RL78/I1C(512KB) Continuous Metrology FOTA

FOTA demonstration package

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1. Introduction

This Operation Guide provides:

- An overview of the Continuous Metrology FOTA Project for the RL78/I1C (512KB) Fast Prototyping Board.
- Instructions for powering, connecting, and running the Continuous Metrology FOTA Project.
- Instructions for modifying and building the Continuous Metrology FOTA Project using the CS+ Integrated Development Environment (CS+ IDE).

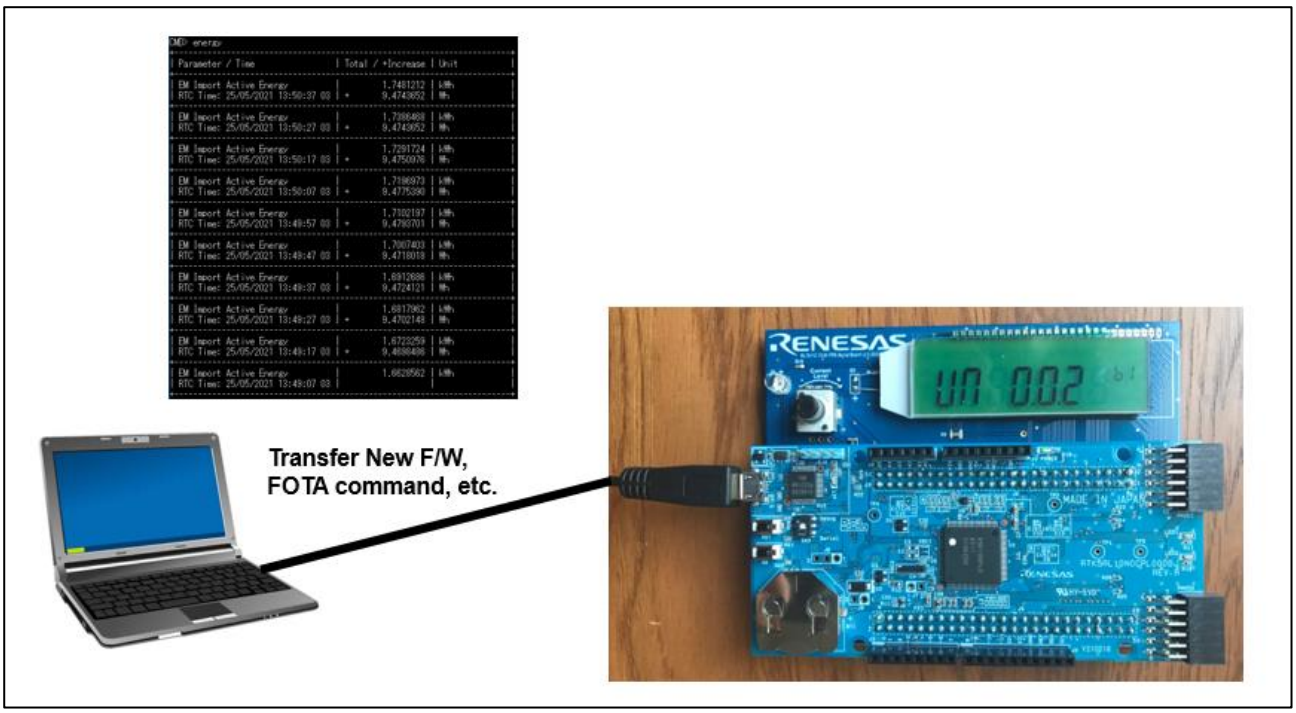


Figure 1: FOTA Demo Overlooking

1.1. Assumptions and Advisory Notes

1. Tool experience: It is assumed that the user has prior experience working with IDEs such as CS+ and terminal emulation programs such as Tera Term.
2. Subject Knowledge: It is assumed that the user has basic knowledge about microcontrollers, embedded systems, and Code Generator in CS+ to create and modify the example project as described in this document.
3. The screenshots provided throughout this document are for reference. The actual screen content may differ depending on the version of software and development tools.

2. Required Environments

Hardware Requirements:

1. RL78/I1C (512KB) Fast Prototyping Board [RTK5RL10N0CPL000BJ]
2. RL78/I1C (512KB) FPB Signal Board [Not for sale].
   (Refer to Hardware User Guide R01TU0344ES0100.)
3. Coin-cell battery [CR2032 (3V)]
4. Micro USB Device Cable
5. PC with at least 1 USB port

Software Requirements:

- Windows® 10 operating system
- USB Serial Drivers (included in Windows 10)
- Tera Term (or similar) terminal console application
- CS+ Ver. 8.05.00 (or above)

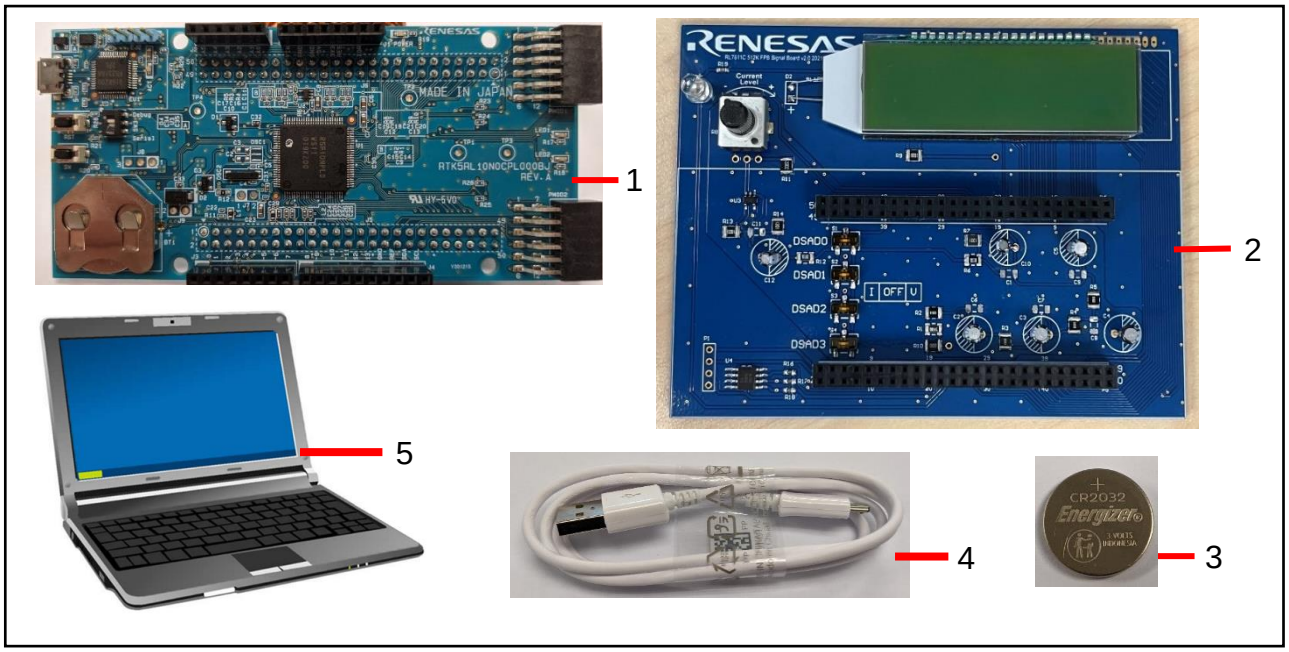


Figure 2: Hardware components

3. Overview of Continuous Metrology FOTA Project

The Continuous Metrology FOTA Project allows the user to:

- Monitor the simulated voltage and current signals generated by the FPB Signal Board.
- Perform calibration of the Meter Metrology based on the simulated signals.
- Transfer an updated Image of the User Application through UART.
- Activate the transferred image without MCU reset using the Bank-Swap feature.
  (7.1. **Bank-Swap Functions**).

  or

- Activate the transferred image through an MCU Reset.
  (7.2. **Fast FOTA Bank-Swap Command**).

