MicroFab Technologies, Inc.

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PH-05 User's Manual

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Warranty

The PH-05 print head is warranted against defects in material and workmanship for a period of thirty days from date of shipment. During the warranty period, MicroFab will, at its option, either repair or replace equipment which proves to be defective.

Limitation of Warranty

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, or operation outside of the environmental specifications for the product. MicroFab makes no claim that the print head will perform with all fluids introduced to the device, or that the device will work at all frequencies and operating parameters selected by the Buyer.

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Equipment Series: PH-05 Print Head

Mfg Date:

General Safety Considerations

Warning	**The jetting device itself presents no general chemical hazard. However, when fluids are selected to be dispensed by the operator, appropriate safety measures should be followed as outlined in the selected material's MSDS.**
Warning	**If this product is not used as specified, the protection provided by the equipment could be impaired. This product must be used in a normal condition (in which all means for protection are intact) only.**

Table of Contents

Section 1 - General Information

Introduction

MicroFab's PH-05 print head was specifically designed for use with molten solders that have a liquidus point below 250°C. The print head incorporates a MicroFab MJ-SF jetting device and the Nitrogen flow necessary to enable the dispensing of solder.

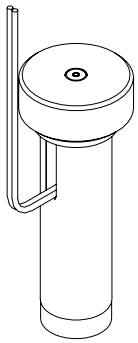


Figure 1 - MJ-SF-01 Jetting Device

Technical Specification

The print head and jetting device are tightly integrated to provide the proper environment for dispensing molten solder. A full description of the MJ-SF device is provided in a separate manual. However, operation of the jetting device with solder requires some techniques that are unique to this application.

Operating Range

- Operating temperature between 20 and 250°C.

Physical Dimensions

- Physical dimensions are shown in Figure 2.

Power Requirements

- Required power - 115VAC/2A max; 50/60 Hz. (Power is not supplied directly to the print head. Values here represent that which would be routed through temperature controllers to supply the heaters.)

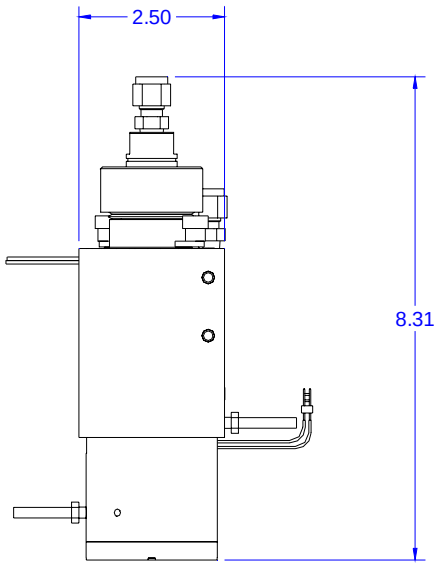


Figure 2 - PH-05 Overall Dimensions

Facility Requirements

Pneumatics

Gas connections to the PH-05 print head are made in two locations. One connection provides back pressure to the reservoir and serves to maintain proper control of the location of the meniscus. The second connection provides nitrogen flow to the drop dispensing zone and reduces the local oxygen concentration in order to avoid oxidation of the solder during drop formation.

In both cases, the gas supplied to the print head should be a high purity nitrogen. Liquid nitrogen, or tanks rated at 99.99% purity should be used to minimize oxygen contamination of the solder.

Electrical

The PH-05 requires three electrical inputs: (a) a voltage pulse to the jetting device, (b) power for the reservoir heater, and (c) power for the device heater.

In order to generate drops, a pulse is sent to the PZT surrounding the glass capillary. The shape of this waveform is shown in Figure 3. Acceptable ranges for the jetting device are listed in *Initializing Jetting Hardware*, later in this document. MicroFab offers a controller (part no. CT-M3-01) that has been designed to meet these parameters. However the same function can be accomplished by properly implementing a wave form generator and a voltage amplifier from qualified manufacturers and this is recommended for use with solder. In either case, power to the drive electronics – which is transformed to a PZT signal – is 110 VAC, 1 A. 240V units are also available.

Heaters for the PH-05 are controlled through PID units which read thermocouple signals and regulate the duty cycle of the heating element. Typical temperature controllers accept 100-240

VAC supply voltage. The heater for the reservoir is 200 W, and the heater for the jetting device is 100 W. Power should be supplied accordingly. MicroFab offers a pneumatics / thermal control unit which houses regulators, flow controls, and temperature controllers to support the PH-05.

