

Getting Started With EEMBC ULPBench™ on MSP-EXP432P401R

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MSP Applications

ABSTRACT

This is a getting started guide for obtaining the ULPMark™-CP score using the Embedded Microprocessor Benchmark Consortium (EEMBC) ULPBench™ and EnergyMonitor with the MSP432P401R microcontroller (MCU). This document uses the [MSP-EXP432P401R LaunchPad™](#) development kit as the target evaluation module (EVM) for performing the benchmark. [ULPBench](#) is an EEMBC benchmark that provides an industry-standard method to measure the ultra-low-power capabilities of MCUs.

The ULPBench firmware can be downloaded from the [EEMBC website](#).

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1 The MSP-EXP432P401R LaunchPad Development Kit

The ULPBench-ready MSP-EXP432P401R LaunchPad kit features the MSP432P401R microcontroller and onboard XDS110-ET emulator for programming and debugging. The MSP432P401R, TI's first 32-bit Low-Power + Performance MCU, features:

- 256KB of flash, 14-bit 1-MSPS ADC, timers, IP protection, AES256 module, comparators, serial communication (SPI, UART, I²C), and more
- High performance with up to 48-MHz CPU and floating point unit
- Low-power active and LPM3 modes
 - Active: <100 µA/MHz
 - RAM retention with RTC: <1 µA

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IAR Embedded Workbench is a registered trademark of IAR Systems AB.

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2 Download ULPBench and Setting Up

ULPBench firmware can be downloaded from the [EEMBC website](#). Create a new folder where the files can be extracted on your local computer. The MSP432 ULPBench project can be located at:

```
<EXTRACT ROOT FOLDER>\ulp_1.1.11\Platforms\TI-MSP432\ULP_StateMachine.eww
```

3 Modifications Required to Use EnergyMonitor

No physical hardware modification is required to use this EVM with EEMBC EnergyMonitor v1.0. For ULPBench measurement, remove all jumpers from the LaunchPad and configure the JTAG switch as described in [Section 4.1](#), to program the device with the ULPBench firmware. Then, the JTAG and USB cables must be disconnected to perform ULPBench measurements, as described in [Section 5](#).

4 Programming ULPBench Firmware

The MSP432P401R device must first be programmed with the ULPBench firmware. This LaunchPad has an onboard emulator that is used to program the device. The LaunchPad, by default out-of-the-box, is configured ready for programming.

For all ULPBench procedures, all jumpers can be unpopulated except for the LED1 jumper, which can be used during programming, debug, and verification but should be unpopulated before measurement.

Connect the Micro-USB from the EEMBC EnergyMonitor board to the PC. If this is the first time connecting this board, see [Appendix A](#) on installing the USB drivers.

