

## EZ Vibrating Sample Magnetometers



MicroSense (formerly known as DMS and ADE Technologies and previously part of KLA-Tencor) has been manufacturing Vibrating Sample magnetometers and other magnetic measurement systems for more than 30 years. The latest generation VSMs, the Easy (EZ) VSM systems, are the most sensitive and versatile resistive magnet VSM systems available today. The EZ VSMs are extremely sensitive, fast and easy to use.

Virtually any type of magnetic material can be characterized on the Easy (EZ) VSM systems. The sensitivity and exceptional low and high field performance make the system ideal for thin films, solids, liquids, powders, rocks etc..

### CHOICE OF MODELS

The VSM models differ only in the size of the electromagnet used and the maximum field that can be reached.

Sample Space	EZ 7	EZ 9 HF	EZ 11 HF
3.5 mm	2.6 T	3.08 T	3.5 T
With temperature option	2.02 T	2.54 T	3.0 T
With Vector Option	1.8 T	2.3 T	2.85 T

See details on specification page. HF version is optional.

### GREAT LOW AND HIGH FIELD CAPABILITIES

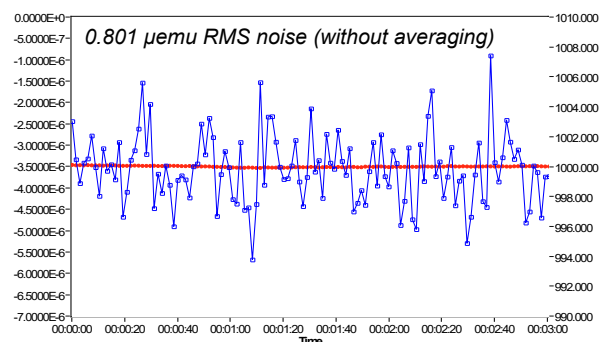
Due to a proprietary real-time field control system with exceptionally low field noise, the EZ VSMs are suited for measuring samples with very low coercivities without the need to switch to a Helmholtz coil based system. At the same time, the EZ 9 HF VSM is the most compact electromagnet based VSM that can reach a maximum field of > 2.3T with the temperature option and/or vector coil option in place.

### BENEFITS OF THE EZ VSM SYSTEMS

- **New: Higher Maximum Field**
- **New: Higher Sensitivity**
- **NEW High sensitivity MOKE (Kerr Effect Measurement) Option** with measurement time < 1 minute for a full loop
- **New: Automation Option** available for automatic sample changes. See <https://youtu.be/1-p7nGmT75g>
- Sweep option, up to 1 T/s, 1000 points/sec (depending on sample and type of measurement)
- Lowest noise of any resistive magnet VSM at any gap and especially when used with temperature or vector.
- Highest Maximum field of up to 3.6 Tesla (EZ11 HF)
- Highest magnetic field of 2.85 T with temperature chamber in place of any similarly sized electromagnet based system
- Most versatile with Vector, True Torque, AC and DC magneto-resistance, Kerr Effect (MOKE), Magneto-Electric and FMR options
- No hardware change between cooling and heating from 77 K to 1000 K
- Slide mounted oven/cryostat for quick change between room temperature and low/high temperatures
- Largest sample space (10 mm) with oven/cryostat
- True Torque Magnetometer option
- Safe, efficient and reliable air-cooled magnet power supply
- Single cabinet providing a small footprint

### HIGHEST SENSITIVITY

The EZ VSM system sensitivity advantage is largest with the temperature and/or vector options, which have lower noise than other similar systems. Furthermore, due to the large ID of the temperature chamber, larger samples can be used. The 2.46 times larger sample volume (for a thin film sample) give the MicroSense VSMs a **very large Signal to Noise Ratio advantage**.