The back pressure for the reservoir is controlled through a pressure regulator. For the PH-05, a digital pressure regulator, connected to the COM port of the system computer, is required to maintain precise control.

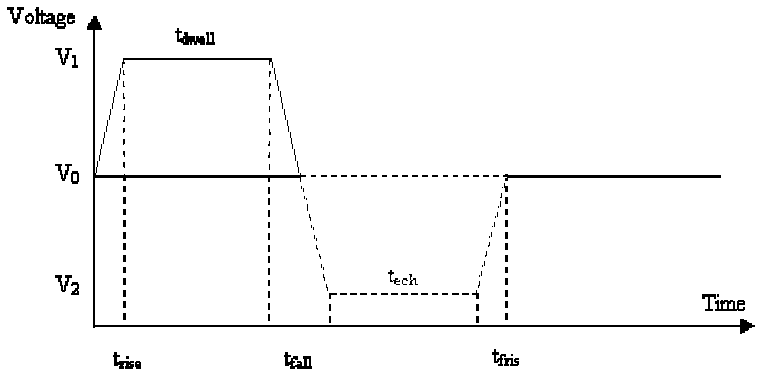


Figure 3 - Waveform definition

Section 2 - Equipment Ratings

Supply Voltage

Consult the manufacturer's data sheet for supply voltage requirements of the pulse generator used for operation.

Range of environmental conditions

The MJ-SF device has been successfully operated in the temperature range of 20° to 250° C. It is intended for use in a normal laboratory environment.

Equipment Installation

Unpacking and Inspection

When received, the PH-05 will be packaged in a plastic bag. There will be no jetting device installed in the print head. After removing the print head from it's package, it can be mounted on the test structure and a jetting device can be installed.

Assembly

The jetting device is installed as described in the MJ-SF-01 manual. In order to access the mounting gland of the reservoir, the reservoir is removed from the heating block. The reservoir clamps must be loosened and rotated out of the way before the reservoir can be removed. Once removed from the heating block, the jetting device can be mounted to the outlet end of the reservoir.

With the jetting device securely mounted, the reservoir/jetting device assembly will be re-installed in the heater blocks. The device wires must be threaded the side of the lower device heater until they have passed through the heater and are positioned as shown in Figure 4.

Note:

Working with the print head when parts of the assembly are heated above room temperature exposes the operator to risk of being burned. Performing a jet

replacement to a hot assembly is not recommended and should be done at your own risk, and then only with adequate protective equipment.

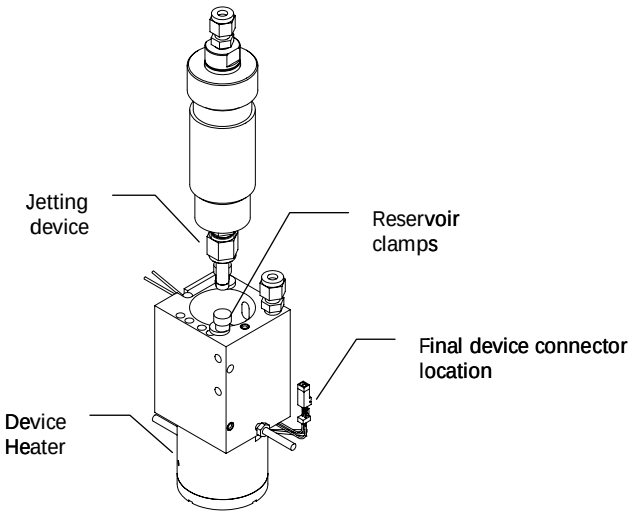


Figure 4 - Device installation

Instructions for Protective Earthing

Protective earthing for the JetDrive III controller is provided through the ground terminal of the plug providing power. Source power to the controller, or to a wave form generator selected as an alternate, must provide protective earthing to this terminal in order to minimize the hazard of a possible shock.

Ventilation

The PH-05 print head requires no special ventilation for operation. However, when the print head is used to dispense solder, normal cautions should be taken in the handling of the solder material. Refer to the MSDS sheet for the material in use for more details. Additionally, when the print head is used with other dispensed fluids, they may emit volatile fumes which must be captured and disposed of. This situation is the responsibility of the user of the device and beyond MicroFab's control.