3.1. Continuous Metrology FOTA Start-up Flowchart

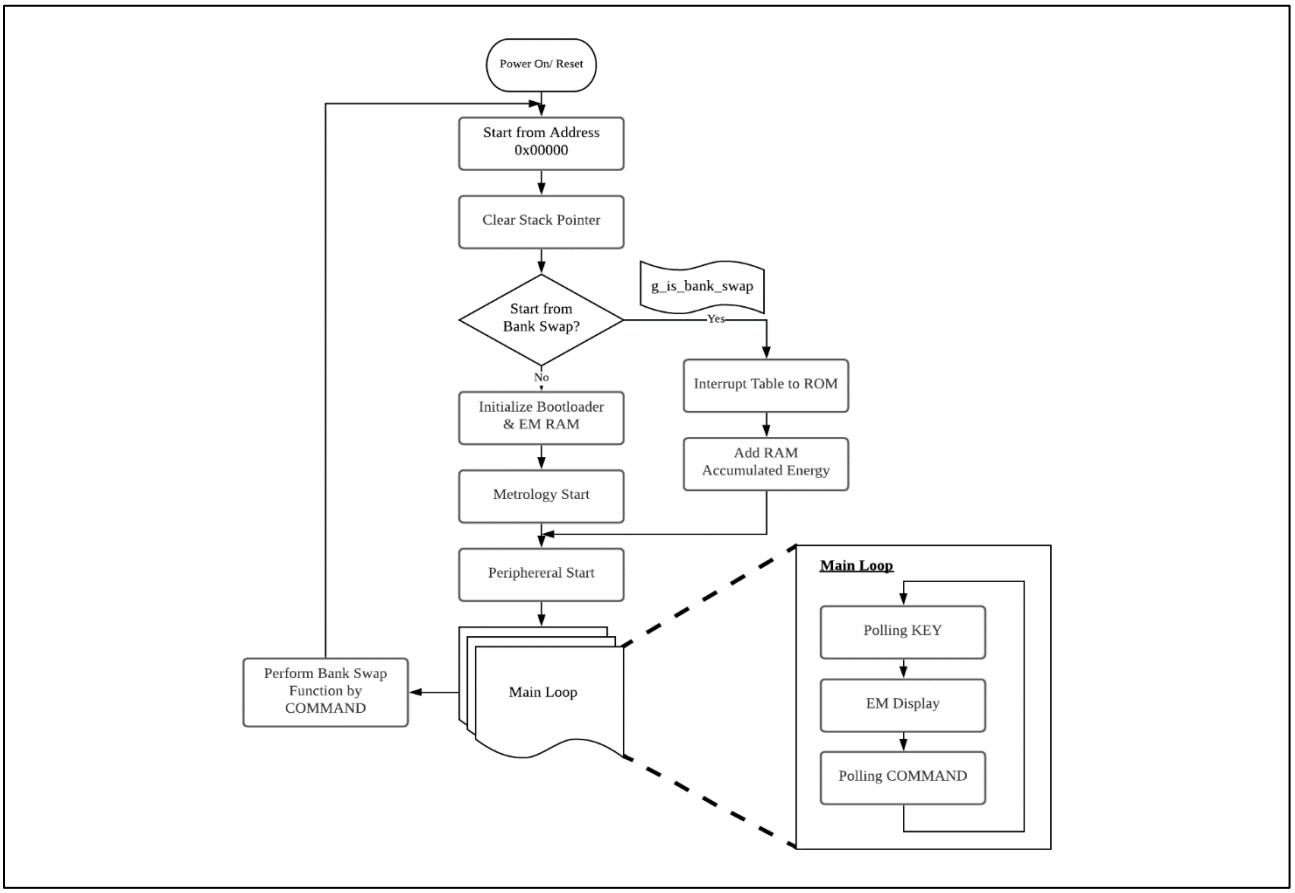


Figure 3: Continuous Metrology FOTA Project Flowchart

The User Application has two possible start-up procedures. On normal start-up after Power-On-Reset or after pressing the reset button on the Fast Prototyping Board, the Meter Metrology will be initialized followed by the hardware peripherals.

If the start-up is following a Bank-Swap command, only the hardware peripherals are initialized as the Meter Metrology does not stop running during Bank-Swap. This is the principle of Continuous Metrology FOTA, where measurements are not interrupted by the image updating process.

The Infinite Loop describes the normal operation state of the User Application. Commands are issued to the application during this state, such as Image Transfer and Bank-Swap.

4. Running the Continuous Metrology FOTA Project

This section lists the instructions to communicate and program the RL78/I1C (512KB) Fast Prototyping Board and run the Continuous Metrology FOTA Project.

4.1. Extracting the Packages

The Example Project package contains two sub-folders:

1. **RFP RI78I1C Production**, containing the Renesas Flash Programmer project **i1c_512k_production.rpj**, and main MOT file of **rl78i1c_production.mot**, which version is “v0.0.1”.

   Note: This MOT file is generated from the sample project of R01TU0357ES0100.

2. **New Application File**, containing the MOT files of **rl78i1c0 v001.mot**, **rl78i1c0 v002.mot**, and **rl78i1c0 v003.mot**. These files are used in the Image Transfer function. Their versions are “v0.0.1”, “v0.0.2” and “v0.0.3”, respectively.

   Note: These MOT files are generated from the sample project of R01TU0357ES0100.

4.2. RTK5RL10N0CPL000BJ Board Outline

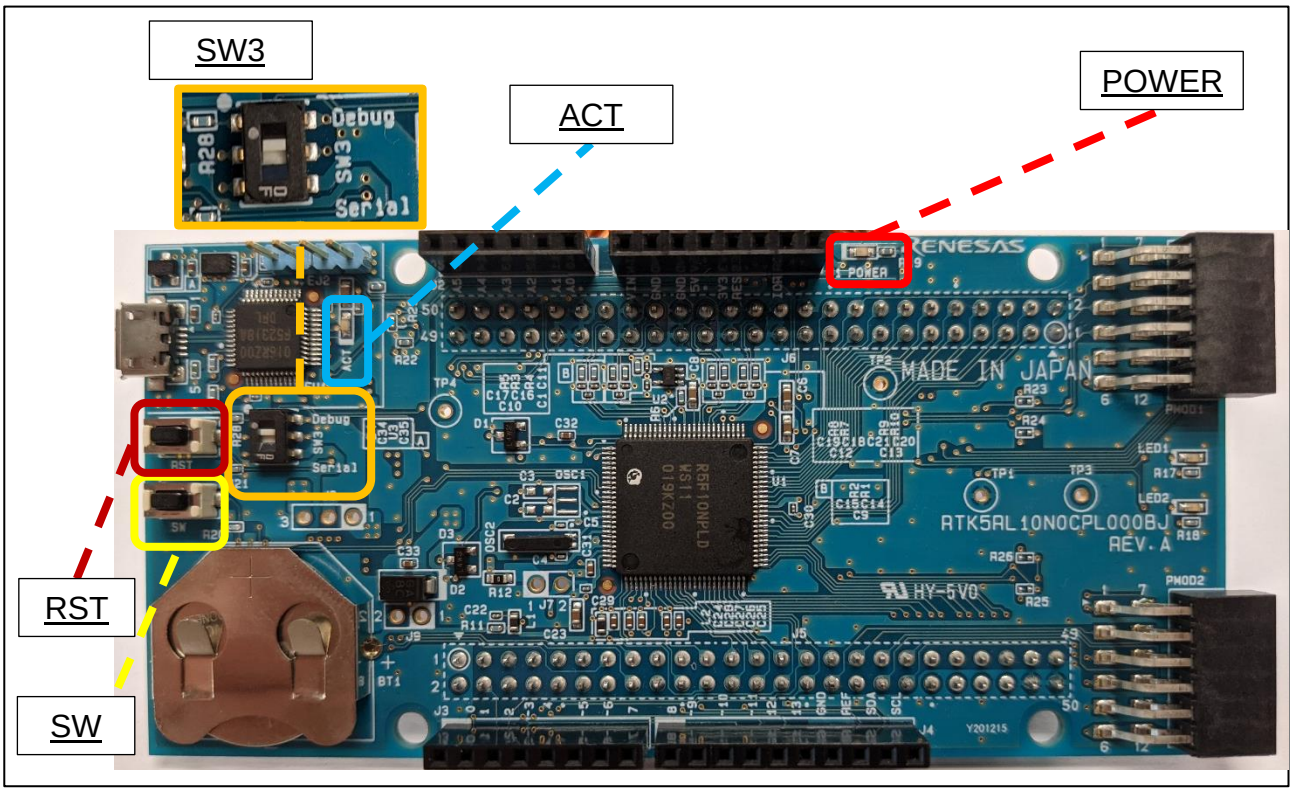
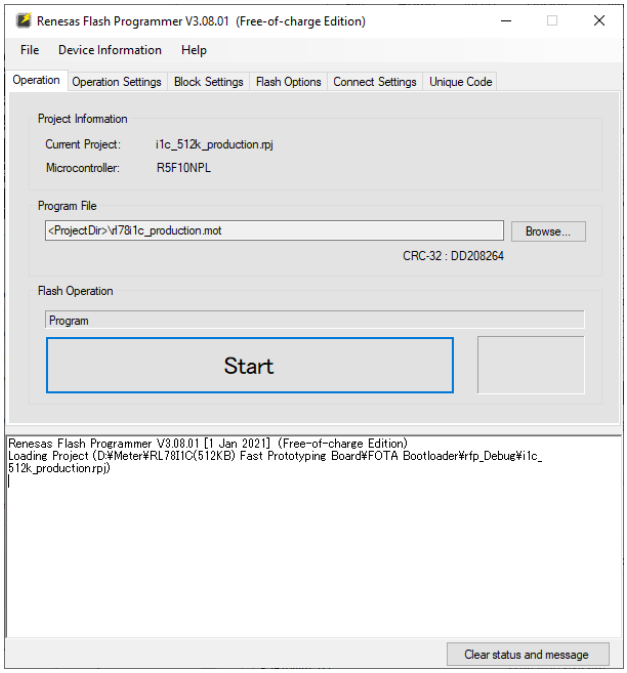


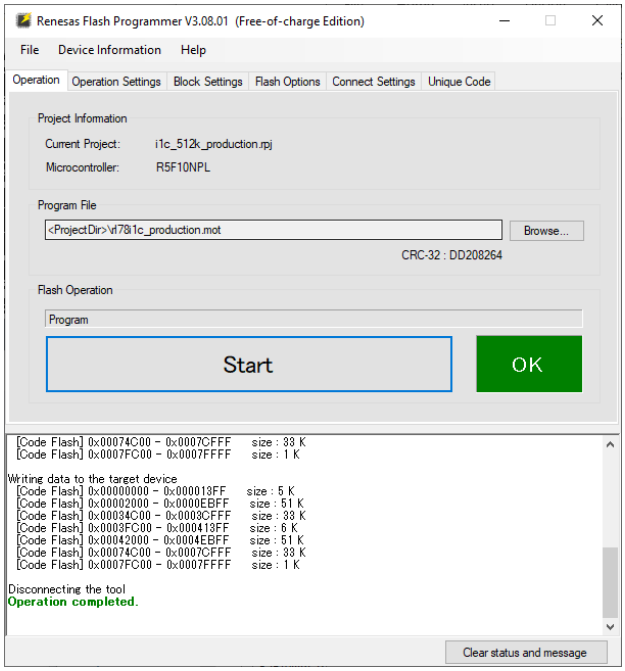
Figure 4: Outline of Board when Connecting to Host PC

- The RST button will trigger a hardware reset of the MCU.

4.3. Programming the MCU

1. Set the on-board dip switch (SW3) into “**Debug**” and connect the Micro USB cable into the Micro USB connector on the RL78 I1C(512KB) Fast Prototyping Board.
2. Connect the other end of the Micro USB cable (USB Head) into the host PC. LED1 (ACT) will start blinking, indicating that the RL78 I1C(512KB) Fast Prototyping Board is in “**Debug**” mode.
3. While LED3 (POWER) will light up solid green, indicating that the RL78 I1C(512KB) Fast Prototyping Board is powered.
4. Open the project [**i1c_512k_production.rpj**] in the RFP RI78I1C Production directory in Renesas Flash Programmer. This project will flash the [**rl78i1c_production.mot**] binary file to the MCU.
5. Click the Start button to initiate the download.

