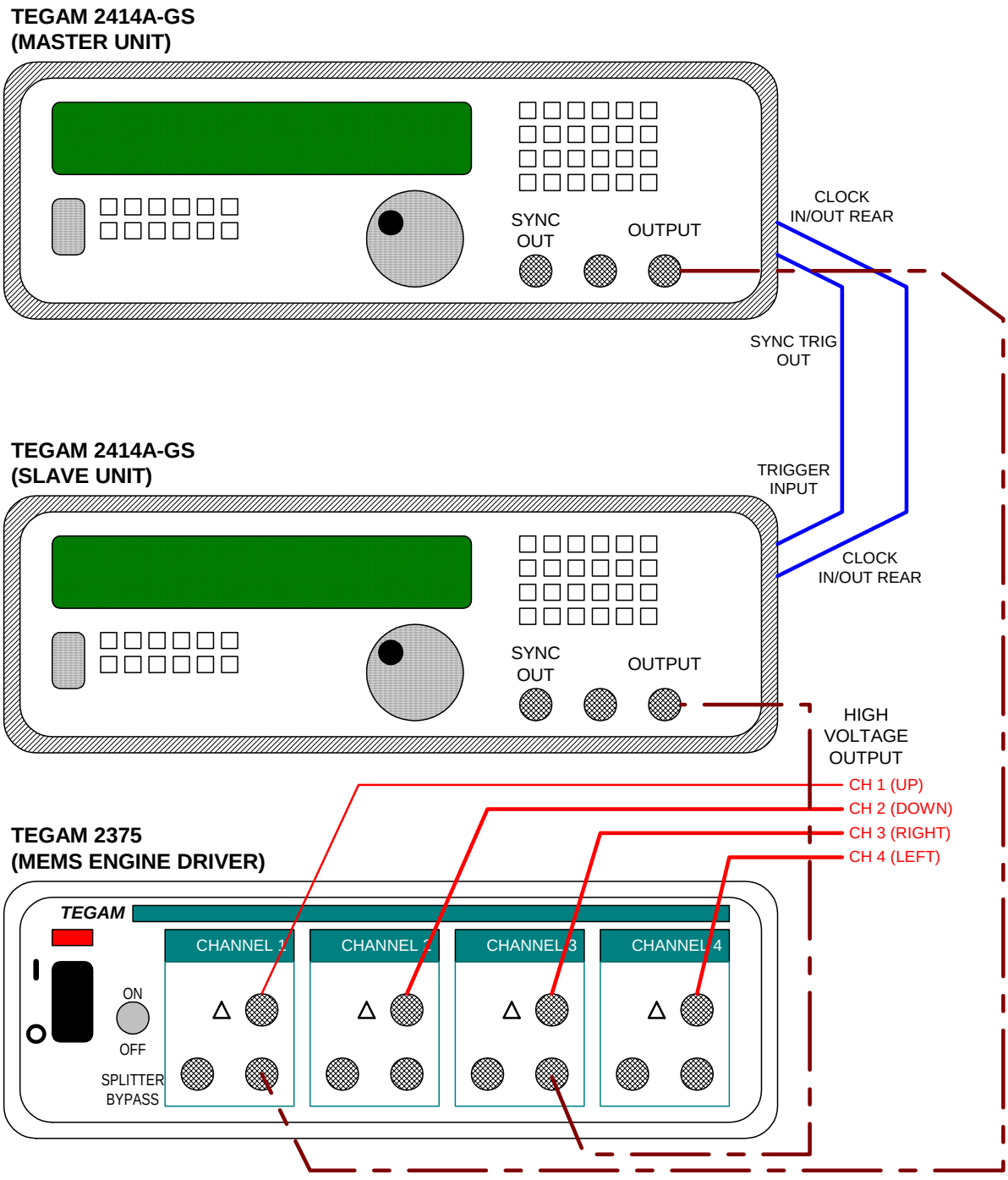
5. ***Caution 1*:** Connecting the amplifier OUTPUT to the load is a step that must be fulfilled with great caution. Signals at the OUTPUT connectors may be as high as +170 volts dc. Furthermore, the output impedance of the amplifier is low and the current limit is set for approximately 20 mA. This combination could be lethal. Therefore, when making these connections, be certain that the amplifier POWER is OFF.

   Caution 2: A second precaution is the use of special high voltage BNC connectors to reduce the shock hazard when handling the associated cables. All connections of the High-Voltage Output should be made before applying power to the amplifier or the load.

