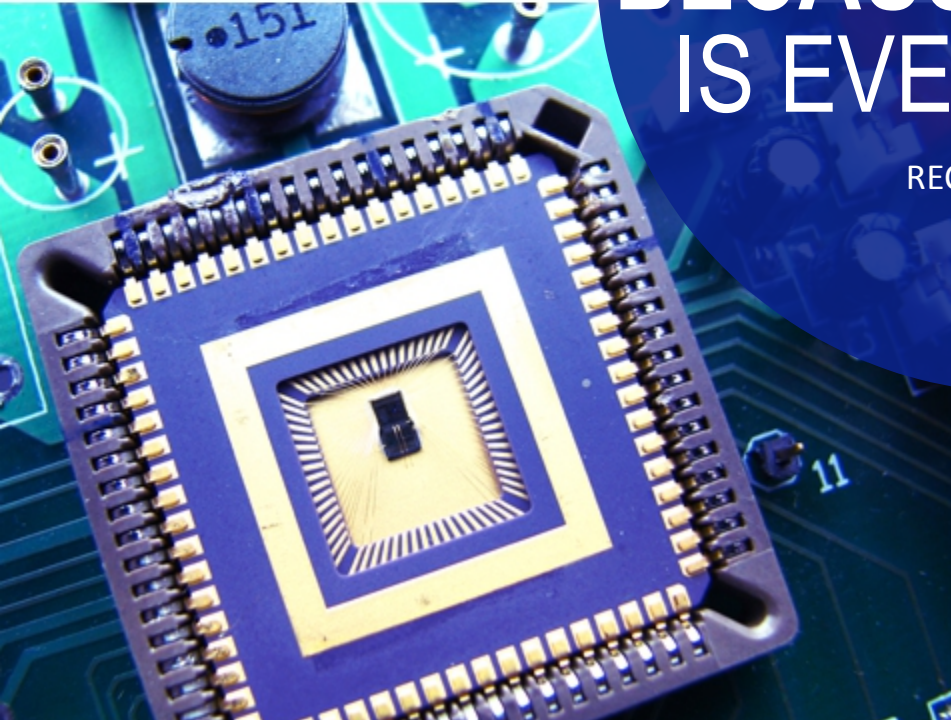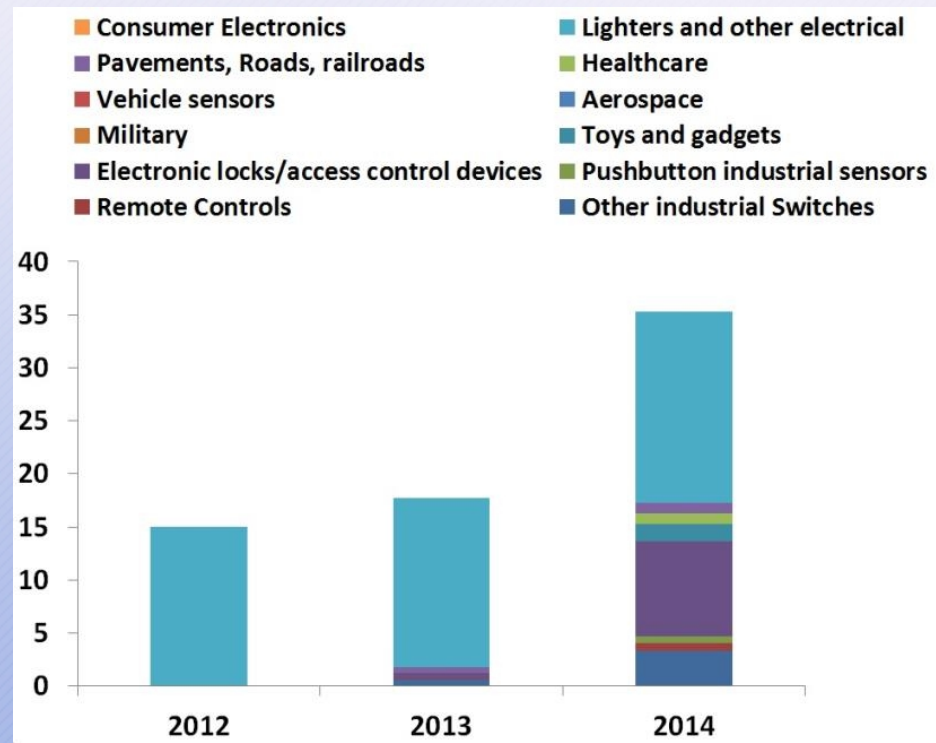# SILICONREEF: BECAUSE ENERGY IS EVERYWHERE