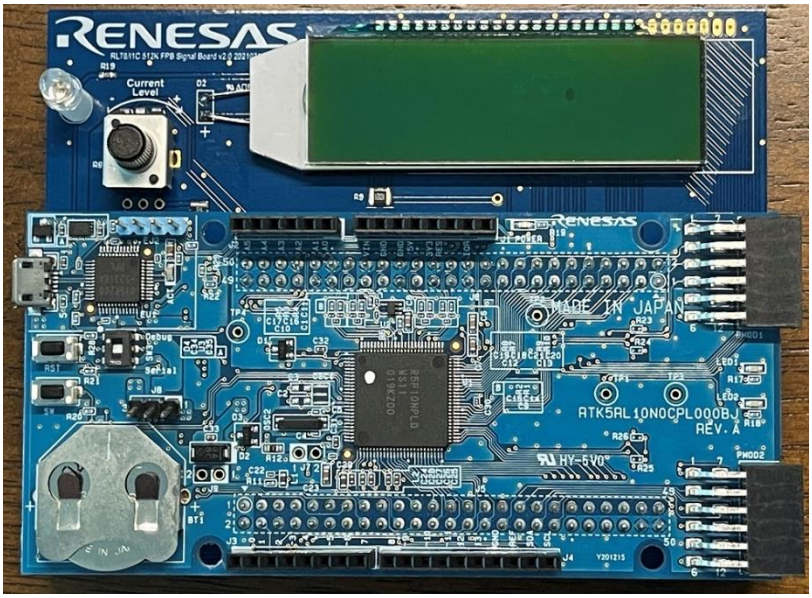




4.4. Running the Example Project

To run the Continuous Metrology FOTA Project, use the following instructions:

1. Insert the Coin-cell battery into the battery holder (**BT1)** on the RL78 I1C(512KB) Fast Prototyping Board.
2. Set the on-board dip switch (SW3) into "**Serial**" and connect the Micro USB cable into the Micro USB connector on the RL78 I1C(512KB) Fast Prototyping Board.
3. Connect the FPB Signal Board to the RL78 I1C(512KB) Fast Prototyping Board.



Pay attention to the board direction when connecting.

Figure 5: Fast Prototyping Board Connection to FPB Signal Board

4. Connect the other end of the Micro USB cable (USB Head) into the host PC. LED3 (POWER) will light up solid green, indicating that the RL78 I1C(512KB) Fast Prototyping Board is powered.
5. On the host PC, open Windows Device Manager. Expand **Ports (Com & LPT)**, located **USB Serial Device (COMxx)** and note down the COM port number for reference in the next step.

Note: USB Serial Device drivers are required to communicate between the RL78 I1C(512KB) Fast Prototyping Board and the terminal application on the host PC.

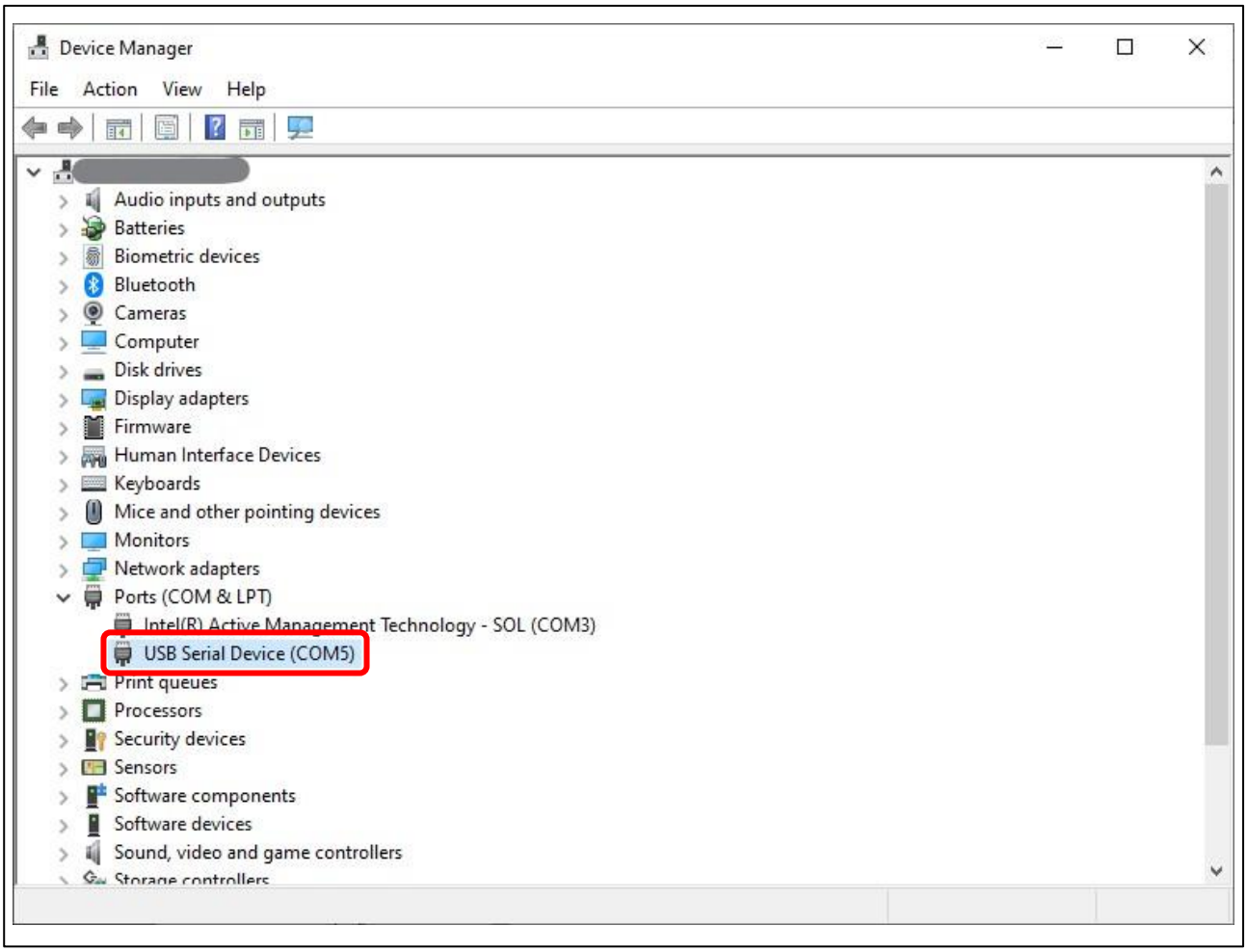


Figure 6: USB Serial Device in Windows Device Manager

6. Open Tera Term, select **Serial** and **COMxx: Serial Device (COMxx)** and click **OK.**

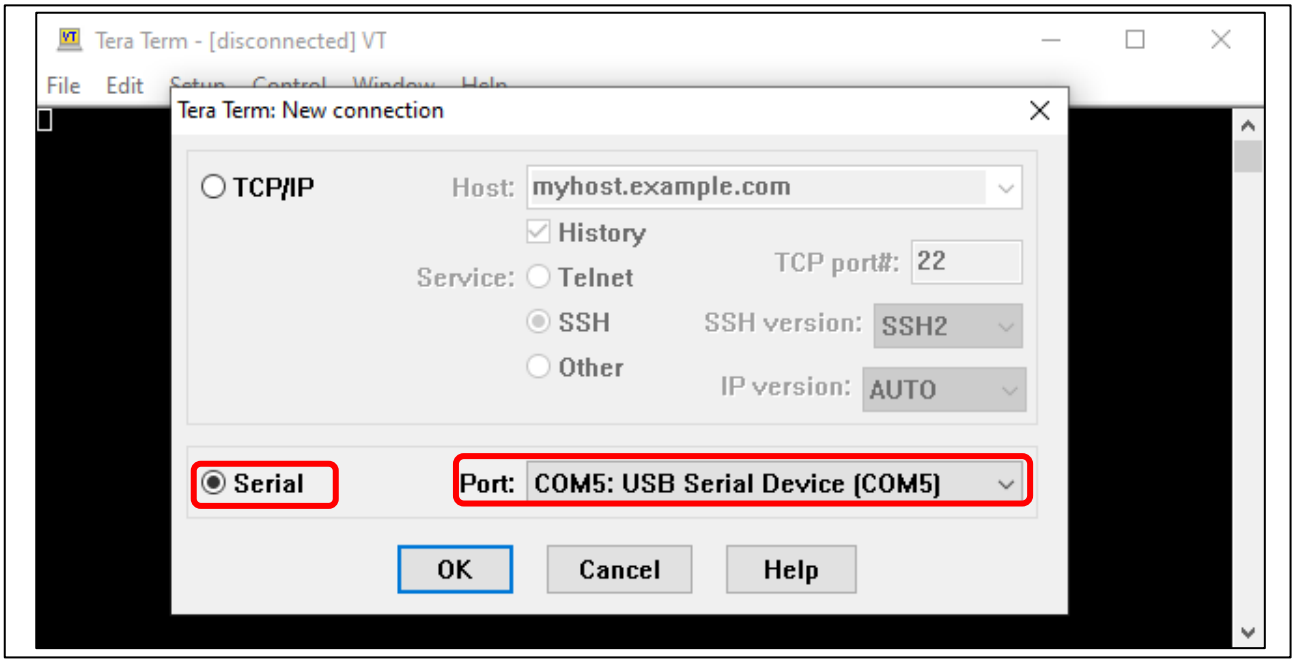


Figure 7: Selecting the Serial Port on Tera Term

7. In Tera Term, select **Setup** and **Serial Port…** for the **Tera Term: Serial port setup and connection** window. Configure the setup as follows (**38400 baud, 8N1**) and click **New setting**.

