

SOPHISTICATED MULTIPLE INSTRUMENT SYNCHRONIZATION

COMPLETE MICROENGINE DRIVER SYSTEMS

COMPLEX SIGNAL SEQUENCING

ROBUST SIGNAL AMPLIFIERS

PRECISION WAVEFORMS



TEST SOLUTIONS FOR MEMS AND NEMS FROM

TEGAM



Testing and driving MEMS and NEMS devices is unique and yet familiar.

The techniques used to drive, exercise, analyze and test MEMS devices for functionality and reliability have been around for years.

At the same time, MEMS and NEMS are much more complicated than traditional IC's. New and more sophisticated instruments with improved accuracies and repeatability are needed to test MEMS devices. Test systems require precision signal and waveform generation, high levels of amplification and sophisticated software control.

With closed loop designs, inputs and outputs from multiple instruments and sources must be accurately synchronized both simultaneously and sequentially. Add to that the need for higher voltage and current levels than those used for traditional IC's, plus the importance of small changes in those parameters and you are facing what appears to be a daunting task when developing test systems for MEMS devices.

Also, we must not forget reliability. Factors that can be ignored in macro scale become important in micro scale. Eliminating a single failure mode in a MEMS device can save months of development time and hundreds of thousands of dollars of unnecessary redesign, fabrication, and test expenses.

WOW! Overwhelming! What's a person to do? First, don't reinvent the wheel. You don't need to design a test stand from the ground up for your MEMS application. Instead, discuss your requirements with a test expert.

For 25 years, TEGAM has been manufacturing high accuracy instrumentation for metrology, calibration and production test. This unique background is ideally suited to understanding MEMS testing issues. We provide off-the-shelf and custom designed instruments, software, and systems that are cost effective and enhance your bottom line.

In this brochure we will discuss signal creation, generation, and amplification in greater detail. We will also address sequence generators and instrument synchronization. These are the critical elements of a MEMS test system.

Whether you need precision waveforms, robust signal amplifiers, complex signal sequencing, sophisticated multiple instrument synchronization or a complete micro-engine driver system, TEGAM has the hardware, software and expertise to solve your MEMS testing challenges. Our experience includes comb-type micro-engines, optical mirror positioning, mass spectrometry, interactive robotic systems, actuators, accelerometers, RF switches and more.

**If you want to get started immediately,
call applications engineering at 1-800-666-1010.**

SIGNAL GENERATION

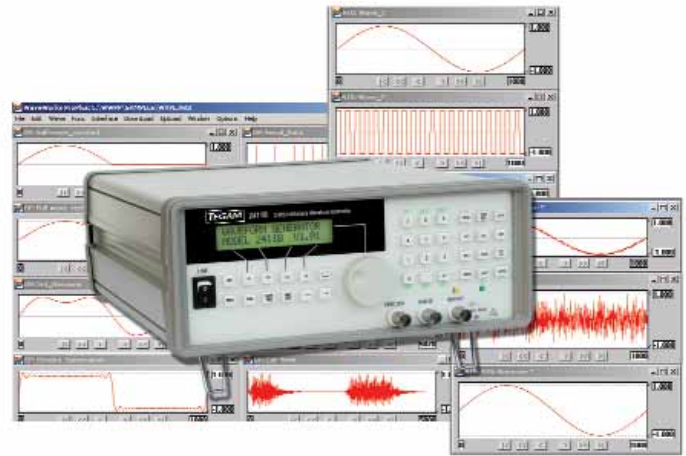
TEGAM's true arbitrary waveform generators do much more than make waves.

They provide such exceptional signal quality, timing accuracy and repeatability that they improve the performance and extend the life of MEMS and NEMS devices.

For the past decade, arbitrary waveform generators (AWGs) have increasingly replaced other signal generation devices as applications became more complex. The reason for this change is the multi-functional capability of today's AWGs and the growing demand for specialized signal creation.

AWGs are implemented in two variations, Direct Digital Synthesis, which is actually a function generator with arbitrary capabilities, and True AWGs. True AWGs provide superior performance for MEMS applications. Traditional DDS generators cause excessive jitter, distortion, and signal inaccuracies. These waveform anomalies cause unnecessary electrical and mechanical stresses in the device which can lead to premature failure. A more detailed comparison of DDS and True AWGs is provided in TEGAM's Application Note No. 401, available at www.tegam.com.

By design, TEGAM's AWGs provide the highest levels of signal quality and accuracy. Features include 16-bit voltage resolution, low distortion and noise, minimal phase jitter, and more. Then we add sequence generators and multiple programmable synchronous outputs, functions that are not offered by any other waveform generator. These advanced functions and high signal accuracy, all available only from TEGAM, optimize system performance and maximize design flexibility.



Superior Sequencing

"Experiments show that MEMS actuators driven by model-based drive signals have 5 orders of magnitude longer life than those driven by square wave signals." A sequence generator allows you to cut and paste waveforms created in our software programs to build sequences. An example would be a soft start, controlled run speed and soft deceleration for a microengine.

