

Microwave Power Source User Manual



Bridge12 Technologies, Inc.

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Contents



Figure 1: The Bridge12 Microwave Power Source (MPS) for ODNP Spectroscopy

The Bridge12 MPS (Figure 1) is a Microwave Power Source (MPS) for Overhauser Dynamic Nuclear Polarization (ODNP) Spectroscopy.

Detailed technical information about the MPS can be found by visiting the website.

The current firmware version as of July 15th, 2020 is: **1.5.5**

Note: This documentation is valid for all firmware versions > 1.5. If you have an older firmware version please contact Bridge12 at support@bridge12.com to request a firmware upgrade. Keeping your system up to date ensures that you will always have access to the newest features.

CHAPTER 1

System Description



The Bridge12 Microwave Power Source (MPS) is a compact, high-power microwave source for X-Band (9 GHz) Overhauser Dynamic Nuclear Polarization (O-DNP) spectroscopy. It is a turn-key, easy to operate, stand-alone microwave source. The

microwave radiation is generated using a phase-locked digital synthesizer and amplified using a high-power microwave amplifier. The system constantly monitors the forward and reflected power and can tolerate 100% reflected power without being damaged. The system can control an external waveguide switch to alternate between EPR and DNP operation. The Bridge12 MPS is a versatile research instrument which can be operated as a stand-alone unit, or integrated into an existing EPR spectrometer.

1.1 Front Panel Elements

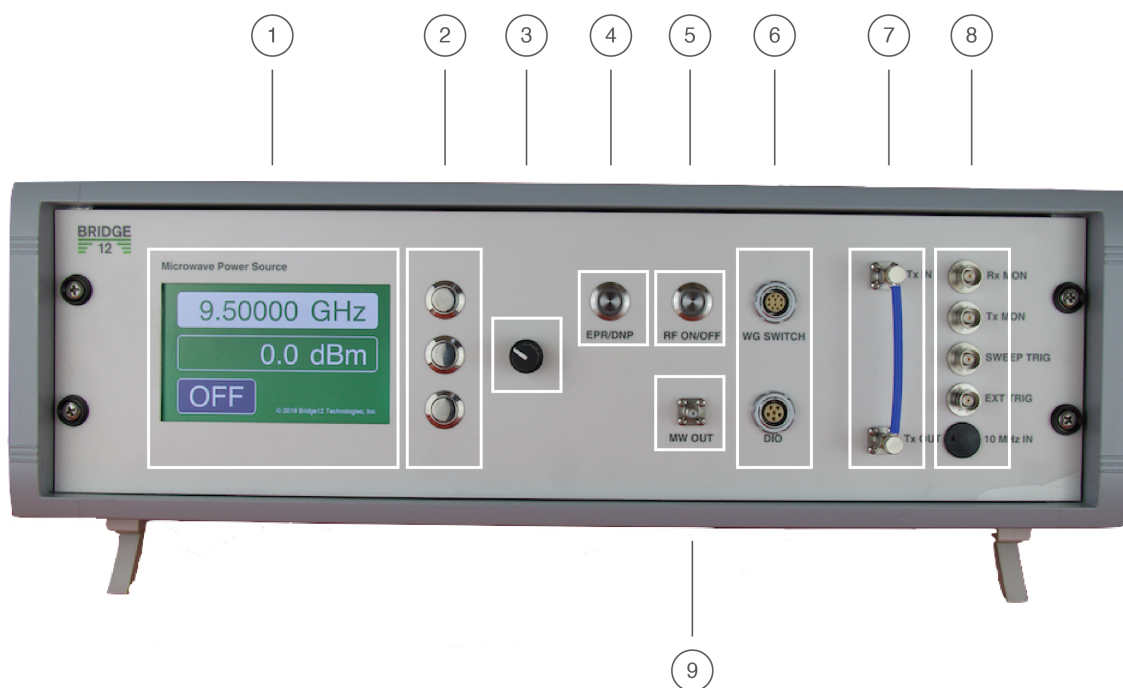


Figure 1.1: Bridge12 MPS Front Panel

The following control and display elements of the Bridge12 MPS are located on the front panel (see Figure 1.1)

1. 5" TFT Display
2. Buttons to control the frequency or microwave power
3. Rotary encode
4. Switch to select between EPR and DNP operation
5. Microwave ON/OFF button

6. Waveguide switch and DIO connector
7. SMA breakout cable
8. Front panel connectors for Receiver Monitor (Rx, analog), Transmitter Monitor (Tx, analog), Sweep Trigger (digital, TTL), External Trigger (digital, TTL), External 10 MHz reference input
9. RF Output (SMA connection)

1.2 Back Panel Elements



Figure 1.2: Bridge12 MPS Back Panel

The following elements are located on the back pane (see [Figure 1.2](#))

1. System power ON/OFF switch
2. Fuse
3. Power connection
4. USB connection (A type)

Warning: Only use the power supply delivered with the system for powering the MPS.

The USB connection is for remote operation only. Do not connect any other auxiliary devices (e.g. phones, tablets etc.) to provide power.

This section of the manual will give a general overview of the system and its capabilities. For specific instructions how to operate the instruments consults the Operation section of the manual. The system has several different screens that can be accessed by pressing the rotary encoder on the front panel. The screens are in the following order:

1. *Main Screen*
2. *Sweep Screen*
3. *Operate Screen*

The *Status Screen* is an additional screen, which is accessible by pressing and holding the rotary encoder button for > 2 seconds.

2.1 System screens

2.1.1 Main Screen

Once the Bridge12 MPS has started and completed its initialization the system shows the main screen (see [Figure 2.1](#)). The system is ready.

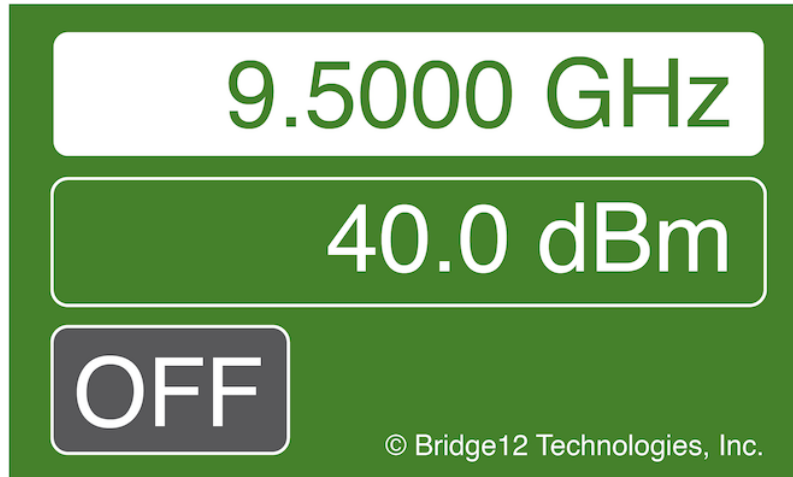


Figure 2.1: MPS Main Screen with RF output power OFF.

