- **Complete Set of Software Tools**
- **Precise Signal Generation**
- **0 to 150 V Peak Output Voltage**
- **4 Channel Splitter**
- **Event Trigger Signals**
- **Internal Crystal Oscillator Reference**
- **GPIB Interface**

MEMS Driver System

System Overview

TEGAM's 9070 MEMS Driver System is an accurate, highly stable signal source designed to drive MEMS rotating microengines. This high-voltage, multi-channel, totally integrated system provides the necessary waveforms and instrument controls to drive MEMS devices with maximum reliability. Signal parameter stability is based on the digital synthesis techniques applied throughout the system. Frequency stability is assured by the internal crystal reference. Output frequencies range from dc to 5 kHz (equivalent to 1 to 300,000 RPM), and the waveform fidelity is outstanding.

A typical system consists of Super µDriver Software, two 2414A-GS Waveform™ Generators, and one 2375 MEMS Driver Amplifier providing four flexible output channels. The channels may be operated in pairs using the built-in splitter or individually. The waveform generator may be programmed to output ideal MEMS drive signal, sinewaves, squarewaves, or any arbitrary waveshape. Amplifier gain is fixed at x15 and the signal amplitude is set at the waveform generator.

Remote Programming

All four channels are remotely programmed using IEEE-488.2 (GPIB). Waveforms and drive parameters for each channel may be created and downloaded using Sandia's Super µDriver.™ software. The versatility of the 9070 accomodates complete parameter control. This maintains the flexibility requirement for MEMS microengine development.

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Model 9070 System Connection

System Diagram

The System Connection Diagram illustrates the interconnections between the major components of the system and indicates the functional interrelationships between the components. A typical setup consisting of two waveform generators and one MEMS driver amplifier, although any arrangement of the four channels is permissible, including four waveform generators.

For the application shown, two waveform generators are synchronized to each other. In this case, the frequencies are referenced to the internal crystal of the Master Unit.

The Master sample clock determines the frequency at which the system will operate. This same sample clock is furnished to the Slave unit which guarantees synchronous operation.

Signal Precision

Each of the phase AWGs outputs a high-precision waveform achieved by using 12-bit resolution digital-to-analog converters. A second benefit provided by the AWG is the ability to mathematically compute the phase-shifted waveshape. Using this waveform description, precise control is provided by the 12-bit resolution AWG. Likewise, stability and repeatability is assured because the system is digitally based.

A unique signal splitter circuit is provided to assure system simplicity, signal quality, and proper signal levels at the load.

The high-voltage amplifiers for all channels are similar and the gain is fixed at 15. The output voltage range
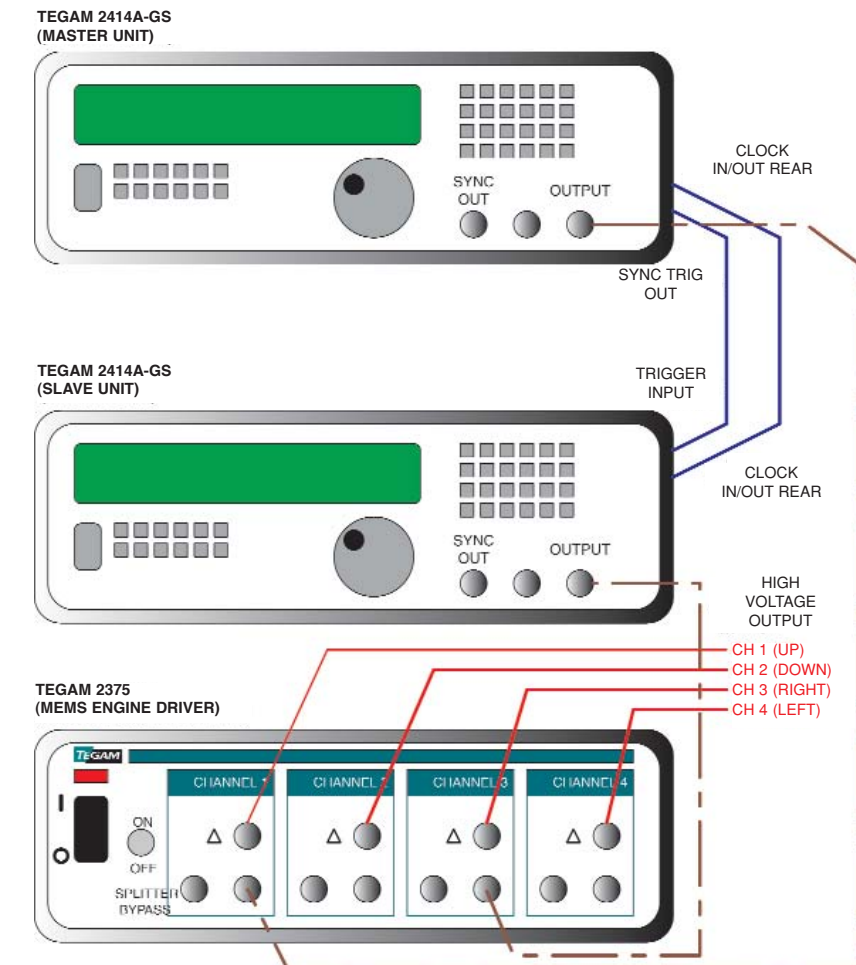
is +0 V peak to +150 V peak. In general, the system provides a total output current of 20 mA. All related components in each of the channels are interchangeable to offer convenient maintenance. The system is compact, flexible, and versatile, and each channel is individually programmed in frequency, amplitude, and waveshape.

