Contents

1 Introduction

The MicroXplorer Power Consumption Calculator helps you estimate, in the context of your application, the power consumption of a chosen microcontroller as well as the attached battery lifetime for the configuration set.

By the selection of power mode and the configuration of relevant parameters, a user obtains:

- An estimation of the average power consumption
- An estimation of the battery life
- An estimation of the average DMIPS.

Power consumption and DMIPS data are directly taken from datasheets and are not interpolated or extrapolated.

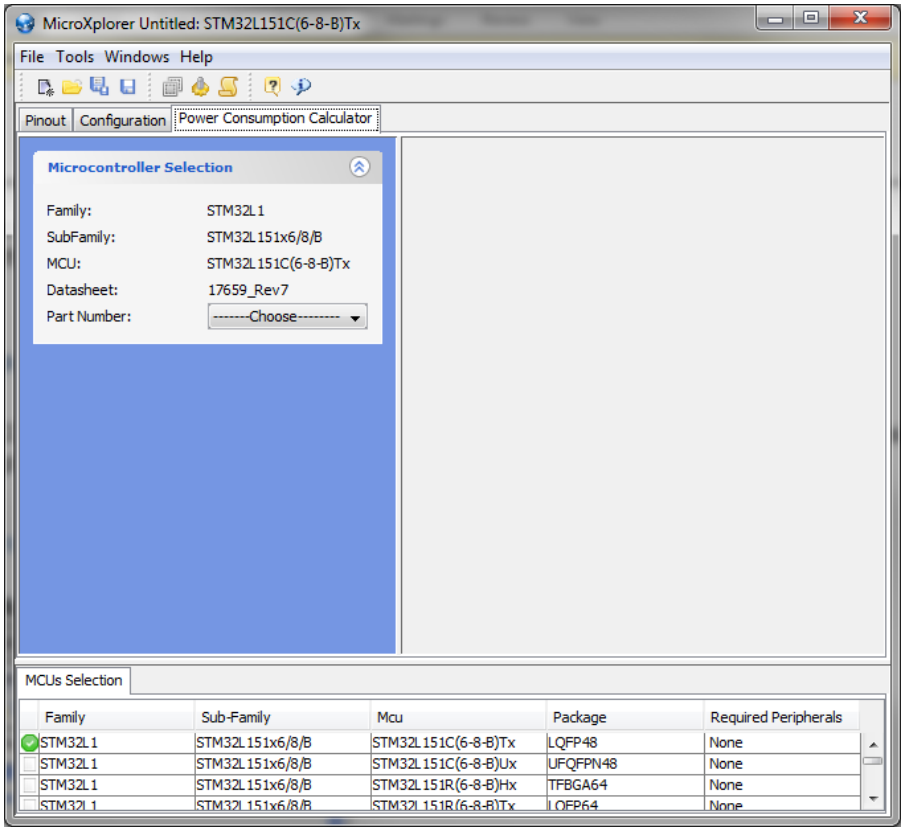
The user navigates through different windows and panel such as:

- MicroXplorer Launch window
- MCU Selection windows
- Power plugin Main Configuration panel
- Power plugin Step Configuration window
- Power plugin Main window with Results panel

2 Power Consumption Main User Interface

The Power Consumption Calculator plugin can be displayed by selecting the “Power Consumption Calculator” tab. If the microcontroller is supported, the following window will be displayed (see *Figure 1*):

Figure 1 Power plugin initial view



The Power plugin view provides access to 3 panels when a configuration is done (see *Figure 2*).

The left panel providing:

- Global Power plugin parameters to be configured to initialize the plugin view: MCU Part Number, temperature, Vdd, battery model
- Power plugin version and Datasheets references
- Power information notes and Help

The bottom panel providing:

- **MCUs Selection** panel displays all possible MCUs for the selected MCU Family. It can be deactivated from the **Windows** menu.

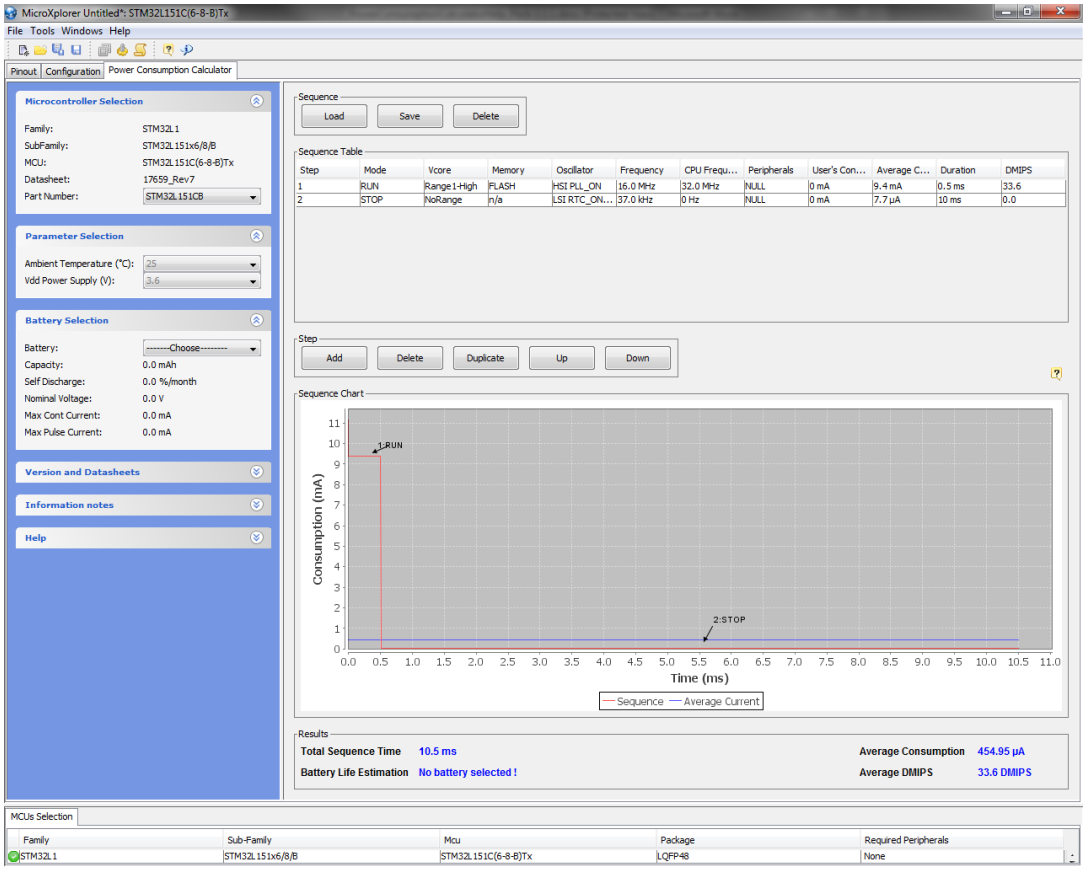
The right panel providing:

- Power sequences, steps configuration and a display of results.

As a general rule, when no choice is available for a parameter, the combo box is fixed to the parameter's default value and is grayed out.

The following chapters will guide you in a step by step configuration of the Power Consumption Calculator.

Figure 2 Power plugin panels

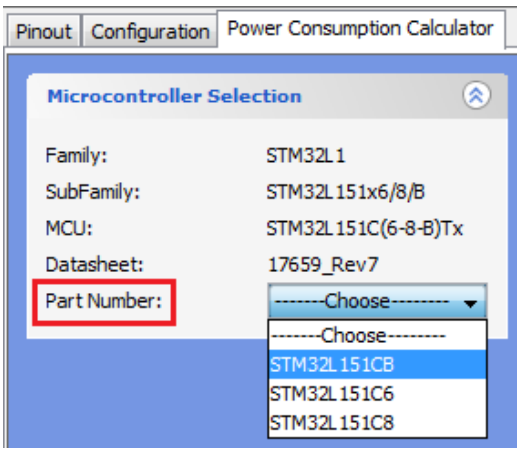


2.1 Step 1: Select a Part Number

The first step consist in choosing a Part Number covered by the selected MCU even in most of the cases the power consumption is not impacted.

Click the **Part Number** combo box to select the desired part number (see *Figure 3*)

Figure 3 MCU Part Number Selection

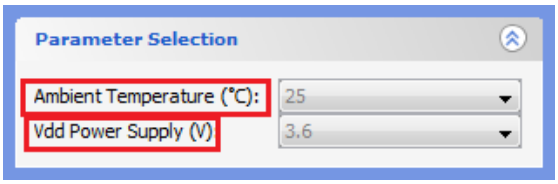


Once the part number is selected, the Power plugin is instantiated and ready to use.

2.2 Step 2: Select ambient temperature and Vdd Power Supply

If multiple choices are available, select the **Ambient Temperature** and **Vdd Power Supply** from combo boxes (see *Figure 4*).

Figure 4 Ambient Temperature and Vdd Power Supply selection



2.3 Step 3 or later: Select a battery model

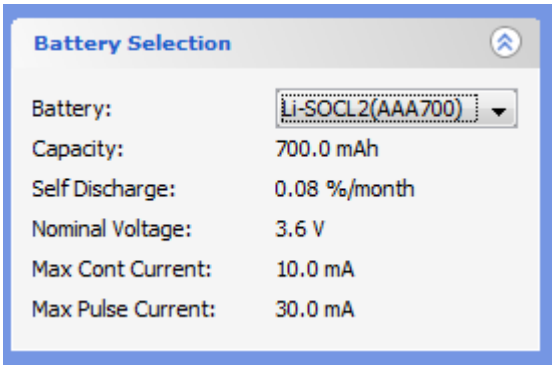
At this stage, the Power plugin is ready for use.

The user can proceed in the sequence and step configuration with or without the selection of the battery.

The **Battery Selection** section displays the main parameters of the selected battery (see *Figure 5*):

- Capacity (mAh): Amount of energy that can be delivered in a single discharge
- Self-discharge (%/month): This percentage over a specified period represents the loss of battery capacity when the battery is not in use (open-circuit conditions) as a result of internal leakage
- Nominal voltage (V): Voltage of a fully charged battery
- Max. Continuous Current (mA): The value of the maximum current that can be delivered during the battery lifetime period without damaging the battery
- Max. Pulse Current (mA): The value of the maximum pulse current that can be delivered exceptionally as for instance when the application is switched on during starting phase.

Figure 5 Battery Selection



There is a check on battery parameters upon building a new step so that the user will be notified if the battery selected is not compliant with step parameters.

2.4 Additional information

The **Version and Datasheets** section contains the current version of the Power plugin and datasheets references compliant with.

The **Information notes** section contains some notes and assumptions about Power plugin settings.

3 Build Power Consumption step(s)

A Power plugin sequence is composed of at least one step. At each step definition, the Power plugin recalculates the power consumption of the current sequence. A step can be considered as the time in hours, minutes or seconds that the user application is in a given power mode with its associated configuration settings. In a sequence, when several steps share the same configuration settings, they can be grouped in a single step by adding the steps duration to maintain the same calculation.