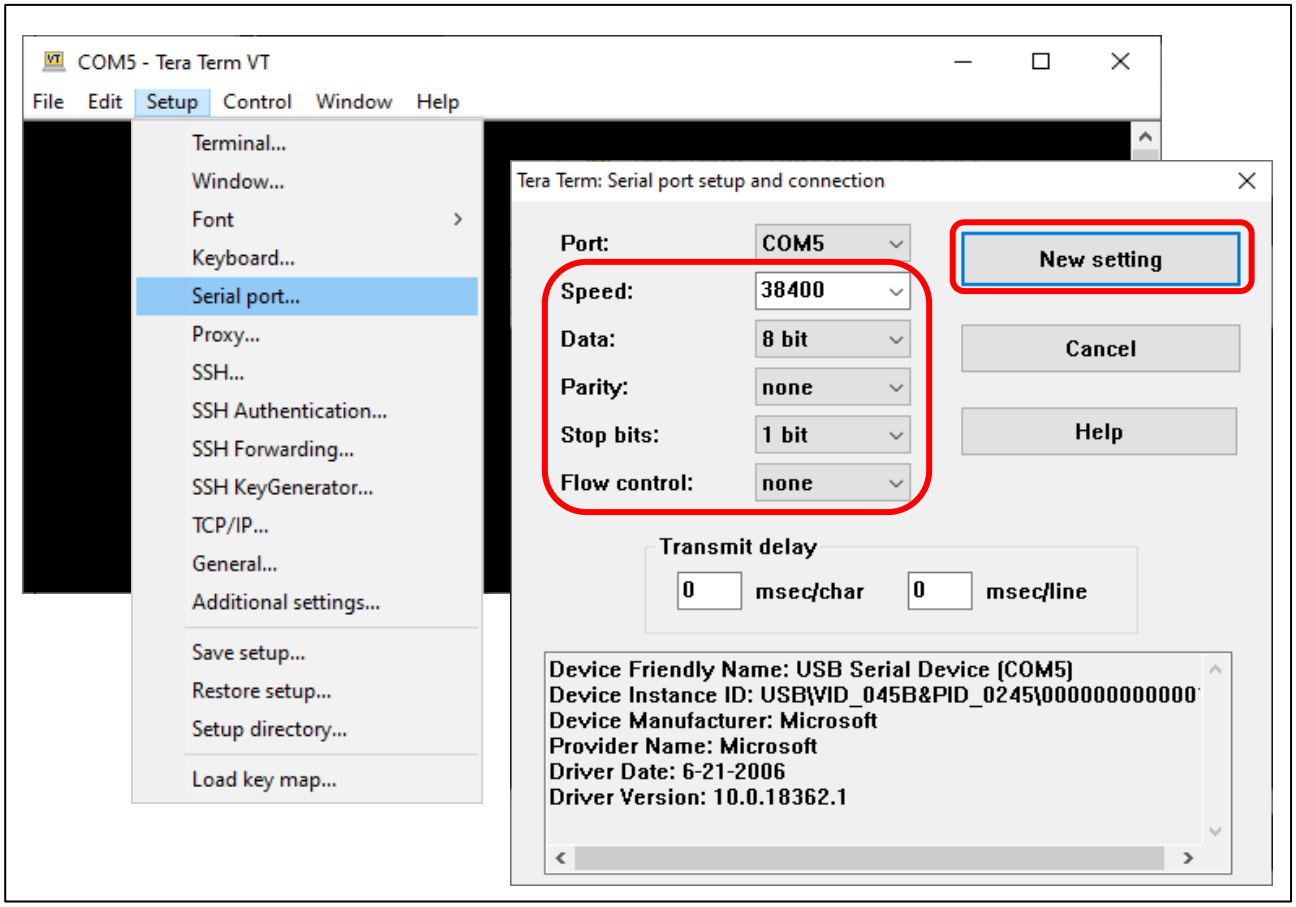


Figure 8: Setting Up the Serial Port in Tera Term

8. Press the on-board **RST** button once to reset the RL78/I1C(512KB) Fast Prototyping Board.
9. Wait for the start-up message to be displayed.

Note: The software will only run if a CR2032 battery is present to power the MCU RTC module.

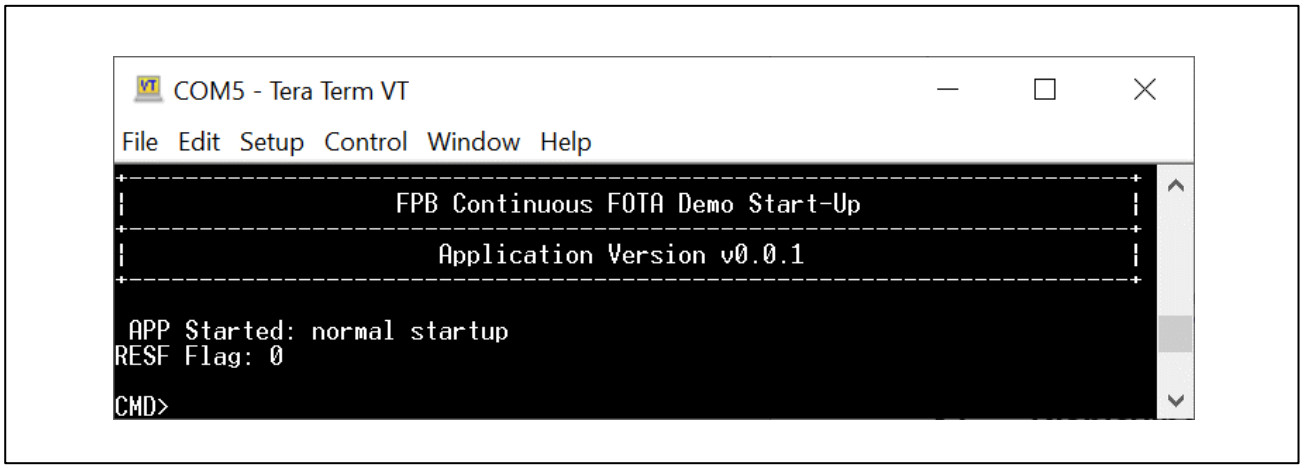


Figure 9: Start-up Message Displayed on Tera Term

10. Type "**?**" and press **Enter** key to observe the possible functions.

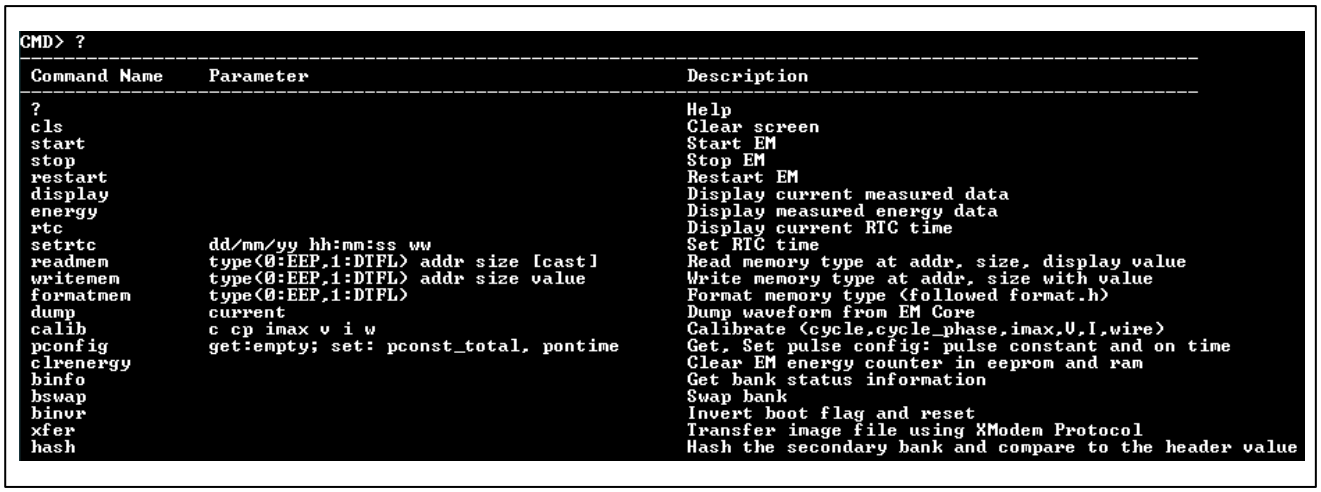


Figure 10: Available Commands in Continuous Metrology FOTA

Enter the commands as defined to observe each function. The input parameter format is printed for functions that require additional input parameters.

4.5. Displaying Measurement Values

- Type “**display**” and press **Enter** key.
- Voltage (DSAD2), Phase Current (DSAD0), Neutral Current (DSAD1) are displayed, together with calculated Power and Energy.

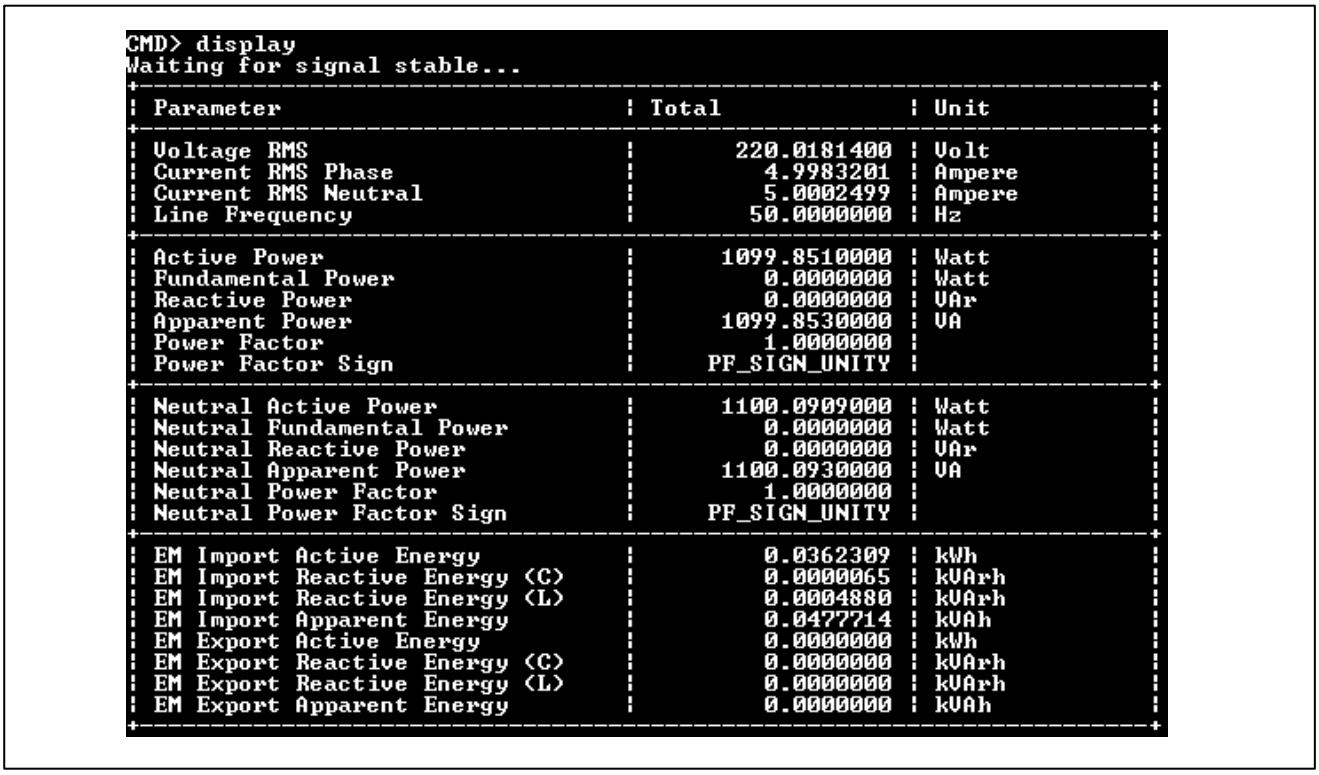


Figure 11: Output of the Display command

- On the first time running of the RL78/I1C(512KB) Fast Prototyping Board with the FPB Signal Board, the EEPROM module will not be initialized.
- Please format the EEPROM using the “**clrenergy**” command in order to clear the data used for Energy storage.

