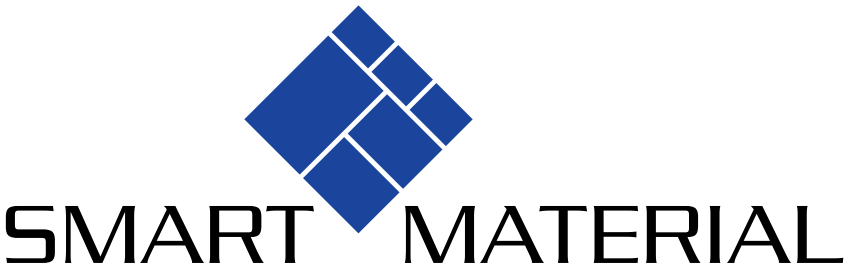
VERSION 1.4 NOV. 2019



Energy Harvesting Kit User Manual

Version 1.4

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1. INTRODUCTION

The Energy Harvesting Kit is for educational use.
The Kit is using the Macro Fiber Composite (MFC) as the kinetic energy harvester. The MFC is a piezo ceramic fiber composite that is flexible, robust and encapsulated. Straining the MFC will produce electrical energy which can be retrieved as electric charge (current). The MFCs contained in the kit are bonded to glass fiber composite (GFC) cantilevers. Straining the MFC is achieved by bending the cantilevers with the attached MFCs.

In order to keep the condition for the mechanical energy generation constant, the use of a shaker controlled by a frequency generator with a power amplifier is preferred. It allows the user to simplify the research and development for energy harvesting applications with different MFCs and electrical converter modules.

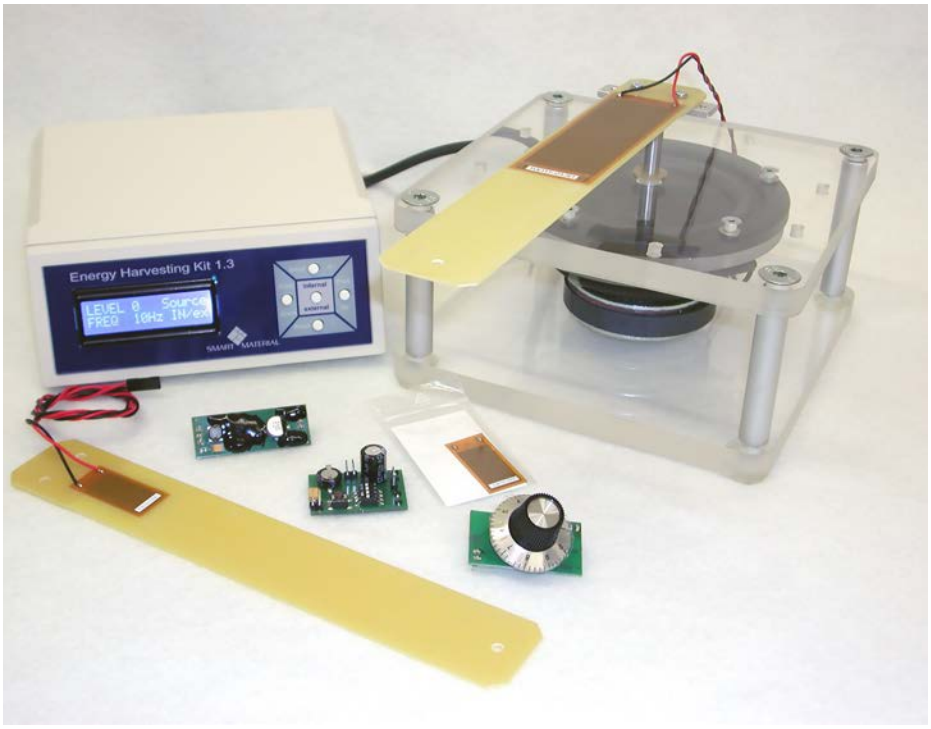
1.1 OPERATING VALUES

Electrical	Kit	Input Voltage +12V
		Input Current +1A
	Smart Module	Input Voltage max 10V
	CL-50	V_{out} = 3.3V $I_{out\ max}$ = 40mA $W_{out\ max}$ = 0.5 to 2 mJ (mWs)
Temperature	Storing Temperature	-10°C to +80°C (+14°F to +176°F)
	Operating Temperature	+5°C to +30°C (+41°F to +86°F)
Mechanical Stress	Maximum Strain for MFC	500ppm (parts per million)

2. ENERGY HARVESTING KIT

The Energy Harvesting Kit contains:

1. A shaker,
2. An amplifier module,
3. Three Modules,
4. Two MFCs bonded to cantilevers.
5. One MFC, not bonded, for additional use.