Example of measured noise level **WITHOUT** signal averaging at 1000K, 0.8  $\mu\text{emu}$  RMS noise (4.8  $\mu\text{emu}$  peak to peak noise). The red plot shows the temperature, the blue plot the moment. (Spec is 1.7  $\mu\text{emu}$  RMS)

### HIGH ACCURACY

The high precision real time, direct field control used in conjunction with high performance signal acquisition and processing, leads to increased accuracy of the measured graphs and measured parameters, while at the same time facilitating measurements on soft magnetic samples with a 24 bit field resolution (better than 1 mOe).

## SMALL FOOTPRINT, SAFE AND EFFICIENT AIR COOLED POWER SUPPLY

All EZ VSM magnets are powered by a small and very energy efficient air cooled power supply. As a result the entire system fits in a single electronics cabinet taking up less space than systems that require a separate power supply cabinet. Also, because the power supply is air cooled, the system can run many types of measurements without the need to turn on the water chiller.

The system is controlled by a large touch screen computer and keyboard mounted on an arm on the cabinet. Because of the flexible arm, the computer can be used both standing and sitting. Alternatively, if so desired, the computer can be mounted on a desk. The software allows you to analyze completed measurements while continuing to run other measurements.



Even the high field EZ11 has a small footprint thanks to the single cabinet design.

## FLEXIBLE OPTIONS: 5 SYSTEMS IN ONE

All EZ VSMs can be equipped with or field upgraded with a range of options to offer a unique combination system. These options can be added to the VSM without increasing the system footprint and they reduce the cost compared to buying separate systems.

**The VSM** Measures the magnetic moment of materials as a function of field, angle, temperature, time and applied electric voltage (with the magneto-electric option)

**The MOKE option** offers the ability to do very fast longitudinal or perpendicular Kerr measurements. Typical measurement time for a hysteresis loop with thousands of points is less than 1 minute. Switching between VSM and MOKE options (and back) takes less than 1 minute and doesn't require gap changes or recalibration (when the VSM is set to the typical 17 mm gap for the EZ1-LNA option).

**The Torque option** measures the torque of materials as a function of rotation angle and applied field, resulting in Anisotropy data.

**The Magneto Resistance option** measures the resistance of thin film samples as a function of magnetic field, temperature, and angle. Magneto Resistance Measurements (with > 5000 points) take less than two minutes.

### The FMR Option

2-17 GHz and 2-40 GHz options available. Switching between VSM and FMR in minutes. Extracts  $M_s$ , damping and gyromagnetic ratio. Measures thin films down to 1.4 nm.

## FAST AND EASY TO USE

A unique sample vibrating mechanism makes sample mounting and alignment fast and convenient. Thanks to the real-time field control and high sensitivity the EZ VSMs are typically 3 times faster than competing systems (in field step mode).

## EASY TO USE TEMPERATURE OPTION

The temperature option (if it is included with the system) remains installed on the system and can be moved in and out of place using a simple lever-slide mechanism. This allows very fast changes between room temperature and low or high temperature measurements. Typically your measurement is already done in the time that it takes in another system to just re-install and prepare the temperature chamber. See video at <http://youtu.be/69nnwSqPFjI>



Temperature chamber in down position for room temperature measurements

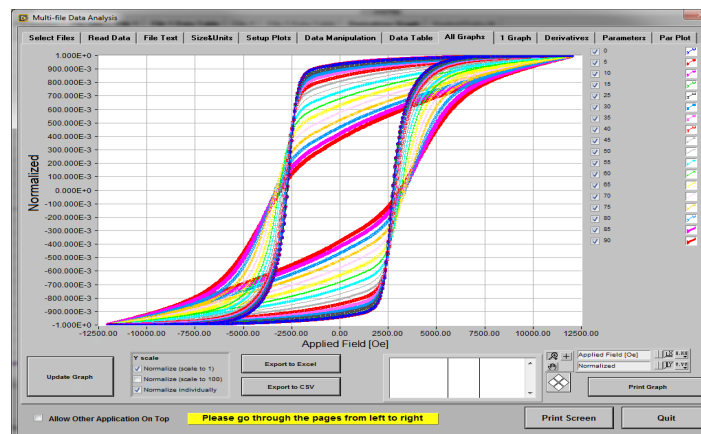
Temperature chamber in up position (for low and high temperature measurements)

## EASY TO USE AND POWERFUL SOFTWARE

The Powerful EasyVSM software allows quick setup of simple as well as complicated measurements and measurement sequences.