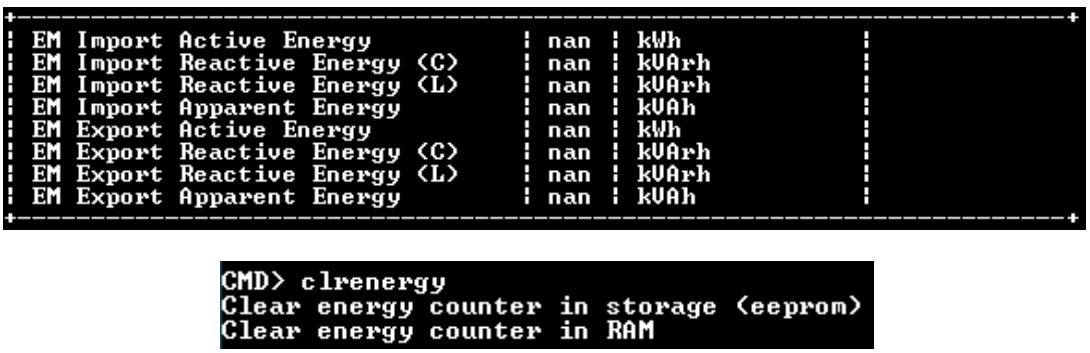


Figure 12: Clearing the Energy data stored in the EEPROM module

4.6. Displaying the Periodic Energy Table

- Energy will be periodically stored in a round-robin array, together with the timestamp of when the energy was recorded.
- The default interval time is set to 10 seconds.
- Type “**energy**” and press the **Enter** key to display the Energy Table.

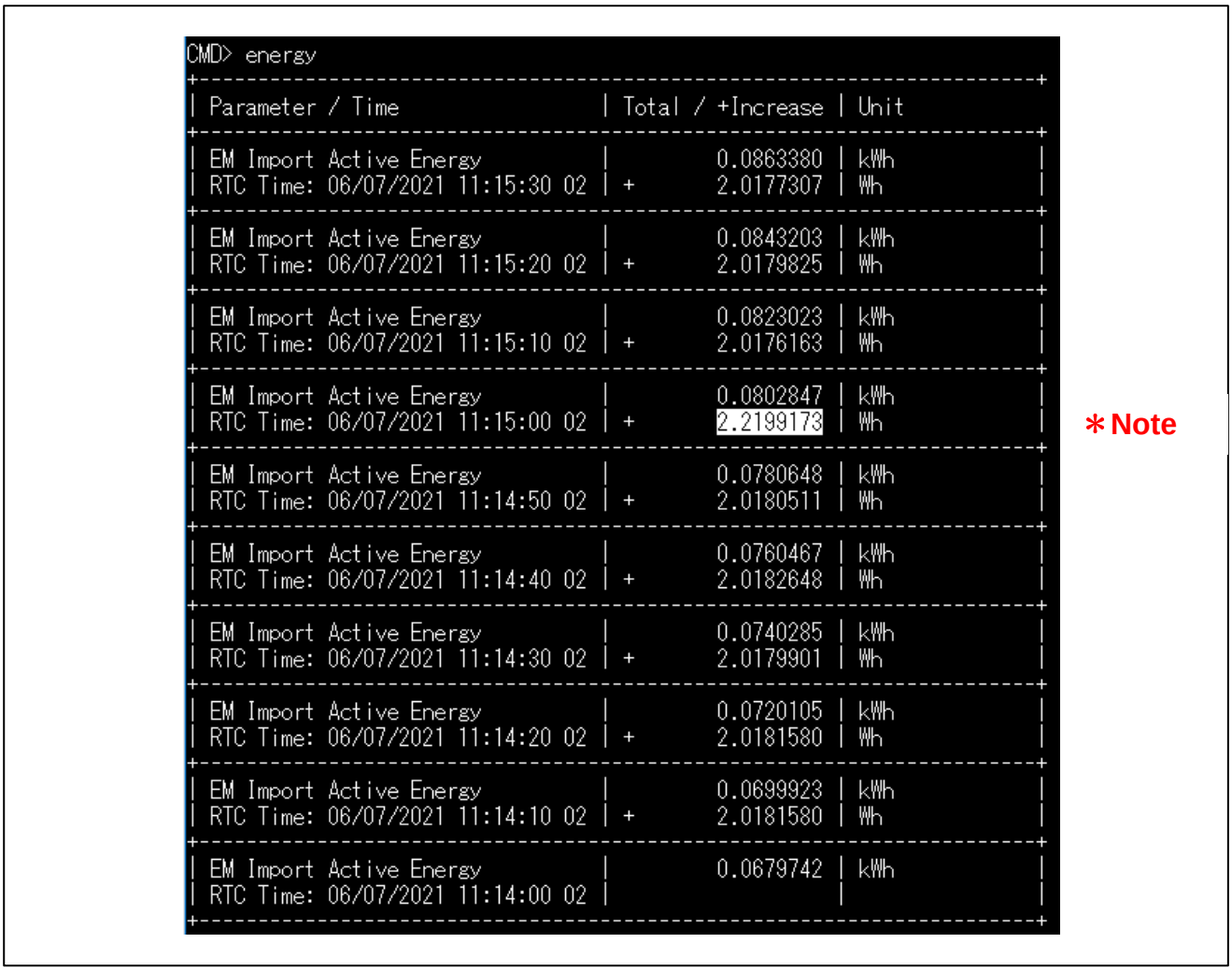


Figure 13: Energy Table

- The Energy Table is used to demonstrate the capability of the Continuous Metrology FOTA process.
- There should be no loss of energy logged during the Image Transfer and Continuous Metrology Bank-Swap operations.

Note :

The "Increase" values of 10-second energy are sometimes fluctuated logically by the frequency deviation on the asynchronous clocks as shown in the timing chart below.

(e.g.)

In the conditions that The Clock (A) has a frequency deviation of minus X [ppm] while the Clock (B) has a frequency deviation of plus Y [ppm]. In addition, whether it happens depends on the phase relationship of the 1-second boundary of both clocks.

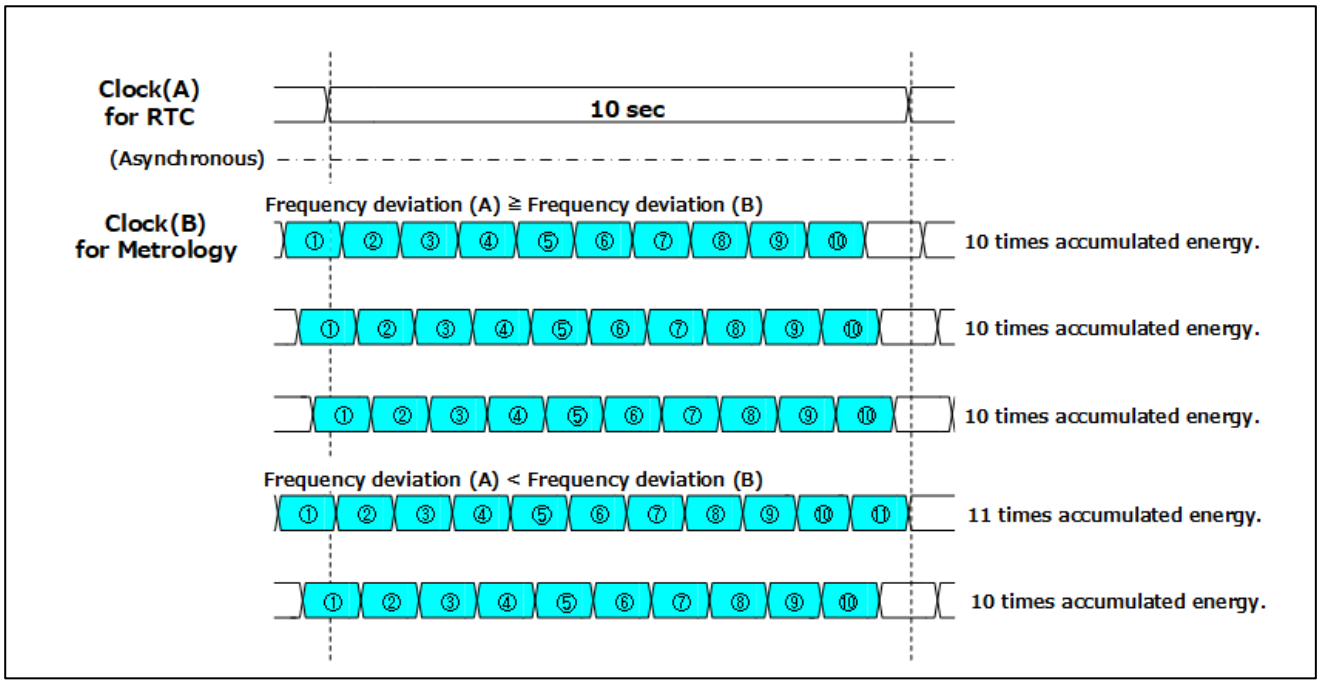


Figure 14: Timing chart of Energy Accumulation

5. Calibration of the Metrology

- Calibration of the metrology can be performed using the "**calib**" command.
- The potentiometer R8 should be in the furthest counter-clockwise position during calibration, which represents **Ib** current.

