Energy Harvesting IC for Fuzing Applications

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Presented at the 56th Annual Fuze Conference in Baltimore, MD on May 15, 2012

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This presentation is about the use of the standard product MSRFIF for energy harvesting in fuze technology.

Mixed Signal Integration is a Silicon Valley chip maker specializing in mixed signal CMOS based Application Specific Integrated Circuits. Incorporated in 1997, Mixed Signal Integration specializes in analog and mixed-signal integrated circuits. MSI offers both standard products and custom ASICs in CMOS technologies. Consumer audio and video, wireless personal communications, automatic test equipment and defense are some of the markets where MSI enjoys excellent customer relationships.

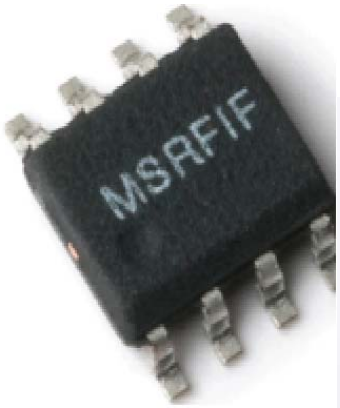
What is Energy Harvesting?

- Vibration detection
  - Using transducer
  - or Piezoelectric device
- Applications
  - Sensors for remote equipment
    - motors (bearing failure detection).

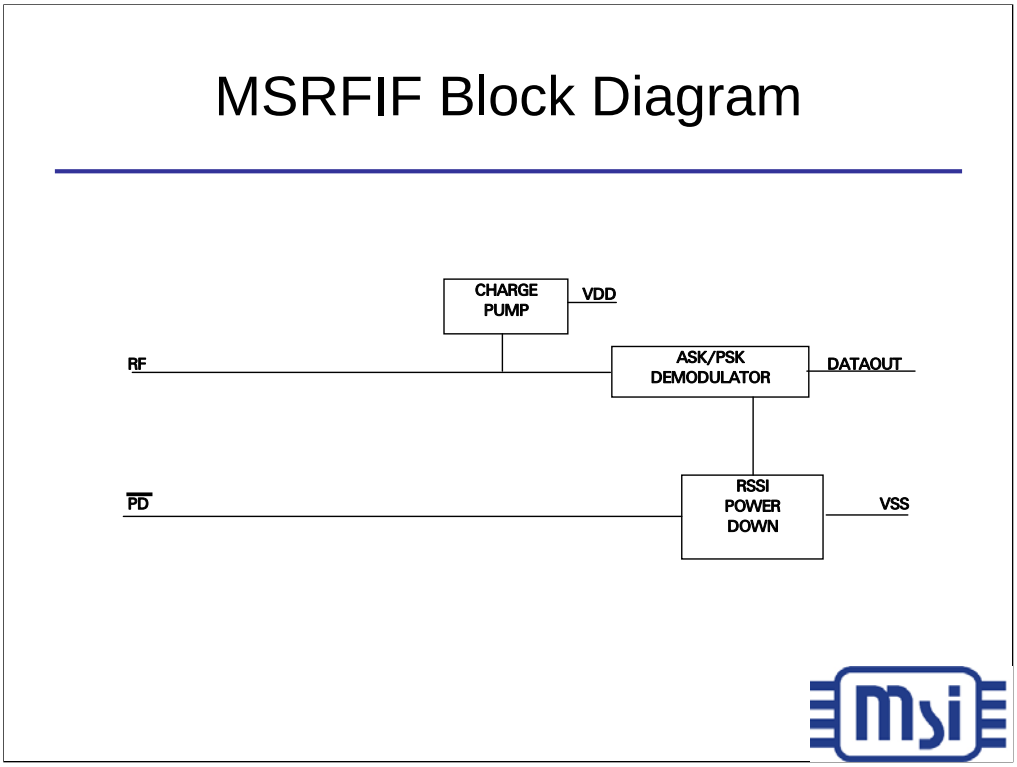
Vibration detected by a transducer or Piezoelectric device is applied to a charge pump. Using this technique, wasted energy can be used to power devices.

At present, applications have been sensors for remote equipment, such as motors (bearing failure detection).

MSRFIF

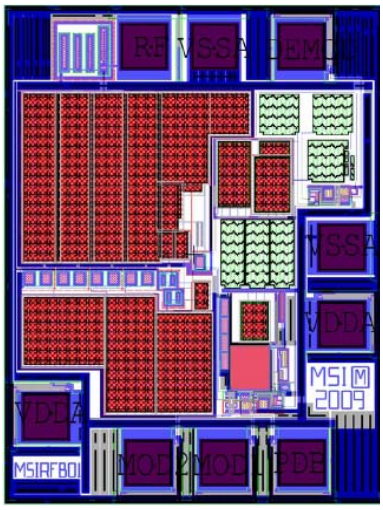


The MSRFIF is available in both a SOIC-8 package, 150 mils wide and a TSSOP-8 package 173 mils wide. Both devices are Lead free, but, can be assemble in more traditional Tin/Lead lead finish.