4.1 Hardware Configuration

MSP-EXP432P401R ULPBench Connections

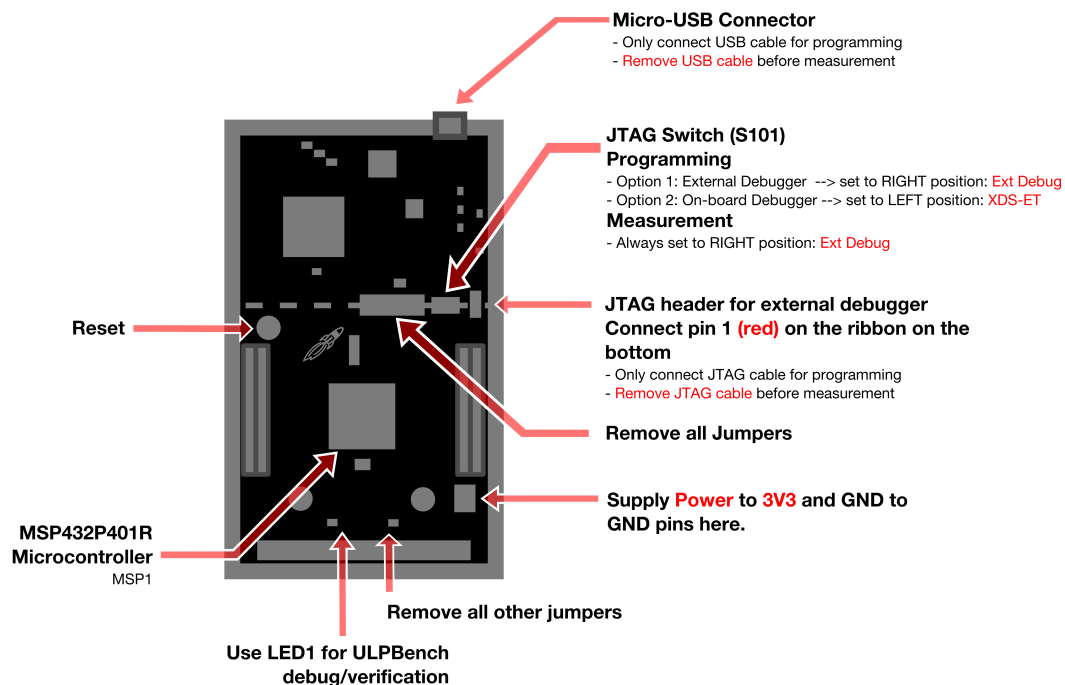


Figure 1. Default Configuration

Option 1: Using an external debugger

1. Ensure all jumpers are removed except for LED1 used for ULPBench verification.
2. Set JTAG switch to the RIGHT position.
3. Supply power and ground to the 3V3 and GND pins, respectively.
4. Connect the JTAG header for the external debugger, orienting the 10-pin cable to the right of the board, pin 1 (usually the red line on the ribbon cable) should be at the bottom.

MSP-EXP432P401R ULPBench Programming with External Debugger

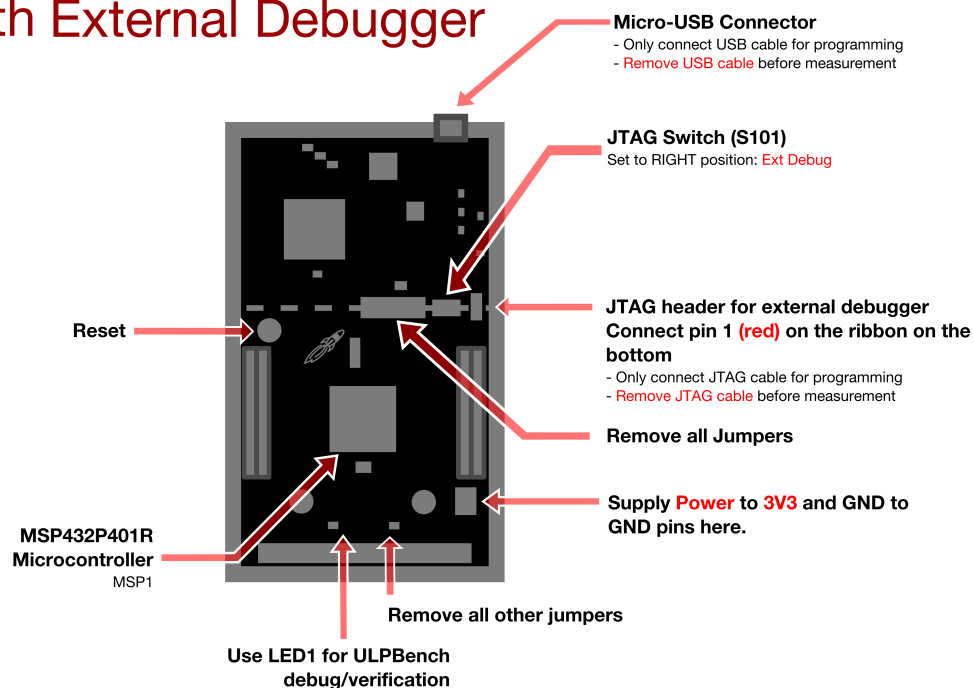


Figure 2. External Programming Connection

Option 2: Using the onboard debugger

1. Ensure all jumpers are removed except for LED1 used for ULPBench verification.
2. Set the JTAG switch to the LEFT position.
3. Supply power and ground to the 3V3 and GND pins, respectively.
4. Ensure the JTAG header for the external bugger is not connected to any cable.