There are two possible ways to build a step:

1. Build new steps from scratch

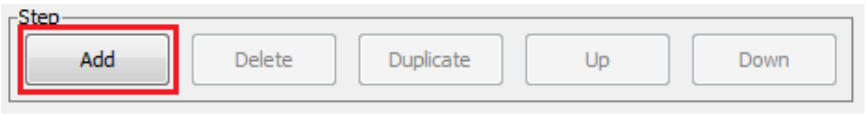
2. Reuse already defined steps to build new ones (duplicate step or load a sequence).

3.1 Add a step

To add a new step, follow the sequence below:

1. Click on the **Add** button in Step section to open the New Step window (see *Figure 6*)

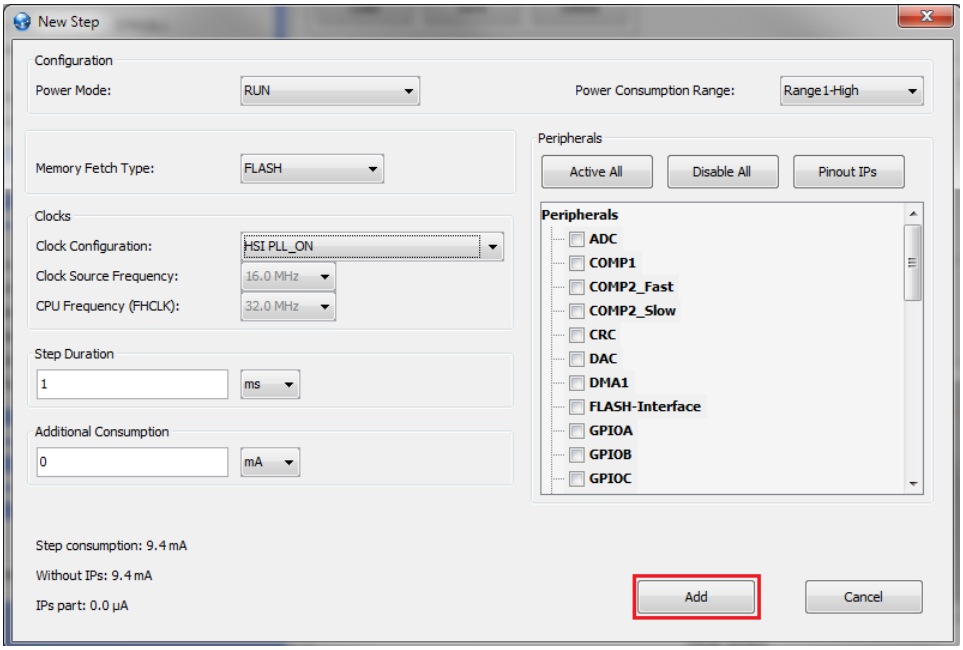
Figure 6 Add Step



2. Configure the step (see "*Power plugin step configuration* details" paragraph)

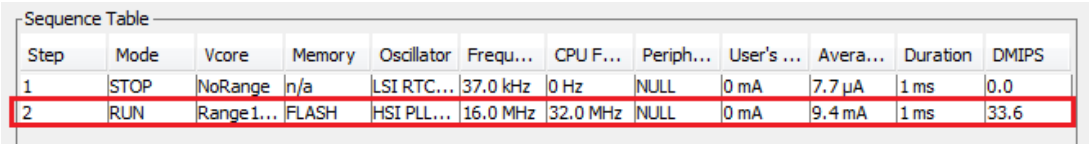
3. Click **Add** button from the New Step window (see *Figure 7*) to add the step with defined parameters into the current sequence

Figure 7 Add Step



The step will be inserted at the end of the defined steps and numbered in "Step" column (see *Figure 8*).

Figure 8 Step added to the Sequence Table

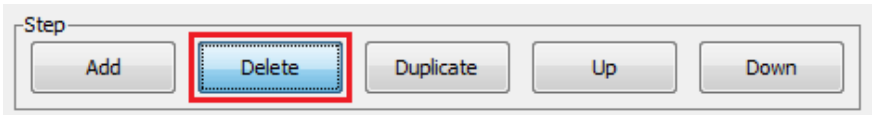


3.2 Delete a step

To remove an existing step, follow the sequence below:

1. Select the step to be removed in the sequence table
2. Click on **Delete** button (see *Figure 9*), the step is removed from the sequence

Figure 9 Delete Step



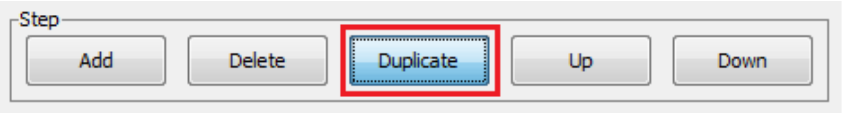
3.3 Duplicate a step

To duplicate an existing step, follow the sequence below:

1. Select in the sequence table the step to be duplicated

2. Click on the **Duplicate** button (see *Figure 10*), the New step window is opened with selected step configuration
3. Keep same configuration or update it
4. Click on **Add** button to insert the new step in the sequence table

Figure 10 Duplicate Step



3.4 Move up or down a step

To move a step up or down in a sequence, select it in the sequence table and click the **Up** or **Down** button (see *Figure 11* and *Figure 12*).

Figure 11 Step Up

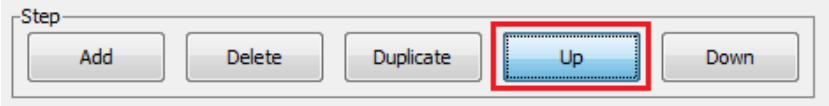
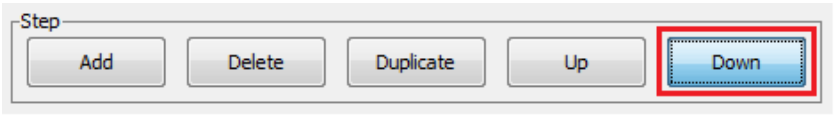


Figure 12 Step Down



Moving a step has no effect on power consumption calculation.