To use the Energy Harvesting Kit, please follow these steps:

1. Mount the MFC on the shaker
2. Attach or solder the various modules to the MFC
   (the MFC is considered to have an A/C output)
3. Plug the shaker into the Audio-Out plug of the Amplifier Module
4. Connect the Amplifier Module to the 12V Power Supply

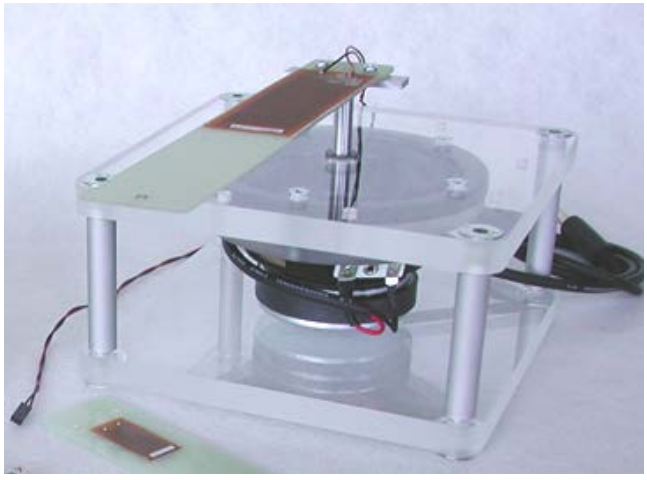
2.1 AMPLIFIER MODULE

The Amplifier Module generates the control output voltage for the shaker.

The integrated Amplifier can also be powered from an external source via the BNC connector. The operating range is 5Hz – 60Hz and the input voltage maximum 1Vpp. The Module switches between internal and external frequency source by pressing Internal/External button.

Frequency can be selected from 5 Hz to 60 Hz intervals by pressing Frq- or Frq+ for increased value. The amplitude or power is set with A- or A+. Note that at level 0 the output is disabled. The corresponding mechanical strain is a result of mechanic load and power level selection.

2.2 SHAKER



The shaker generates kinetic energy by moving the MFC cantilevers up and down using variable frequencies. The Shaker is powered by the Amplifier Module. The MFC cantilevers will be mounted onto the shaker rod.

2.3 MFCs

The EH-Kit includes the following MFCs:

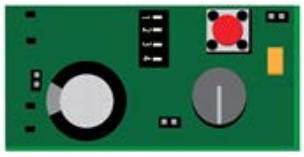
- 1 piece M8528 P2 bonded to a glass fiber cantilever
- 1 piece M2814 P2 bonded to a glass fiber cantilever
- 1 piece M2814 P2 for additional use

2.4 HARVESTING MODULES

The EH Kit comes with three harvesting modules which can be connected to the MFCs:

