## MSA-650 IRIS Micro System Analyzer

Dynamic characterization of MEMS devices to measure and visualize mechanical response is important for product development, trouble shooting and FE model validation. The MSA Micro System Analyzers from Polytec provide fast, accurate optical measurements of out-of-plane (OOP) and in-plane motion (IP). Until now, this has been limited to unpacked devices that are optically accessible. Now, the Polytec MSA-650 IRIS Micro System Anlayzer allows even measuring through intact silicon caps on encapsulated microstructres like e.g. intertial sensors, MEMS microphones, pressure sensors and more.

The MSA-650 IRIS turn-key measurement solution comprises a controller, function generator with additional reference channels, powerful optical scanning software suite and optical sensor head with a sophisticated IR-optical design. With its dedicated IR camera and a low-coherence SLD source it is the premier full-field vibration measurement system to capture entire sample layers through silicon caps under operating conditions. This patented interferometer technology delivers excellent data quality due to superior separation of the individual device layers.


**Highlights**

- IR capability to measure MEMS dynamics through different layers of Si-capped devices
- Real-time out-of-plane response measurement up to 25 MHz (w/o post-processing)
- Sub-picometer out-of-plane displacement resolution
- Superior separation of individual device layers
- Stroboscopic video microscope to measure in-plane motion up to 2.5 MHz

# MSA-650 IRIS Micro System Analyzer

## Optical characterization of dynamics inside Si-capped MEMS

## Datasheet

# Technical data

| MSA-650 IRIS system configurations | | |
|---|---|---|
| Basic configuration | Out-of-plane vibration measurement up to 2.5 MHz | |
| Options | | |
| Bandwidth extension | Out-of-plane vibration measurement up to 25 MHz | |
| Planar Motion analysis | In-plane-motion analysis | |

| Metrological Specifications | | |
|---|---|---|
| **Out-of-plane measurement** | **Laser Doppler vibrometry** | |
| Version | MSA-650-M (standard) | MSA-650-V (with bandwidth extension) |
| Max. frequency | 2.5 MHz | 25 MHz |
| Number of ranges | 13 velocity ranges | 13 velocity ranges |
| Max. velocity | 0.003 m/s ... 30 m/s, range dependent | 0.003 m/s ... 30 m/s, range dependent |
| Velocity resolution, average value [1] | 0.015 (µm/s)/√Hz ... 4 (µm/s)/√Hz, range and frequency dependent | 0.015 (µm/s)/√Hz ... 9 (µm/s)/√Hz, range and frequency dependent |
| Displacement resolution | 100 fm/√Hz | 100 fm/√Hz |
| **In-plane measurement** | **Stroboscopic video microscopy** | |
| Version | MSA-650 with planar montion analysis option | |
| Frequency range | 1 Hz ... 2.5 MHz | |
| Max. velocity | > 0.1 m/s ... 10 m/s (magnification dependent) | |
| Displacment amplitude resolution [2] | 30 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] Frequency noise floor for 512 shots per frequency on vibration isolated table.

| MSA-650 IRIS system configurations | |
|---|---|
| MSA-I-650 Sensor Head | |
| Laser wavelength [1] | 1530-1570 nm |
| Laser safety class | class 1 laser product (< 10 mW visible output) |
| Light source wavelength [2] | 1300 nm |
| Light source safety class | risk group 0 – Exempt Group |
| Camera | Full-field InGaAs SWIR camera |
| Camera resolution | 640 x 512 pixel |

[1] Central wavelength range of low coherence source.
[2] Nominal wavelength.

| Objectives | Magnification | Working distance (WD) mm | Spot diameter ($1/e^2$) µm | Field of view mm x mm |
|---|---|---|---|---|
| A-MOB-02X5-NIR | 2.5 | 28.0 | 39.5 | 3.8 x 3.1 |
| A-MOB-005X-NIR | 5 | 37.5 | 19.7 | 1.9 x 1.5 |
| A-MOB-010X-NIR | 10 | 30.5 | 9.9 | 0.96 x 0.77 |
| A-MOB-020X-NIR | 20 | 20.0 | 4.9 | 0.48 x 0.38 |
| A-MOB-050X-SI [1] | 55.6 | 4.5 | 2.0 | 0.17 x 0.14 |

[1] The A-MOB-050X-SI objective has a correction collar to adjust for varying thicknesses of silicon or glass covers
[2] Nominal spot diameter, real values may differ up to 35%

| General specifications | | | | |
|---|---|---|---|---|
| **Component** | **MSA-I-650 Sensor Head** | **MSA-F-600 Front-End** | **MSA-W-600 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 | 13.0 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<br>Emission: Limit Class A, IEC/EN 61000-3-2 and 61000-3-3<br>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 uncertainty of measurement | SEMI MS4-0416 and MS2-113 |

| Options and accessories | |
|---|---|
| Stands and sample positioning | Please refer to the document “Accessories for stand-based instruments” |
| Probe station compatibility | with manual, semi-automatic, automatic probers of different vendors 1 |

