Application Note 1601

BPM User Menu

List of Revisions

Revision	Date	Remarks
00	04-Feb-2016	Original version.
01	26-Feb-2018	Major update. Treat as new document.

Table of Contents

1. Introduction

The BPM bidirectional power meters are devices serving for accurate simultaneous measurement of incident and reflected powers in rectangular waveguides in high-power industrial applications. This application note is concerning the serial RS232 (or RS422) digital interface and the methods of customizing the BPM behavior through the BPM User Menu.

For more details, specifications and installation tips see the respective BPM datasheets.

2. Serial RS232 Connection

The BPM devices operate in an endless loop, continuously sending results to the RS232 port in the form of ASCII strings (and at the same time updating the analog outputs).

For testing and configuring purposes using a PC, any RS232 COM Port terminal program should run in the PC.

One possibility is using **Tera Term**, which is an open-source free terminal emulator. The program can be downloaded from http://ttssh2.sourceforge.jp/index.html.en (see also http://en.wikipedia.org/wiki/Tera_Term). Examples in this application note will be presented using this terminal emulator.

The default *serial port* should be configured as follows (see example in Fig. 1 left):

Baud Rate:	115200 bits/s (see Note 1)
Data Bits:	8
Parity:	NO
Stop Bits:	1
Flow Control:	NO

Note 1: The baud rate should be set to 57600 or 38400 bits/s if those baud rates are set on the BPM device.

An example of the *terminal* configuration is shown in Fig. 1 right. Proper menu display is ensured by setting <LF> as new line receive character. The rest are defaults.

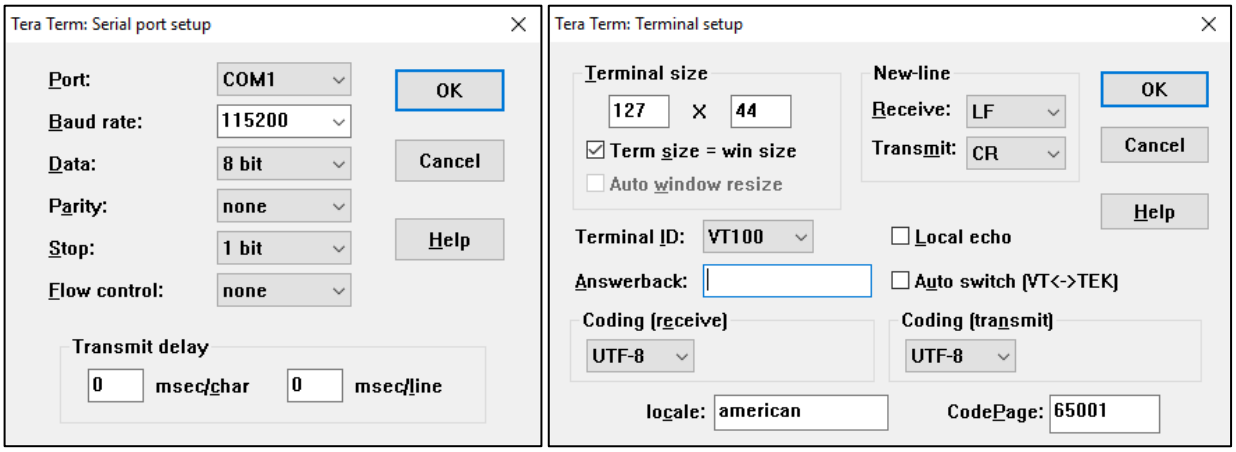

Fig. 1. Configuration Tera Term COM port (left) and terminal (right).

After setting up the terminal, connecting the BPM (see the datasheets for instructions) and switching the DC power to BPM, the measured results will show in the terminal display. An example is shown in Fig. 2.