To enable RF power output, switch the MPS to DNP and press the RF ON/OFF button. When the EPR/DNP button is pressed and the system switches to DNP mode the orange light of the button comes on. When the RF ON/OFF button is pressed and the RF power is enabled the green light of the button comes on. Also, on the main screen, the grey background changes to red, indicating that the output power is enabled (see Figure 2.2).

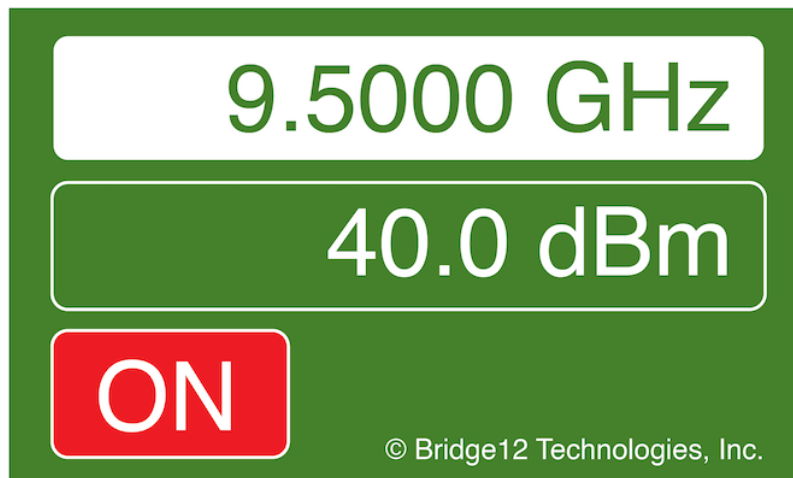


Figure 2.2: MPS Main Screen with RF output power ON.

Warning: Do not enable the microwave power without a load (e.g. tuned EPR cavity) attached to the output. When no load is connected, the output power is reflected into the system and can lead to permanent damages.

If you like to use an external trigger you can switch the MPS in a mode that accepts an external TTL trigger using the BNC connector located on the front panel. This mode is indicated by the orange background (see Figure 2.3).

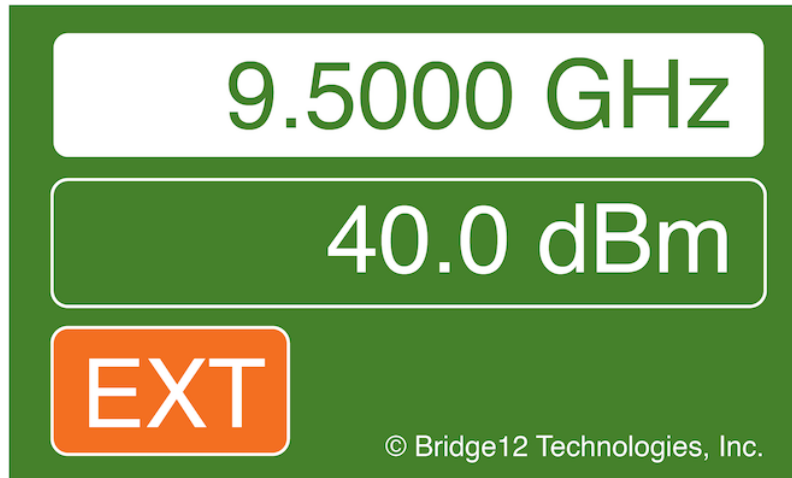


Figure 2.3: MPS Main Screen with RF output power in external trigger mode.

The RF status (ON/OFF/EXT) can also be controlled through the serial interface. For more information about how to use the remote interface see section [Remote Interface](#).

2.1.2 Sweep Screen

The sweep screen allows measuring the reflected power from the microwave cavity. Using this screen it is possible to perform a critical tuning of the resonator.

A typical screen is shown in Figure 2.4. The top row indicates the center frequency (CF) of the sweep. In this case it is set to 9.5 GHz. The default microwave power to perform a sweep is set to 10 dBm. Other values can be set through the serial interface. If the RF sweep power not equal to 10 dBm, the actual value is shown in parentheses.

Warning: Do not exceed a value of 20 dBm for tuning. Exceeding this value may lead to permanent damages of the system.

The row below the Frequency indicates the sweep width (SW). Several pre-defined values for the sweep width are accessible: 250, 100, 50 and 20 MHz. The default value is 250 MHz.

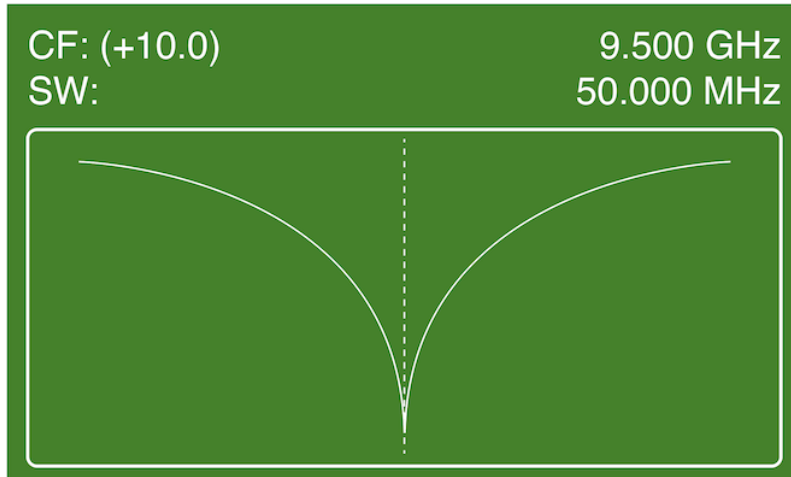


Figure 2.4: MPS Sweep Screen (the actual screen may differ depending on the installed firmware version)

2.1.3 Operate Screen

The operate screen provides vital information while performing ODNP experiments. Two bar graphs display the forward and reflected microwave power (see :Figure 2.5).