4 Build a sequence

A sequence is composed of at least one step.

To duplicate a sequence, save the sequence and load it, keep existing step(s) in the Sequence Table.

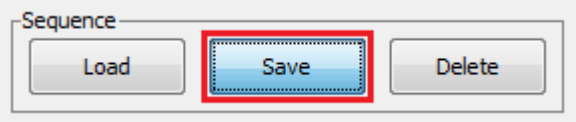
4.1 Save Sequence

A sequence already built can be saved for future usage. The sequence table displayed is saved in a **pcs** file that will be stored on a user defined location.

To save a sequence, follow the sequence below:

1. Click on **Save Sequence** button (see *Figure 13*)

Figure 13 Save Sequence



2. Browse to a user defined location and give a proper name to the sequence file (*.pcs)
3. Click on **Save** button.

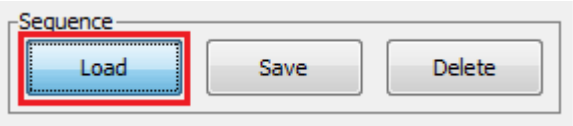
4.2 Load Sequence

Already saved sequence can be loaded and are inserted at the end of currently defined sequence.

For loading a sequence, follow the sequence below:

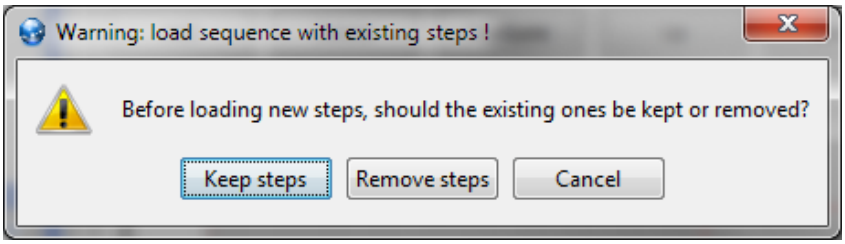
1. Click on **Load Sequence** button (see *Figure 14*)

Figure 14 Load Sequence



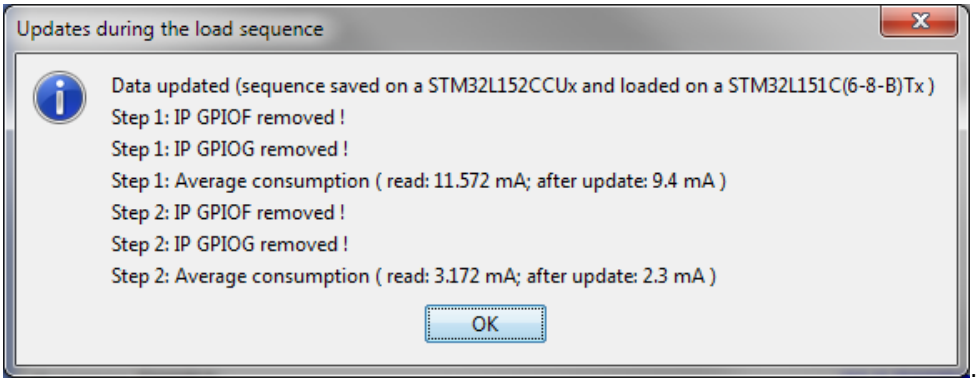
2. Browse a sequence file (*.pcs) and select it
3. A Warning message is displayed (see *Figure 15*). Click the **Keep steps** button for keeping current steps or **Remove steps** button to remove current steps.

Figure 15 Load Warning message



4. Then all updates done upon loading the sequence are displayed in a dedicated window (see *Figure 16*). Click the OK button to finish the sequence loading

Figure 16 Updates done upon sequence loading



The loaded sequence is inserted at the end of the sequence table and is taken into account for power consumption calculation.

Note: Loading several times the same sequence will only impact the sequence chart and the total sequence time. DMIPS, average power consumption and battery lifetime will obviously remain unchanged.

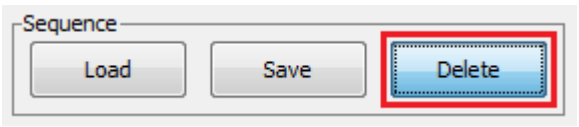
4.3 Delete Sequence

A sequence can be entirely deleted but this action must be carefully executed as this cannot be recovered.

To delete a sequence, follow the sequence below:

1. Click on Delete Sequence button (see *Figure 17*)

Figure 17 Delete Sequence

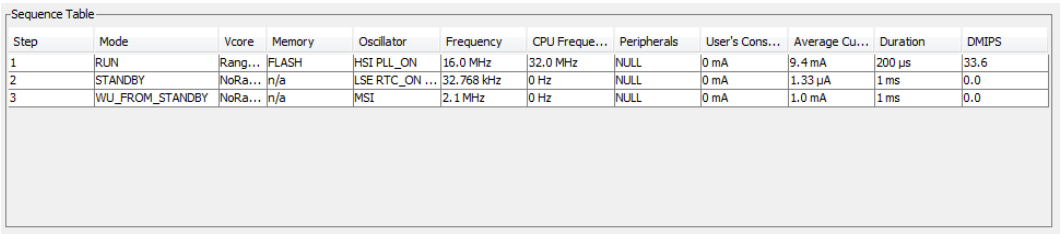


Once the sequence is deleted, the sequence table will be empty.

