MSA-600-X/U Micro System Analyzer

Visualization of dynamic response and static characterization are key to testing and developing MEMS devices. They are indispensable for validating FE calculations, determining cross-talk effects and measuring surface deformation. The MSA-600-X/U Micro System Analyzer covering a frequency range of up to 2.5 GHz is an all-in-one optical measurement workstation ideally suited for ultra-high-frequency vibration analysis, characterizing surface topography as well as in-plane and out-of-plane motions.

The versions MSA-600-X/U cover the high and very high frequency range up to 2.5 GHz, perfect for the assessment of HF MEMS resonators, micro-acoustic devices like SAW, BAW and more.

The high-performance laser Doppler vibrometer delivers fast, real-time response measurement with sub-pm displacement resolution. The integrated stroboscopic video microscope enables the straightforward characterization and live-animation of in-plane motion. And the white-light interferometer option provides millions of 3D surface data in seconds.

Complemented by its straightforward operation and intuitive user interface, the MSA-600 is your powerful optical measurement solution in MEMS R&D and quality control.

Highlights

- All-in-one optical measurement workstation
- Real-time response measurements without post-processing up to 2.5 GHz
- Unparalleled sub-pm displacement resolution
- Fast measurement and visualization of deflection shapes
- Straightforward and intuitive operation
- Automated system for easy integration into probe stations

MSA-600-X/U Micro System Analyzer

Measuring dynamic response and topography of MEMS and microstructures

Technical data

MSA-600-X/U system configurations	
Basic configuration	Out-of-plane vibration measurement up to 300 MHz / 600 MHz
Options	
Bandwidth extension (BWX) [1]	Out-of-plane vibration measurement up to 1300 MHz / 2500 MHz
Differential measurement	Differential out-of-plane measurement
Planar motion analysis [2]	In-plane-motion analysis
Topography measurement	Topography measurement

[1] suitable for model MSA-600-U
[2] suitable for model MSA-600-X

Metrological specifications				
Out-of-plane measurement				**Laser Doppler vibrometry**
Configuration	MSA-600-X	MSA-600-U	BWX1	BWX2
Min. frequency	6.25 Hz	6.25 Hz	200 MHz	1300 MHz
Max. frequency	300 MHz	600 MHz	1300 MHz	2500 MHz
Best Frequency resolution				
up to 200 MHz	6.25 Hz	6.25 Hz	-	-
500 MHz	15.625 Hz	15.625 Hz	-	-
600 MHz	-	31.25 Hz	-	-
1300 MHz	-	-	62.5 Hz	-
2500 MHz	-	-	-	125 Hz
Time Domain Measurement				
Max. sampling time	160 ms	160 ms	-	-
Maximum object velocity				
up to 300 MHz	≥ 150 m/s	≥ 150 m/s	13...19 m/s [1 2]	-
300...600 MHz	-	80...150 m/s [1]	19...38 m/s [1 2]	-
600...1300 MHz	-	-	38...80 m/s [1 2]	-
1300...2500 MHz	-	-	-	80...150 m/s [1 2]
Displacement resolution [3 4]				
up to 1 MHz	100 fm/√Hz	100 fm/√Hz	-	-
1 MHz...f max [5]	7.5 fm/√Hz	7.5 fm/√Hz	12.5 fm/√Hz	12.5 fm/√Hz
1 MHz...f max [6]	15 fm/√Hz	15 fm/√Hz	25 fm/√Hz	25 fm/√Hz
1 MHz...f max [7]	30 fm/√Hz	30 fm/√Hz	50 fm/√Hz	50 fm/√Hz

[1] Frequency dependend
[2] Maximum displacement amplitude ≤ 10 nm
[3] The noise-limited resolution is defined as the signal amplitude (rms) at a signal-to-noise ratio of 0 dB and a spectral resolution of 1 Hz.
[4] The attainable resolution is frequency-dependent. The specified values are average values across the given bandwidth.
[5] MSA-600-X/-U without MSA-A-DIF option
[6] With MSA-A-DIF option, non-differential measurement mode
[7] With MSA-A-DIF option, differential measurement mode

In-plane measurement	**Stroboscopic video microscopy**
Configuration	MSA-600-X with planar motion analysis option
Frequency range	1 Hz ...2.5 MHz
Max. velocity	> 0.1 m/s ... 10 m/s (magnification dependent)
Objective magnification [2]	1x ... 100x
Displacement amplitude resolution [3]	5 nm
Time resolution	100 ns (strobe exposure time); max. strobe jitter ±40 ns
System output	Displacement data, bode diagram, step-response plots, decay plots, trajectory plots

[1] Averaging is performed over the maximum bandwidth fmax of the respective range.
[2] Objective specifications, as specified in table below.
[3] Frequency noise floor for 512 shots per frequency on vibration isolated table.