RECIFE - BRASIL

Silicon Reef

EH02 Applications

- Industrial and Building
  - Process automation
  - Remote control
  - Pushbotton industrial sensors
  - Electronic locks/acess control devices
- Equipament monitoring
  - Lighting control
- Planes, Trains and Automobiles
  - Tire pressure sensors
  - Vehicle sensors
- Pavements, Roads, railroads
- Civil infrastructure monitoring
  - Bridge structural integrity
- Defense and Homeland Security
  - Asset tracking
- Custumer applications
- Mobile Electronics
  - Toys and gadgets
- Healthcare

Legend:
- Consumer Electronics
- Pavements, Roads, railroads
- Vehicle sensors
- Military
- Electronic locks/access control devices
- Remote Controls
- Lighters and other electrical
- Healthcare
- Aerospace
- Toys and gadgets
- Pushbutton industrial sensors
- Other industrial Switches

Piezo Energy Harvesting - Company profiles:
- Advanced Cerametrics
- Agency for Defense Development
- Algra
- Arveni
- Boeing
- Carnegie Mellon University
- Chinese University of Hong Kong
- Fraunhofer IKTS
- Georgia Institute of Technology
- Holst Centre
- Honeywell
- IMEC
- ITT
- Imperial College
- Meggitt Sensing Systems
- MicroStrain Inc.
- Midé Technology Corporation
- NNL - Universita del Salento
- National Taiwan University,
- PulseSwitch Systems
- Shanghai Jiao Tong University
- Smart Material Corp.
- Technical University of Ilmenau
- Texas Micropower
- Tokyo Institute of Technology
- Tyndall National Institute
- University of Idaho
- University of Princeton
- Virginia Tech

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Main Suppliers

Some examples of main suppliers of commercial piezoelectric vibration based energy harvesters are:

- MicroStrain Inc. (Willston, VT, USA);
- EoPLEX Technologies Inc. (San Joes, CA, USA);
- Mide Technology Corporation (Meddord, MA, USA);
- PI (Physik Instrumente) Ltd., (Karlsruhe, Germany);
- Smart Materials Corp., (Dresden, Germany);
- Advanced Cerametrics Inc., (Lambertville, NJ, USA);
- Arveni (Bron, France);
- MicroGen Systems (Rochester, NY, USA);
- Measurement Specialties (US, Europe and China);
- Morgan Advenced Materials (Southampton, UK).

References:
A Comprehensive Study on Technologies of Tyre Monitoring Systems and Possible Energy Solutions
Ali E. Kubba 1,* and Kyle Jiang 2
Sensors 2014
Piezoelectric energy harvesting: Developments, challenges, future
http://www.idtechex.com/research/articles/piezoelectric-energy-harvesting-developments-challenges-future-00005074.asp?donotredirect=true

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MicroStrain

EH-Link™ Energy Harvesting Wireless Node

The EH-Link™ is a versatile multi-sensor node that runs on ambient energy sources such as vibration, light, and inductance.

G-Link2™ -LXRS® Wireless Accelerometer Node

The G-Link2™ -LXRS® is a ruggedized wireless sensor node with high-speed sampling and optional integrated three-axis accelerometer or external single-axis accelerometer.
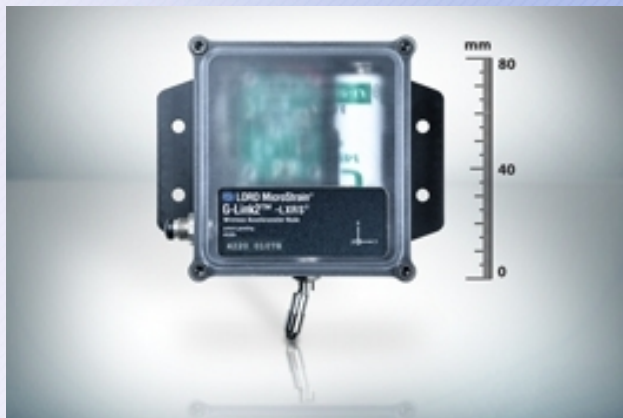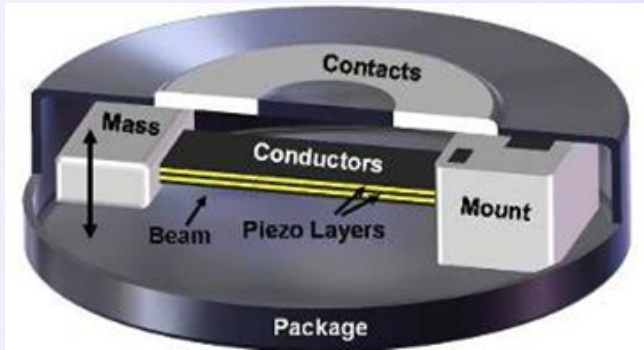

## G-Link® -LXRS® Wireless Accelerometer Node

The G-Link® -LXRS® is a low-cost integrated accelerometer node with ± 2 or ±10 g measurement range and many sampling options.