In addition, nitrogen is used to provide an inert environment around the jetting device at the rate of 4 SCFH. Ventilation in the room should be adequate to allow this low level of nitrogen to be dispersed.

Equipment Operation

Hardware Overview

Figure 5 shows a typical set-up for a jetting test station. The key components are:

1. Print head with MJ-SF-01 jetting device
2. Drive electronics with strobe interface
3. Pneumatics / Temperature Control panel
4. Drop observation camera and monitor

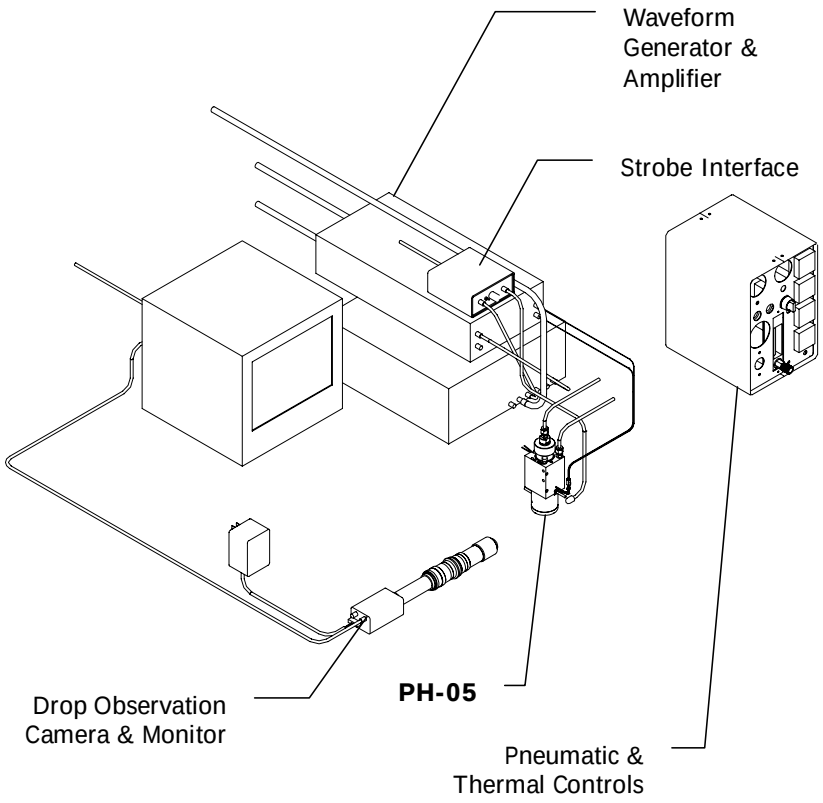


Figure 5 - Component set-up

Not shown in the figure is a personal computer. A PC is required in order to serve as the user interface to download operating parameters to the wave form generator. The software required to perform this interface is included with the drive electronics. For systems where the voltage

pulse is supplied by other equipment, variations on the figure will occur, although the same components are required.

Interconnection Diagram

Figure 7 shows the pneumatic, electric, and heater connections for the PH-05 print head.