Topography measurement				**White-light interferometry**
Configuration	MSA-600 with topography measurement option			
Vertical measurement range	250 µm			
Method of evaluation	smooth surface [1]	rough surface [2]		
Z performance:				
Measurement noise [3]	0.09 nm	6 nm		
Vertical resolution [4]	<1 nm	<37 nm		
Flatness measurement:				
Average flatness deviation [5]	4.5 nm	45 nm		
Repeatability [6]	0.25 nm	14 nm		
Step height measurement on a calibrated depth setting standard [2 7]				
Nominal step height	0.24 µm	0.75 µm	7.5 µm	75 µm
Repeatability [8]	0.02 µm	0.04 µm	0.05 µm	0.06 µm
Maximum deviation [9]	0.05 µm	0.12 µm	0.16 µm	0.18 µm

[1] Analysis of the correlogram phase, can be used on flat surfaces.
[2] Analysis of the correlogram envelope, for usage on unsteady/rough surfaces
[3] RMS value of the signal amplitude for an averaged measurement on a parallelly aligned plane mirror (R ≈ 4%, λ/20), calculated from 25 single measurements, under repeatability conditions.
[4] Measurement noise (N = 1) · √8
[5] Mean value of measured flatness values (according to ISO 1101) of 50 measurements on a parallelly aligned plane mirror (R ≈ 4%, λ/20) under repeatability conditions.
[6] Standard deviation of the measured flatness values (according to ISO 1101) of 50 measurements on a parallelly aligned plane mirror (R ≈ 4%, λ/20) under repeatability conditions.
[7] 15 measurements per step on a calibrated depth setting standard, type KNT 4080/30 (ISO 5436-1)
[8] Standard deviation of the measured deviation of the calibrated step height under repeatability conditions.
[9] Largest measured deviation in relation to the calibrated step height out of 15 measurements per step under reproducibility conditions.

Optical specifications	
MSA-I-620 Sensor Head	
Laser wavelength	532 nm
Laser safety class	class 3R (< 5 mW visible output)
Light source wavelength	470 nm
Light source safety class	class 2 LED product (< 20 mW visible output)
Camera	Full-field progressive scan camera
Camera resolution	1732 x 1200 pixel

Bright field objectives	Magnification	Working distance (WD) mm	Spot diameter ($1/e^2$) µm	Field of view mm x mm
A-MOB-001X	1	13	46	10.0 x 7.0
A-MOB-002X	2	34	23	5.1 x 3.5
A-MOB-005X	5	36.5	9.3	2.0 x 1.4
A-MOB-010X	10	33.5	4.6	1.0 x 0.7
A-MOB-010B-LD	10	48.9	4.6	1.0 x 0.7
A-MOB-020X	20	20	2.3	0.51 x 0.35
A-MOB-050X	50	13	1.4	0.20 x 0.14
A-MOB-100X	100	6	0.8	0.10 x 0.07

Interference objectives	Magnification	Working distance (WD) mm	Type	Field of view mm x mm
A-IOB-02X5-B	2.5	10.3	Michelson	4.0 x 2.8
A-IOB-005X-B	5	9.3		2.0 x 1.4
A-IOB-010X-B	10	7.4	Mirau	1.0 x 0.7
A-IOB-020X-B	20	4.7		0.51 x 0.35
A-IOB-050X-B	50	3.4		0.20 x 0.14
A-IOB-100X-B	100	2		0.10 x 0.07