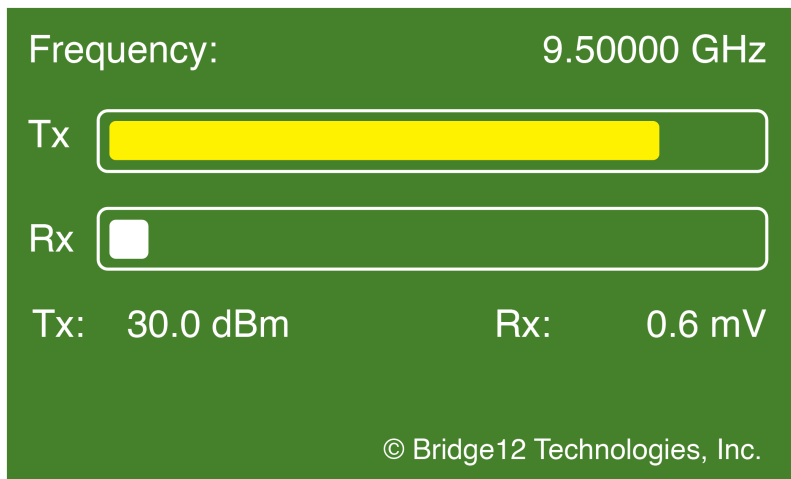


Figure 2.5: MPS Operate Screen

Note: If your system is not equipped with a detector for the forward power, the bar graph displays the set power. Only if a forward power monitor is installed, the actual forward power is displayed.

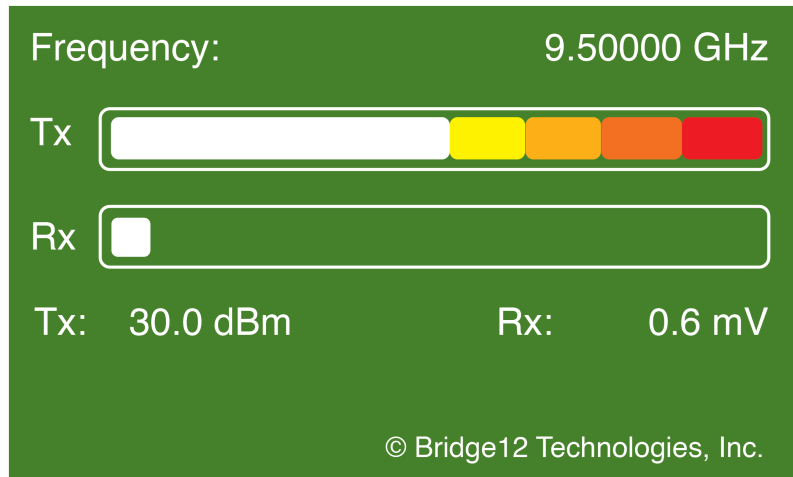


Figure 2.6: MPS Operate Screen, Color Code

Both, the Tx and Rx bar graph will change their color, depending on the amount of power. At low powers, the bar graph will be white. With increasing power the color will change from yellow, to orange at medium powers to red at high powers. This is indicated in [Figure 2.6](#). The levels for the color to change are different for the Tx and Rx bar and are indicated in [Table 2.1](#).

Table 2.1: Color Code for Power Levels

Color	Tx [dBm]	Rx [dBm]
White	0.0 - 23.0	0.0 - 15.0
Light Yellow	> 23.0 - 28.0	> 15.0 - 18.0
Yellow	> 28.0 - 31.0	> 18.0 - 21.0
Light Orange	> 31.0 - 34.0	> 21.0 - 24.0
Orange	> 34.0 - 37.0	> 24.0 - 27.0
Red	> 37.0	> 27.0

Once the center frequency of the resonator has been determined using the [Sweep Screen](#) the resonator can be fine tuned by moving the frequency and adjusting the resonator iris to minimize the reflected microwave power.

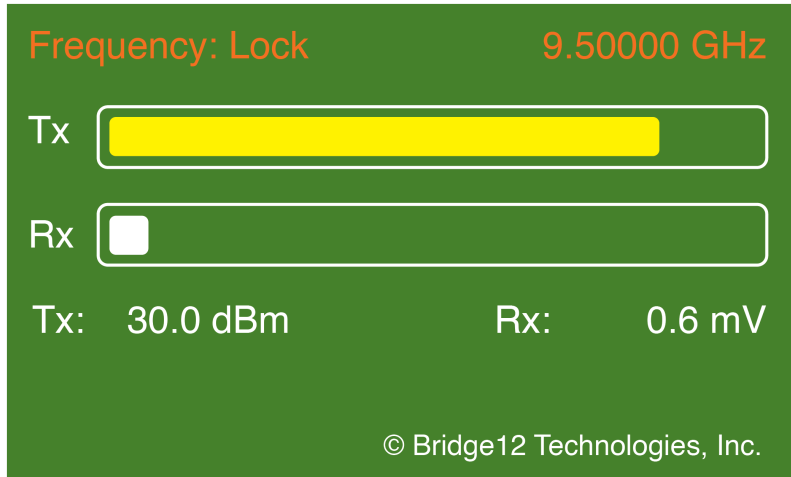


Figure 2.7: MPS Operate Screen and Frequency Lock enabled

2.1.4 Status Screen

The status screen can be accessed by pressing the rotary button for more than 2 seconds. To exit the status screen press the rotary button again.

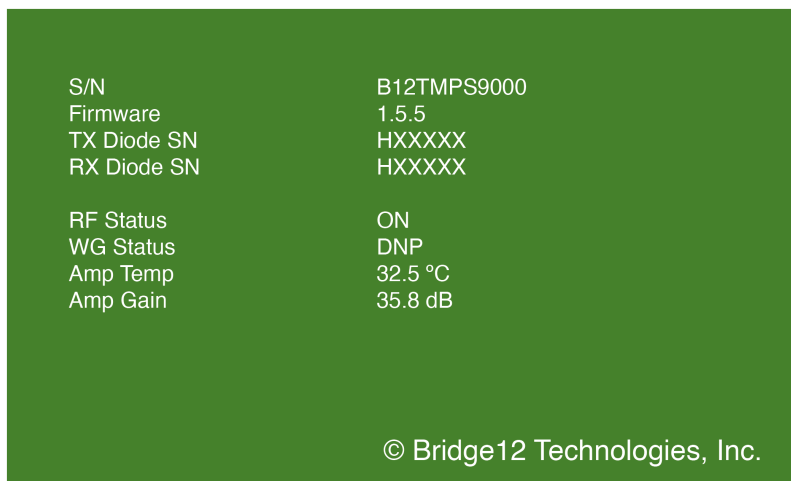


Figure 2.8: MPS Status Screen (the actual screen may vary depending on the firmware version)

The status screen provides additional system information, such as the amplifier temperature, the serial number and the current firmware version (see Figure 2.8).