[1] Please contact your sales representative for further information

# Software features

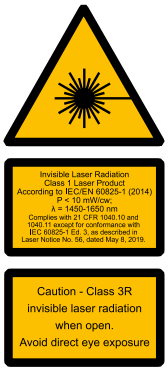
| Out-of-plane measurement | |
|---|---|
| **Data acquisition** | |
| Video display | Live, full field, black & white video image of test object directly incorporated into user interface for interactive scan set up and beam positioning. Digital zoom into live video image. |
| Laser positioning | Visible 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; 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 | 819,200 |
| Window functions | Rectangular, Hamming, Hanning, Flat top, Blackman Harris, Bartlett, Exponential |

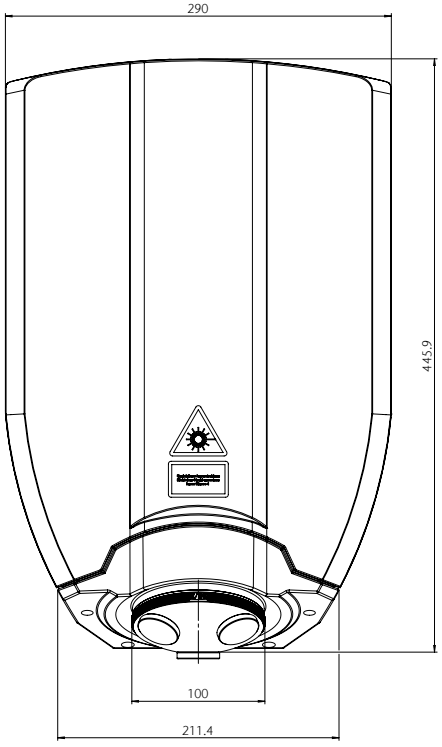
[1] Requires portal stand with automatic z-stage.

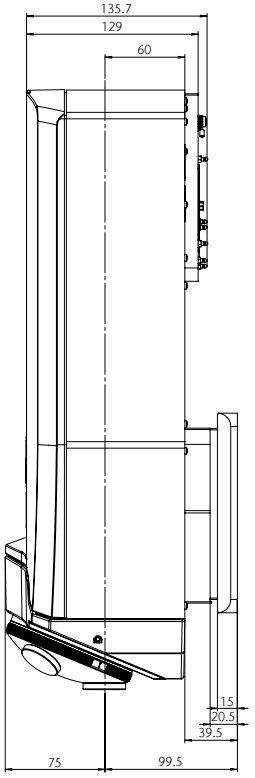
| | |
|---|---|
| **Data processing and analysis** | |
| Data organisation | Support for project oriented workflow by a tree-style file browser for measurements, settings, macros, user defined waveforms, amplitude correction files. Context based actions on different file types. |
| Display | Color/gray, 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. |

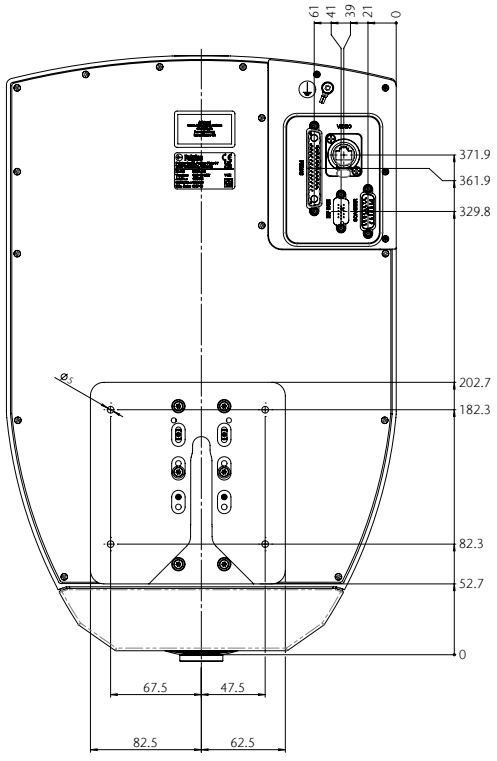
| | |
|---|---|
| **In-plane measurements** | |
| **Data acquisition** | |
| Working principle | In the Acquisition Mode, video sequences are sampled and analyzed using proprietary measurement algorithms. |
| Strobe illumination control | Control of the strobe pulses (interval, pulse length). |
| Data 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).<br>■ Bode plots for both – horizontal and vertical – motion.<br>■ 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. |