General specifications

Component	MSA-I-620 Sensor Head	MSA-F-620 Front-End	MSA-W-620 Data Management System	MSA-E-600 Controller
Power	via MSA-F-600 Front End	100 ... 240 VAC ± 10%, 50/60 Hz max. 100 VA	100... 240 VAC ± 10%, 50/60 Hz max. 525 VA	100... 240 VAC ± 10%, 50/60 Hz max. 450 VA
Dimensions [W x L x H]	see figure	485 x 150 x 380 mm (19", 84 TE/3 HE)	485 x 190 x 550 mm (19", 84 TE/4 HE)	499 x 177 x 373 mm (19", 98 TE/4 HE)
Weight	12.6 kg	9.0 kg	18.0 kg	12.0 kg
Operating temperature	18 ... 30 °C (64.4 ... 86 °F)	+5...+40 °C (41...104 °F)		
Storage temperature	–10 ... + 65 °C (14 ... 149 °F)	–10 ... + 65 °C (14 ... 149 °F)		
Relative humidity	max. 80%, non-condensing			

Compliance with standards	
Electrical safety	IEC/EN 61010-1
EMC	IEC/EN 61326-1 Emission: Limit Class A, IEC/EN 61000-3-2 and 61000-3-3 Immunity: IEC/EN 61000-4-2 to 61000-4-6 and IEC/EN 61000-4-11
Laser safety	IEC/EN 60825-1 (CFR 1040.10, CFR 1040.11)
Expanded uncertaintyof measurement	SEMI MS4-0416 and MS2-113

Software features

Out-of-plane measurement	
Data acquisition	
Video display	Live, full field, black & white video image of test object directly incorporated into user interface for interactive scan set up and beam positioning. Digital zoom into live video image.
Laser positioning	Visible laser moves with cursor on live video image by clicking or dragging the mouse.
Defining scan geometry	Utilizing APS Professional mode for up to 512 x 512 points per object of any shape. Measurement points are defined graphically over the live video image using a mouse. User can draw individual objects using polar, cartesian or hexagonal grids, or define single points. Define single points (optional): Single point geometry can be optimized by refining or coarsening the grid. Automatic generation of surface elements to connect scan points.
Scan geometry import	Geometry import from UFF or ME'scope format.
Autofocus option	Automatic focusing of the laser at the current position of the specimen or during the scan; allowing for an optimized signal level at every scan position [1].
Sample positioning	Interactive control of X-Y positioning stage (optional) by using the mouse and absolute or relative displacements by precisely defined distances. Measurements at different positions can be acquired separately and combined for analysis and presentation.
Vibrometer control	All vibrometer parameters such as velocity range and tracking filter are software controlled.
Display	Simultaneous display of live video showing actual laser spot, entire scan area including scan points, and multiple analyzer displays of various signals (time traces and spectra).
Specimen excitation	Wide range of waveforms including sine, periodic chirp, white noise, random signals, sweep and arbitrary signals.
Acquired scan data	Entire spectrum acquired for all channels at all scan points
FastScan	Fast acquisition mode (up to 50 points/s) for measurements at a single frequency. Bandwidth is definable. Complex and magnitude averaging and signal enhancement are available.
Time domain data (optional)	Time domain acquisition, time domain averaging, time domain animation.
Gate input	Gate input for intermittent scan control.
Scan data validity check	Data quality check at all scanned points in Signal Enhancement (SE) mode. MSA-600 checks the quality of data in each spectrum. The averaged spectrum is weighted toward those spectra with the best signal to noise ratio. Measured points are labeled: optimal (SE only), valid, or A/D overload.
Trigger	Auto or manual threshold, rising or falling edge, source: external or any measurement signal
Averaging	Complex or magnitude averaging of spectra, peak hold, time
FFT lines	2,343,750; 4,687,500 with BWX 1/2 option
Window functions	Rectangular, Hamming, Hanning, Flat top, Blackman Harris, Bartlett, Exponential