MSP-EXP432P401R ULPBench Programming with On-board Debugger

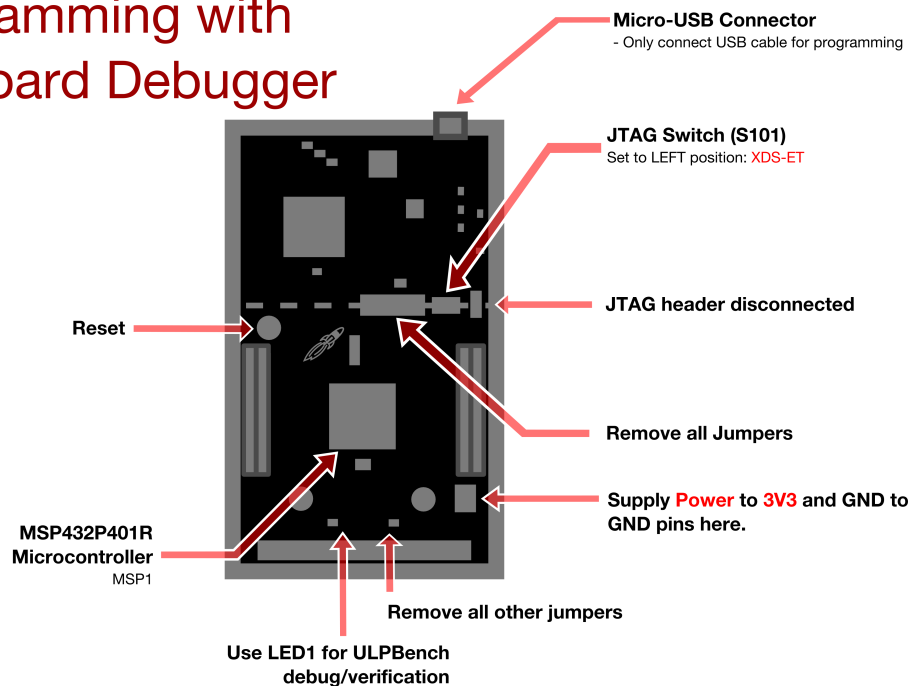


Figure 3. Onboard Programming Connection

4.2 Software Requirements

To install the ULPBench firmware, IAR Embedded Workbench® for ARM v7.30 or newer is required. Download and install the integrated development environment (IDE) from www.iar.com.

4.2.1 IAR Embedded Workbench

1. Open the IAR ULP_StateMachine.eww workspace project.
2. Select the debugger. Click Project > Options > Debugger.
Note that the onboard debugger can be selected as CMSIS-DAP.