4.4 Sequence Table

The **Sequence Table** contains all the information filled up by the user in the different configuration steps (see *Figure 18*). Each step is identified by its step number and its associated parameters. All the parameters will be taken into account for the final results.

Figure 18 Sequence Table



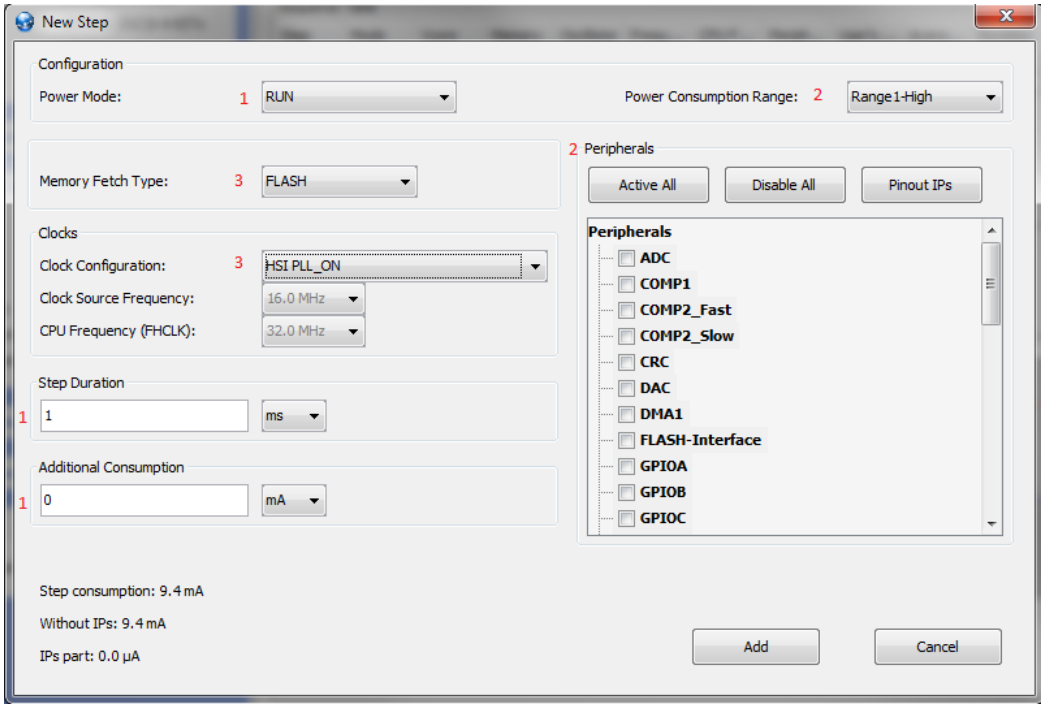
5 Power plugin step configuration details

The Power plugin step configuration can be done either from scratch or by using an already defined step. A step is configured by setting parameters in a pre-defined order. The parameters are set either by the user or by the Power plugin when there is only one possible value (the settings appears in grey in this case).

To configure a step, perform the following actions (see *Figure 19*):

1. At first
    - Select the **Power Mode**
    - (Optional) Specify a **Step Duration** (default value is 1ms)
    - (Optional) Specify an **Additional Consumption**
2. Then
    - Select the **peripherals**
    - Select the **Power Consumption Range**
3. Finally
    - Select **Memory Fetch Type**
    - Select a **Clock Configuration**
    - In a few cases, select a **Clock Source Frequency**

Figure 19 Step configuration



Changing the power mode or the power consumption range discards all subsequent configurations done.

5.1 Power Mode selection

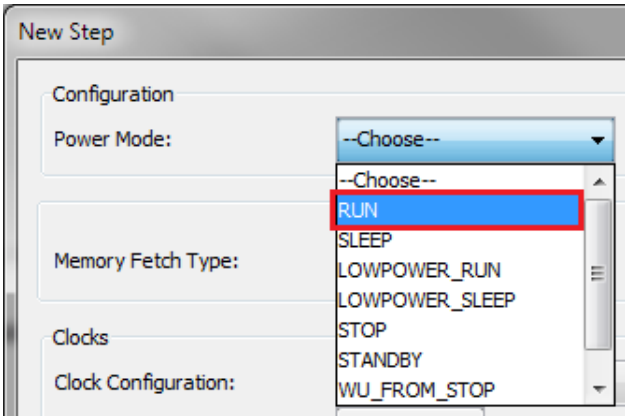
There are several power modes depending on the family. For more details about STM32L1 power modes, see the ***Appendix A STM32L1 power parameters specificities***.

In general and to save power, the user operates the microcontroller by switching it from running modes where full operation is required to idle modes where limited resources are needed. These different power modes called steps are grouped into a sequence that can be repeated indefinitely according to user needs

The Power Mode can be selected by the sequence below:

1. Click on **Add** button or double-click on the step from the sequence table
2. Open the **Power Mode** combo box (see *Figure 20*)
3. Select one Power Mode in the list

Figure 20 Power Mode



Once the Power Mode is selected, the peripherals are displayed. The step configuration can be continued either by selecting a Power Consumption Range or by selecting the peripherals for this step.