   Caution 3: The third precaution that must be observed is to insert a resistor in series with each load in the range of 150 kΩ to 1 MΩ. These resistors should be located as close to the actual load as possible. If multiple loads are connected to a common OUTPUT, each line must have a series resistor to avoid catastrophic failure of the MEMS engine.

DANGER *CAUTION* DANGER

Figure 2.1: 9070 System Connections



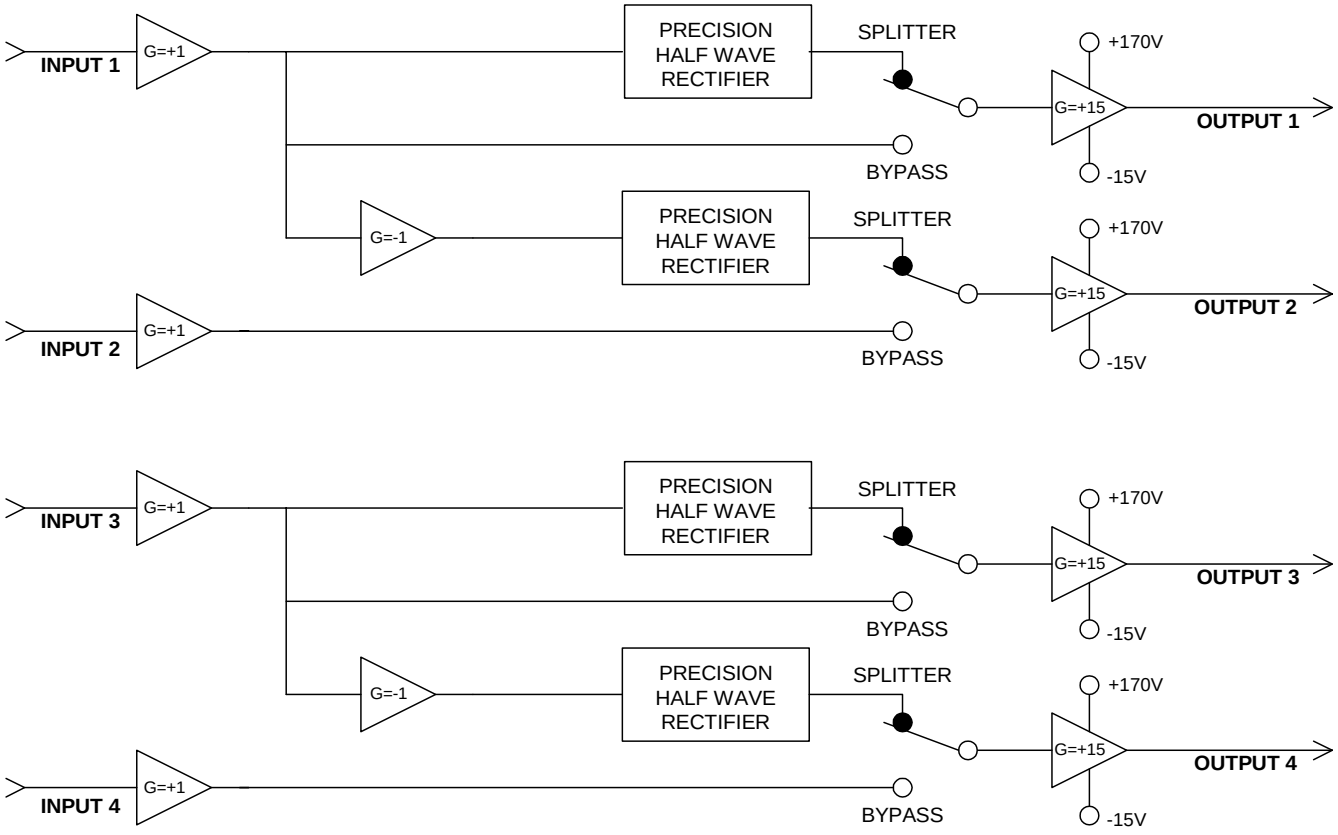
Model 2375 MEMS Amplifier Block Diagram

The overall block diagram of the amplifier shows the inputs, outputs and major elements of this amplifier.

Waveform generation can be obtained by using either two or four TEGAM Instruments' 2414A-GS Arbitrary Waveform Generators.

All TEGAM 2414A-GS AWGs are connected to the front panel using BNC cables.