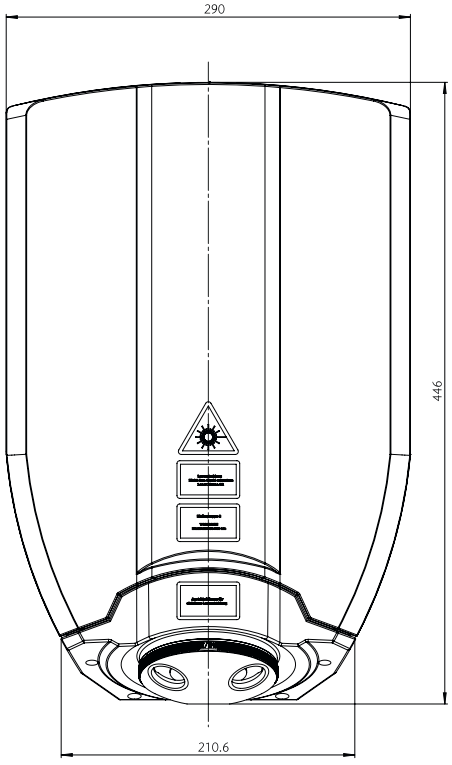
[1] Requires portal stand with automatic z-stage.

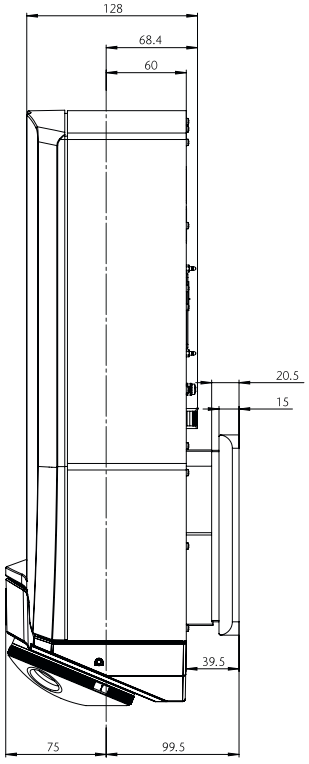
Data processing and analysis	
Data organisation	Support for project oriented workflow by a tree-style file browser for measurements, settings, macros, user defined waveforms, amplitude correction files. Context based actions on different file types.
Display	Color/gray, filled/unfilled contours and 3-D relief maps over stored video image (static or animated), averaged spectra over all scan points, individual spectra at each point as Bode or Nyquist plots, line profiles. Animation of video image for easy visualization of results. Data are scaled in velocity, acceleration or displacement. Logarithmic/linear axes
Data transfer	ASCII, Universal File Format (UFF), ME'scope and PolyWave binary data interface (optional). UFF and ME'scope data can be imported, analyzed and processed as user defined datasets and combined with measured data.
Graphics transfer	Graphic formats AVI (for animations), JPEG, BMP, TIFF, PNG, GIF.
Data processing	Complex spectral analysis provides the following quantities and functions for area and/or single-point data: magnitude, magnitude dB(A), phase, real, imaginary, frequency response function (FRF), H1, H2, auto power, cross power, coherence, averaged RMS over frequency. 3rd octave analysis, ESD, PSD.
Polytec Signal Processor	The Polytec Signal Processor is the user interface to the PolyMath library included in the PSV software. Easy-to-use spreadsheet for post processing of scan data.
Automated processing	Software can be fully automated.

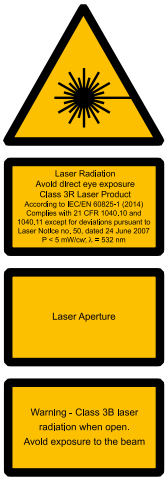
In-plane measurements	
Data acquisition	
Working principle	In the Acquisition Mode, video sequences are sampled and analyzed using proprietary measurement algorithms.
Strobe illumination control	Control of the strobe pulses (interval, pulse length).
Data acquisition	Acquisition of the stroboscopic video image and live view of object movement.
Specimen excitation	Integrated signal generator software for specimen excitation with sine and pulse signals with excitation frequencies up to 2.5 MHz. Support for arbitrary, user-provided excitation signals.
Data processing and analysis	
Working principle	Motion analysis is performed interactively. Motion data are based on image correlation and displayed as X, Y displacement values. Sub-pixel resolution enables in-plane motion measurements with resolution in the nanometer range.
Data organization	Support for project oriented workflow by a tree-style file browser for measurements and settings.
Live video display	The live video mode provides a steady, slow-motion image sequence of the test object's motion for visual characterization.
Display	■ Displacements for individual frequencies and their differentiations as well as frequency spectra, step responses and decay (ring down). ■ Bode plots for both – horizontal and vertical – motion. ■ Graphs can be examined using cursors, zoomed and panned. For each graph, different line and marker styles are selectable.
Data transfer	Graphs can be exported as image or ASCII file and sequences of images can be saved as AVI files.