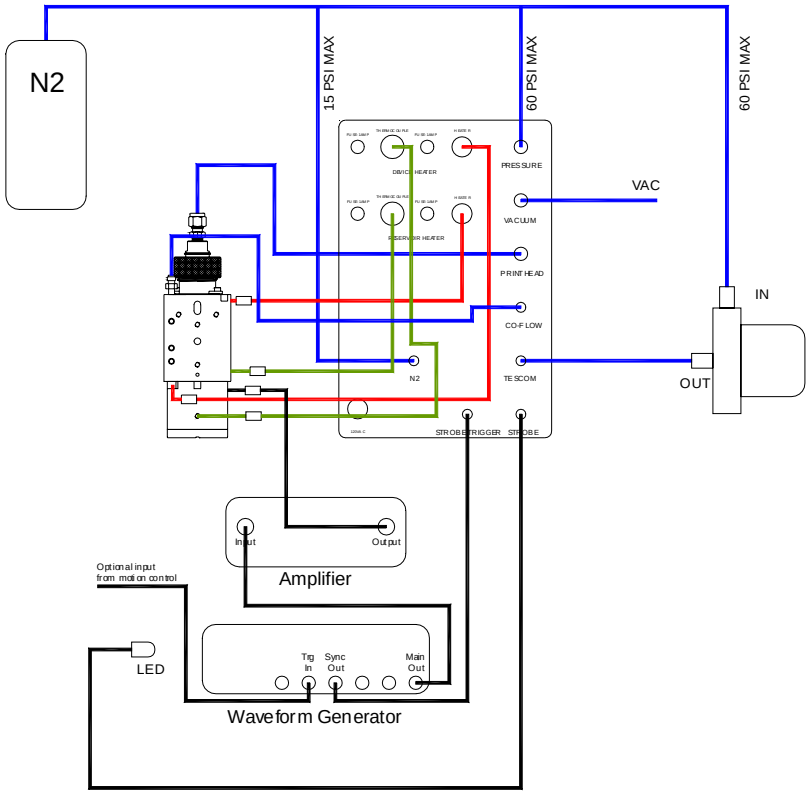


Figure 7 - Connection diagram

Initializing Jetting Hardware

Heating a Solder Jet Print Head

The first step in initiating a jet of solder is to melt the solder supply stored in the reservoir. This is done by ramping the temperature of the reservoir and device in a controlled manner to avoid thermal stresses to the device.

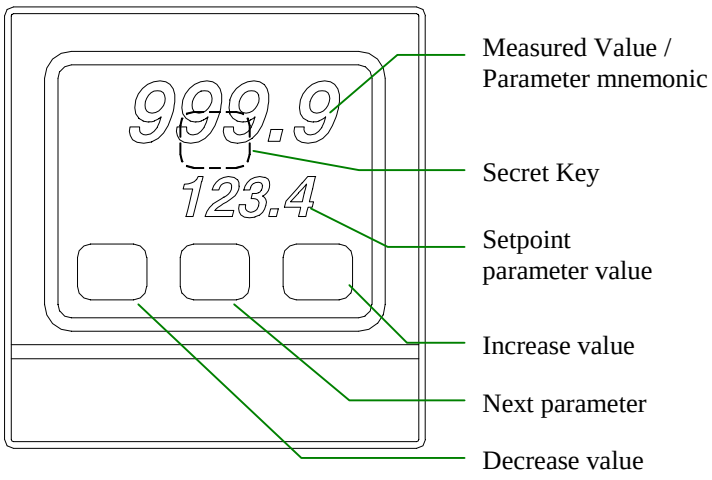
Step 1: At the pneumatics control box, there are two Eurotherm temperature controllers for the print head, one for the device and one for the reservoir. To modify the temperature set point of the reservoir, press the increase (or decrease) button on that controller until the setpoint display

shows the correct value. Set the temperature set point to 130°C. Repeat for the device controller. The heaters should run freely to 130°C.

Step 2: When the print head has reached 130°C, the operator needs to program the controllers to ramp the temperature from 130°C to 200°C in increments of 4°C/min.

To do this, complete the following steps:

- Press the Next Parameter button up until AL.SP is displayed.
- Press the Secret Key
- Press the Next Parameter button until SP.rr is displayed
- Press the increase (or decrease) button until the desired rate of 4°C/minute, is displayed.
- The controller will time-out after the value is entered and display the SP.rr mnemonic intermittently as an indication that the rate of change is being controlled.
- Set the temperature set point to 200°C.



Establishing a Jet

It should be noted that stable operation of a Solder Jet print head usually requires the device to be at operating temperature (200°C) for 3 to 4 hours. Before operation begins, set the co-flow to 3 SCFH on the front panel of the pneumatics panel.

> ***Important:*** The glass tip of device is very fragile! Care should be taken to avoid contact with the tip that might break the glass and allow the solder reservoir to flow freely onto the substrate.

Set the waveform parameters on the jetlab user interface screen as follows:

Rise	1000 μsecs
Dwell	2 μsecs
Fall	50 μsecs
Echo Dwell	2 μsecs
Final Rise	1000 μsec
DC Level	-100 Volts
Dwell Voltage	-50 Volts
Echo Voltage	-150 Volts
Frequency	240 Hz
Echo Flag	ON

On the pneumatics panel, set purge pressure to 12 psi. Set the backpressure to 1 psi. This is accomplished through the user interface of the Tescom digital pressure regulator. Note: Vacuum should never be used on a solder jet print head.

Click the Start Jet button to enable a signal to the device and purge the print head with 10-15 psi for approximately 10 seconds to insure all air is out of the system. The operator should see a straight column of fluid, coming from the tip of the device, visible on the monitor. Switch from purge to back pressure.