2.2 Power Monitor (Rx and Tx)

The Bridge12 MPS has a built-in power monitoring circuit to constantly monitor the forward and reflected microwave power. An overview of the system is shown in Figure 2.9.

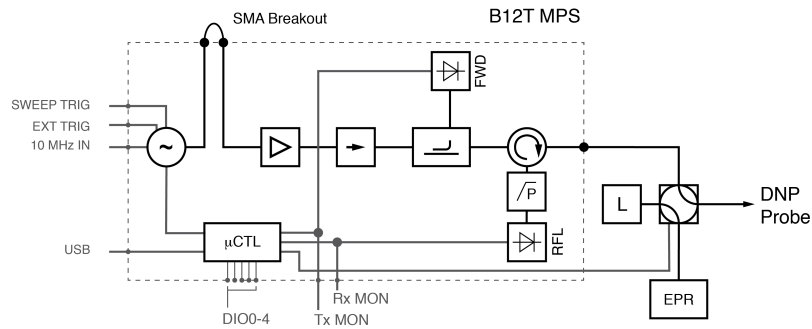


Figure 2.9: High-level schematics of the Bridge12 MPS

The forward and reflected power is detected using microwave detection diodes, which generate a voltage proportional to the measured microwave power. From this voltage, the integrated microcontroller calculates the microwave power. The microwave diodes are calibrated by Bridge12 at the time of delivery of the system. The calibration data is available upon request. Please contact Bridge12 at support@bridge12.com for further information.

The power monitor enables the following features:

1. **Emergency Shutoff:** If the reflected microwave power exceed 33 dBm (2 W) the RF output power is automatically disabled. The user has to manually enable the RF output power to continue. Upon request, the default value can be changed.
2. **Resonator Tuning:** By sweeping the microwave frequency and monitoring the reflected power, the tuning dip of the resonator can be recorded.
3. **Frequency Lock:** Once the microwave power is increased, the resonator frequency can change due to thermal expansion of the resonator. The Frequency Lock will change the microwave frequency to minimize the reflected power, even when using the maximum output power.

These features are described in the Operation Section of this manual.

CHAPTER 3

Unpacking the System

The Bridge12 MPS is shipped in a wooden crate to protect the system during shipping.



After unpacking the system, Bridge12 recommends storing the wooden crate and the cardboard box in a dry place. This is the safest method of re-packing the system if the system must be returned to Bridge12 for repair or maintenance.

Setting Up the System

Warning: Do not enable the microwave power without a load (e.g. tuned EPR cavity) attached to the output. When no load is connected, the output power is reflected into the system and can lead to permanent damages.

4.1 Setting up the MPS for Operation

To setup the system for operation, follow these steps:

1. Unpack the power supply and connect it to the microwave source. The power supply is connected to the back of the system (see [Figure 4.1](#)).

Make the following connections as shown in [Figure 4.2](#):

2. Connect the SMA to the SMA front panel connector labeled “MW OUT” (Panel A). The other end of the SMA cable is connected to the SMA to WR-90 adapter of the connection kit, connecting the waveguide switch to the Bridge12 MPS (see the Connection Kit manual for details).
3. Install the 3” semi-rigid jumper cable to the front of the system (Panel B)



Figure 4.1: Back panel power connector

4. Connect the cable controlling the waveguide switch to the connector labeled WG switch (Panel C).

4.2 Turning ON the MPS

Once all connections are made, turn on the system by pressing the power button located on the back panel of the MPS. The green light will come on, indicating that the system is switched on (note, that the actual color of the light can be different. Some system will have a blue indicator.)

When the MPS is powered on, the system will go through an initialization process. During this process the front screen will display the Bridge12 logo (see Figure 8) and other information, such as the serial number and the version number of the currently installed firmware.

Once the initialization process is completed, the front panel display of the Bridge12 MPS will switch to its default display mode.

For safety reasons, the output power is always disabled after the MPS is switched on. Once the main screen is displayed the system is ready.

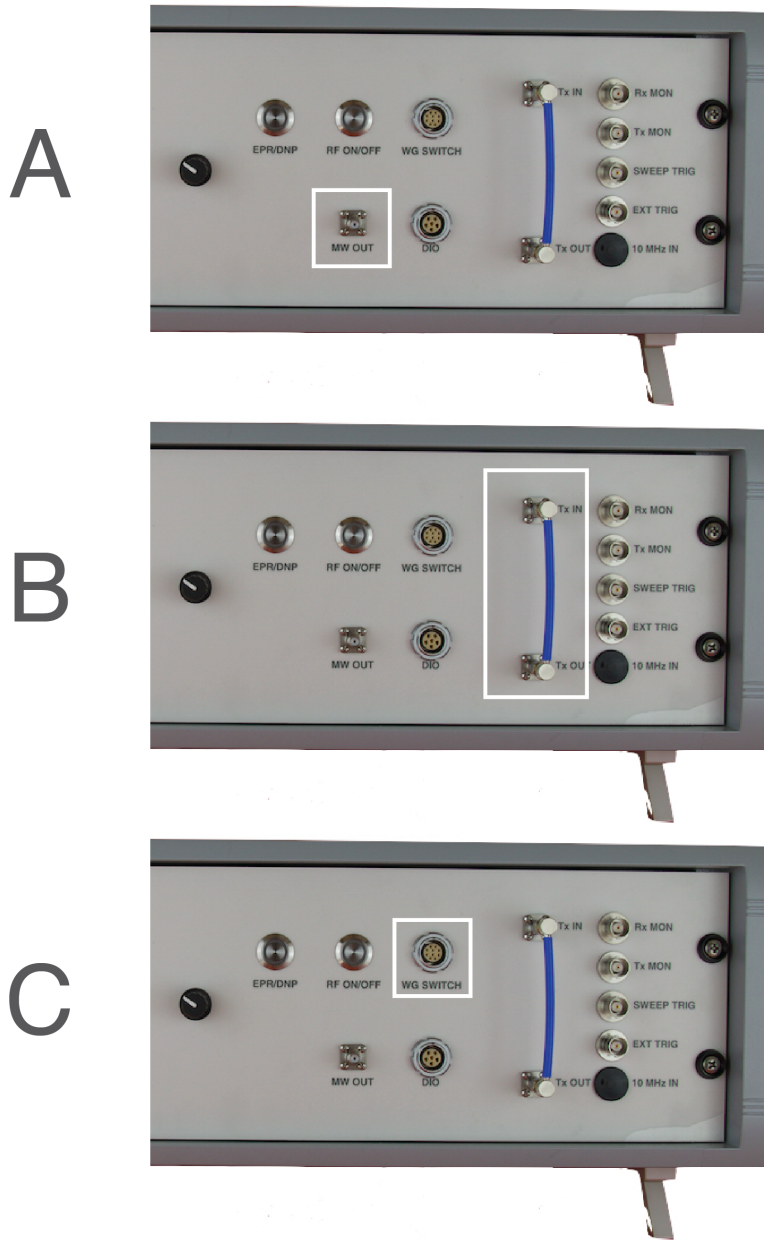


Figure 4.2: Microwave connections for SMA breakout and resonator. Connection to the automated waveguide switch