- Variable Impedance Module (VIM):
  Use to measure energy output

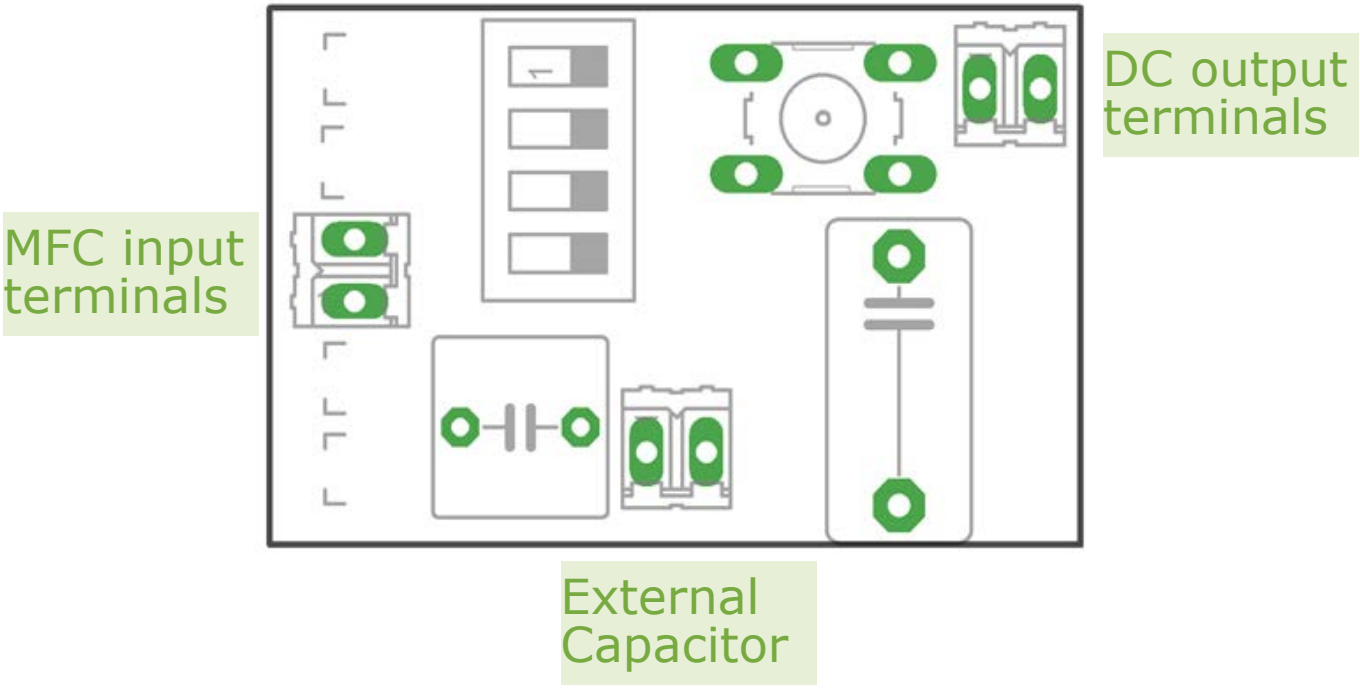
- Energy Measurement Circuitry:
  Use to measure harvested energy over time



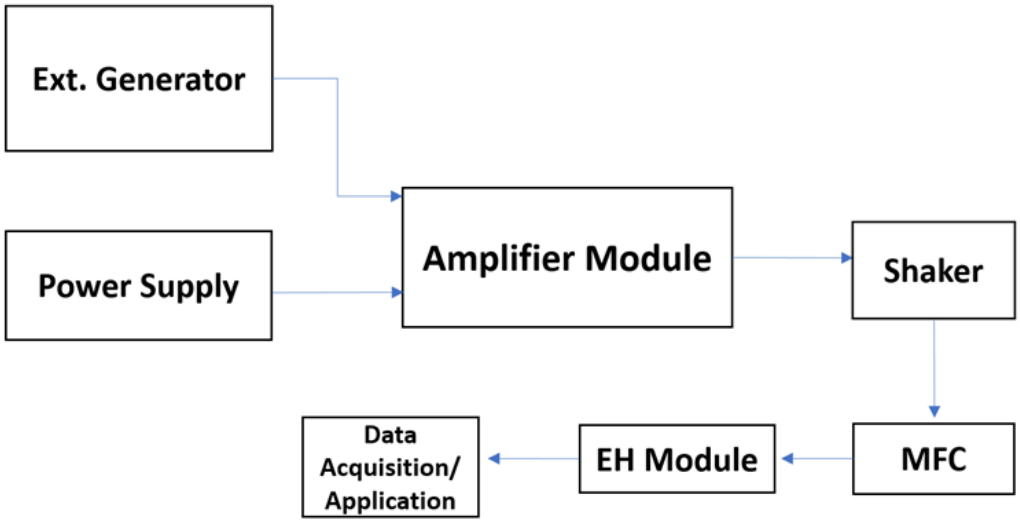
- CL-50/Smart Module 1.3:
  Use to power electronics requiring 3.3V, DC

3. ENERGY MEASUREMENT CIRCUITRY

The Energy Measurement Module contains a bridge rectifier to load different capacities, which can be jumper selected. The active capacitor load can be discharged by pressing the push button.