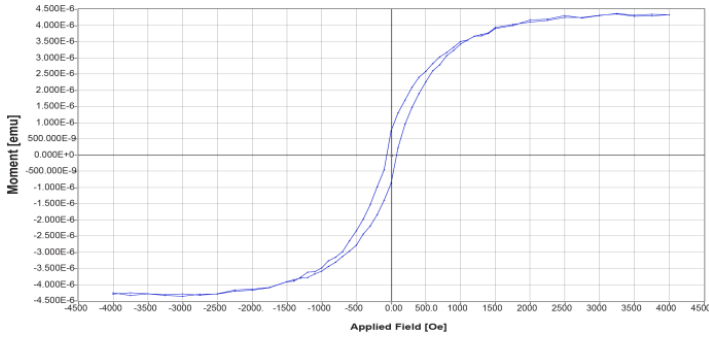
The software supports all known types of magnetic measurements such as Hysteresis and minor loops, IRM and DCD Remanence Loops, SFD, Delta M, delta H and Henkel Plots, FORC Measurements as well as Angular and AC Remanence, Temperature scans and Time decay measurements. Additionally, the user has the option to custom create measurements with full control over system functions. Any series of measurements can be run without user intervention

The powerful data analysis system allows the analysis and comparison of many measurements simultaneously and while the software itself produces virtually presentation ready graphs and tables, data exporting to other software packages is as easy as right clicking on a graph or table and selecting the export function. All data is saved in ASCII format.

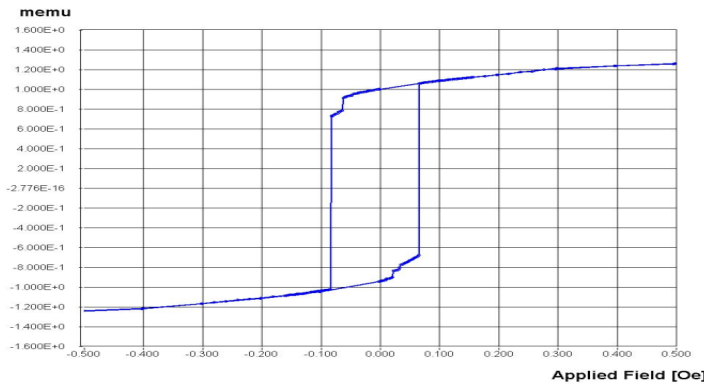


Screenshot of Multifile Data Analysis Menu showing the results of a series of VSM measurements as a function of the angle on a tape sample. The software will also automatically generate graphs of all the measurement parameters as a function of the angle (or temperature).

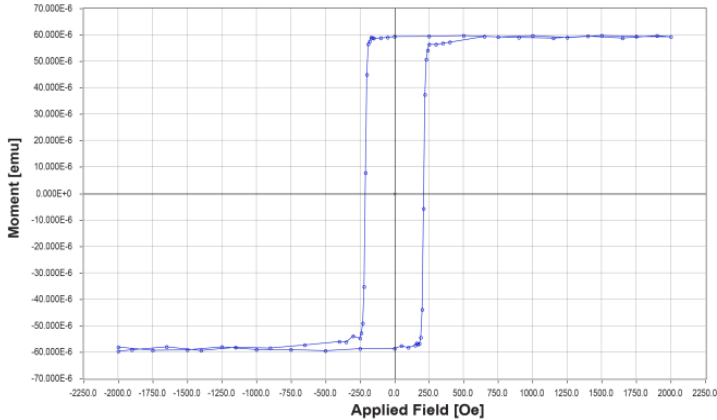
# Examples of VSM Data (all graphs shown were produced with the EasyVSM software)