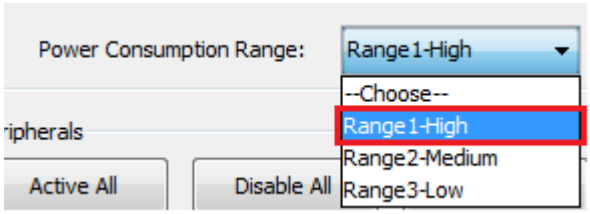
5.2 Power Consumption Range Selection

They are specific power ranges selection for STM32L1 family (see ***Appendix A STM32L1 power parameters specificities***)

The Power Consumption Range can be selected by the sequence below:

1. If not already done, Click on **Add Step** button or double-click on the step from the sequence table
2. Prerequisite: Power Mode should be selected (see *Power Mode selection*)
3. Open the **Power Consumption Range** combo box (see *Figure 21*)
4. Select one Power Consumption Range in the list

Figure 21 Power Consumption Range



Once the Power Consumption Range is selected, the Memory Fetch Type and the clock can be configured.

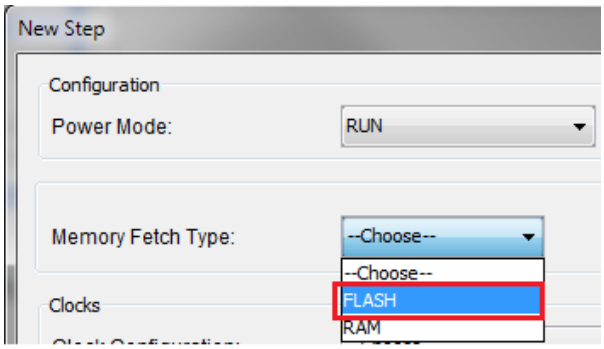
5.3 Memory Fetch Type selection

The user shall specify the memory location for application code execution by selecting FLASH or RAM under Memory Fetch Type combo box.

The Power Fetch Type can be selected by the sequence below:

1. If not already done, Click on **Add** button or double-click on the step from the sequence table
2. Prerequisite: Power Consumption Range should be selected (see *Power Consumption Range Selection*)
3. Open the **Memory Fetch Type** combo box (see *Figure 22*)
4. Select one Memory Fetch Type in the list

Figure 22 Memory Fetch Type



5.4 Clock Configuration

Clock configuration consists in defining the CPU frequency based on setting of clock parameters.

Clock configuration selection allows to choose among the different oscillator sources that can be internal or external to the device (Ex: MSI, HSI, LSI or HSE, LSE).

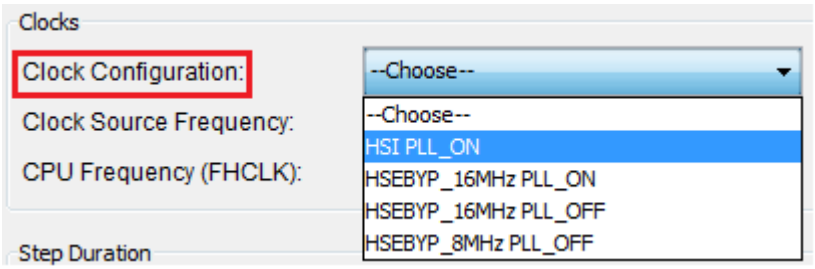
Some other parameters have been added to complete the clock configuration like: PLL, LSE or HSE Bypass, AHB prescaler value and some specific IPs like RTC, LCD with duty, IWDG for STOP and STANDBY modes.

Whenever possible, the values of clock source frequency and CPU frequency will appear upon choosing a Clock Configuration.

The Clock can be configured as follows:

1. If not already done, Click on **Add** button or double-click on the step from the sequence table
2. Prerequisite: Power Consumption Range should be selected (see *Power Consumption Range Selection*)
3. Open the **Clock Configuration** combo box
4. Select one Clock Configuration in the list (see *Figure 23*)
5. If not already set, open the **Clock Source Frequency** combo box and select one Clock Source Frequency in the list
6. If not already set, open the **CPU Frequency (F_{HCLK})** combo box and select one Clock Source Frequency in the list

Figure 23 Clock Configuration



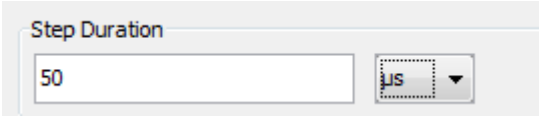
5.5 Step Duration

The user may enter the duration of the step (integer time unit) or use the 1ms default value.

The Step Duration can be set as follows:

1. If not already done, Click on **Add** button or double-click on the step from the sequence table
2. Enter a valid **Step Duration** value (positive number) in the Step Duration field (see *Figure 24*). If the user entry is not correct, the entry will be automatically discarded.

Figure 24 Step Duration



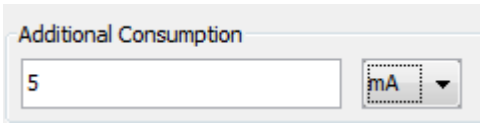
5.6 Additional consumption (Optional part)

The user may specify an additional consumption value, to reflect for example external components used by the application (Ex: external regulator, external pull-up, DELs or other displays...). This current will be added to the microcontroller power consumption to be taken into account for final power consumption calculation.

The Additional Consumption can be set as follows:

3. If not already done, Click on **Add** button or double-click on the step from the sequence table to open a new step window
4. In New Step window, enter a valid **Additional Consumption** value (zero, positive or even negative number) in the Additional Consumption field (see *Figure 25*). If the user entry is not correct, the entry will be automatically discarded.

Figure 25 Additional Consumption



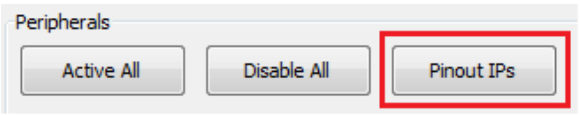
5.7 Peripherals activation

For a specific power mode, peripherals can be active or disabled by hardware. User can choose to select only peripherals that are used by the application.