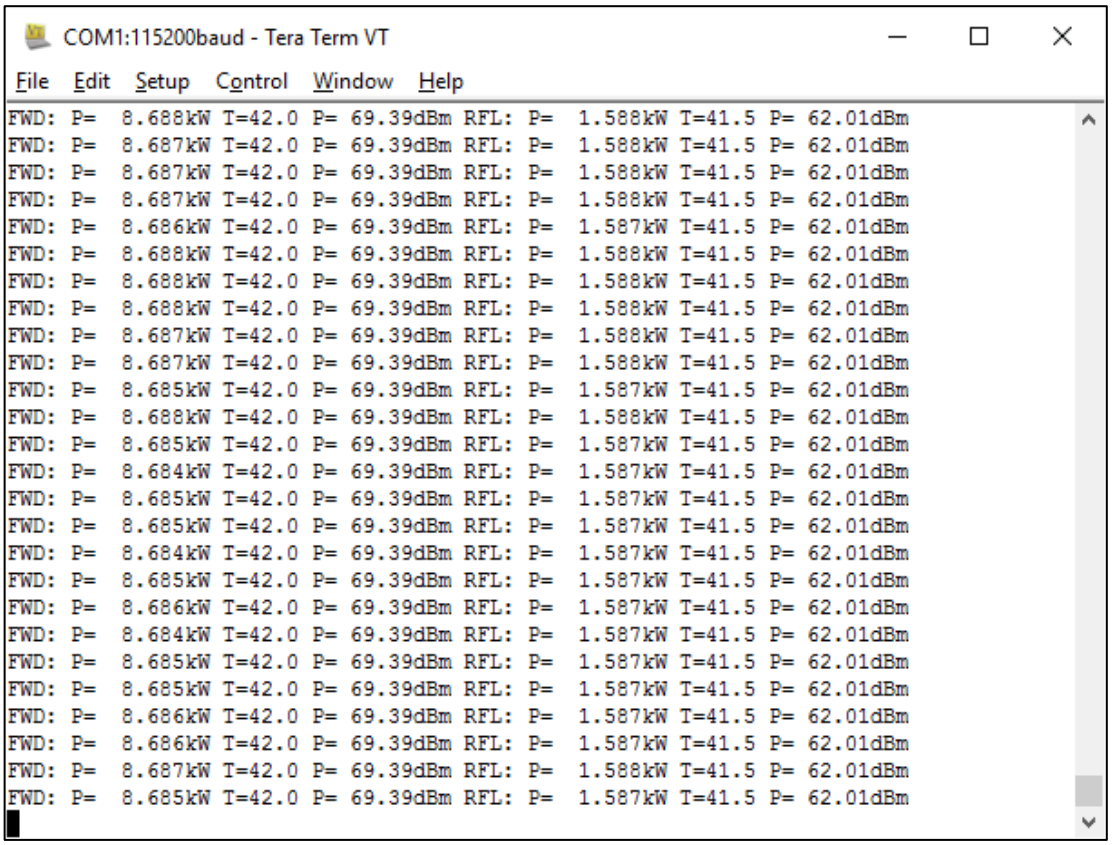

Fig. 2. Display of measured data.

Details about the received strings are described in the datasheets. This state is the starting point for invoking the BPM User Menu.

3. BPM User Menu

The BPM User Menu serves for:

- Configuring the signal sampling.
- Switching the type of analog output.
- Setting of RS232 baud rate.
- Changing orientation of the LCD display.
- Scaling the analog outputs.
- Introducing power offset to measured data (e.g. to correct for a waveguide wall thickness differing from the nominal).

An RS232 terminal installed in your PC is needed for this. The BPM User Menu is invoked by transmitting ASCII character x (ASCII #32) from the terminal (pressing the lower-case **x** key on the PC keyboard). Following this, BPM parameters are read from the internal EEPROM and the most important, such as the SW version, model designation, serial number and others are displayed. Example of BPM User Menu is shown in Fig. 3.