Topography measurements	
Data acquisition	
Working principle	By shifting an interference objective with respect to the sample, a high resolution X-Y-Z mapping is generated. The interference pattern is captured with the video camera.
Measurement modes	■ Short coherent measurement ■ Smart Surface Scanning technique for extended contrast range
Data processing and analysis	
Data organization	Support for project oriented workflow by a tree-style file browser for measurements and settings.
Post-processing	Envelope or phase evaluation
Data evaluation	Linear regression; polynomial fit; subtracting; averaging; filters like median, erosion, high pass and low pass filter; masking functions
Data display	■ Surface view: 2D, 3D presentation and isolines view, with video overlay ■ Profile view: profile sections; correlogram; roughness/waviness parameters; graphs/diagrams, geometrical data like angle, heights, radius etc.
Data transfer	Graphs can be exported in various common image graphic formats; measurement data can be exported as ASCII file.
Automated processing	Software can be fully automated.

Options and accessories
Please refer to the document “Accessories for stand-based instruments”

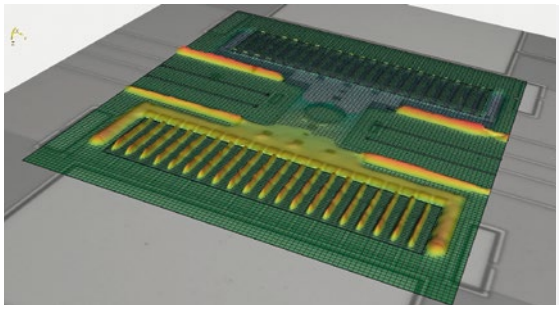




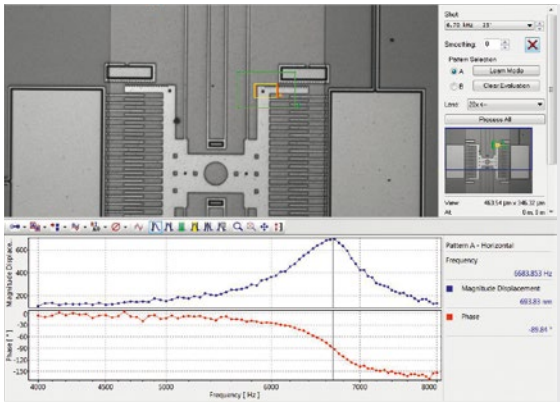


All dimensions given in mm

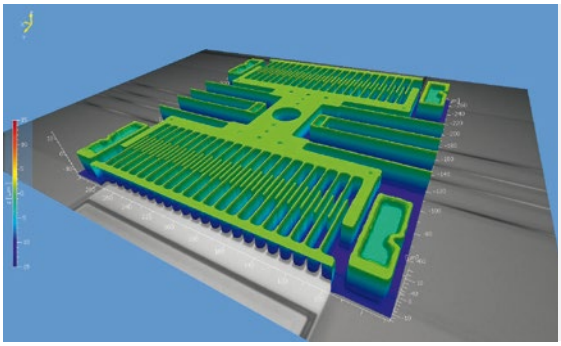
Comprehensive analysis of a MEMS electrostatic combdrive



Fast, real-time response measurement of the combdrive's out-of-plane dynamics reveals all system resonances. In addition, detect all in-plane modes with ultra-high sensitivity laser Doppler vibrometry measuring their minute parasitic out-of-plane contribution.



Bode plot of the combdrive's principal in-plane driving mode. Visualize the device operation with live-mode animation.



High-resolution surface topography measurement revealing every detail of the device topography – even as fully automated measurements on wafer-level.

Shaping the future since 1967

High tech for research and industry.
Pioneers. Innovators. Perfectionists.

Find your Polytec representative:
www.polytec.com/contact

Polytec GmbH · Germany
Polytec-Platz 1-7 · 76337 Waldbronn