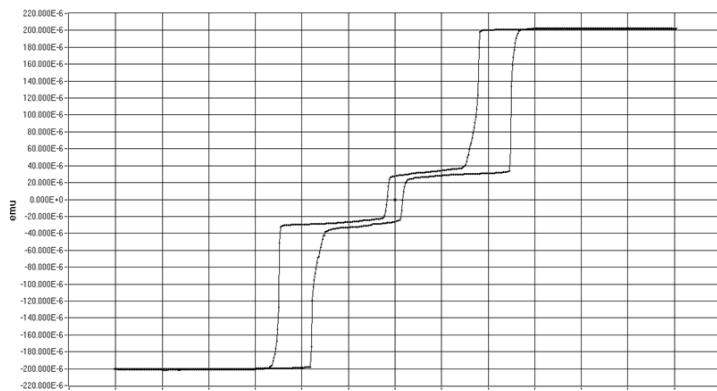
Measurement on a 4.2 micro-emu sample



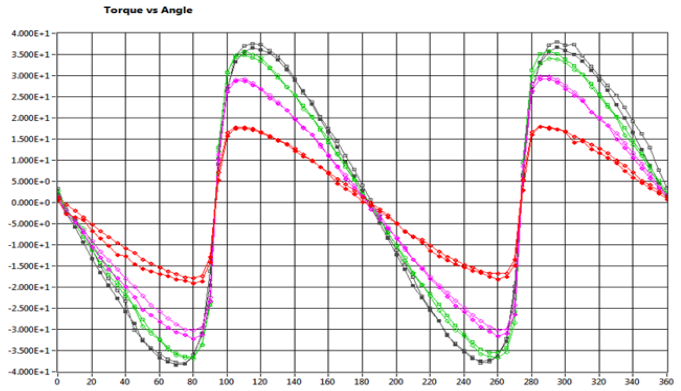
Measurement on microwire with 0.07 Oe coercivity. In the critical region 2 mOe field steps were used. The steps shown are Barkhausen jumps.



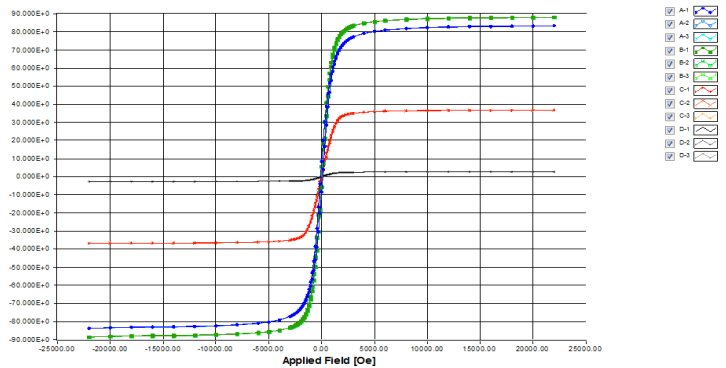
6:24 minute measurement on a 60 micro-emu sample. Measured at a 5 mm gap with 0.75 second/pt averaging.



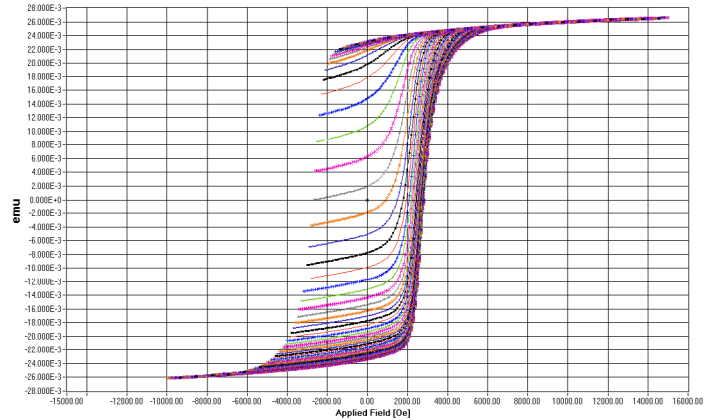
10.5 minute test, 0.5 s/pt averaging. Sweep mode. 1200 data points