Figure 4.3: Bridge12 MPS startup screen



Figure 4.4: Front panel display of main screen. The system is ready.

CHAPTER 5

Operation

The Bridge12 MPS can be completely operated from the front panel. To the right of the TFT display are three silver push buttons and a dial (rotary encoder) that can be rotated in either direction. The top two buttons are used to either select and change the frequency, or select and change the power level (see Figure 5.1).



Figure 5.1: Left: MPS set to change the output frequency. Right: MPS set to change the output power level

5.1 Manual Operation

5.1.1 Setting the Output Frequency

To set the microwave output frequency:

1. Push the top button located to the right of the screen. The background color of the frequency will change from green to white (see [Figure 5.1](#), left).
2. Using the rotary encoder, dial in the desired output frequency. Turn the dial clockwise to increase the frequency and counter clockwise to decrease the frequency. The step size to increase or decrease the frequency will change depending on how fast the dial is turned. For large steps, quickly turn the dial. For fine adjustments, turn the dial one click at a time.

5.1.2 Setting the Output Power

To set the microwave output power:

1. Push the middle button located to the right of the screen. The background color of the amplitude will change from green to white (see [Figure 5.1](#), right).
2. Using the rotary encoder, dial in the desired output power. Turn the dial clockwise to increase the output power level and counter clockwise to decrease the output power level. The step size to increase or decrease the power level will change depending on how fast the dial is turned. For large steps, quickly turn the dial. For fine adjustments, turn the dial one click at a time.

Note: The power on the MPS system is given in dBm to easily facilitate displaying power levels over several orders of magnitude. This unit may be foreign to some researchers and a conversion table is given in the appendix to convert the power reading into Watts (see [Table 9.1](#)).

5.1.3 Switching between EPR and DNP Operation

Warning: Do not enable the microwave power without a load (e.g. tuned EPR cavity) attached to the output. When no load is connected, the output power is reflected into the system and can lead to permanent damages.

The Bridge12 MPS can control an external waveguide switch. The waveguide switch is part of the optional Bridge12 ODNP Connection Kit and is installed between the EPR bridge and the EPR resonator to easily switch between EPR and DNP operation. For details about the Connection Kit and how to install it, please consult the Connection Kit manual.



Figure 5.2: Left: Waveguide switch control button (orange). Right: Microwave (RF) ON/OFF button (green)

To switch to DNP operation, simply press the button labeled EPR/DNP. If your system is equipped with a waveguide switch, you will hear the waveguide switch changing direction. In any case, the orange light of the button will light up to indicate that the system is switched into DNP operation mode (see [Figure 5.2](#)). A schematic explaining the function of the waveguide switch is shown below.

The waveguide switch has four ports. The way the ports are connected depends upon the position of the waveguide switch (see [Figure 12](#), middle and right). The position of the switch is indicated on the top of the silver cap (see [Figure 12](#) left).

Note: For safety reason, the microwave power will always be disabled when the waveguide switch is switched from DNP operation to EPR. Switching back to the DNP

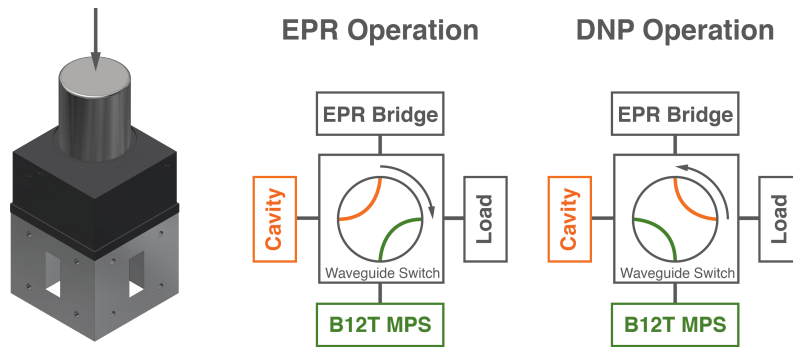


Figure 5.3: Waveguide switch positions

mode will not automatically enable the microwave power.

The microwave power can only be enabled if the waveguide switch is in the DNP position (orange button light is on). Even if your system is not equipped with a waveguide switch, the EPR/DNP button must be pressed before the microwave power can be enabled. This feature can be disabled upon special request in the firmware.

5.1.4 Enabling/Disabling the Output Power

By default, the output power is disabled when the Bridge12 MPS is initially powered up. To enable the microwave output power, make sure the system is in DNP mode (orange light is on) and press the button labeled RF ON/OFF. The button will light up with a green light and the status on the display will change from OFF to ON (see Figure 5.2). Pressing the same button again will disable the microwave output power.

5.1.5 Using the External Trigger

The output power of the Bridge12 MPS can be controlled (modulated) using an external trigger connected to the front panel BNC connector labeled “EXT TRIG”. This is an optional feature. Please make sure this feature is requested at the time of ordering the MPS. Please contact Bridge12 at info@bridge12.com with any questions regarding this feature.

The external trigger accepts a TTL signal (low: < 0.8 V, high: > 2 V). Please make sure to not exceed these limits. To enable the external trigger:

1. Press and hold the microwave ON/OFF button for at least 3 seconds.
2. The background of the output power indicator on the Main Screen will change to EXT (with an orange background color).

The unit is now ready to be controlled by an external trigger. To return to manual mode, press the microwave ON/OFF button again.

