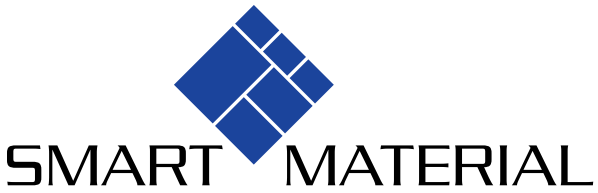
VERSION 1.1 MAR. 2020

PHYSICAL INSTRUMENTS



*micro*HVA-2
User Manual

Version 1.1

CONTENTS

1. SAFETY INSTRUCTIONS
READ FIRST

To ensure safe operation and to keep the operator and the product safe, **THE INFORMATION, CAUTIONS, AND WARNINGS IN THIS MANUAL MUST BE HEEDED.**

The high voltage amplifier microHVA-2 generates voltages up to 2000V. These voltages are present on either side of the PCB of the unit and are danger to life.

Place the microHVA-2 on an insulated base or in an insulated housing which can withstand > 2000V.

NEVER place the microHVA-2 on a conducting surface.
NEVER touch the microHVA-2 during operation.

Make sure that attached cables are electrically and mechanically NOT defective. Replace cables only with the high voltage amplifier switched off.

Before removing the cables from the load, switch off the amplifier and wait at least 10 minutes until the load capacitors are discharged.

Warning!

HAZARDOUS VOLTAGES UP TO 2000V ARE PRESENT AT THE OUTPUT OF THE HIGH VOLTAGE AMPLIFIER.
TAKE APPROPRIATE PRECAUTIONS DURING MEASUREMENT PROCEDURES.
BEFORE TURNING ON THE AMPLIFIER, REMOVE HANDS AND ALL TEST EQUIPMENT FROM THE microHVA-2 AND CONNECTED CABLES!!

1.1 WHAT COMES WITH THE *micro*HVA–2

The *micro*HVA–2 package contains the following items:

1. The *micro*HVA-2 printed circuit board (PCB)
2. Two jumpers for setting the function mode with Jumper K2
3. Six crimp connectors for connecting the output cable to the PCB
4. Input cable with plug for the Input Connector K1 for applying power and signals to the PCB. The 5 wires of the cable are color coded. Please refer to the table in 3.5 on page 7 for color/input assignment.

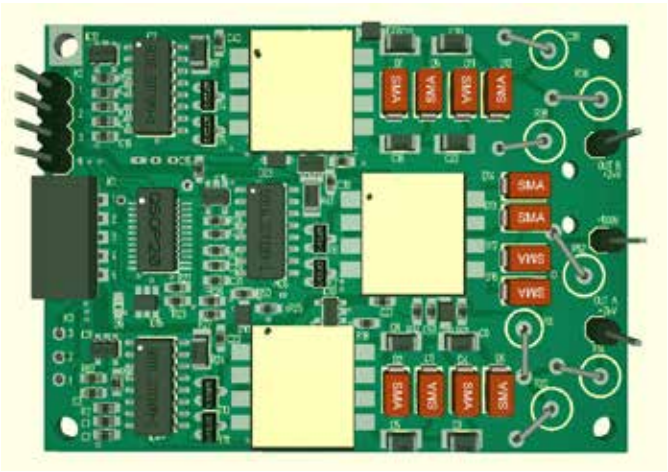
2. OVERVIEW

The microHVA-2 is a triple output power supply with one fixed output and two variable outputs from 0 to 2kV with a signal bandwidth of DC to 250Hz depending on the load capacitance and output voltage swing. This power supply is specifically designed for Macro Fiber Composite© (MFC) applications.

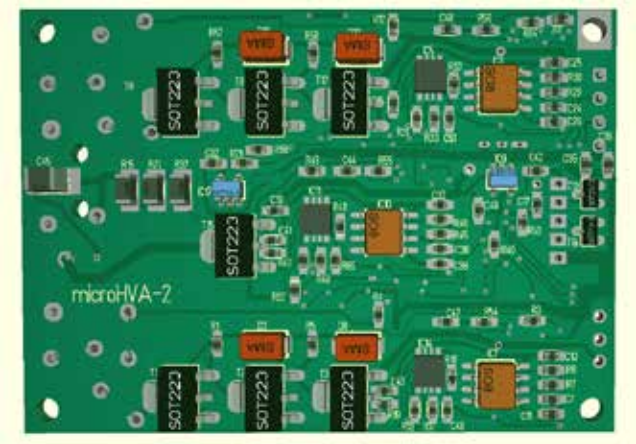
Use of the bias supply allows a voltage range of -500V to +1500V to be applied simultaneously to two different MFC.