Jumper	1	2	3	4
Capacitor	External	0.1 µF	22 µF	470 µF
Capacitor Type	Custom	Double Layer Gold Cap	Tantal	Ceramic



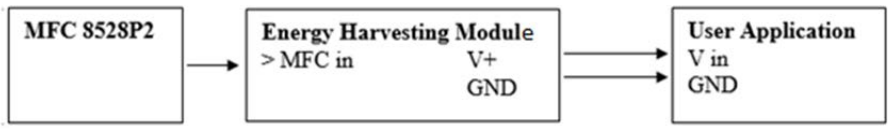
Schematic Overview of the Energy Measurement Circuitry

4. SMART EH MODULE 1.3 (CL-50)

The Macro Fiber Composite MFC Sensors produce an electric charge which is proportional to the induced strain.

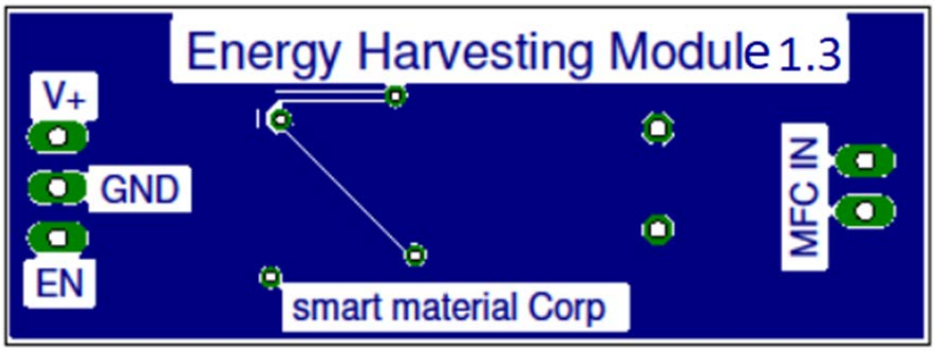
This charge energy can be collected and conditioned to meet various electrical application requirements. The CL-50 is called an energy harvester conditioner which consists of

- impedance matching for the piezo generator
- rectifier
- energy storage
- 3.3V DC output stabilization



Schematic overview CL-50

The CL-50 is an interface between the high impedance source characteristic of the MFC and the user's application. In most cases these applications are microcontroller based.



CL-50 outline, input and output connectors

4.1 HOW TO USE THE CL-50

Plug the MFC to *"MFC in"* without preferred polarity. The user's application power supply input should be connected to *V+* and *GND*. After vibration of the MFC, the energy is temporarily stored in the module until it reaches a minimum energy level. After this the output of the module is enabled and 3.3V is supplied for the time the energy is converted. The *"On"* time depends on the user application's current consumption and can be calculated as

$$t = W_{out} / (3.3V * I_{app})$$

After the output voltage is disabled, depending on the energy delivery of the MFC, the output will be enabled after a certain time period. Make sure the *EN* pin starts at high – not pulled to low. When pulled low, all the stored energy is transferred to the output until the internal accumulator is empty. The module will only start collecting energy from the MFC when the *EN* is high.

4.2 CL-50 SPECIFICATIONS

Electrical	V_{out} = 3.3V
	$I_{out\ max}$ = 40mA
	$W_{out\ max}$ = 0.5 to 2 mJ (mWs)
	Plug 2.54mm pitch AMP connector
Mechanical	Length 47mm
	Width 22mm
	Depth 5mm

5. FURTHER RESOURCES

We feature our popular in-depth tutorial on Energy Harvesting on our YouTube channel SmartMaterialCorp.
www.youtube.com/watch?v=CNSTzSfVckU

Keep up to date with our latest events and see some great tips and resources on our Facebook page:
www.facebook.com/SmartMaterialUSA

Join our interactive Macro Fiber Composite Forum for research, questions, and comments about our MFC:
www.macrofibercomposite.com