5.2 Tuning the EPR Resonator

5.2.1 Coarse Tuning

To tune the resonator first switch to the Sweep Screen (see [Figure 2.4](#)). If this is the first time that the sweep screen is entered, no sweep data is available and only a flat line at the bottom of the sweep screen is displayed. To perform a cavity sweep:

1. Set the center frequency (an initial estimate is sufficient). Press the frequency button (top button of the three buttons to the right of the display) and dial the frequency using the front panel dial.
2. Use the default sweep width of 250 MHz for the first sweep.
3. Switch the system into DNP mode.
4. Enable the RF output.
5. Press the sweep button (third button of the three buttons to the right of the display) to perform a sweep. The system will perform sweeps of the microwave frequency.
6. Press the frequency button and adjust the frequency so that the cavity dip is aligned with the center vertical line of the display. Adjust the iris coupling to match the resonator.
7. Once you found the resonator dip you can decrease the sweep width by pressing the center button of the three buttons to the right of the display. By pressing this button you will cycle through different predefined sweep widths: 250, 100, 50 and 10 MHz.

Once you followed these steps, you will have a fairly matched and tuned microwave resonator and you can move on to fine tune the resonator as described in the next section.

5.2.2 Fine Tuning

For fine tuning of the resonator switch to the Operate Screen (see [Figure 2.5](#)). Fine tuning is important before starting an ODNP experiment when using high microwave power levels to ensure the resonator is critically coupled. For this process the reflected microwave power is monitored:

1. With the microwave output power disabled, dial in the resonance frequency of the empty resonator (see the previous section to determine the center frequency).
2. Switch the microwave power ON and slowly increase the microwave output power to about 10 dBm. The exact value is not critical, but should not exceed 20 dBm.
3. Slowly vary the microwave output frequency and monitor the reflected power. At a certain frequency, a clear power minimum should be detected if the resonator is critically coupled.
4. Set the microwave frequency to a value corresponding to the minimum reflected power. This is the resonance frequency of the EPR resonator.
5. Check that the resonator is critically coupled. Slowly (!) turn the iris screw of the resonator and observe the reflected microwave power. Ensure that the reflected power is at a minimum.
6. Slowly increase or decrease the microwave frequency. Adjust if necessary to minimize the reflected microwave power.
7. Increase the microwave output power and repeat steps 5 through 7.

If the microwave resonator is critically coupled, the reflected microwave power will not increase when the forward power is increased. At high output power levels (> 30 dBm, 1 W) the reflected output power may change, but can be corrected by moving the microwave frequency. This is due to heating effects inside the EPR resonator, which will lead to thermal expansion of the cavity and the resonance frequency will decrease slightly.

Note: During experiments, make sure a constant flow of air through the resonator. This helps compensating for microwave induced sample heating effects.

5.3 Enabling the Frequency Lock

The Bridge12 MPS can operate in a *Frequency Lock* mode which constantly minimizes the reflected power from the microwave bridge by varying the microwave frequency. This mode is only available on the Operate Screen while the microwave output is enabled. The lock mode will be automatically turned off upon exiting the operate view or disabling the microwave output.

The lock feature can be enabled/disabled by pressing the 3rd (bottom silver) button next to the display. When the lock feature is enabled, the text color indicating the frequency will change to orange and the word “LOCK” will be displayed.

If the microwave frequency is within a few MHz of the resonator frequency, the lock feature should automatically find the center of the dip. If the microwave frequency is not close to the resonator frequency, it is unlikely the lock feature will be able to find the dip. The lock feature can aid in fine tuning the microwave resonator. A brief description of tuning with the lock feature is given below:

1. Set the microwave power to 10 dBm and set the microwave frequency to within a few MHz of the resonator frequency.
2. Make sure the operate view is displayed and enable the microwave output.
3. Enable lock mode by pressing the 3rd button next to the display. Once enabled, the frequency should change to minimize the reflections from the resonator. This may take a moment until the frequency is centered on the dip.
4. Once the Rx monitor has stabilized to a minimum value, slowly adjust the iris screw to minimize the reflections from the resonator (Rx).
5. The resonator is critically coupled when the Rx monitor reading is minimized.
6. If required, steps 4 and 5 can be repeated at higher power.

At high microwave power, e.g. > 30 dBm, the microwaves will induce significant heating in the cavity walls which will reduce the resonance frequency of the resonator. At very high powers, e.g. 40 dBm, the frequency can shift by more than 5 MHz. The lock feature is intended to compensate for temperature dependent shifts in the frequency of the resonator. Several of the default lock parameters are accessible through the serial port. These are detailed in the remote interface section.

5.4 Status Screen

5.4.1 Microwave Amplifier Temperature Monitor

The Bridge12 MPS continuously monitors the temperature of the microwave amplifier and disables the output power if the amplifier temperature reaches 55°C. The amplifier temperature is displayed on the Status Screen.

If the MPS frequently overheats and the microwave power is disabled, contact Bridge12 immediately at support@bridge12.com.

CHAPTER 6

Remote Interface

The Bridge12 MPS is equipped with a Serial Interface to allow control of the system remotely from a computer. Communication is enabled using standard serial communication (RS232) over USB.

Warning: The remote interface should only be used by users familiar with the operation of the MPS. Please contact Bridge12 at support@bridge12.com if you have any questions about the serial interface.

6.1 Serial Port Configuration

The Serial Interface is configured with the following operation parameters:

Table 6.1: Serial Port Configuration

Parameter	Value
Baud Rate	115200
Data Bits	8
Parity Bit	No
Stop Bit	1

It is possible to communicate with the MPS through any serial terminal. Make sure the baud rate, number of data bits, number of parity bits, and the number of stop bits is set to the correct values (see [Table 6.1](#)).

6.2 Communicating with the MPS

Most likely, the Bridge12 MPS will perform a reset at the time the serial connection (socket) is established. This is very normal behavior of the interface. When developing customer applications to control the MPS through the serial interface, the serial socket should only be opened once when the customer program goes through its initialization routine. The serial socket is kept open until the customer application closes. Closing the serial socket is important, otherwise the remote computer may report an error.

When opening the serial socket the system will respond with the following message:

```
Bridge12 MPS Started
```

Once the system is initialized and ready the system will respond with the following message:

```
System Ready  
Synthesizer detected
```

The user needs to wait for the System Ready statement before issuing any command. All commands that are issued before the System Ready message will be ignored.

6.3 Command Syntax

Commands are not case sensitive. When opening a serial socket to the MPS, the microcontroller will reset. Therefore, the serial socket should only be opened once and closed only after the last command is sent to the unit.

The general structure for sending a command is:

```
COMMAND VALUE <CR>
```

The general structure to query a value is:

```
COMMAND? <CR>
```

6.4 Python Package to Control the MPS

Bridge12 has developed a python package to control the MPS. The python package can be installed as a python module and its functionality can be integrated into user specific applications.