For the output voltage control, the microHVA-2 provides four jumper-selectable interfaces, an analog interface, a PWM interface, an 8-bit I^2C interface, and a 12-bit I^2C interface. It is also designed for battery operation and requires a DC supply voltage from 12V to 16V.

microHVA-2 printed circuit board top view



microHVA-2 printed circuit board bottom view



3. SPECIFICATIONS

3.1 GENERAL SPECIFICATIONS

The microHVA-2 is designed to be operated as a high voltage power supply for the MFC, P1 type products.

DC Power supply	Nominally +12V, maximum +16VDC Maximum current 2A (during charging)
Operating Conditions	Ambient Temperature 0°C to 40°C
	Relative Humidity up to 85%, noncondensing
Mechanical	PCB Dimensions : W x D x H = 45mm x 67mm x 18mm. Components are mounted on both sides of the PB
	PCB Weight approx. 50 g
Input Impedance	All input impedances are 15kOhm

3.2 OUTPUT VOLTAGE, MAXIMUM CURRENT AND CURRENT LIMITER

Variable Output 1 Range	0V to +2000V, 0mA to 1.5mA, maximum 3W
Variable Output 2 Range	0V to +2000V, 0mA to 1.5mA, maximum 3W
Fixed Bias Output	+500V, 0mA to 10mA, 5W

The power supply provides three independent current limiter for the three outputs. In case any output current limit is reached, the corresponding current limiter will be activated.

If the output voltage has a sinusoidal shape, the current limiter changes the voltage shape from sinusoidal to triangle shape and reduces the voltage amplitude. The longer the current limit lasts, the bigger the voltage shape change and the reduction of the amplitude become.

If the output is shorted to the ground, the current limiter turns off the output. After a few seconds the output will be turned on. If the short-circuit is not removed, the output will be turned off again and so on.

3.3 OUTPUT CONNECTIONS

The power supply is capable of supplying two MFCs or several MFCs connected in parallel to the two output channels simultaneously and independently.

Output 1	MFC 1 (or several MFCs connected in parallel) is connected to the ***OUT A*** connector and to the ***BIAS*** connector. The voltage across the MFC1 ranges from -500V to +1500V. The voltage swing across the MFC is 2000V.
Output 2	MFC 1 (or several MFCs connected in parallel) is connected to the ***OUT B*** connector and to the ***BIAS*** connector. The voltage across the MFC1 ranges from -500V to +1500V. The voltage swing across the MFC is 2000V.

3.4 CONTROL MODE JUMPER K2

The microHVA-2 has four different control modes four controlling the high voltage output signals. A four pin jumper connector, labeled K2 controls the input signal mode.

Jumper Positions:

Pin 1 to pin 2 connected	Analog control mode
Pin 2 to pin 3 connected	PWM control mode
Pin 3 to pin 4 connected	8-bit I2C control mode
Pin 1 to pin 2 AND pin 3 to pin 4 connected	12-bit I2C control mode

3.5 INPUT CONNECTOR K1

A 5-pin JST style connector, labeled K1 is used for applying the DC power and the control signals to the microHVA-2 power supply board.

Pin Assignment and cable color coding:

Pin 1  black	GND
Pin 2  pink	Signal input 1 (analog 1 or PWM 1 or I2C-Data)
Pin 3  brown	Signal input 2 (analog 2 or PWM 2 or I2C-Clock)
Pin 4  green	Enable signal
Pin 5  orange	Power input, +12V DC

3.6 ENABLE SIGNAL INPUT

The output voltages can be enabled/disabled by using the enable signal input on Pin 4 of the K1 JST connector.