The purpose of peripherals selection performed in MicroXplorer **MCUs Selector** window is only to filter the MCUs supporting peripherals selected. For having the possibility to get these peripherals selected in Power plugin peripheral tree, they need first to be configured in MicroXplorer Pinout Peripherals **Tree Interface** by selecting for each one available peripheral mode.

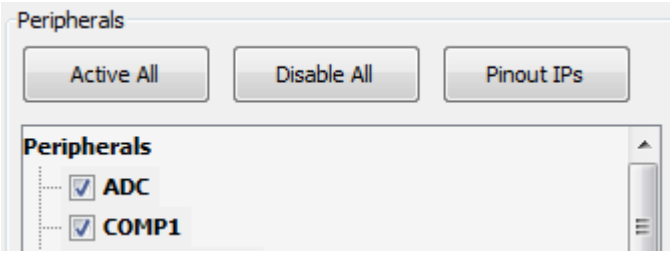
For taking the peripherals already configured in MicroXplorer GUI, press on the **Pinout IPs** button (see *Figure 26*) from the Step configuration window.

Figure 26 Pinout IPs selection



When a peripheral is selected, the Power plugin will calculate its consumption (see *Figure 27*).

Figure 27 Peripheral Selection

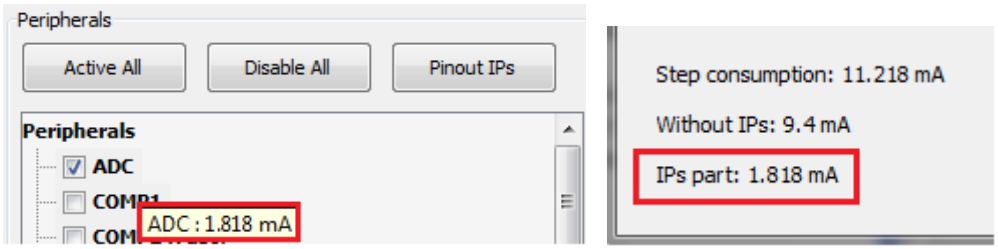


A peripheral configured in MicroXplorer Pinout Peripherals **Tree Interface** will not be taken into account for power consumption calculation unless it has been selected in Peripherals section of Power plugin view.

Note: Some peripherals are only available from Power plugin GUI.

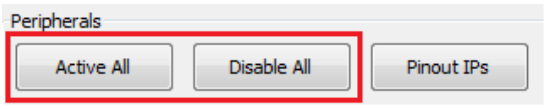
For a peripheral consumption measurement, peripheral is just clocked and its consumption under this operating condition is indicated as an information tip (see on the left of *Figure 28*). The consumption due to peripherals activation is provided at the bottom left side of the Step window (see on the right of *Figure 28*). Note that the consumption of the Step configured is also given with and without peripherals consumption part.

Figure 28 Peripheral Consumption



Peripherals can all be selected or unselected using **Active All** or **Disable All** buttons (see *Figure 29*).

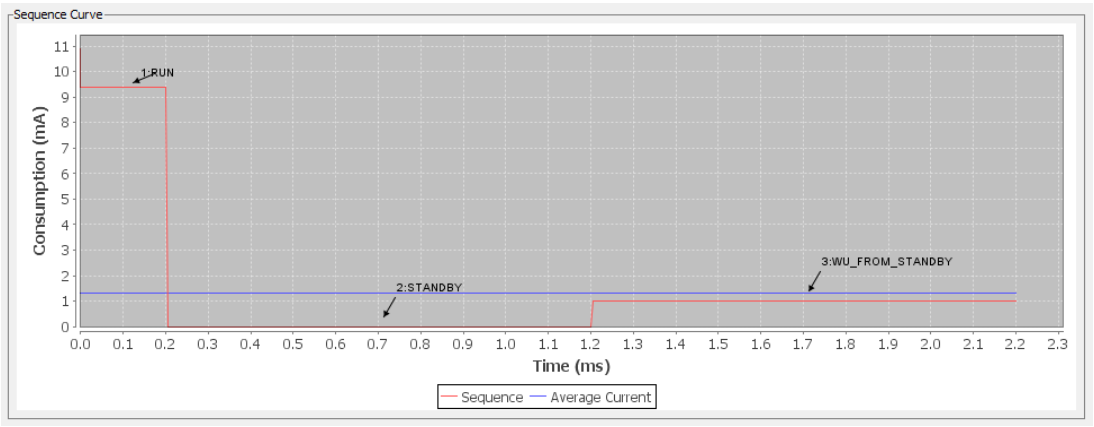
Figure 29 All Peripherals Activation or Deactivation



6 Sequence Chart

The power **Sequence Chart** shows the average power consumption and the sequence steps vs. time. The horizontal scale is time in “ms” unit and the vertical one displays the power consumption in “mA” unit (see *Figure 30*).