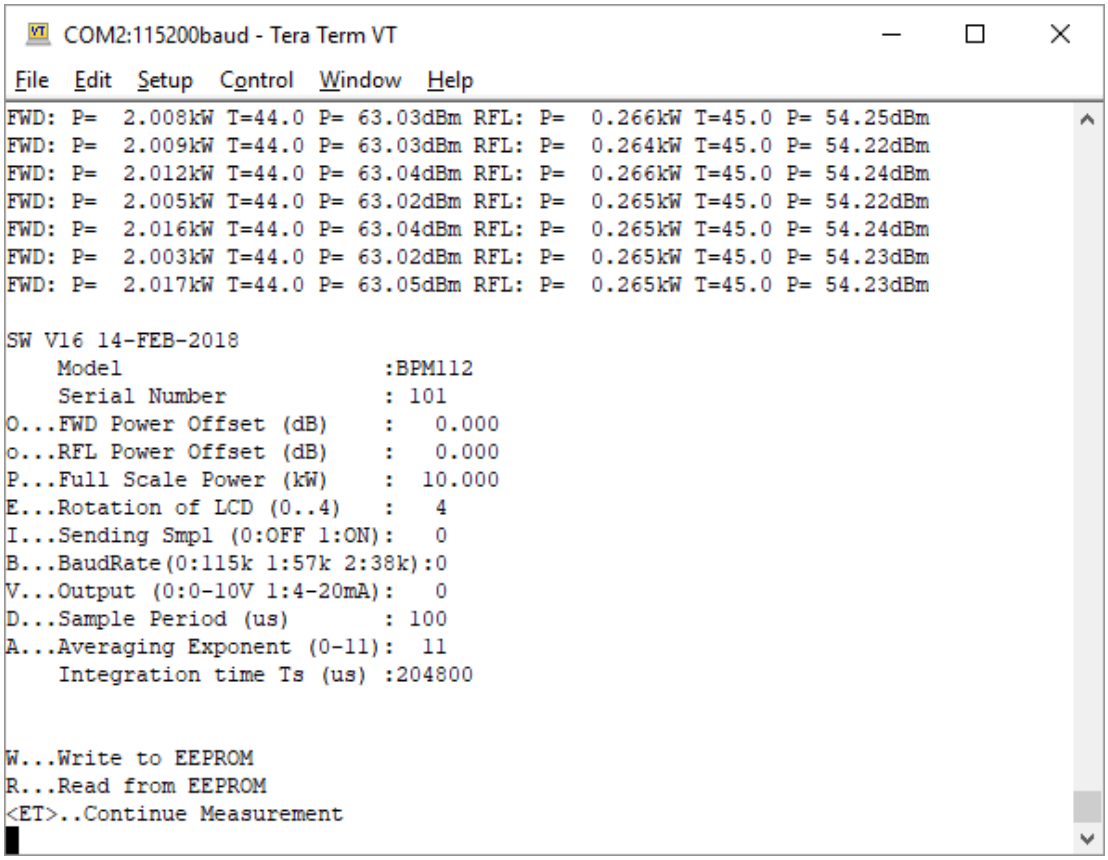

Fig. 3. BPM User Menu.

Now, some of the parameters can be modified by the user. Only the following keys are enabled:

`O`, `o`, `P`, `E`, `I`, `B`, `V`, `D`, `A`, `W`, `R`, `<ET>` = `<Enter>`

Note that letter case matters.

Notes:

- Before any change of the parameters it is strongly recommended to remember all original data.
- The user must act (hit a key) within 40 seconds from the previous action, otherwise the internal watchdog resets the BPM and restarts sending results.

4. Changing BPM Parameters

Changing BPM parameters generally involves the following steps:

1. Hit the key corresponding to the desired parameter (e.g. `O` to change Power Offset in the FWD channel).
2. Following this, a prompt appears to enter the new value. In case of Sample Period and Averaging Exponent, the lower and upper limits are also shown.
3. Type the new value and press `<Enter>`. Following this, the new value is shown in the BPM User Menu. If the entered value was outside of the allowed interval, it will be clipped into the valid range (if, for instance the Averaging Exponent `20` was typed, the actually set value will be 11).
4. Change any other parameter by the same procedure.
5. To make the changes permanent, press the upper-case `W` key to write the new parameters to the BPM EEPROM memory. The progress and success are announced by messages (Fig. 4). Note that the command writes *all* parameters, not only those you have modified.
6. To ultimately check the successful parameters change, you may wish to switch BPM DC power supply OFF and ON and re-invoke the BPM User Menu again.