Silicon Reef

EoPlex

Piezo energy harvesters take advantage of EoPlex's unique 3DHVPF™ manufacturing platform. Energy harvesters are made out of PZT and metals in small complex structures that are primarily used to power remote sensors. EoPlex's fugitive materials are used to create space for moving parts that enable PZT material to vibrate and produce energy.
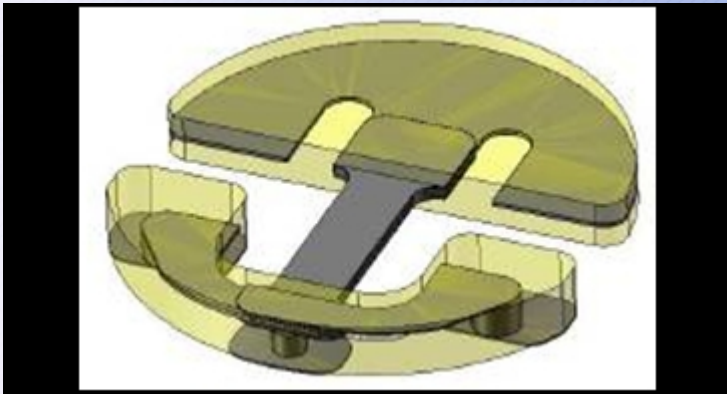
Midé

Piezoelectric Vibration Energy Harvester
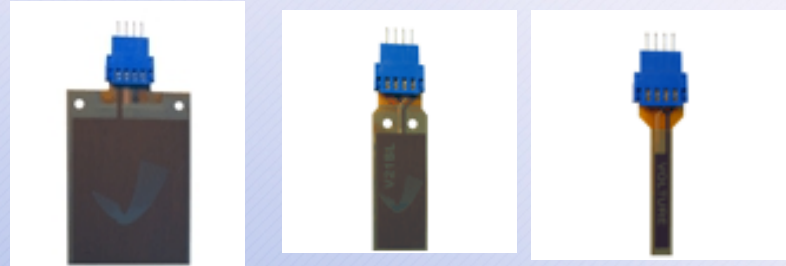
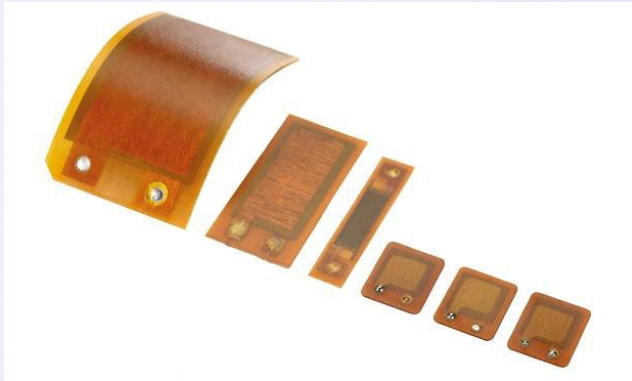Vibration and Solar Energy Harvester System

Slam Stick X
High Frequency Vibration, Pressure, & Temperature Data Logger

Slam Stick Lite - Vibration Data Logger

PI - Physik Instrumente

Smart Material

AmbioMote Wireless Energy Harvester Kit

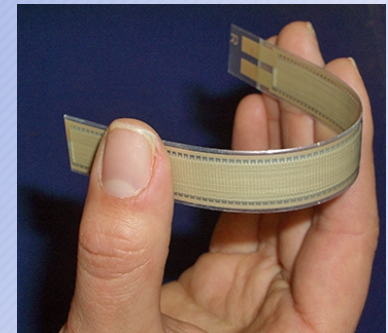E-821.EHD Piezoelectric Energy
Harvesting Evaluation Kit
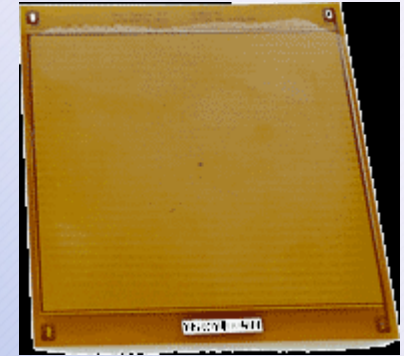
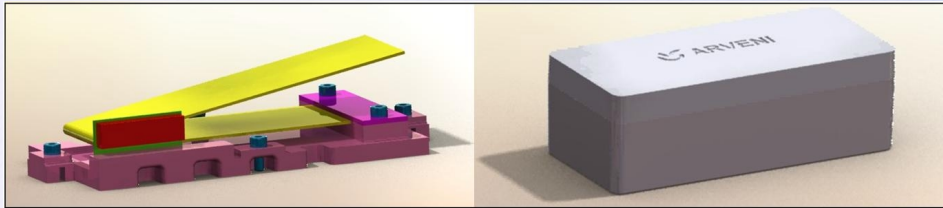# Advanced Cerametrics

Self-Powered Wireless Sensor System
Advanced Cerametrics Inc. has developed a piezoelectric fiber
composite generator capable of producing electricity from
vibration, shock, and any other sources of mechanical energy.