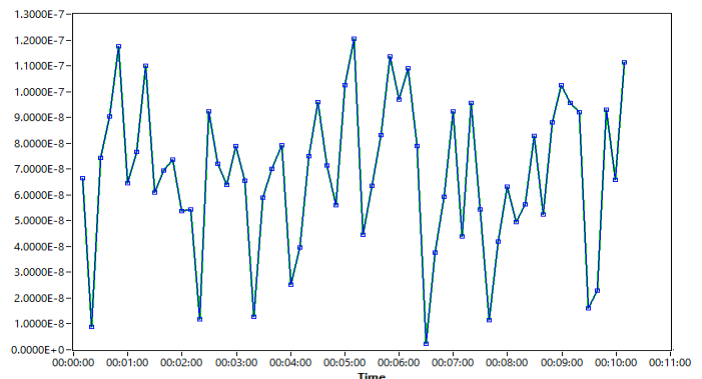
Torque Measurement.



Repeatability test on 4 different samples. The data reproduces so well that only 4 curves are visible.



FORC measurement on tape sample.



Noise at 10s per point averaging at a 4 mm sample space. The observed noise is 29.06 nemuRMS and 119 nemu PP. (The spec is 70 nemu RMS)

# EZ VSM Series - Preliminary Specifications

Magnetic Field - Maximum Fields [T] ( $\pm 1\%$ ) with 50 mm pole face, other pole faces on request

Sample Space	EZ7	EZ9	EZ9 HF	EZ11	EZ11 HF
3.5 mm	2.6	3.0	3.08	3.4	3.5
10 mm	2.32	2.75	2.85	3.25	3.3
16 mm	2.06	2.47	2.58	3.0	3.07
With 77K-1000K temperature option	2.02	2.4	2.54	2.9	3.0
With LHe or HT temperature option	1.6	2.15	2.3	2.6	2.7
With EZ1-VSC Vector Option or MOKE option	1.8	2.2	2.3	2.75	2.85
With Torque (VSM coils in place)	2.32	2.7	2.88	3.25	3.3
With Torque (VSM Coils removed)	2.4	2.8	3.0	3.3	3.35

Magnet at  $\leq 18^\circ\text{C}$ . HF is optional.

## Magnetic Field - Field Resolution and Field Noise

Range		Resolution		Noise [RMS]	
Gauss	Tesla	Gauss	Tesla	Gauss	Tesla
100 Gs	10 mT	0.2 mGs	20 nT	5 mGs	500 nT
200 Gs / 20 mT	20 mT	0.4 mGs	40 nT	5 mGs	500 nT
400 Gs / 40 mT	40 mT	1 mGs	100 nT	10 mGs	1 $\mu\text{T}$
1 kGs / 0.1T	0.1 T	2 mGs	200 nT	10 mGs	1 $\mu\text{T}$
2 kGs /	0.2 T	4 mGs	400 nT	15 mGs	1.5 $\mu\text{T}$
4 kGs	0.4 T	10 mGs	1 $\mu\text{T}$	15 mGs	1.5 $\mu\text{T}$
10 kGs	1 T	20 mGs	2 $\mu\text{T}$	20 mGs	2 $\mu\text{T}$
20 kGs	2 T	40 mGs	4 $\mu\text{T}$	20 mGs	2 $\mu\text{T}$
40 kGs	4 T	0.1 Gs	10 $\mu\text{T}$	50 mGs	5 $\mu\text{T}$

## Magnetic Moment Noise

(Standard configuration, step field mode)