On the pneumatics panel, locate the strobe delay knob and adjust delay until a drop appears on the monitor. If no droplet appears on the monitor increase back pressure until one does. If backpressure has increased to the point where the device is "dripping", decrease back pressure until the dripping stops.

Go to the jetlab user interface screen on the computer and increase Dwell Voltage and Echo Voltage, in 10 volt increments, until a droplet appears on the monitor. Remember to look at the monitor and adjust the delay to view the drops between each voltage increase.

Once a droplet has been established, optimize back pressure to get maximum drop velocity, ie., increase back pressure very slightly and observe droplet. If it moves farther away from the tip of the device, it is increasing in velocity. If the droplet moves toward the tip you have passed the optimum setting and need to reduce back pressure. Continue in whichever direction until it reaches a maximum. The back pressure should then be set.

Setting Drop Velocity

As you have seen, backpressure has a direct influence on droplet velocity but, once set, it should remain set. Variations in fluid level inside the reservoir will require changes in backpressure. Check it daily to insure optimum performance.

Voltage is the key factor in adjusting drop velocity. Keep the voltage symmetric. Raise or lower to get the desired drop velocity, typically 1.5 M/sec is an ideal velocity for printing. Velocities below 1.0 M/sec may not give accurate drop placement. For drops that have a trailing satellite, simply reduce the voltage to eliminate the satellite.

Fall Time is also a factor in determining drop velocity. Lower fall times give higher velocity drops and also reduce drop size. Higher fall times will give lower velocities and larger drop sizes. In either case, once the fall time has been set, the voltage will need to be adjusted to obtain the printing velocity.

It is important to remember that all these parameters have an effect on jetting and they can all be used at any time to optimize drop formation. The preceding is a baseline and once a droplet is established, adjusting any and all parameters to maximize performance is allowable.

Observation system

To observe the drop formation, a CCD camera can be used to observe the jet tip. MicroFab offers a suitable system (model no. CM-VS-01). The camera can also be replaced by an appropriate microscope.

The total magnification to the display should be in the range of 50 to 100 times. An LED synchronized with the PZT pulse provides lighting. The delay between the PZT pulse and LED pulse is adjustable, allowing the capture of the drop formation at different stages of development.

Basic Drop Formation Troubleshooting

No drops formed

- Set the delay to zero then increase to about 3 times t_1.
- Check (visualize with an oscilloscope) that the drive waveform is the same waveform you wanted.
- Inspect the tip. Turning the LED strobe off and lighting constantly (with a white background) will show you a change in the light reflection when no fluid is present in the nozzle. Purge to recover the meniscus or to eliminate any large air bubbles observed in the nozzle area.
- Pressurize the reservoir. If no fluid is purged, the device is clogged. Several possible techniques exist for removing a clog from the orifice. Contact MicroFab for determining the best solution for your system.
- Repeat steps 3 to 9 in the setup procedure

No drops are formed with a fluid puddle formed on the device tip

- Wipe of the front surface with a cotton swab until dry and readjust the reservoir back pressure if necessary.
- Air may have been ingested through the orifice – Purge the device, or decrease the voltage to the device
- Satellites are formed in addition to the main drop – Decrease the voltage to the device or adjust the dwell time.

Jet is not straight

- Could be produced by a low velocity drop. In this case increase the velocity (increase the voltage or adjust the t_{dwell})
- Could be produced by non-uniform wetting. Wipe off the device face until dry and readjust the syringe level if necessary.
- Could be a foreign particle at, or in the orifice, use cleaning procedures.

Supplemental Parts

In many instances, the MJ-SF jetting device is purchased as a "stand-alone" component of a larger subsystem. In order to make both fluid and electrical connections, details regarding the electrical connector, tubing, etc., is required. Below is a partial listing of some of these items that are known to interface correctly with the supplied device. *This is, in no way, an endorsement of these products, or does it attempt to address questions of fluid / material compatibility.*

- Electrical connector
    - The default connector is Molex P.N. 50-57-9402
        - The appropriate mating connector is Molex P.N. 70107-0001, with two Molex male crimp terminals, P.N. 16-02-0115
- Fluid connection
    - The nut that mounts the device is a Swagelok SS-4-VCO-4.

Factory Support

For any questions regarding the MJ-SF-01 jetting device, or ink jet technology, contact

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