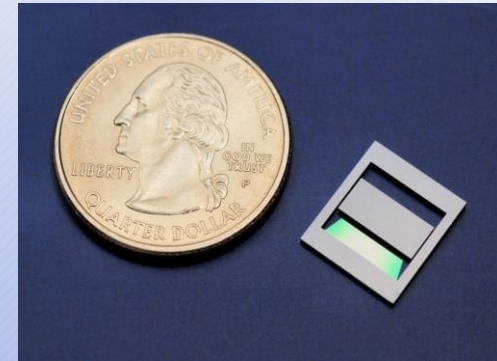Piezoelectric Fiber Composites

Silicon Reef

Arveni

T-Rex Harvester

Our new T. Rex Vibration Energy Harvester (200 mW @ 50Hz 5m/s²) certified World 'best in class' delivers 200 mW @ 50Hz 5 m/s².
Electric motors, ventilations, fans, pumps, gear-boxes, power plants, rail/road/air transportations, continuous processes, oil & gas machinery, mining machinery, paper/pulp process.

BOLT™ Energy Harvesting Products

22,000 μF ultra-cap

7.0mA-hr coin-cell

50 μA-hr *EnerChip™*

Energy Cells

Included: LTC 3588-1 Piezo Energy Harvesting Converter

Piezo-MEMS generator

Power Cells (DC)

BOLT™ Power Cell

TI eZ430 mote

MicroGen Systems

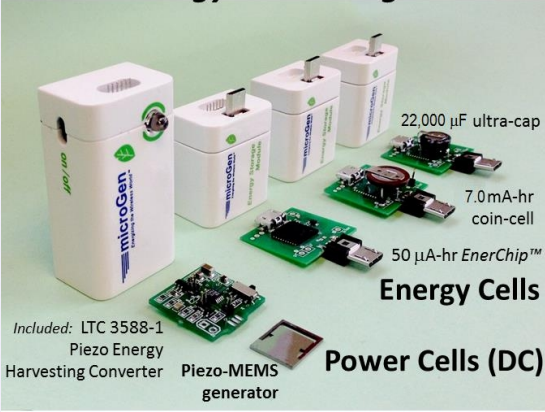## BOLT™-R Vibrational Energy Harvesting Micro Power Generator

MEMS-based Vibrational Energy Harvesting Micro Power Generators (MPGs) MicroGen Systems' BOLT family of Micro Power Generator products based on piezoelectric energy harvesting are fabricated using MEMS technology. MicroGen's micro-generators are ideal to power autonomous non-wireless electronics, wireless sensors, and rechargeable batteries for a wide range of applications.

Energy harvesting applications:
• Industrial and building (Factory automation, Equipment monitoring, Lighting control)
• Civil infrastructure monitoring (Bridge structural integrity)
• Automotive and aerospace (Tire pressure sensors)
• Homeland security (Asset tracking)
• Military
• Consumer (Hand held electronic devices)

Now, MicroGen's PZEH and piezoelectric platform technology for piezoelectric sensor integration is being transferred to X-FAB located in Germany, Malaysia and the USA. X-FAB is world renowned for its microelectronics and MEMS technology foundry production capabilities.