Note: The arrow on the knob represents the position of the potentiometer indicator for **Ib**

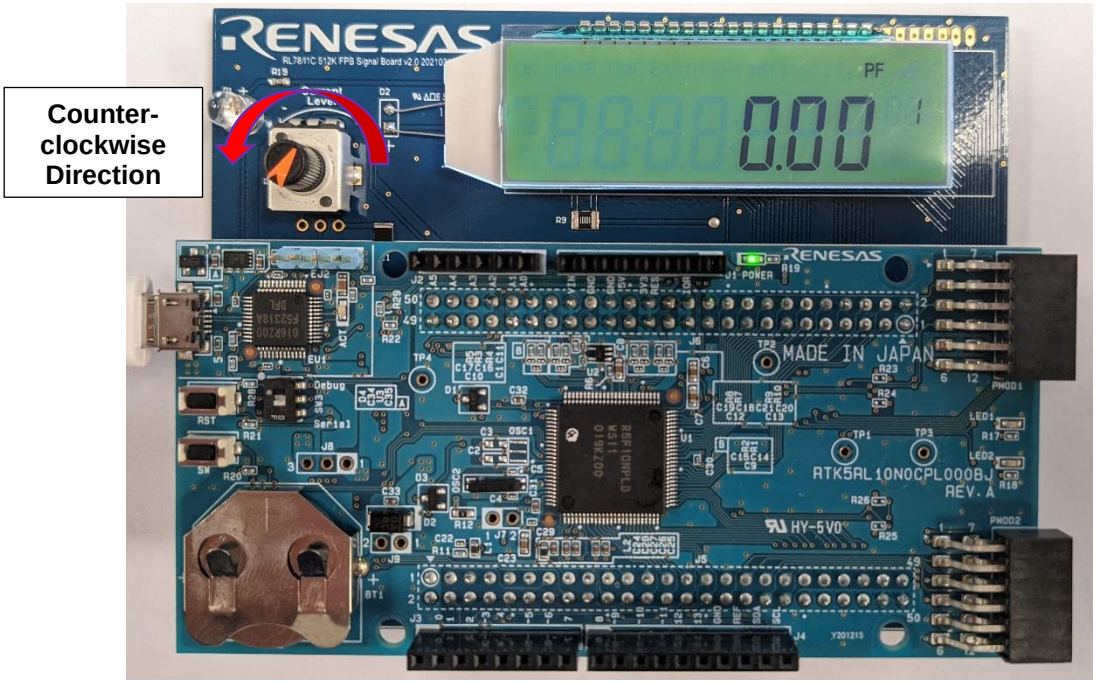


Figure 15: Potentiometer Setting and Display

- The furthest clockwise position of R8 outputs a signal roughly 5x that of **Ib**, representing **Imax** current.
- The parameters entered for calibration represent:
  a. Number of cycles to accumulate for coefficient calculation.
  b. Number of cycles to accumulate for phase angle calculation.
  c. Maximum expected current value (**Imax**).
  d. Voltage.
  e. Calibration current value (**Ib**).
  f. DSAD Current channel (Phase = 1, Neutral = 0).

- The suggested parameters to use for calibration when paired with the FPB Signal Board are:

  calib 50 50 30 220 5 0
  calib 50 50 30 220 5 1

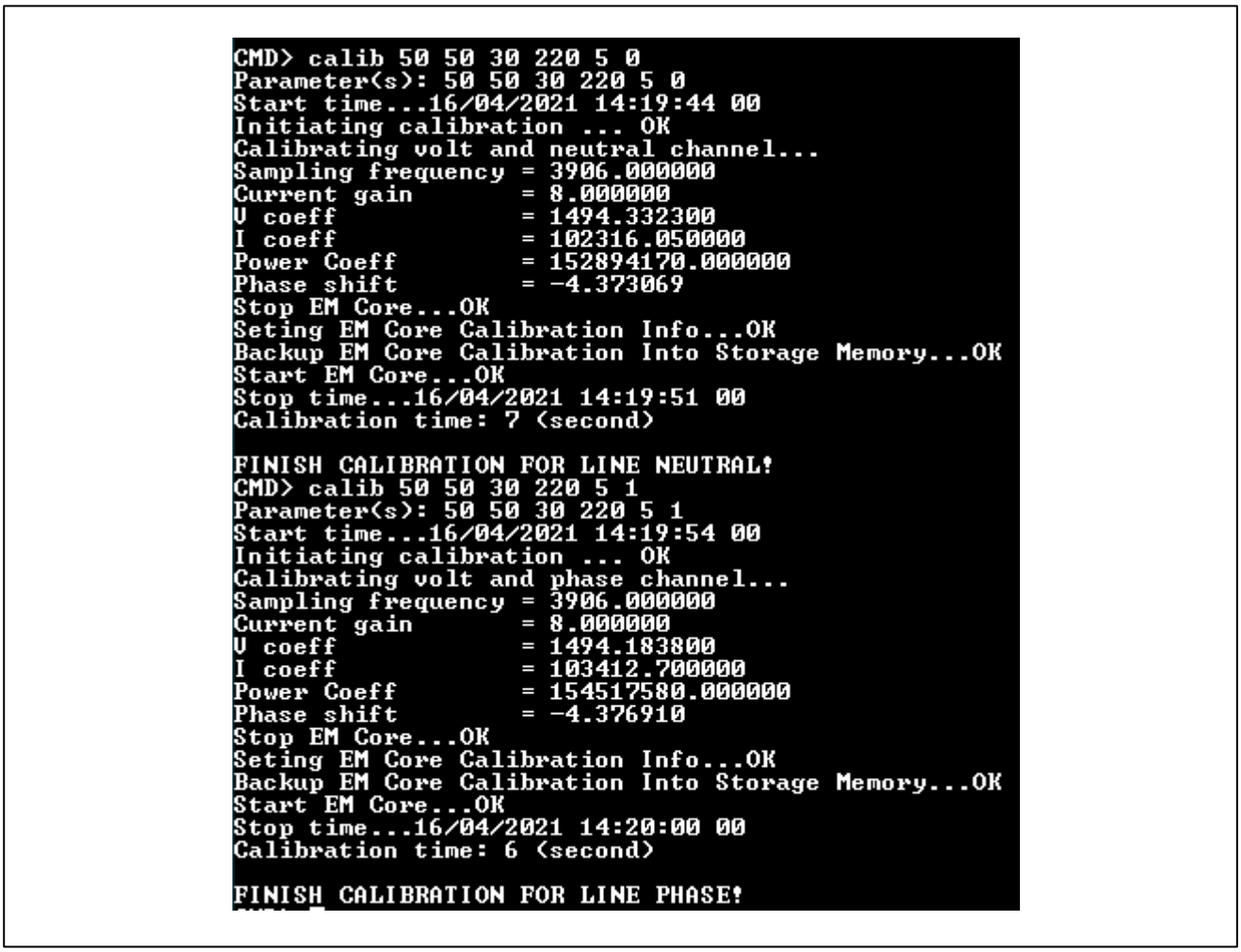
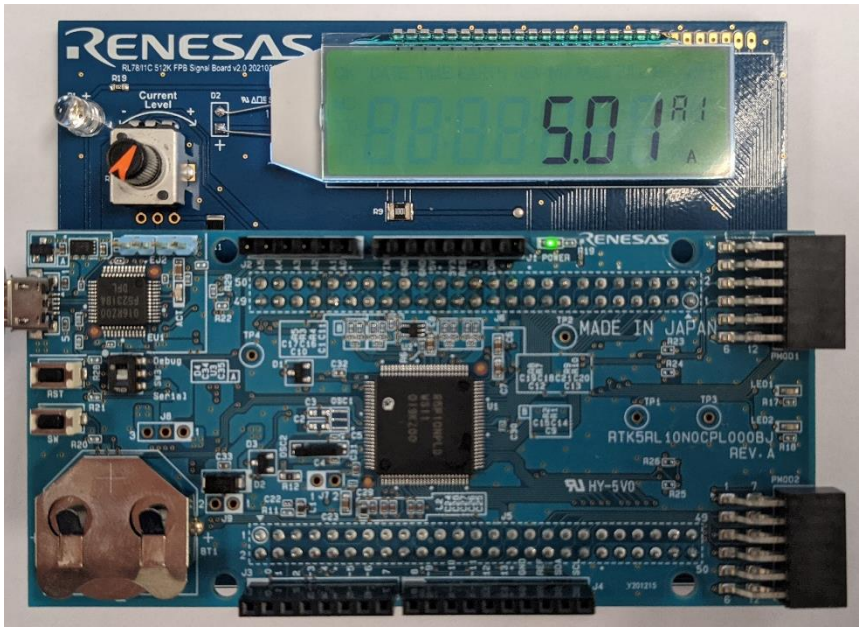


Figure 16: Calibration of EM Core

- The calibration can be verified using the "**display**" command, with the potentiometer R8 set to minimum and maximum values.