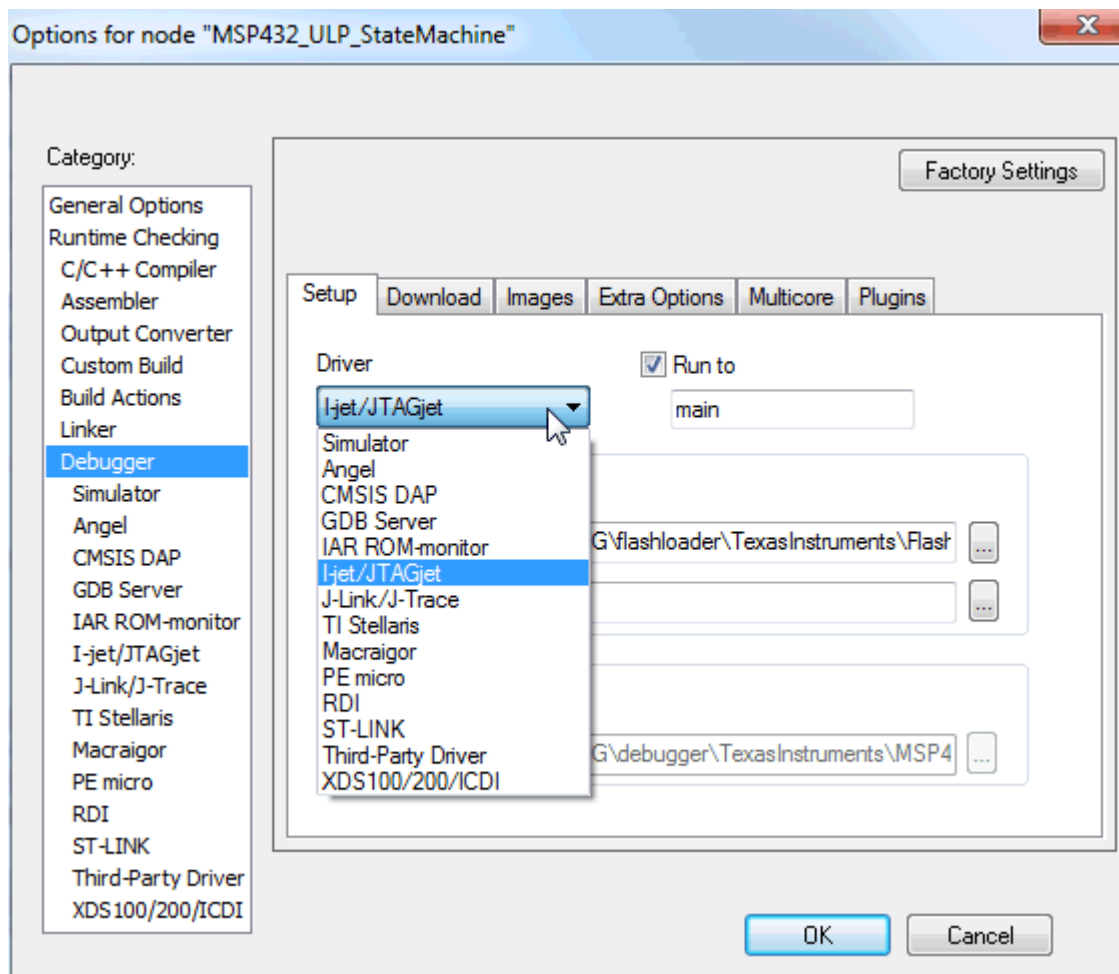




Figure 4. Selecting Debugger

3. Click the Download and Debug button , which downloads the ULPBench firmware to the device.
4. Terminate the debug session by clicking Stop Debugging .

5 Execute ULPBench Test

The EEMBC EnergyMonitor is used to source power to the target device and measure the energy consumed. The LaunchPad must be configured through several jumper configurations such that the EnergyMonitor does not back-power the emulator circuit, which would skew the measurements.

5.1 Hardware Configurations

Remove all jumpers, disconnect the USB and JTAG cable, and set the JTAG switch to the RIGHT position. Perform this step only after the device has been programmed with the ULPBench firmware as described in [Section 3](#).