System Software

Super µDriver™ was developed by Sandia National Laboratories to control the system and to provide the signals to achieve maximum device reliability. System control for all operating speeds are uniquely computed for every operating condition. TEGAM, Inc. is licensed to distribute this product.
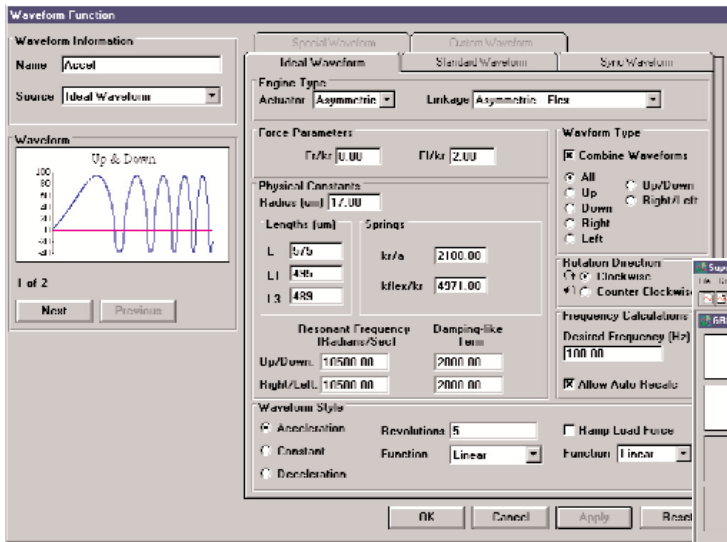

TEGAM 2414A-GS (MASTER UNIT)

SYNC OUT   OUTPUT

CLOCK IN/OUT REAR

SYNC TRIG OUT

TEGAM 2414A-GS (SLAVE UNIT)

TRIGGER INPUT

SYNC OUT   OUTPUT

CLOCK IN/OUT REAR

HIGH VOLTAGE OUTPUT

CH 1 (UP)
CH 2 (DOWN)
CH 3 (RIGHT)
CH 4 (LEFT)

TEGAM 2375 (MEMS ENGINE DRIVER)

CHANNEL 1   CHANNEL 2   CHANNEL 3   CHANNEL 4

ON
OFF
SPLITTER BYPASS

Model 9070 System Control Software - Super µDriver™

Providing the proper parameters in this screen easily creates ideal waveforms for each of the four electrostatic actuators. All dynamic elements of the device are incorporated in the calculation of the waveform.

UP& DOWN and RIGHT & LEFT waveforms are shown including the total waveform profile. Transients are minimized by the acceleration and deceleration signals at the beginning and end of the profile.
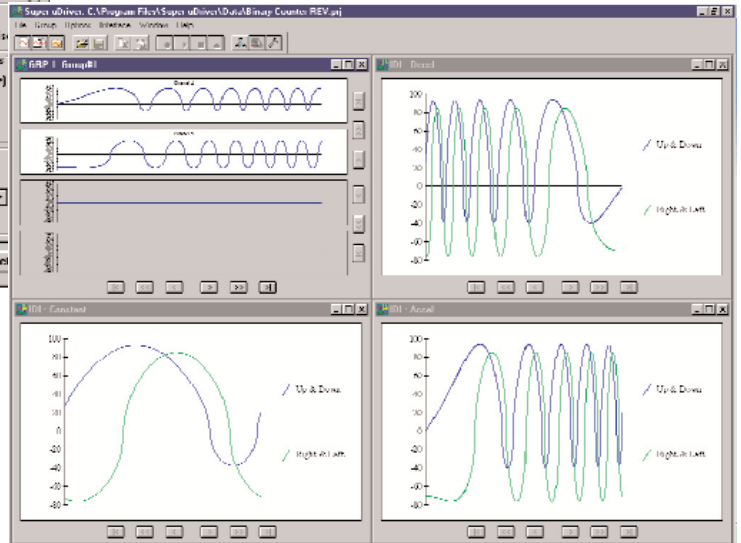
Figure 1: Operational Diagram of Model 2375, High-Voltage Driver Amplifier for MEMS Engines