Silicon Reef

Measurement Specialties

DT1 & SDT1

- **Package:** Unshielded elemt with twisted pair or shielded element with shielded cable
- **Type:** Plexible film, addhesive mount
- **Range:** 15mV/uε Up to 1% strain
- **Unique Features:** Thin, flexible, robust. Withstands up to 1% strain. Ultra-low power (self generating)
- **Accuracy:** +- 20% (typ)
- **Operating Temp:** -40C to 70C (up to 125C available)
- **Dimentions (mm):** Applications dependent
- **Typical Apps:** Energy harvesting to power sensors
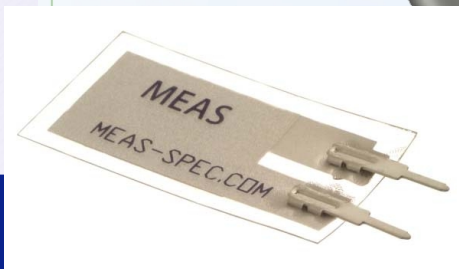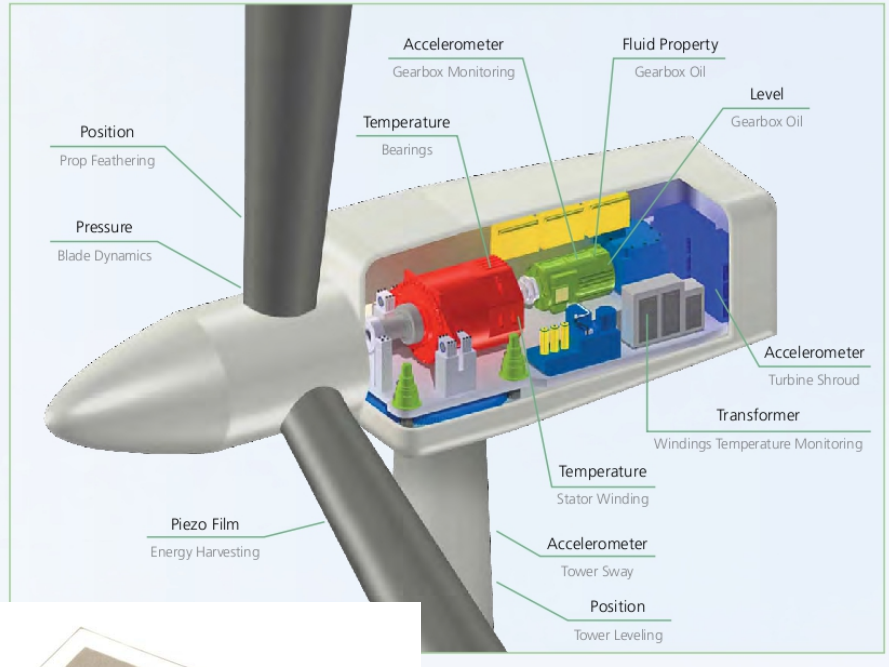
Morgan Advanced Materials

MTC ElectroCeramics piezo bimorphs is find in a host of specialist application areas, including ultrasonic atomizers, positioning transducers, printing technologies, pneumatic valves, textile machinery, energy harvesting in car-tyres and many more.
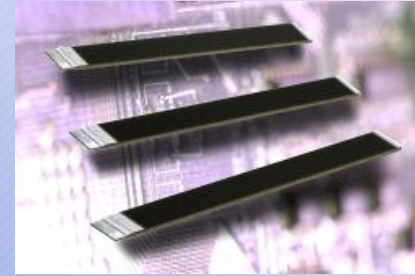
MTC ElectroCeramics also manufactures and designs PZT bimorph elements for use in various applications in automotive, aerospace, medical, industrial markets. MTC ElectoCeramics' co-fired PZT bimorph is a two layer PZT device that is configured with a central encapsulated electrode region. The benefit of this construction is that the bimorph is more mechanically stable and can be used in harsh environments since there is a uniform mechanical interface at the edges (no seams for potential filtration) as well as the device behaviour having similar characteristics to the bulk PZT properties.
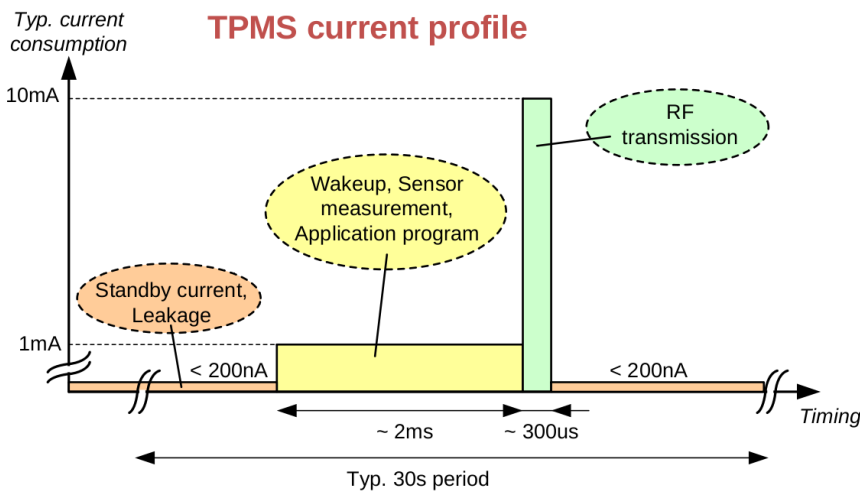
Examples of applications:
- Oil exploration
- Machine and equipment monitoring
- Automotive engines
- Feedback sensors
- High temperature accelerometers
- Rate & gyroscope sensors
- Intrusion alarms

Tire Pressure Sensor

Tire Pressure Sensor Supply Requirements

- Mechanical reliability to shocks and vibration up to 2000g
- Operating temperature -40°C to 125°C
- Life time > 10 years
- High efficiency of energy scavenger even at low vehicle speed
- Low-leakage energy storage device
- Competitive costs to rim-mounted supply unit