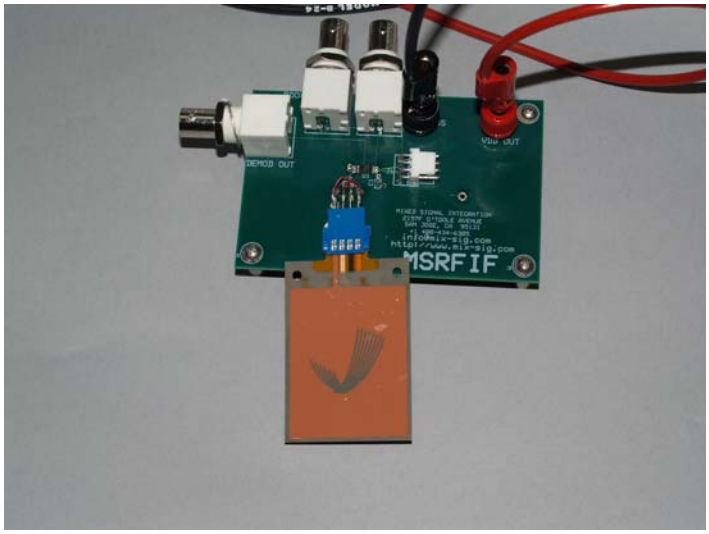
The MSRFIF provides the following functions: Charge pump that can convert from sub-audio frequencies up to RF into DC; an ASK/PSK demodulator and a power down indicator when VDD has not reached the correct value. The charge pump also includes a voltage clamp so the maximum voltage from the MSRFIF does not exceed 4 Volts. What is not shown is the modulator for the received RF carrier, which did not seem to have a purpose in an energy harvesting application.

MSRFIF Die Plot



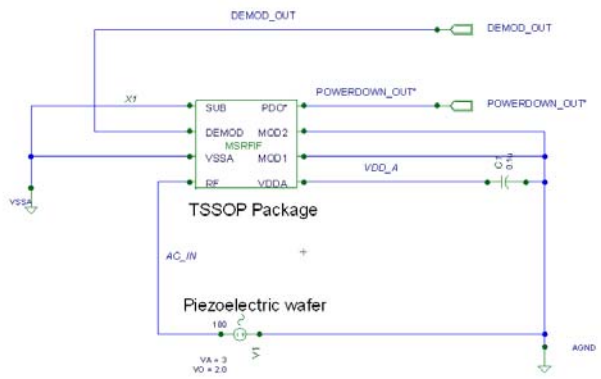
This plot is of the MSRFIF, showing the charge pump and filtering capacitors. The device is integrated in a 0.6 um double-polysilicon, double metal CMOS process.

MSRFIF Evaluation Board



This photograph is of the MSRFIF evaluation board with Mide'Technology Center's Volture V25W piezoelectric wafer attached. The charge pump in the MSRFIF takes the input from the piezoelectric wafer and outputs DC to the binding posts. The MSRFIF is also capable of amplitude shift keying demodulation. If the vibration of the piezo device can be modulated, data can be demodulated by the MSRFIF.

Simplified Schematic



This is a schematic of the MSRFIF. The Piezoelectric wafer is shown as a sine source, since the wafer will vibrate in a sinusoidal motion in most applications. VDDA is the DC output, tied to a filter capacitor. PDO will start out low, with no DC, then as 2V+ is achieved, will clamp low, indicating proper voltage for microcontroller's operation has been achieved. If the vibration has an amplitude shift keying (ASK) component, the DEMOD_OUT pin will show the data, up to the limit of the carrier frequency.

Bench Data

- Piezoelectric wafer is tuned
- Voltage generated by Motion fed to charge pump of MSRFIF.
- VDD out is 2.5V at 100 μA

The piezoelectric wafer is tuned to the resonant frequency expected by adding weight to the end of the wafer. The maximum for the large wafer is 120 Hz with no weight applied. The MSRFIF's charge pump works down to less than 50 Hz, so, even if the tuned frequency is not reached, DC will be produced. The output of the MSRFIF is fine for running a single micropower microcontroller, but, when this is integrated into a custom circuit, the size of the charge pump will be increased to produce more current and a higher voltage for other fuze circuits.

The Volture pieozoelectric device outputs the greatest voltage and power at 40 Hz. At that frequency, the output expected is 1 mW at 3V.

Technical Issues

- Piezo efficiency
  - Amount of motion limited for application
- Piezo size
  - Need larger size for voltage/current needs
- Charge pump efficiency
  - Optimized for RF

The problems with this present solution is the efficiency of the piezoelectric wafer and the size of the piezoelectric wafer. The motion needed to generate the 2+ volts is close to 1 inch. The size of the wafer is 2.3x1.6 inches. Finally the MSRFIF is optimized for radio frequency operation. The fact it works at much lower frequencies allows us to demonstrate the charge pump function. If integrated into a new design, the cells could be optimized for the lower frequency operation.

Summary

MSRFIF provides a charge pump to power Fuzing technology

- Piezoelectric wafer for energy harvesting.
- Perfect for micropower microcontrollers
- Possible to achieve more current in future designs

The standard product MSRFIF provides a charge pump and demodulator for use in energy harvesting. With piezoelectric wafers, low frequency vibration will generate a DC voltage and current adequate for the newer very low power microcontrollers. This function could be integrated into a custom integrated circuit and achieve higher voltage and current.