RMS Noise in  $\mu\text{emu} = \text{nAm}^2$

### Conditions

Room Temperature	
4 mm sample space, 0.1s TC, No Averaging	0.3
4 mm sample space, 0.1s TC, 1s/pt	0.2
4 mm sample space, 0.1s TC, 10s/pt	0.07
10 mm sample space, 0.1s TC, No Averaging	0.6
10 mm sample space, 0.1s TC, 10 s/pt	0.15
With Single Stage Temperature Option, No averaging	1.7
10 s/point averaging	0.4
With Vector Option, No averaging	2.0
10 s/point averaging	0.5
With LHe or HT Temperature Option, 10 s/point averaging	2.5 (He) 1.7 (HT)

## Moment Accuracy, Repeatability and Drift

Accuracy	$\pm 1\%$ + noise if sample and calibration standard are equal in shape and size.
Repeatability	Stdev 0.5% + noise (Typical: 0.1%) at constant room temperature when sample is undisturbed
Stability/Drift	0.05% RMS of full scale (Measured over 48 hours at constant field and room temperature with calibration standard at gap big enough to fit the EZ1-LNA temperature option)

## Automatic Rotation - Standard Included

Range	+/- 400°
Resolution	0.002°
Accuracy	$\pm 0.2^\circ$

## Temperature Control Options

	EZ1-LNA	EZ1-LHe	EZ1-HT
Range	77K fixed 100K-1000K Control	4.2K Fixed 8K-450K Control	300K- 1173K
Resolution	0.01K	0.01 K	0.01K
Inside Diameter	10 mm	9 mm	10 mm
Ramp Rate	Up to 120K/min	Up to 30K/min	60-120K/min
Noise 0.1 s/pt	1.7 $\mu\text{emu}$ 1.7 nAm <sup>2</sup>	10 $\mu\text{emu}$ 10 nAm <sup>2</sup>	7 $\mu\text{emu}$ 7 nAm <sup>2</sup>
Noise 10 s/pt Avg.	0.4 $\mu\text{emu}$ 0.4 nAm <sup>2</sup>	2.5 $\mu\text{emu}$ 2.5 nAm <sup>2</sup>	1.7 $\mu\text{emu}$ 1.7 nAm <sup>2</sup>
Gas/Liquid requirements	LN2 < 300K N2 Gas 77K-573K Ar 300K-1000K	Liquid Helium and He Gas	AR Gas
Note	Open flow design, gas cannot be recycled.		

## Torque Option

Range	1-400 dyn-cm
Noise	0.005 dyn cm (5s/pt averaging)

## Magneto Resistance Option

	DC MR	DC MR NV	AC MR
Current Ranges	$\pm 2$ mA, $\pm 20$ mA	2 nA .. 100 mA	2 nA .. 100 mA
Current Resolution	0.1 $\mu\text{A}$	100 fA	100 fA
Voltage Measurement	60 $\mu\text{V}$ to 9 V	100 nV- 100 V	2nV – 1V
Frequency Range	DC	DC w. polarity reversal 24x/s	1 Hz-100 kHz
Points per second	Up to 1000 points/second		
Measurement Time	> 10s, 1 min. typical		
Sample Size	< 3.5mm Wide, 8.1 - 9mm Long		
Pin Sacing	Current Pins: 7.77 mm, Voltage Pins: 4.978 mm		
Temperature Range	77K - 673K		

## Magneto Electric Option

Voltage Range	-10V to + 10V, higher with optional amplifier.
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## Magneto Optic Kerr Effect (MOKE) Option (NEW)

Available Directions	Polar (perpendicular) and Longitudinal (in Plane)
Measurement Time	> 10s, < 1 minute typical
Switch time VSM $\leftrightarrow$ MOKE	1 minute
Sample exchange time	~1 minute
Spot Slze	~1 x 1.5 mm
Temperature	Ambient

Specifications apply to new systems built after December 1, 2016. Clerical errors subject to correction at all times. Specifications subject to change without notice. For more information please visit <http://www.microsense.net/products-vsm.htm>