TPMS current profile

Tire Pressure Sensor Requirements	
Power Supply	Energy harvesting technique
Energy Harvester	Generate sufficient energy to power the sensor and last the lifetime of tire (20k to 40k miles)
Operating Temperature	-40°C to 125°C
Pressure Monitoring Range	0 to 300kPa
Operating Frequency	2,4GHz
Pressure Reading Accuracy	+7kPa
Temperature Reading Accuracy	±1°C
Transmission Power	0-5dBm
Voltage	3,6V
Power Comsumption	Less than 250uW
Duty Cycle	To report faulty tyre pressure (reduction of up to 20% of inflation pressure) after no more than 10 min from detecting it and to transmit tyre pressure reading within not more than 60 min of cumulative driving (by summing up time while vehicle speed is larger than 40km/h)

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Tire Pressure Sensor

The majority TPMS (Tire Pressure Measurement System) modules are currently powered by coin cell batteries (600mAh), but there are a lot of research in energy harvesting field to give more autonomy, reduce warranty cost and extend life operation more than 10 years of TPMS.

There are three main methods of energy harvesting: electrostatic, piezoelectric and electromagnetic, but piezoelectric method offers the highest power density. Because of the low frequency levels caracteristic of this application (~100Hz), piezoelectric energy extraction is more suited for this application.

In vibration-based energy harvesting systems, there are two main inescapable problems. Firstly, these systems need to operate at a particular value of vibration frequency in order to achieve optimum performance. Otherwise, a slight difference in the vibration frequency decreases the system efficiency dramatically. The second problem is the size and weight issues with these systems, if a reasonable amount of power generation is required. Some piezo designs are based on harvesting the strain energy directly without the complications of a vibration mechanism, generating energy proportional to subjected stress. This makes the device functional over a wider frequency range and generates energy almost linearly with the applied frequency.

Battery-Less TPMS Industry

All the commercially available TPMSs are battery powered and designed to be mounted on the rim or fixed to the tyre valve. However, some companies are currently working on developing a battery-free TPMS.

For instance, Transense Technologies plc is using a surface acoustic wave (SAW) based technology, in addition to companies such as Honeywell (UK) and Michelin (USA). SAW systems measure pressure with temperature compensation and can either be attached to the wheel (e.g., back of valve or to run-flat system), embedded in the wheel or it can be attached to the tyre itself.

Visityre (Australia) is using an electromagnetic closed-coupling technology. In this design, relatively large hardware is needed to be installed in the tyre brake structure.

The Hong Kong Applied Science and Technology Research Institute Company Ltd. (ASTRI, Hong Kong) have recently developed a piezoelectric vibration-based energy harvesting TPMS. Although the specification of this device is not precisely clear, ASTRI claims that the commercial model of this device can be reduced in size to 2.5 × 2.5cm. Eoplex is also developing a vibration energy harvester. This company focuses only on producing the energy harvester to be used in energy scavenging based TPMS systems as a power supply.

Battery-Less TPMS Industry

Perilli (Milan, Italy), in collaboration with Schrader Electronics Ltd. (Antrim, UK) has developed a tyre monitoring system, approximately 24mm in diameter with a flexible rubber base, that can be attached to the inside surface of the tyre. The system measures pressure, temperature, the average load supported by each wheel and speed, sending the information directly to the electronic control unit of the vehicle the device harvests energy through tyre mechanical vibration and supplies the collected energy to the device circuitry.

Siemens VDO (Germany), now Continental, collaborating with Goodyear Tyre and Rubber Co. (USA), has developed a TPMS that can be mounted in the tyre's rim. The device is powered by a piezoelectric based vibration energy harvester. The manufacturer claims that this device is capable of transmitting data every 60 s or less.

Piezotag has developed a TPMS which can be mounted on the inside surface of the tyre and it harvests energy from tyre deformation, particularly bending.

Others Vibration Meters

Data logger with three-axis PCE-VDL
for G force for more than 3 axes, memory for 349,525 measurement values, interface, software to store measurement values, G force as the maximum acceleration in a predefined time, real time operation.

PCE-VD 3 Vibration Meter
Vibration meter with FFT analysis, measures axis acceleration, measurement range ±18 g, frequency range from 0 to 60 Hz, wall bracket.