The 2375 has two modes of operation. These are normal (splitter bypass) mode and splitter mode. The normal mode of operation will amplify each of the inputs (1 ~ 4) with a gain of +15. The splitter mode precision rectifies channels 1 & 3 and the negative going cycles of these channels are inverted and rerouted to channels 2 & 4. The primary drive signal is created by Sandia's Super µDriver™ software and TEGAM model 2414A-GS arbitrary waveform generators. See Figure 1 for details.
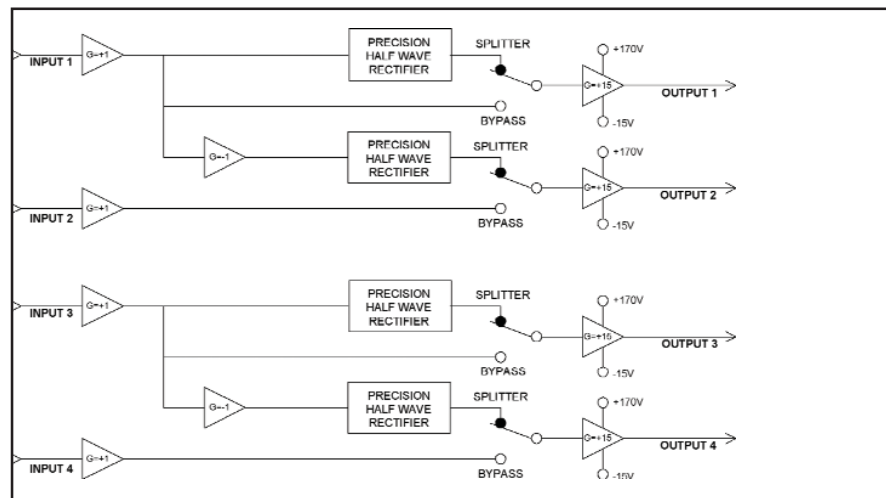
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Specifications

Primary System Components
Model 2414A-GS Arbitrary Waveform Generator with GPIB and programmable sequencer (2 each)
Model 2375 MEMS Driver Amplifier
Super µDriver™ Software by Sandia National Labs
4-BNC-High Voltage Output Cables for 2375
4-BNC-BNC Cables for Arbitrary Waveform Generators

System Configuration

Number of Channels	4 each, High-Voltage Output
Output Signal Connector	4 each, BNC-HVFront Panel
Output Signal Monitor	4 each, 1 per channel
Output Event Signals	Sync 1 (Front Panel), Sync 3, 4 (Rear Panel) 1 set per Generator
Splitter Bypass	ON/OFF Switch (Front Panel)

Electrical Specifications Description   **MEMS DriverAmplifierOutput**

Voltage Range	0 Vto +150 Vpeak
Voltage Adjustment	±0.1 V
Voltage Stability	<0.1 % per 24 hours
Voltage Tracking	50 mV rms
Sine Distortion	< 0.1 %
Frequency Range	DC to 5,000 Hz
Current Output	20 mA per phase

Note: External current limiting series resistors is recommended to protect MEMS devices in actual use.

Computer Interface	GPIB: IEEE 488.2-1987

Programmable Parameters

Frequency	Controlled by Super mDriver™
	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	Super µDriver™
Operating System	Windows 98 or 95
Computer Requirement	Pentium 166 MHz or better with 16 MB RAM space
Interface Card	National Instruments® AT-GPIB/TNT Card (or equivalent)

Environmental

Operating Temperature	0 ºC to +40 ºC, ambient
Specified Accuracy	+23 ºC ±3 ºC
Storage Temperature	-20 ºC to +60 ºC
Humidity Range	80 % RH

General

Mains   100/120/220/240 VAC, +5 % -10 %; 48 ~ 63 Hz

	Waveform Generator (2414A-GS)	MEMS DriverAmplifier (2375)
Power Rating	55 VA; 45 W max	100 VA; 80 W max
Dimensions (H x W x L)	11.5 x 25.8 x 30.0 cm	11.5 x 25.8 x 30.0 cm
	(4.51 in x 10.14 in x 11.81 in)	(4.51 in x 10.14 in x 11.81 in)
Weight (approximate)	4.5 kg (10 lb)	4.5 kg (10 lb)

Included Accessories

Manual	P/N 810046-CD
Arbitrary Waveform Generators (x 2)	P/N 2414A-GS
Mems Amplifier	P/N 2375
Super µDriver Software	P/N 200022
BNC to BNC Cables, 3' (x 4)	P/N CBL-3102

Optional Accessories

MEMS Test Fixture	P/N 2301
WaveWorks™ Pro+ Wave Creation Software	P/N 200020A
Rack Mount Kits for 2414A-GS or 2375	P/N 740532
BNC Cables	P/N CBL-3102
1-Meter GPIB Cables	P/N 1583-3
2-Meter GPIB Cables	P/N 1583-6
Z540 Compliant Calibration with Certificate and Data for 9070	P/N OPT-Z540