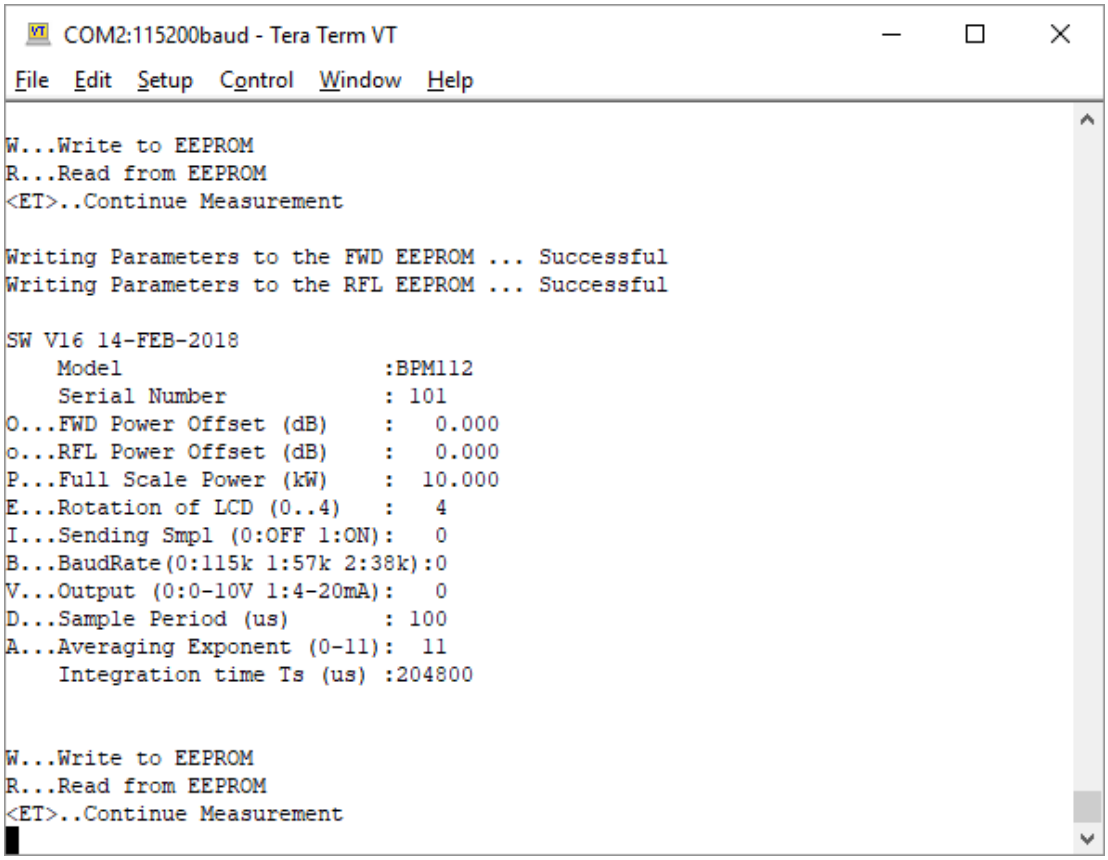

Fig. 4. Writing parameters to BPM non-volatile memory.

4.1 Power Offset

The user can easily modify measured powers with Power Offset parameters. Those offsets are added in dB scale to the measured powers.

To change Power Offset in FWD channel, press uppercase `O` key. The prompt occurs

```
Enter FORWARD Power Offset (dB):
```

Now, enter the desired Power Offset in dB units.

To change Power Offset in RFL channel, press lowercase `o` key. The prompt occurs

```
Enter REFLECTED Power Offset (dB):
```

Now, enter the desired Power Offset in dB units.

See also the example at the end of this document.

4.2 Full Scale Power Reading

This Full Scale Power means the measured power that would provide the maximum analog output (10 V or 20 mA, respectively). It does not affect the actual rated peak working power of the BPM; it is merely a scaling factor.

Because the peak working power of the BPM is fixed by its hardware, it is not recommended to change the Full Scale Power value in wide range. For example, if a BPM's peak working power is 10 kW, setting Full Scale Power value to 100 kW is not wise because the analog output voltage would never exceed 1 V. On the opposite, if a BPM's peak working power is 100 kW and the Full Scale Power will be set to 10 kW, all measured powers above 10 kW will produce analog output overrange. However, such setting is meaningful if the actual power never exceeds 10 kW.