3 Axis Shock / Acceleration Recorder
Y-Axis
Shock Range
-50g to +50g
Z-Axis
X-Axis
PCE-VDL Series
SN:

PRICES £

PRICES £

Wireless Vibration Monitor PCE-VMS 504
wireless vibration monitor with external vibration sensors to measure acceleration, speed, offset and temperature optional extension: max. 60 dispatchers per base with max. 6 base stations (360 dispatchers)
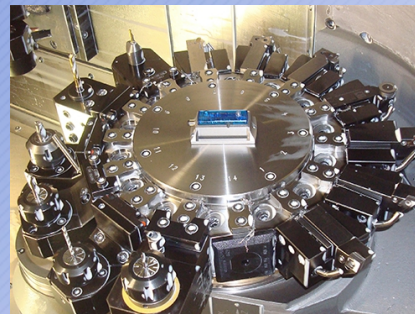
Acceleration Datalogger (3 axis) PCE-MSR165
Acceleration, humidity, pressure, temperature and light data logger, 69g weight.

WIRELESS COM BOX
PCE-VMS 504
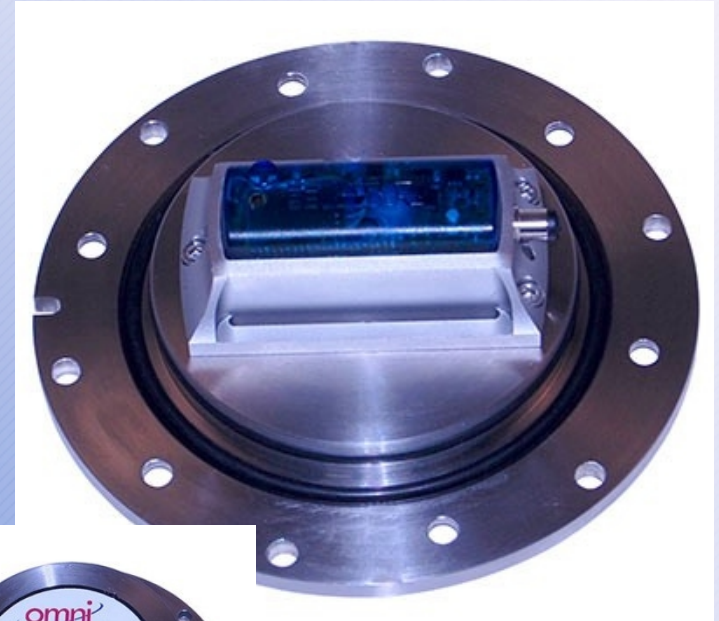
PRICES £

PRICES £

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Others Vibration Meters

TGP-0650
Vibration data-logger / shock

Subsea Vibration & Acceleration Data Logger

Geokon Wireless Datalogger | Model 8026
The Model 8026 is a wireless datalogger designed to transmit data from buried sensors installed in inaccessible locations.

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Slam Stick X - Compact High Speed Vibration Data Logger also Measures Temperature & Pressure

$1,250 Polycarbonate
$1,750 Aluminum

Get $100 off each product when purchasing two or more.

Sampling Rate: 100 Hz to 20 kHz

Acceleration Ranges: ±25g, ±100g, & ±500g

Storage Size: 2GB

Size (in): 3 x 1.18 x 0.59

Mass: 40 & 65 grams

Sensors: Triaxial Accelerometer, Temperature, Pressure

Model: Slam Stick X - LOG-0002

Slam Stick X mounted to an air-compressor

Features

Configurable Sampling Rate up to 20 kHz

Available in ±25g, ±100g, and ±500g ranges

Miniature - 3 x 1.18 x 0.59 inches

Embedded Triaxial Accelerometer

Temperature & Pressure Sensors

Time Stamped Data with Local Calendar Time

Manual & Automatic Start/Trigger Modes

Rechargeable Battery Life of Over 4 Hours

Lightweight (40 grams)

USB Interface for Set-Up & Data Download

Analysis Software Included

Temperature Compensating Accelerometer

5th Order Hardware Anti-Aliasing Filter

Applications

Structural Analysis

Equipment Testing and Evaluation

Structural Health Monitoring

Determine Mechanical Resonances

Research and Development

Impact Detection

Bearing Monitoring

Shipping and Transportation Monitoring

Automotive Diagnostics

Battery needs to be charged at a minimum twice a year.

DT-178A 3-Axis Vibration DataLogger Accelerometer 4 Mb USB Shock Acceleration Data Logger

Sales Price: $189.95

This is a brand new DT-178A 3-axis vibration datalogger from Ruby Electronics. This device records shocks and vibration on all three axis (X, Y, Z). The data are stores in the built-in 4 Mb flash memory for up loading to a computer at a later time. This device uses USB interface to ensure compatibility with your Windows PC.

DT-178A is engineered to record acceleration data of vibration. It records and time 3-axis vibrations with peaks to provide a history of shock and vibration conditions. I also records the time when freefall happens. It measures and computes real-time spectral data using an FFT (Fast Fourier Transform) from 0 to 60 Hz.

This device is compact and portable. It comes with Windows software and battery.