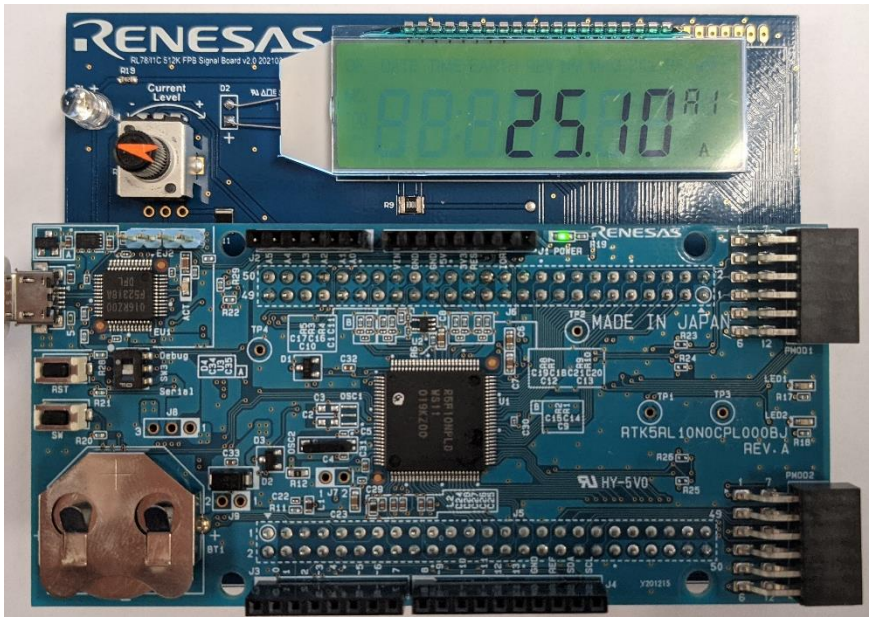
a. Potentiometer set to Minimum value (**lb**)




```
CMD> display
Waiting for signal stable...
+-------------------------------------+-----------------+-----------+
| Parameter                           | Total           | Unit      |
+-------------------------------------+-----------------+-----------+
| Voltage RMS                         |     220.0181400 | Volt      |
| Current RMS Phase                   |       4.9983201 | Ampere    |
| Current RMS Neutral                 |       5.0002499 | Ampere    |
| Line Frequency                      |      50.0000000 | Hz        |
+-------------------------------------+-----------------+-----------+
| Active Power                        |    1099.8510000 | Watt      |
| Fundamental Power                   |       0.0000000 | Watt      |
| Reactive Power                      |       0.0000000 | VAr       |
| Apparent Power                      |    1099.8530000 | VA        |
| Power Factor                        |       1.0000000 |           |
| Power Factor Sign                   |    PF_SIGN_UNITY |           |
+-------------------------------------+-----------------+-----------+
| Neutral Active Power                |    1100.0909000 | Watt      |
| Neutral Fundamental Power           |       0.0000000 | Watt      |
| Neutral Reactive Power              |       0.0000000 | VAr       |
| Neutral Apparent Power              |    1100.0930000 | VA        |
| Neutral Power Factor                |       1.0000000 |           |
| Neutral Power Factor Sign           |    PF_SIGN_UNITY |           |
+-------------------------------------+-----------------+-----------+
| EM Import Active Energy             |       0.0362309 | kWh       |
| EM Import Reactive Energy (C)       |       0.0000065 | kVArh     |
| EM Import Reactive Energy (L)       |       0.0004880 | kVArh     |
| EM Import Apparent Energy           |       0.0477714 | kVAh      |
| EM Export Active Energy             |       0.0000000 | kWh       |
| EM Export Reactive Energy (C)       |       0.0000000 | kVArh     |
| EM Export Reactive Energy (L)       |       0.0000000 | kVArh     |
| EM Export Apparent Energy           |       0.0000000 | kVAh      |
+-------------------------------------+-----------------+-----------+
```

Figure 17: Potentiometer R8 set to Minimum after Calibration.

b. Potentiometer set to Maximum value (**Imax**)




```
CMD> display
Waiting for signal stable...
+-------------------------------------------------------------------------+
| Parameter                      | Total              | Unit              |
+-------------------------------------------------------------------------+
| Voltage RMS                    |       219.9564100 | Volt              |
| Current RMS Phase              |        25.2800410 | Ampere            |
| Current RMS Neutral            |        25.2887000 | Ampere            |
| Line Frequency                 |        50.0000000 | Hz                |
+-------------------------------------------------------------------------+
| Active Power                   |      5561.2788000 | Watt              |
| Fundamental Power              |         0.0000000 | Watt              |
| Reactive Power                 |         3.0200000 | VAr               |
| Apparent Power                 |      5561.2808000 | VA                |
| Power Factor                   |         1.0000000 |                   |
| Power Factor Sign              |     PF_SIGN_UNITY |                   |
+-------------------------------------------------------------------------+
| Neutral Active Power           |      5562.6948000 | Watt              |
| Neutral Fundamental Power      |         0.0000000 | Watt              |
| Neutral Reactive Power         |         3.0230000 | VAr               |
| Neutral Apparent Power         |      5562.6982000 | VA                |
| Neutral Power Factor           |         1.0000000 |                   |
| Neutral Power Factor Sign      |     PF_SIGN_UNITY |                   |
+-------------------------------------------------------------------------+
| EM Import Active Energy        |         0.0551739 | kWh               |
| EM Import Reactive Energy (C)  |         0.0000065 | kVArh             |
| EM Import Reactive Energy (L)  |         0.0004940 | kVArh             |
| EM Import Apparent Energy      |         0.0667418 | kVAh              |
| EM Export Active Energy        |         0.0000000 | kWh               |
| EM Export Reactive Energy (C)  |         0.0000000 | kVArh             |
| EM Export Reactive Energy (L)  |         0.0000000 | kVArh             |
| EM Export Apparent Energy      |         0.0000000 | kVAh              |
+-------------------------------------------------------------------------+
```

Figure 18: Potentiometer R8 set to Maximum after Calibration.

6. Image Transfer

This section covers the Image Transfer process of the Continuous Metrology FOTA demonstration.

6.1. Required Software

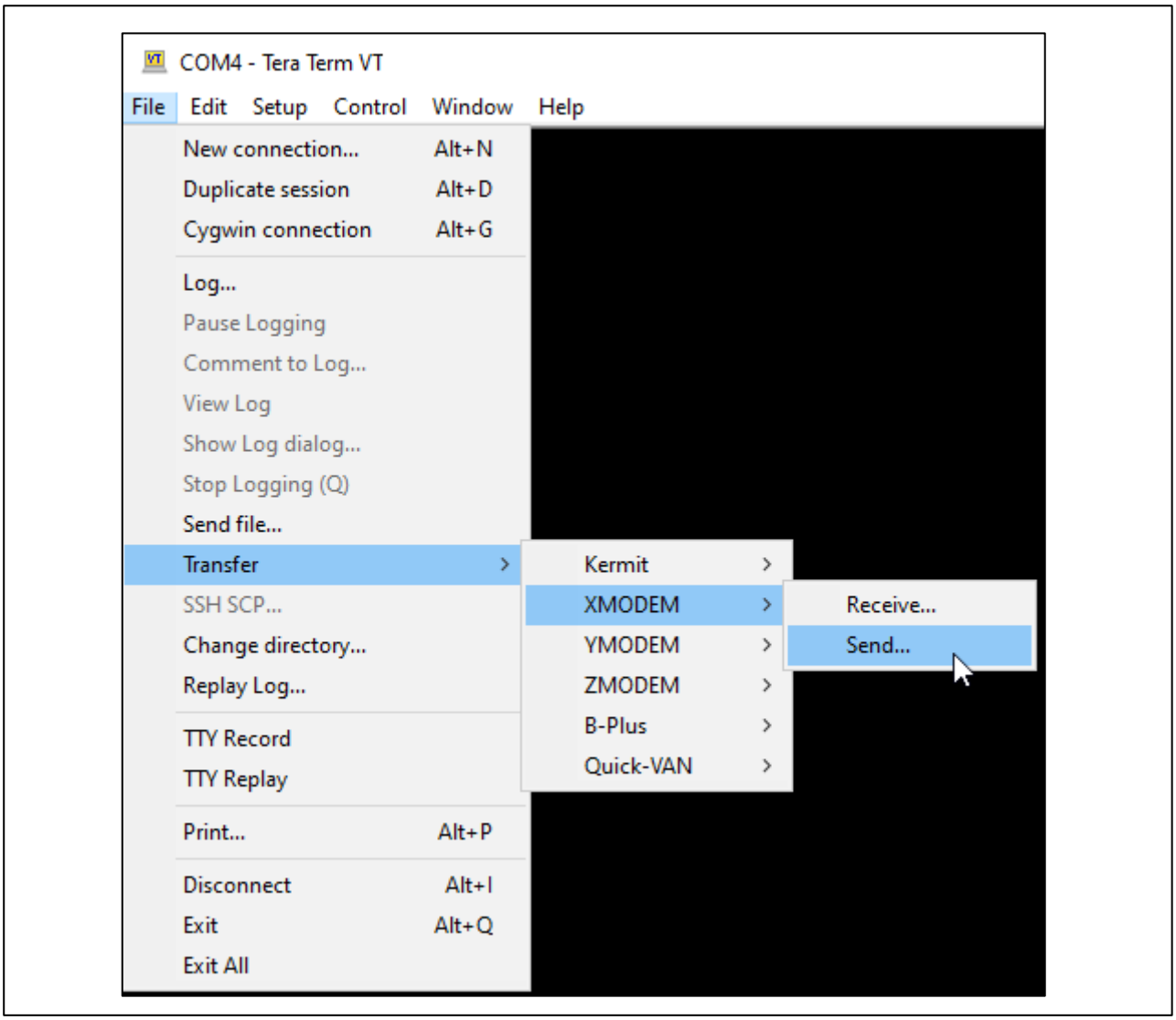
- The Image Transfer is performed using the XMODEM checksum protocol. Variations such as XMODEM CRC are not supported.
- The Image Transfer function was tested and developed using Tera Term v4.105.

6.2. Starting the Image Transfer

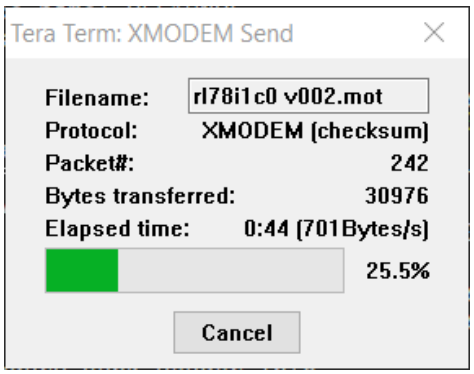
1. Type “xfer” and press the Enter key to initiate the XMODEM Image Transfer function.

```
CMD> xfer
Please start file transfer using XModem protocol.
Transfer will initiate within 10 seconds.
```

2. Send the **rl78i1c0.mot** file using the Tera Term (or equivalent) XMODEM send function.



3. Tera Term will wait for the Acknowledgement (ACK) packet, which is sent out by the User Application every 10 seconds while waiting for the data transfer to start.



4. On receiving the ACK, Tera Term will initiate the data transfer. **LED1** on the RL78/I1C(512KB) Fast Prototyping Board will flash during writing of received packets to the secondary memory bank.