To change Full Scale Power, press `P` key. The prompt occurs

```
Enter Full Scale Power (kW):
```

Now, enter the desired Full Scale Power value in units of kW.

4.3 Changing LCD Display Orientation

If the LCD display is present, the BPM microcontroller unit (MCU) sends an initialization string via a serial port to the display module for configuring it during power-up of the device. Here is an example of such initialization string:

```
US-TEAM,BPM112,S/N=101,Pmax=10kW,Output 0-10V,LCD=4,SW V16 14-FEB-2018
```

(If the the LCD display is not present, this string will not be sent.)

To change the orientation of the LCD display, press `E` key. The prompt occurs

```
Enter Rotation of LCD (0..4):
```

This is a list of valid codes with corresponding prompts:

0	"No LCD"	For BPM devices without LCD display.
1	"Normal Text"	LCD text is oriented in the direction of the arrow indicating the incident wave.
2	"Rot. Text Down"	LCD text is rotated 90° relative to the arrow direction.
3	"Rot. Text Up"	LCD text is rotated 270° relative to the arrow direction.
4	"Rot. Text 180"	LCD text is rotated 180° relative to the arrow direction.

4.4 Sending Samples

To switch ON and OFF sending of individual samples constituting one measured point, press `I` key. The prompt occurs

```
Enter Sending Smpl (0:OFF 1:ON):
```

Enter 0 or 1 to switch the BPM to not sending (0) or to sending samples (1). If the parameter is set to 1, all measured samples, separated with <LF> (ASCII #10), are send to the serial port. After tansmitting the last sample, the Sampling Period in µs and Number of Samples are sent.

This is an example of the transmitted data stream, which includes sending 8 samples after each measurement:

```
FWD: P=  2.216kW T=45.0 P= 63.46dBm RFL: P=  0.264kW T=45.0 P= 54.21dBm
  2.310
  2.264
  2.220
  2.188
  2.168
  2.166
  2.181
  2.215
100
8
```

4.5 Baud Rate

To change Baud Rate, press `B` key. The prompt occurs

```
Enter Baudrate code (0:115200 1:57600 2:38400):
```

Enter the code for the desired baud rate. Only the values 0, 1, 2 are accepted. This is a list of valid codes with corresponding baud rates:

0	This is the default baud rate 115200 bits/s.
1	Baud rate 57600 bits/s.
2	Baud rate 38400 bits/s.

The new value must then be written to the EEPROM by entering `W` key. The new baud rate will be used after device reboot.

4.6 Analog Output

To switch Analog Output type, press `V` key. The prompt occurs

```
Enter Analog Output code (0:0-10V  1:4-20mA):
```

Valid codes are:

0	Voltage output 0 – 10V

1 Current output 4 – 20 mA

Note that there are separate outputs pins for the voltage outputs and for the current outputs (see the connection diagrams in the BPM datasheet).

4.7 Setting Sampling Parameters

The sampling of the measured power waveforms is controlled by two input parameters:

- Sampling Period
- Averaging Exponent

These parameters also determine the BPM sampling duration (ntegration time), as explained in the BPM datasheet, chapter Sampling. The maximum sampling duration of the BPM device is 5 s. To not exceed it, the upper bounds of Sample Period and Averaging Exponent ar automatically limited at entering the parameters.

To change Sampling Period, press D key. The prompt occurs, such as

```
Enter Sampling Period 12.. 2441  (us):
```

Now, enter the desired Sampling Period in units of µs. Only integer values are allowed. The minimal value is always12 µs. The upper bound in this example (2441 µs) has been automatically computed for the current Averaging Exponent.

To change Averaging Exponent, press A key. The prompt occurs

```
Enter Power Averaging Exponent (0-11):
```

Now, enter the desired Averaging Exponent. Only integer values are allowed.

The bottom line of the BPM Parameters menu displays the sampling duration (ntegration time) resulting from the current Sampling Period and Averaging Exponent. An exampe of the bottom of the menu is below:

```
D...Sampling Period (us)       : 100
A...Averaging Exponent (0-11):    11
    Integration time Ts (us) :204700
```

In this case, the integration time has been computed as 100 µs × (2^{11} – 1) = 204700 µs.