Enable input 0V (GND)	all the three output voltages are enabled
Enable input open or 5V	all the output voltages are at 0V

3.7 ANALOG INTERFACE

Input Voltage Range	0V to +5V corresponds to -500V to +1500V across the output channels OUT A/B and BIAS. The amplification factor is 400.
Signal Frequency Range	0Hz to 250Hz, depending on the connected capacitance (MFC) and voltage swing on the output channel (see also chapter 4).
Input Protection	Overvoltage and negative voltage protected

3.8 PWM INTERFACE

Pulse Width Range	1ms to 2ms corresponds to -500V to +1500V across the output channels OUT A/B and BIAS
Pulse Width Limits	Pulses less than 0.1 or greater than 5ms are ignored Pulses between 0.1 and 1ms are treated as 1ms Pulses between 2ms and 5ms are treated as 2ms
Pulse Voltage Range	Pulse voltage range is 0 V to 5V. Signals below 3V are treated as 0V.
Repetition Rate	50Hz nominally, minimum 5Hz and maximum 300Hz
Input Protection	Overvoltage and negative voltage protected

3.9 I²C INTERFACE

The I2C slave address is: **0x78 hex.**
The I2C Bus interface supports four data transfer speeds:

- Up to 100 kbit/s in standard mode
- Up to 400 kbit/s in fast mode
- Up to 1 Mbit/s in fast plus mode
- Up to 3.4 Mbit/s in high speed mode

The I2C bus master must provide a pull-up resistor on the open collector data line. The pull-up resistor must be connected between the data line and the +5V power line of the master. The power supply bus driver provides a sink current of maximum 12mA for sending the acknowledge signal on the data line to the master. Thus the pull-up resistor on the data line may not be less than 420 Ohms.

The maximum I2C cable length from master to the power supply depends on the data transfer rate, pull-up resistor on the data line and type of the serial cable, e.g. twisted pair, shielded cable etc.

3.9 I²C COMMUNICATION WITH THE microHVA-2 BOARD

The I2C slave address: **0x78 hex.**

In case of read operations:
address byte send over bus = ((I2C-slave-address<<1)|0x01)

In case of write operations:
address byte send over bus = ((I2C-slave-address<<1)&0xFE)

If Reading from address 0x78 hex, it will return 1 byte. This byte is used to indicate the presence of both mode jumpers (I2C and Analog) and thus 12-bit vs. 8-bit DAC mode.
If this byte is 0, then both jumpers are inserted and all data written to the board will be interpreted as 2-byte wide right justified 12-bit DAC data. If the byte is 1, then data written to the board are interpreted as 1 byte wide 8-bit DAC data.

If writing to Address 0x78 hex and depending on the mode determined by the 2 jumpers, the address byte will be followed by 2, respectively 4 bytes of data. In 1-byte mode the first byte contains 8 bits of data for DAC A (OUT A) and the second byte the data for DAC B (OUT B). In 2-byte mode the first 2 bytes contain right justified 12-bit of data for DAC A (OUT A) and bytes 3 and 4 contain right justified 12-bit data for DAC B (OUT B).

Note: Writing and reading of an address and two or four data bytes must be framed by an I2C-START and an I2C-STOP condition.

4. PERFORMANCE

The table below gives an overview of the maximum achievable sine wave frequency at some listed MFC capacitances and output voltage swings. For the calculation of the maximum achievable frequency, the following formula may be used:

$$f_{max} = 480\,000 / U_{swing} \times (C + 5)$$

f_{max} = the maximum achievable frequency in Hz.
U_{swing} = the voltage swing across the MFC in volt.
C = the MFC capacitance in nF.
The internal capacitance of the power supply is 5nF and added to C.

MFC capacitance	f_{max} @ MFC U_{swing} 2kV	f_{max} @ MFC U_{swing} 1kV
2nF	35Hz	70Hz
5nF	24Hz	48Hz
10nF	16Hz	32Hz
20nF	10Hz	20Hz
50nF	5Hz	10Hz
75nF	3Hz	6Hz
100nF	2Hz	4Hz

5. FURTHER RESOURCES

We feature our popular in-depth tutorials on on our YouTube channel SmartMaterialCorp.

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