For more information about the package please visit .

6.5 Description of Available Commands

Currently the following commands are implemented. If a special command is required, please contact Bridge12 at support@bridge12.com.

6.5.1 General Remote Commands

Table 6.2: Serial Port Configuration

Command	Description	Firmware
ampstatus	Set/Query amplifier power.	1.0.0
amptemp	Query amplifier temperature	1.3.1
firmware	Query firmware version	1.1.0
freq	Set/query microwave frequency in kHz	1.0.0
help	Get help instructions on serial port	1.0.0
id	Query MPS ID number	1.1.0
lockdelay	Set/Query frequency lock delay in ms	1.4.0
lockstatus	Set/Query frequency lock	1.4.0
lockstep	Set/Query frequency lock step in kHz	1.4.0
power	Set/query microwave power in dBm times 10	1.0.0
rfstatus	Set/Query RF status	1.1.0
rfsweepsw	Set/query the sweep width for cavity tune sweeps. The following arguments are allowed: 0 - 250 MHz, 1 - 100 MHz, 2 - 50 MHz, 3 - 10 MHz.	1.5.4
rfsweepdosweep	Trigger a single cavity tune sweep through the serial interface. The values of the reflected power are stored internally in an array, which can be access using the rfsweepdata command. IMPORTANT: Any character sent to the serial interface will abort the current sweep. This functionality can be used to abort an active sweep.	1.5.4
rfsweepnpts	Set/query number of points of cavity tune sweep. The default is 50 points. The maximum number of points is 1024.	1.5.4
rxpowerdbm	Query Rx diode power in dBm times 10	1.0.0
rxpowermv	Query Rx diode reading in mV times 10	1.0.0
screen	Set/Query frequency lock step in kHz	1.4.0
	Query serial number	1.1.0

6.5. Description of Available Commands

6.5.2 Specialized Remote Commands

The following list of serial commands is for reference only, and are typically not used in a day-to-day operation. Extreme caution should be used when using any of these commands since permanent damage can occur to the system if commands are used incorrectly.

Table 6.3: Special Serial Port Configuration

Command	Description	Firmware
ampgain	Set/query the amplifier gain on the fly. This parameter is used only for small adjustments during the calibration process. Users should not attempt to change this since it can cause permanent damage to the system.	1.5.5
debug	Enable debug mode. The following arguments are allowed: 0 - Debug mode disabled, 1 - Debug mode enabled, 2 - Verbose mode enabled	1.3.0
rfsweepdwelltime	Set/query the dwell time in microseconds between points when performing a cavity tune sweep. The default value is 110 us between each step.	1.5.5
rfsweepinitialdwelltime	Set/query the initial dwell time in milliseconds for the first point of the frequency sweep when performing a cavity tune sweep. The default value is 100 ms between each step.	1.5.5
rfsweeppower	Set/query the microwave power level used during a RF sweep. The default is 10 dBm. The maximum power available for a RF sweep is 20 dBm.	1.5.4
rxdiodesn	Query Rx diode serial number	1.1.0
txdiodesn	Query Tx diode serial number	1.1.0

6.6 Example using PuTTY (Windows)

Below is an example using PuTTY to communicate with the MPS. PuTTY can be downloaded from <https://www.putty.org/>. Please follow the instructions for installation.

To communicate with the MPS you first have to determine the COM port. This can be

done using the Windows Device Manager. To open the Device Manager type

```
devmgm
```

into the search box and hit return. The Device Manager opens. Navigate to **Ports (COM & LPT)** and expand this section. Here, you will see MPS listed as **Arduino Due Programming Port**. Note down the COM port number.

To start communication using PuTTY follow these instructions:

1. Start PuTTY
2. In the PuTTY configuration window, click on **Serial** tab (all the way at the bottom)
3. Enter the COM port number (from Windows Device Manager)
4. Enter a **Speed (baud)** of 115200
5. Return to the **Session** tab (all the way to the top right)
6. Choose **Serial** as connection type. In *Serial Line* the correct COM port should be displayed and under *Speed* a speed of 115200 should be displayed
7. Click the **Open** Button to start communication

Once you click the open button a new window will open. You will hear clicks from the MPS and the system will reboot and initialize. This will take a few seconds. In the new window you will see a few messages similar to this:

```
=====  
Bridge12 MPS Started  
=====  
System Ready  
Synthesizer detected
```

You are now ready to send commands to the MPS. For example to set a frequency of 9.543210 GHz type

```
freq 9543210
```

Depending on your settings and the type of serial terminal application you are using, you may not see the command that your typing and there will be no response for a correct

command unless it is a query, in which case the value of the variable will be returned. If the syntax is not correct the MPS will answer with an error:

```
freq 954321
ERROR
```

(Note: this command creates an error since the frequency has to be entered in kHz.)

To close the COM port, simply close the PuTTY window.

6.7 Example with pySerial

Below is an example about how to use the MPS serial interface using pySerial. A MPS specific python package (`mips`) is available for more convenient remote control of the MPS.

```
import serial
import time

# MPS Serial Port
serialPort = 'COM5'

# Start Serial Connection
ser = serial.Serial(serialPort,115200,timeout = 1.)
time.sleep(0.1)

system_ready_string = 'Synthesizer detected'

# Initialize MPS
while not is_system_ready:
    time.sleep(0.1)
    bytes_in_waiting = ser.in_waiting
    if bytes_in_waiting > 0:
        read_bytes = ser.readline()
        read_string = read_bytes.decode('utf-8').rstrip()
        print(read_string)
        if read_string == system_ready_string:
            is_system_ready = True
```

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```
# Command to send to MPS
command = 'freq 9400000\n'