Figure 2.2: 2375 Functional Diagram



Signal Flow

Normal operation of the amplifier is to have the splitter selected (splitter bypass off). The splitter is a precision rectifier, which takes the negative portions of the drive waveforms and inverts them prior to presenting them to the output amplifiers. The four high-voltage amplifier output signals drive the appropriate actuators of the MEMS engine. For monitoring purposes, four BNC connectors are provided on the front panel, which replicate the high-voltage output waveforms.
The details of the internal signal routing are depicted graphically to understand the effect of the signal switches and the gain controls.

For amplifiers provided with GAIN CONTROLS (optional), the setting of these gains must correspond with the gain values shown in the Amplifier Gain, Gain Settings in the dialog box. Maximum gain available is x15. The Super µDriver software will compute the AWG output signal level required to meet the gain value in this set-up.

Splitter

The splitter is provided to simplify the hardware requirements of the total system.
Super µDriver can create the bi-polar waveforms required to drive the MEMS engine.

However, the actuators require a pair of signals, each moving its respective actuator in either a RIGHT/LEFT direction or UP/DOWN direction. The splitter electrically accomplished this waveform generation.

Alternatively, all four signals could be synthesized using four AWGs and greatly increasing both the complexity and cost of the hardware. However, this configuration would add greater flexibilitiy and capability to the overall system.

High-Voltage Amplifier Output

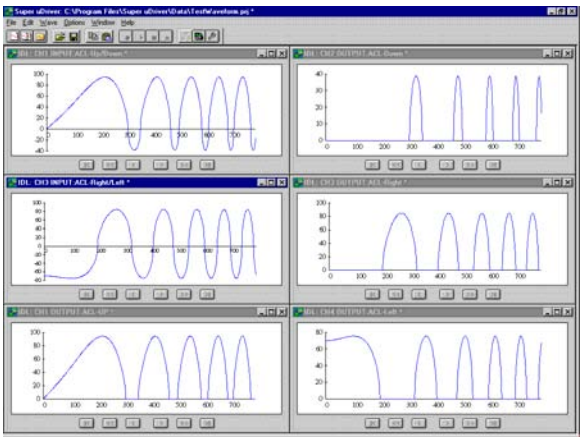
This portion of the system consists of four identical high-voltage amplifiers. Adjustment potentiometers are used to calibrate the gain of each individual channel. All channels are set to a gain of +15. The output voltage at this gain setting is limited to +150 volts maximum with the AWG output limited to +10 volts maximum.
The output impedance is extremely low and the current limit is set to approximately 20 mA. To accommodate driving numerous loads and associated cable capacitance, the output circuit contains no series resistance. However, please note:

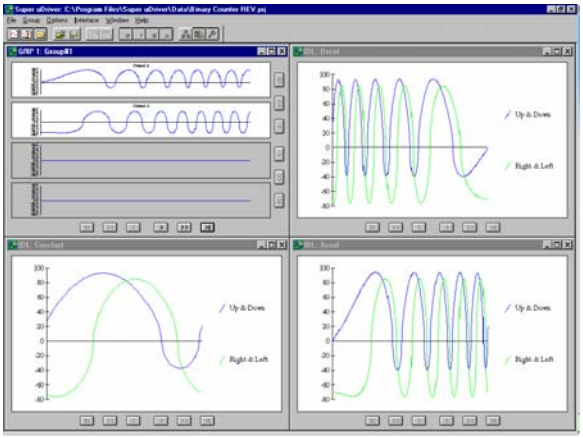
> ***CAUTION – To avoid shock hazard or catastrophic damage to the MEMS engine, it is REQUIRED that a 150 kΩ to 1 MΩ resistor be placed in series with each load. This resistor should be placed as close to the load as practical.***

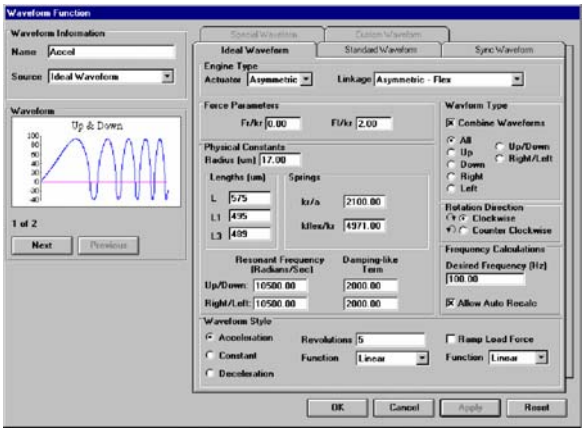
Although this value of resistance is suitable to drive the normal Sandia National Laboratories' MEMS engine, the value may be adjusted for other load characteristics. Examples of the composite waveforms and the individual amplifier waveforms are provided to show actual output signals.