4.8 Example

Tasks

a) Suppose that BPM214 mean incident power reading with waterload is P_r = 50 kW while you know by calorimetry measurements that the actual incident power is P_a = 40 kW. You know that the cause of this discrepancy lies in the waveguide wall thickness. While the BPM has been calibrated for the standard wall thickness h_c = 0.125 inch = 3.175 mm your actual wall thickness is h = 3 mm. The variation of BPM coupling factor C with wall thickness is approximately $\Delta C/\Delta h$ = -6 dB/mm (the thicker the wall the lower the reading). You want to set BPM offset factors so as to correct this difference.

b) Also, there is a 3-blade mode stirrer in your applicator, rotating with frequency one revolution per second. Due to this, the incident power oscillates, resulting in fluctuating reading of the BPM. You want to set the integration time of BPM measurement such as to smooth out these fluctuations.

Calculations

a) BPM power reading is higher than the actual power by 10*log(P_r/P_a) = 10*log(50/40) = 0.969 dB. To correct for this, power offset in both FWD and RFL channels should be set to `-0.969 dB`.

b) Due to the three blades of the stirrer, the frequency of the power ripples is three times the stirrer rotation frequency, i.e. f_r = 3 × 1 Hz = 3 Hz. Therefore, the ripple period is $T_r = 1/f_r$ = 1/3 s ≈ 333 ms. To smooth out the BPM reading, the sampling duration (integration time) T_s should be set to n × 333 ms where n = 1, 2, … We will set the sampling duration to T_s = 333 ms. To achieve this, we have to modify the number of samples N_s taken for one measured result, and sampling period Δt_s (time spacing between two consecutive samples). The possible numbers of samples are $N_s = 2\text{^}E_s$, where E_s = 0, 1, 2, … 11 is the averaging exponent. The three relevant quantities are constrained by the relation

$$(1) \qquad T_s = \Delta t_s \left(N_s - 1\right) = \Delta t_s \left(2^{E_s} - 1\right)$$

If we, for instance, choose the number of samples in terms of E_s, the required sampling interval will be

$$(2) \qquad \Delta t_s = \frac{T_s}{2^{E_s} - 1}$$

We have to round Δt_s expressed in µs because only integers can be entered. Due to the quantization of Δt_s the actual T_s will differ from the desired value. By trying different values of E_s we can find the most suitable Δt_s. Values of E_s below 8 are not recommended because then details of the power waveform may go lost. For our example, the situation for $E_s > 7$ is illustrated in Tab. 1.

Tab. 1. Actual sampling duration T_s for various settings of E_s. The desired T_s = 333 ms.

E_s	N_s	Δt_s (µs)	T_s (ms)	Note
8	256	1307	333.29	
9	512	652	333.17	
10	1024	326	333.50	
11	2048	163	333.66	

A good compromise is E_s = 11, Δt_s = 163. This we shall set for both channels.

Settings

Proceed as follows. Each next step must start within 40 seconds from the previous step.

1. Press the lower-case `x` key on the PC keyboard to invoke the BPM User Menu.
2. Press upper-case `O`. The following prompt occurs: `Enter FORWARD Power Offset (dB):`
3. Type `-0.969` and press `<Enter>`.
4. Press lower-case `o`. The following prompt occurs: `Enter REFLECTED Power Offset (dB):`
5. Type `-0.969` and press `<Enter>`.
6. Press upper-case `A`. The following prompt occurs: `Enter Averaging Exponent (0-11):`
7. Type `11` and press `<Enter>`.
8. Press upper-case `D`. The following prompt occurs: `Enter Sampling Period (us) (12.. 2441) (us):`
9. Type `163` and press `<Enter>`.
10. Check all temperature values by inspection of the BPM User Menu.
11. Press upper-case `W` to write the settings to BPM non-volatile memory. Watch for the success message. In case of fail, press `W` again.
12. Press `<Enter>`to exit the BPM User Menu.
13. Final check: Switch OFF the DC power supply to BPM, wait about 5 seconds, and switch the power supply ON again. Invoke the BPM User Menu by `x` key and check the settings. Then press `<Enter>`to exit the BPM User Menu.

5. Exiting BPM User Menu

To exit BPM User Menu, press `<Enter>` key.