Figure 30 Sequence Chart

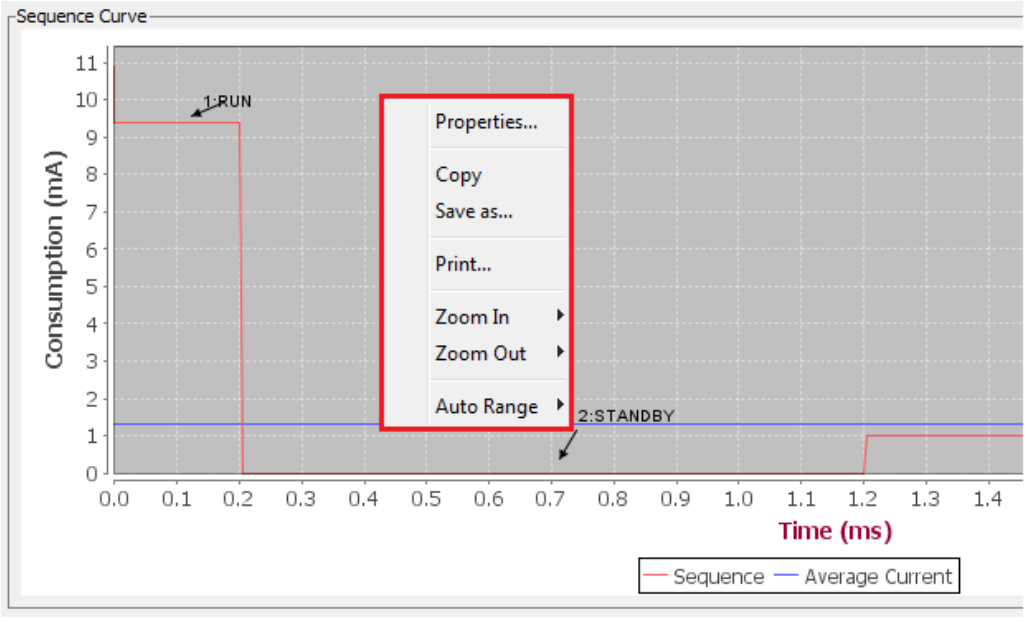


The contextual menu provides an access to some functionalities like (see *Figure 31*):

- Chart properties settings
- Copy the whole Sequence Chart
- Save the current Sequence Chart in a PNG picture file
- Print the current Sequence Chart on a printer
- Zoom In the current Sequence Chart (This can also be done by selecting a zone in the chart to zoom in)

- Zoom Out in the current Sequence Chart
- Reset zoom operations (This can also be done by moving the mouse from the right to the left of the Sequence Chart)

Figure 31 Contextual Menu of Sequence Chart



7 Power Consumption Calculator results

Once a sequence is completed and is visible in the Sequence Table, the Power plugin provides the results into a dedicated **Results** panel (see *Figure 32*).

Figure 32 Results

The following information is provided:

- **Total sequence time**: the sum of the different steps durations
- **Average Consumption**: MCU average power consumption value added to user defined Additional Consumption weighted by the steps duration
- **Average DMIPS**: The **Average DMIPS** (**D**hrystone **M**illions **I**nstructions **P**er **S**econd) based on Dhrystone benchmark. This information gives a vision of global CPU performance for the sequence. This is intended to highlight the CPU performance according to current consumption
- **Battery Life Estimation**: This information is computed based on the average power consumption and the battery self-discharge.

8 Appendix A STM32L1 power parameters specificities

8.1 Power Modes

The STM32 L1 family implements 6 power modes including 5 low-power modes:

- **RUN**: The purpose of this power mode using HSE/HSI is to reach highest performance with the CPU running up to 32MHz. Program code is executed with voltage regulator On.
- **SLEEP**: In this low-power mode using HSE/HSI, only the CPU is stopped but all peripherals continue to operate and can wake up the CPU. Voltage regulator is On.
- **LOWPOWER_RUN**: This low-power mode is using MSI at 65 or 131kHz with voltage regulator in low power mode to minimize the regulator's operating current. The clock frequency and the number of enabled peripherals are both limited.
- **LOWPOWER_SLEEP**: This low-power mode is using MSI at 65 or 131kHz with voltage regulator in low power mode to minimize the regulator's operating current and by executing the WFI (wait for interrupt) or WFE (wait for event) instructions. The clock frequency and the number of enabled peripherals are both limited.
- **STOP**: This low-power mode using LSE/LSI at 32kHz/37kHz achieves very low power consumption, the voltage regulator being in low power mode. The number of enabled peripherals is very limited. RAM is preserved.
- **STANDBY**: This low-power mode using LSE/LSI at 32kHz/37kHz achieves lowest power consumption, the voltage regulator is Off. The number of enabled peripherals is even more limited than in STOP mode. RAM is not preserved. In addition to these 6 power modes, 2 transition modes have been added:
- **WU_FROM_STOP**: Wake-Up from Stop mode
- **WU_FROM_STANDBY**: Wake-Up from Standby mode

When devices are placed in low power modes such STOP or STANDBY, the device needs to be woken up by a specific oscillator such as MSI, which is specified in Clock Configuration combo box.

A special step called transition step should be inserted after these low power modes. There are two transition steps available: WU_FROM_STOP and WU_FROM_STANDBY.

Those transitions steps may have a significant impact on the global power consumption.

8.2 Power Consumption Ranges

The STM32L1 gives the possibility to select different Vcore ranges according to power and MCU performance needed. Vcore is only available for STM32 devices and is the power supply for digital peripherals, SRAM and Flash memory. Three Vcore voltages can be selected by software through different voltage ranges.

The power consumption ranges are defined as followed:

- **Range1**: Vdd [2.0 - 3.6V], Vcore = 1.8V, fCPUmax: 1WS=>32MHz, 0WS=>16MHz High CPU performance, Low Power performance, Program and erase operations on Flash memory possible
- **Range2**: Vdd [1.65 - 3.6V], Vcore = 1.5V, fCPUmax: 1WS=>16MHz, 0WS=>8MHz Medium CPU performance, Medium Power performance, Medium read access time, program and erase operations on Flash memory still possible
- **Range3**: Vdd [1.65 - 3.6V], Vcore = 1.2V, fCPUmax: 1WS=>4MHz, 0WS=>2MHz Low CPU performance, High Power performance Slow read access time, program and erase operations on Flash memory not possible