# Encode MPS command (convert to bytes)
command_bytes = command.encode('utf-8')

# Send command to MPS
ser.write(command_bytes)
```

6.8 Error Codes

If the system does not recognize a command that was sent through the serial interface, it will return an error code. In [Table 6.4](#) the system error codes are listed together with a description. If neither the *debug* nor the *verbose* mode is enabled, no acknowledgement will be returned if the command has the correct syntax. Enabling the *debug*

Table 6.4: Special Serial Port Configuration

Error Code	Description
E001	Value out of range.
E100	USB shield error. Please contact Bridge12 at support@bridge12.com .
E101	USB shield error. USB shield failed to send data. Please contact Bridge12 at support@bridge12.com .
E102	Temperature sensor not recognized.
E999	The command was not recognized, either because the command does not exist or because of a typo. The same error code is returned if the command was sent without a question mark (query).

CHAPTER 7

Maintenance

The Bridge12 MPS does not have any internal or external parts that require frequent maintenance. If any parts of the systems do not work as intended, please contact Bridge12 immediately at support@bridge12.com

7.1 Firmware Upgrade

Warning: Firmware upgrade should only be performed after contacting Bridge12. Do not attempt to overwrite the system firmware since this can lead to permanent damage of the instrument.

The firmware of the MPS is constantly evolving. New features are developed, which are available to our customers through firmware upgrades. Please do not hesitate to reach out to Bridge12 at support@bridge12.com to determine if a firmware upgrade is necessary.

7.1.1 General Requirements

A firmware upgrade can typically be performed by the user following the instructions described below. Alternatively, if you like assistance in the process, a Bridge12 researcher will schedule an appointment with you. To perform the firmware upgrade you will need:

- A working internet connection
- An USB-A to USB-A cable
- A computer running Win 10 or higher (we have successfully used older Windows versions e.g. Windows XP), or macOS
- Files required for firmware upgrade

Please first contact Bridge12 prior to any attempt to upgrade the firmware. A representative will send you all necessary files for the upgrade.

7.1.2 Updating the Firmware from macOS

To update the MPS firmware from a computer operating macOS two files are required, which will be supplied by Bridge12:

1. bossac_mac
2. B12TMPSXXXXX.bin

The first file is the firmware uploader, the second file is the actual firmware. You should have received both files from Bridge12. The file name of the last file should match the serial number of your system.

7.1.2.1 Identifying the Serial Port (macOS)

After you connected the MPS to your computer using the USB-A to USB-A cable, first the serial port needs to be identified following these instructions:

1. Open the Terminal application
2. In the terminal window type the following command:

```
ls /dev/tty.usbmodem*
```


After you hit the return key, the serial port of the MPS is displayed e.g.:

```
ls /dev/tty.usbmodem1411301
```

7.1.2.2 Perform Firmware Update (macOS)

To perform the firmware update follow these steps:

1. Place both files in a folder
2. Open the Terminal application
3. Navigate into the folder
4. In the terminal window type the following command:

```
stty -f /dev/tty.usbmodem1411301 1200
```

Once you hit the return key, the MPS may return some values. This indicates that the connection can be established successfully.

To upload the firmware type the following command into the terminal window:

```
./bossac_mac -i --port=tty.usbmodem1411301 -U true -e -w -b_  
↪B12TMPSXXXX.bin -R
```

Once you hit the return key, a progress bar will be displayed. Once the upload is completed, the unit will reset. After the reset the Bridge12 MPS is ready.

7.1.3 Updating the Firmware from Windows

To update the MPS firmware from a computer operating on Windows, the following four files are required:

1. bossac.exe
2. getBoardInfo.bat
3. uploadFirmware.bat
4. B12TMPSXXXX.bin

The first file is the firmware uploader, the second and third files are helper scripts and the fourth file is the actual firmware. You should have received all files from Bridge12. The file name of the last file should match the serial number of your system.

7.1.3.1 Identifying the Serial Port (Win)

To identify the serial port follow these instructions:

1. Open the Device Manager by typing devmgm into the windows search bar and hit return
2. Navigate to USB ports and LPT and note down the COM port of the Arduino Due Programming Port.

7.1.3.2 Perform Firmware Update (Win)

To update the firmware:

1. On your hard disk create a temporary folder named B12TUpgrade (the actual names is not critical)
2. Place all four files into this folder
3. Open the windows command line terminal by typing cmd into the search bar and hit return
4. In the terminal window, navigate to the folder (B12TUpgrade), which contains all firmware files
5. In the terminal window type the following command:

```
getBoardInfo.bat
```

Once you hit return, upon a successful connection, several parameters will be returned, indicating that a connection can be established to the MPS.

To upload the new firmware to the system type the following command:

```
uploadFirmware.bat
```

A progress bar is displayed. Once the upload is completed, the unit will reset. After the reset the Bridge12 MPS is ready.

CHAPTER 8

System Specifications

System Specifications given here are general specifications. Individual system specifications may differ for each individual system.

Table 8.1: System Specifications (Default Configuration)

Property	Value
Frequency Range	9.4 - 10.5 GHz
Maximum Output Power	+ 40 dBm (10 W)
Maximum Reflected Power	+ 33 dBm (2 W)
Power Resolution	+/- 0.1 dBm
Shortest Pulse Length	100 ns
System Weight	3.3 lbs (1.5 kg)
Physical Dimensions	12 x 7 x 14 inch (w, l, h)
	30.5 x 17.8 x 35.6 cm (w, l, h)
Input Power	90 - 264 VAC

In its standard configuration the systems comes with a TFT front panel display, a SMA breakout connection to connect a fast microwave switch or an Arbitrary Waveform Generator (AWG), a connector to connect the waveguide switch, and a front panel for custom digital input/output signals. In addition, the system accepts an external trigger, to modulate the microwave power, an external 10 MHz reference and a sweep trigger.

The system is also available with custom modifications. For more information contact Bridge12 at info@bridge12.com.

9.1 Conversion Table: dBm to W

Table 9.1: Power conversion from dBm to Watts

P [dBm]	P [W]	P [dBm]	P [W]	P [dBm]	P [W]	P [dBm]	P [W]
0	0.0010	10	0.0100	20	0.1000	30	1.0000
1	0.0013	11	0.0130	21	0.1260	31	1.2600
2	0.0016	12	0.0158	22	0.1580	32	1.5800
3	0.0020	13	0.0200	23	0.2000	33	2.0000
4	0.0025	14	0.0251	24	0.2510	34	2.5100
5	0.0032	15	0.0316	25	0.3160	35	3.1600
6	0.0040	16	0.0398	26	0.3980	36	3.9800
7	0.0050	17	0.0501	27	0.5010	37	5.0100
8	0.0063	18	0.0631	28	0.6310	38	6.3100
9	0.0079	19	0.0794	29	0.7940	39	7.9400
						40	10.0000

CHAPTER 10

The Fineprint

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Bridge12 Technologies, Inc., 37 Loring Drive, Framingham, MA 01702, USA <http://www.bridge12.com>

10.1 Notices

Note: A NOTE notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in damage to the product or loss of important data. Do not proceed beyond an IMPORTANT notice until the indicated conditions are fully understood and met.

Warning: A WARNING notice denotes a hazard. Calling attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in personal injury or death. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood and met.

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