# Dimensions




All dimensions given in mm

# Accessories

XY positioning stage with tip-tilt unit for fine-adjustment of samples

Base stand with manual *z*-axis on breadboard

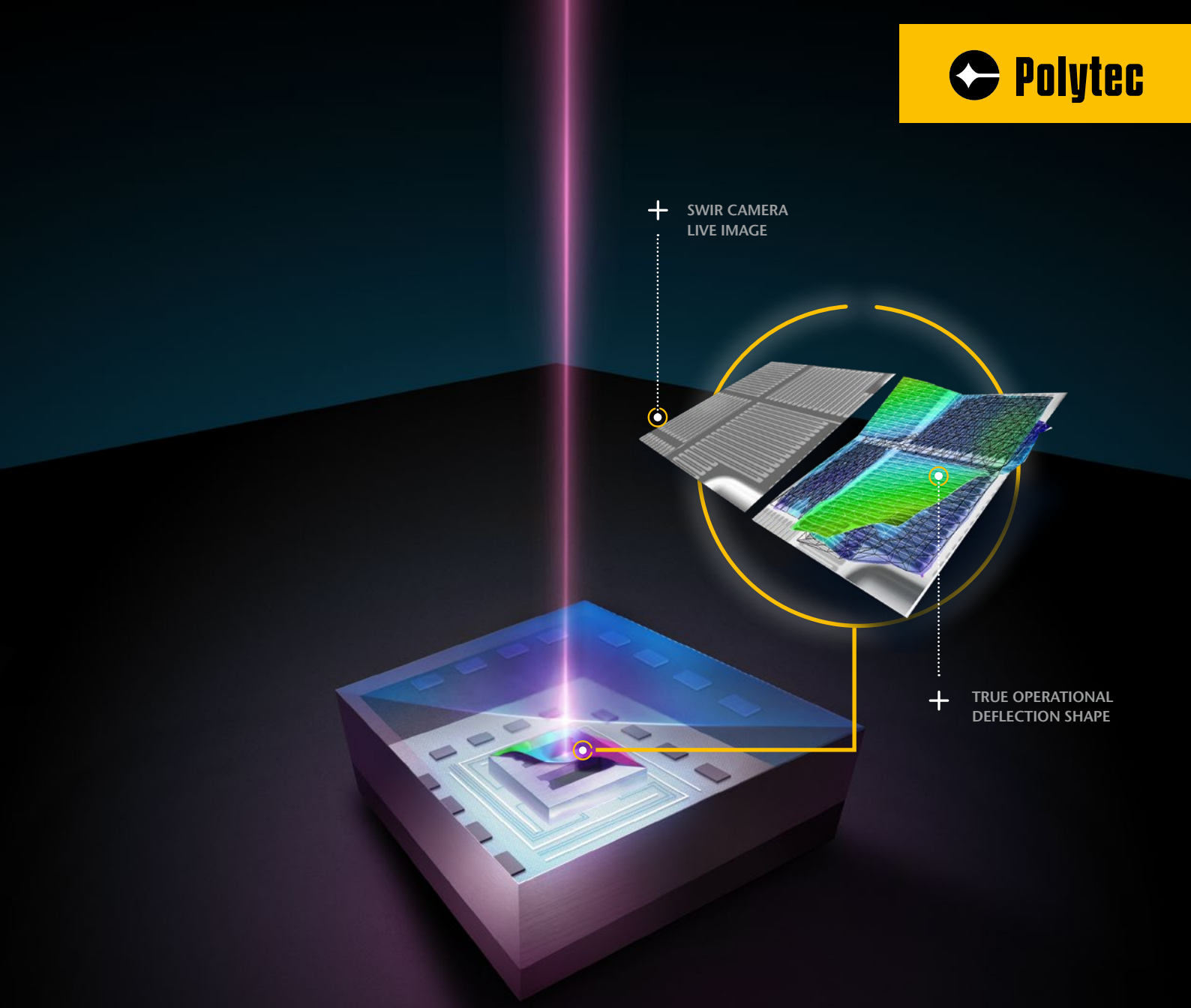
Portal stand with motorized *z*-axis for supporting and focusing the sensor head

Wafer Prober Module for testing at wafer level

Air-damped vibration isolation table with active level adjustment

Electronically controlled voice coil stabilization for highest isolation performance

Polytec




*Measure MEMS through Si caps, visualize Eigenmode & operational deflection shapes in 3D and benefit from excellent data quality due to superior layer separation. Here, on an example measurement of a 2-axis accelerometer MEMS by FGH ENAS.*

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