Examples of µDriver Waveforms

Refer to Sandia Super µDriver's "Getting Started" manual for step-by-step software use instructions. TEGAM's Wave Works Pro+, wave creation software may also be used to create or edit custom waveforms.







Warranty:

TEGAM, Inc. warrants this product and its components to be free from defects in material and workmanship for a period of one year from the date of shipment. During this warranty period, if a product proves to be defective, TEGAM Inc., at its option, will either repair the defective product without charge for parts and labor, or exchange any product that proves to be defective.

TEGAM, Inc. warrants the calibration of this product for a period of 6 months from date of shipment. During this period, TEGAM, Inc. will recalibrate any product, which does not conform to the published accuracy specifications.

In order to exercise this warranty, TEGAM, Inc., must be notified of the defective product before the expiration of the warranty period. The customer shall be responsible for packaging and shipping the product to the designated TEGAM service center with shipping charges prepaid. TEGAM Inc. shall pay for the return of the product to the customer if the shipment is to a location within the country in which the TEGAM service center is located. The customer shall be responsible for paying all shipping, duties, taxes, and additional costs if the product is transported to any other locations. Repaired products are warranted for the remaining balance of the original warranty, or 90 days, whichever period is longer.

Warranty Limitations:

The TEGAM, Inc. warranty does not apply to defects resulting from unauthorized modification or misuse of the product or any part. This warranty does not apply to fuses, batteries, or damage to the instrument caused by battery leakage.

Statement of Calibration:

This instrument has been inspected and tested in accordance with specifications published by TEGAM Inc. The accuracy and calibration of this instrument are traceable to the National Institute of Standards and Technology through equipment, which is calibrated at planned intervals by comparison to certified standards maintained in the laboratories of TEGAM Inc.

Contact Information:

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Equipment Maintenance

The cooling fans of the 2375 and 2414A-GS units are designed for continuous operation. Periodically check the fans to make sure that airflow is not impeded and that there is adequate ventilation to keep the instruments cool.

TEGAM recommends that the 9070 be calibrated and routine functional checks be performed on a regular basis. The recommended interval is every twelve months after the initial 6-month calibration. The actual interval is dependent upon the application and is determined by your company's Quality Assurance policy.

Repair Parts

The Model 9070 has no user replaceable parts. See the user's manuals for replacement cables and accessories.

Preparation for Repair or Calibration Service:

Once you have verified that the cause for a 9070 component's malfunction cannot be solved in the field and the need for repair and calibration service arises, contact TEGAM customer service to obtain an RMA, (Returned Material Authorization), number. You can contact TEGAM customer service via the TEGAM website, www.tegam.com or by calling 440.466.6100 (*All Locations*) OR 800.666.1010 (*United States Only*).

The RMA number is unique to your instrument and will help us identify your instrument and to address the particular service request by you which is assigned to that RMA number. Of even greater importance is a detailed written description of the problem that should be attached to the instrument. Many times repair turnaround is unnecessarily delayed due to a lack of repair instructions or of a detailed description of the problem.

This description should include information such as is the problem intermittent?, when is the problem most frequent?, has anything changed since the last time the instrument was used?, Etc. Any detailed information provided to our technicians will assist them in identifying and correcting the problem in the quickest possible manner. Use the form provided on the next page.

Once this information is prepared and sent with the instrument and RMA number to our service department, we will do our part in making sure that you receive the best possible customer serviced and turnaround time possible.

Expedite Repair & Calibration Form

Use this form to provide additional repair information and service instructions. The Completion of this form and including it with your instrument will expedite the processing and repair process.

RMA#:		Instrument Model #:	
Serial Number:		Company:	
Technical Contact:		Phone Number:	
Additional Contact Info:			

Repair Instructions:

☐ Evaluation ☐ Calibration Only ☐ Repair Only ☐ Repair & Calibration ☐ Z540 (Extra Charge)

Detailed Symptoms:

I*nclude information such as measurement range, instrument settings, type of components being tested, is the problem intermittent? When is the problem most frequent?, Has anything changed with the application since the last time the instrument was used?, etc.*

There is no information contained in the Appendix at this time.