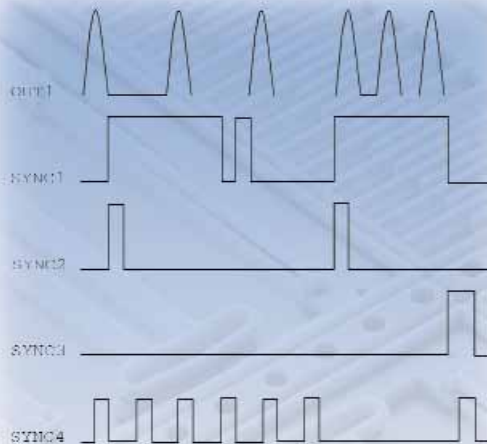
Creating long waveforms, using simple cut and paste techniques, can guarantee repeatability and timing reliability. Large numbers of wave-defining variables can be applied including the number of samples per waveform and the sample clock rate. Sequences can contain up to 4000 data points. Our memory structure includes large memory capacity, and flexible partitioning.

Superior Synchronization

TEGAM is the only manufacturer that offers AWGs with 4 synchronous outputs. These outputs can be daisy-chained or cascaded to precisely time inputs and outputs from any TTL compatible device. Electrostatically driven MEMS devices, whether a simple bi-directional actuator or a more complex rotating gyroscope, can be damaged if the driving signals are not precisely timed. Also, the complex interactions of cross-domain signals induce new failure modes in MEMS devices if they are not properly addressed.

Our experience with a broad range of test equipment allows us to understand the instruments in your setup and the timing issues you face. We can synchronize hardware within the test system, and external to it. If you would like to learn more about developing complex synchronized test programs using programmable multi-sync output pulses, download TEGAM's Application Note No. 400 from www.tegam.com.

1. Pan, Jiantao. "MEMS and Reliability." Spring 1999, <http://www.ece.cmu.edu/~koopman/des_s99/mems/index.html> (accessed December 2004).



SEQUENCE DDS		
STEP 1	WFM 06	LOOP 1E3
STEP 2	WFM 01	LOOP 526
STEP 3	WFM 09	LOOP 007
STEP 4	WFM 100	LOOP 1E6
STEP 5	WFM 23	LOOP 001
STEP 06	WFM 003	LOOP 031

SIGNAL AMPLIFICATION

MEMS/NEMS applications often require voltage and current levels that exceed the capabilities of most signal generators.

TEGAM's voltage amplifiers are designed specifically to produce the high output voltages needed to drive MEMS/NEMS actuators. Inadequate voltages or poor voltage control can cause numerous problems in MEMS applications. For example, small variances in voltages can overdrive micro-engines which leads to inadvertent contact of structural and electrical members in springs and comb fingers and results in premature failure.

Our current amplifiers overcome capacitive losses from cabling, or the added loads from qualification testing. A variety of commercial off-the-shelf amplifiers (COTS) are available.

TEGAM also designs and manufactures custom amplifiers when standard models don't match customer requirements. All of our amplifiers combine high performance with dependability. Modern designs take full advantage of the latest developments in amplifier technology to produce low distortion, high stability, and wide dynamic range amplification that accurately reproduces the signals critical to your application. TEGAM has provided COTS and customized amplifier solutions to numerous clients including research institutions, military, third-party test system integrators, startup companies, and other MEMS development organizations.



SIGNAL CREATION

Managing the capabilities of high performance test equipment requires software tools that are flexible and easy to use.

Every MEMS application requires unique waveforms. Using the best software tools saves development time and reduces budget costs because long, complex waveform sequences can be created without writing computer programs. High quality specialized software allows the test system to operate independently, once downloaded from the PC.

TEGAM offers a variety of software tools to assure that we have software that fits your application. These tools include WaveWorks Pro+™, Super μ Driver™ and LabVIEW™ Instrument Drivers.

WaveWorks Pro+™ is TEGAM's waveform creation and editing software. It includes an extensive wave library, math operations, transfer functions, and time and frequency domain synthesis. You can import, export or create specialty waveforms with WaveWorks Pro+™. It also serves as a control interface for all TEGAM arbitrary waveform generators and has the capability to import or export up to 8 different wave data formats.

Super μ Driver™ developed by Sandia National Laboratories creates phase shifted, multi-channel, sequenced and synchronized signals used for driving MEMS micro-engines and other comb-type actuators. TEGAM is the only licensed distributor of Super μ Driver.

LabVIEW™ Instrument Drivers also allow you to create waveforms and upload them directly to TEGAM AWGs for quality replication. LabVIEW™ drivers are available for all of TEGAM's premium arbitrary waveform generators.

FLEXIBILITY

It makes perfect sense to design your MEMS test system for maximum flexibility, modularity, and compatibility. TEGAM's solutions are compatible with most industry standard products. This means that you can combine TEGAM products with those from other manufacturers' to create the solution that is best for you. Additionally, because TEGAM products are designed to stand alone or perform as modules in a system, you can modify or upgrade your system one piece at a time, as your application evolves.

THE TEGAM SOLUTION

TEGAM provides test solutions for MEMS and NEMS. Whether you need a signal, a signal amplifier, signal sequencing, software, sophisticated multiple instrument synchronization or a complete system, TEGAM has the hardware, software and expertise to overcome your MEMS testing challenges. We can help you select TEGAM products that meet your requirements, design an amplifier to meet your specifications or build a system that fulfills your application. Contact the experts at TEGAM for assistance with your MEMS test challenges.