5. After the data transfer completes successfully, the Image Transfer Time and Software Version stored within the Image Header will be updated.

```
CMD> xfer
Please start file transfer using XModem protocol.
Transfer will initiate within 10 seconds.

End of File.
Updating Image Header...
Transfer Complete.
```

6. The "**hash**" command can then be used to verify that the hash value of the transferred User Application image matches its pre-calculated hash value stored within the Image Header.

```
CMD> hash
Hash value OK
Calculated program hash: 0x6c30
Embedded program hash:   0x6c30
```

7. The Software Version and Transfer Time of the Secondary Bank displayed by the "**binfo**" command will be updated on completing the image transfer.

```
CMD> binfo
Reading device information (embedded in reserved FLASH)
Device name: R5F10NPL
Bankswap support: YES
Code flash size: 0x00080000 (524288) bytes
Code flash size: 0x00000800 (2048) bytes
Reading image header at address 0x01000
Primary Bank Header Info
Platform name: RES_SmartMeter_1P2W_I1C512K
Software version: v0.0.1
User program size: dec: 47167, hex: 0x0b83f (bytes)
User program hash: 0xfa79
User program transfer time (dd/MM/yyyy hh:mm:ss wd): N/A
User program activate time (dd/MM/yyyy hh:mm:ss wd): 30/06/2021 16:18:08 02

Secondary Bank Header Info
Platform name: RES_SmartMeter_1P2W_I1C512K
Software version: v0.0.2
User program size: dec: 47169, hex: 0x0b841 (bytes)
User program hash: 0x6c30
User program transfer time (dd/MM/yyyy hh:mm:ss wd): 01/07/2021 11:12:37 03
User program activate time (dd/MM/yyyy hh:mm:ss wd): N/A
Reading self-programming flash
FSL Library version: SRL78T01L1000GV221
Boot flag: 0
```

8. The transferred User Application image can be activated using the Boot-Swap commands described in section **7.**

7. Bank-Swap Functions

7.1. Continuous Metrology FOTA Bank-Swap Command

Type “**bswap**” and press the **Enter** key to initiate the Continuous Metrology FOTA Bank-Swap command.

- Image Activation time will be updated and stored within the image header.
- The User Application will be restarted from the secondary memory bank without resetting the MCU.
- Metrology processes and data are maintained in RAM during the Bank-Swap.
- Type “**energy**” and press the **Enter** key to display the Energy Table, before and after invoking the “**bswap**” command. There should be no loss of energy accumulation during the Bank-Swap operation.

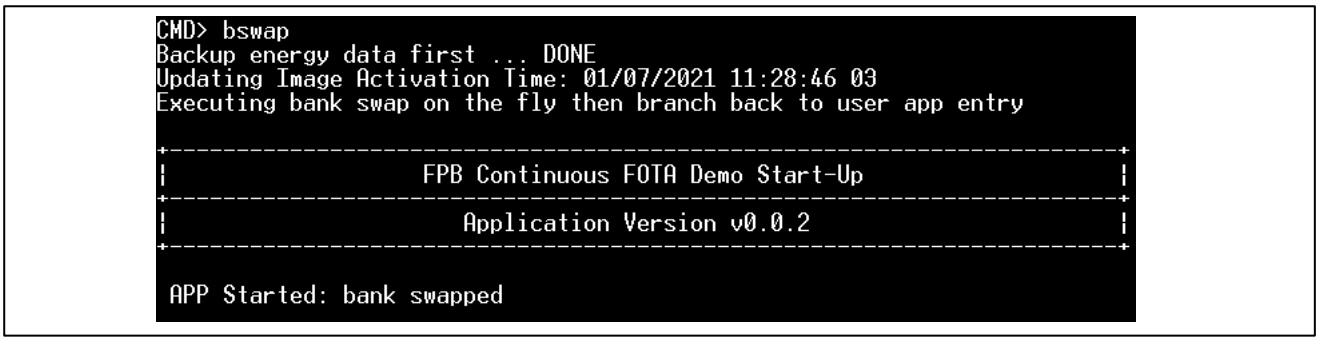


Figure 19: Initiating the Continuous Metrology FOTA Bank-Swap command

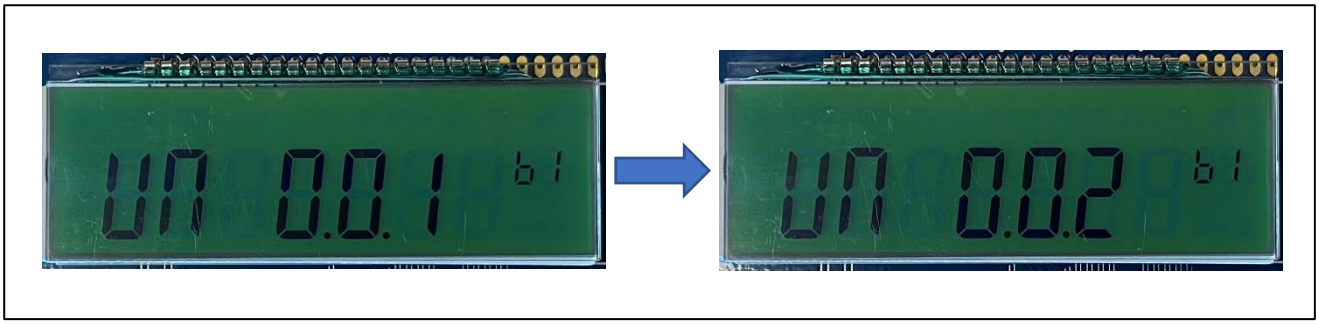


Figure 20: Display Output

- The version of the User Application contained within **rl78i1c_production.mot** is [UN 0.0.1].
- After updating to the new User Application contained within **rl78i1c0.mot**, the version is updated to [UN 0.0.2]
- The push button switch **SW** can be pressed to cycle through the LCD display data to view the User Application version.

7.2. Fast FOTA Bank-Swap Command

- Type “**binvr**” and press the **Enter** key to initiate the Boot Flag and Reset command.
- This will invert the boot flag and reset the MCU, running the User Application from the secondary memory bank.
- RAM is cleared when performing this command, including the Energy Table.

```
CMD> binvr
Wait for next energy log entry ...
Stopping EM...OK
Backup energy data first ... DONE
Clear energy counter in RAM
Updating Image Activation Time: 01/07/2021 11:36:50 03
Executing invert boot flag then reset

+-------------------------------------------------------------------------+
|                   FPB Continuous FOTA Demo Start-Up                     |
+-------------------------------------------------------------------------+
|                      Application Version v0.0.2                         |
+-------------------------------------------------------------------------+

 APP Started: normal startup
RESF Flag: 128

CMD>
```

Figure 21: Initiating the Boot Flag Invert and Reset command

```
CMD> energy
+-------------------------------------------------------------------------+
| Parameter / Time                | Total / +Increase | Unit              |
+-------------------------------------------------------------------------+
| EM Import Active Energy         |         0.2754178 | kWh               |
| RTC Time: 01/07/2021 11:38:20 03 | +      15.4715880 | Wh                | <- bswap
+-------------------------------------------------------------------------+
| EM Import Active Energy         |         0.2599462 | kWh               |
| RTC Time: 01/07/2021 11:38:10 03 | +      15.4713590 | Wh                |
+-------------------------------------------------------------------------+
| EM Import Active Energy         |         0.2444748 | kWh               |
| RTC Time: 01/07/2021 11:38:00 03 | +      15.4717250 | Wh                |
+-------------------------------------------------------------------------+
| EM Import Active Energy         |         0.2290031 | kWh               |
| RTC Time: 01/07/2021 11:37:50 03 | +      17.0191500 | Wh                |
+-------------------------------------------------------------------------+
| EM Import Active Energy         |         0.2119840 | kWh               |
| RTC Time: 01/07/2021 11:37:40 03 | +      15.4730680 | Wh                |
+-------------------------------------------------------------------------+
| EM Import Active Energy         |         0.1965109 | kWh               |
| RTC Time: 01/07/2021 11:37:30 03 | +      15.4721370 | Wh                |
+-------------------------------------------------------------------------+
| EM Import Active Energy         |         0.1810388 | kWh               |
| RTC Time: 01/07/2021 11:37:20 03 | +      15.4732060 | Wh                |
+-------------------------------------------------------------------------+
| EM Import Active Energy         |         0.1655656 | kWh               |
| RTC Time: 01/07/2021 11:37:10 03 | +      15.4739990 | Wh                |
+-------------------------------------------------------------------------+
| EM Import Active Energy         |         0.1500916 | kWh               |
| RTC Time: 01/07/2021 11:37:00 03 | +      12.3712460 | Wh                | <- binvr
+-------------------------------------------------------------------------+
| EM Import Active Energy         |         0.1377203 | kWh               |
| RTC Time: 01/07/2021 11:36:50 03 |                   |                   |
+-------------------------------------------------------------------------+
```

Figure 22: Energy Table showing Bank-Swap history

8. Diving Deeper

1. To learn more about the RL78/I1C (512KB) Fast Prototyping Board, refer to the RL78/I1C (512KB) User's Manual available in the User Guides & Manuals of the RL78/I1C webpage at renesas.com/br/en/products/microcontrollers-microprocessors/rl78-low-power-8-16-bit-mcus/rl78i1c-ultra-low-power-microcontrollers-high-end-smart-electricity-meter-market
2. Renesas provides several example projects that demonstrate different capabilities of the RL78/I1C (512KB) Fast Prototyping Board. These example projects can serve as a good starting point for users to develop custom applications. Example projects (source code and project files) are available in the RL78/I1C (512KB) Fast Prototyping Board Example Project Bundle.

9. Website and Support

Visit the following URLs to learn about the kit and the RA family of microcontrollers, download tools and documentation, and get support.

- RL78/I1C Resource renesas.com/br/en/products/microcontrollers-microprocessors/rl78-low-power-8-16-bit-mcus/rl78i1c-ultra-low-power-microcontrollers-high-end-smart-electricity-meter-market
- RL78 Product Information renesas.com/br/en/products/microcontrollers-microprocessors/rl78-low-power-8-16-bit-mcus
- RL78 Knowledge Base en-support.renesas.com/knowledgeBase#31025
- Renesas Support en-support.renesas.com/dashboard

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	MAY 31, 2021	−	Initial release