Specifications

Acceleration sensor: MEMS semiconductor

Acceleration sensor sampling rate: 200 Hz

Acceleration range: +/- 18G

Acceleration resolution: +/- 0.00625G

Acceleration accuracy: +/- 0.5G

non-linearity: +/- 1%

Bandwidth: about 0 ~ 60 Hz

Trigger range: 0 to 18G (XYZ magnitude)

Sampling rate: 1 second to 24 hours

Memory: 4Mbit flash, (85764 total samples or 28588 samples per X, Y, Z axis)

Battery: 3.6V Lithium battery ; last about 1000 hours

Size: 130mm x 30mm x 25mm

Weight: about 20g

Features

Records 3-axis shock

Comes with built-in accelerometers

Measures dynamic and static acceleration

Comes with freefall detection mode

Designed to handle real time operation and FFT

Includes user settable trigger level

Comes with high speed USB 2.0 interface

Silicon Reef

Spectrum Instruments 'IVDT' In-Transit Data Logger System from VIBES Corp.
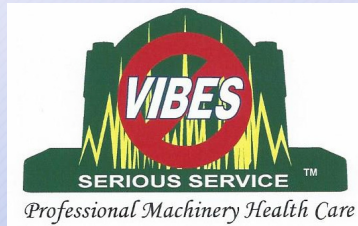
The Model IVDL (In-transit Vibration Data logger) is a powerful, and easy-to-use front end device for recording critical time and vibration/shock data using latest MEMS vibration technology. The vibration data logger generates serialized, permanent records of vibration conditions during transport of each load that has such a data logger attached to it. This provides quality assurance documentation and corroborating evidence to support insurance claims when vibration-sensitive commodities have been damaged. Post shipping or testing, data from the data loggers can be downloaded into a PC using our easy-to-use data download/management software where the data is analyzed, reported or archived as needed.

Specifications

Measurement Range: 0 to +/-18gs AC or DC (in 3 axis simultaneously)

Measurement Resolution: 0.00625g

Calibrated Accuracy: +/- 0.5 g

Frequency Range: 0 Hz to 60 Hz

Available Data Memory: 85,764 samples

Power: 3.6 battery (14250) – provides up to 1000 hrs of operation

Computer Connection: USB2.0

Ambient Temperature Rating: 0 Deg C to 40 Deg C, 10% RH to 90% RH

Physical: 95mm x 28mm x 21mm, 31 grams

Software: Windows XP or newer

Applications

Ground, rail, ship, and air transportation of vibration sensitive goods

New building construction or renovation project monitoring

Part of an expanded QA program that monitors handling of new equipment etc prior to handing

over to customer

Relocation of expensive art work and museum artifacts

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Applications

Satellite Tracking Collar for Livestock

ShockBug

The Lamerholm ShockBug is designed to record shock events experienced during the transportation, storage and usage of products and equipment. The unit has been designed as an event recorder, providing an accurate record of the date and time at which user defined g force limits are exceeded.

These thresholds offer the added advantage, on the Plus model, of being programmable individually for each axis allowing more sensitive axis to be monitored with a lower g level.
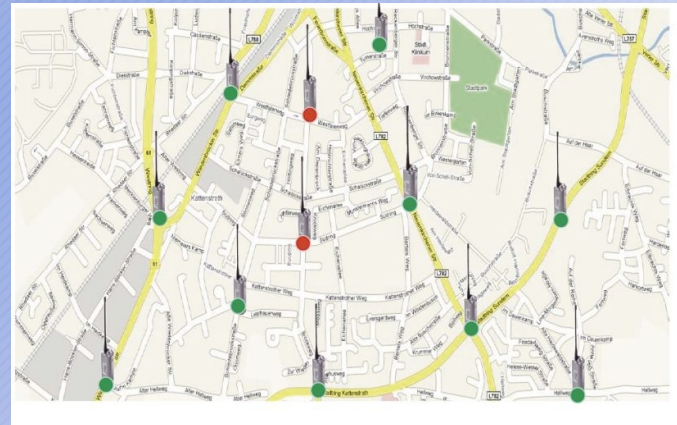

SePem ® 01 radio loggers - Water Leak Detection

The goal is to quickly identify water leaks to reduce the dollars lost, reduce the impact on non-revenue water calculations, be efficient, be good stewards of the environment, and reduce potential property damage. This goal can be achieved with SePem ® 01 Loggers.
SePem ® 01 Loggers are an effective, permanent monitoring tool to quickly identify leaks that may never reach the surface.

SePem ® 01 GSM – loggers with cell phone technology

Highly sensitive noise logger for stationary monitoring of water networks including a GSM module for data transmission.

The compact design of the SePem ® 01 GSM is especially suitable for fire hydrant valves and line valves.