MSP-EXP432P401R ULPBench Measurement

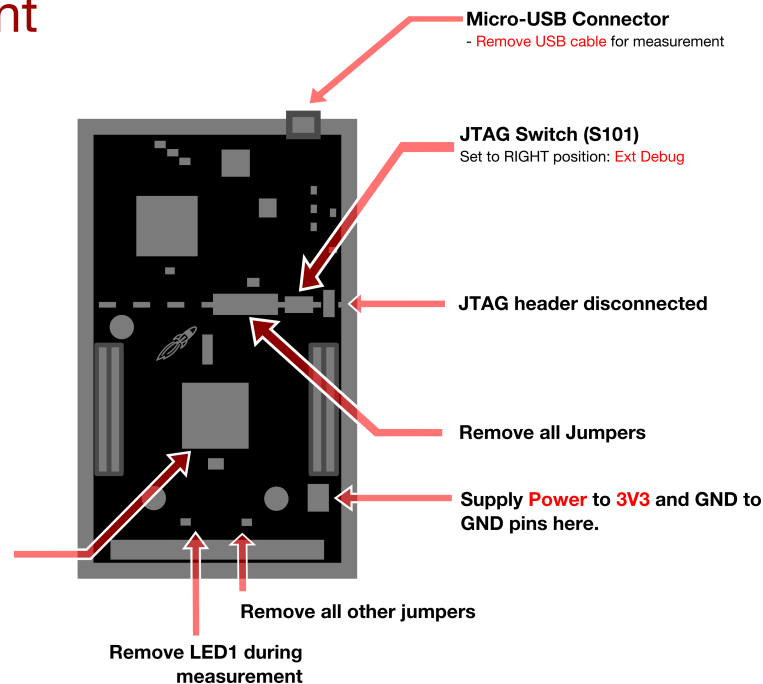


Figure 5. MSP-EXP432P401R Connections for ULPBench Measurement

5.2 Software Tools

To measure the energy and obtain the ULPMark-CP score, open EnergyMonitor.exe software under the bin folder.

In [Figure 6](#), showing the *Configuration Options* section, if you see a red light (and have completed the steps in [Appendix A](#)), close the EnergyMonitor graphical user interface (GUI) and restart it.

Push the *Run ULPBench* button. When the *Accumulated Energy* window displays a staircase line, the ULPBench is started. You will also be able to see the energy consumption of the device in the *History* window and the *Intermediate Results* window.

The energy measurements would then run several times before reporting a score.

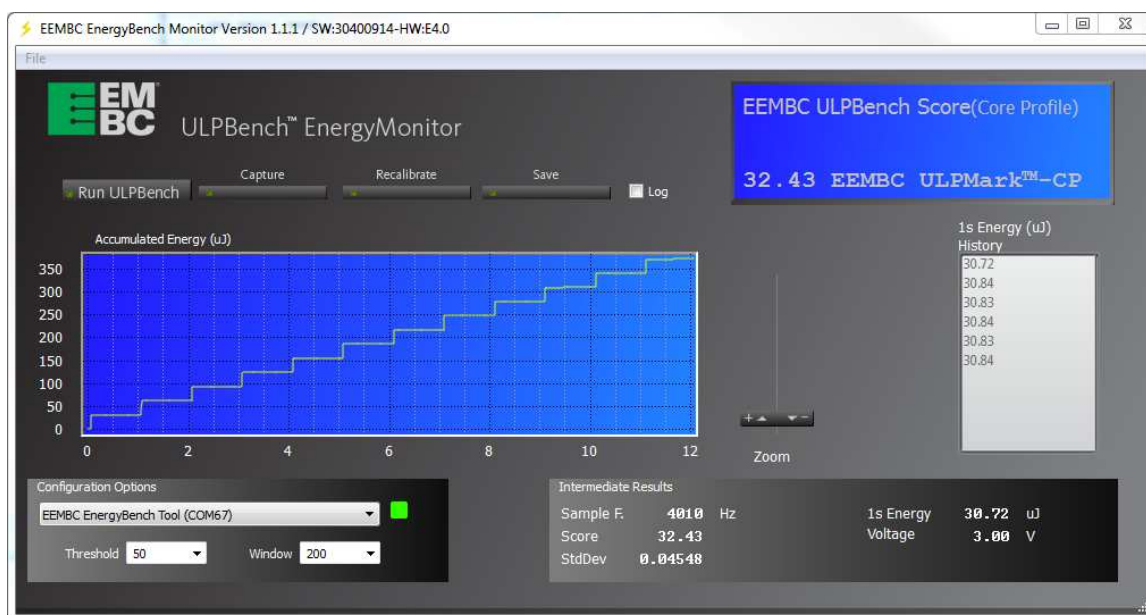


Figure 6. EEMBC EnergyBench Monitor Software

Once the test is completed, the final score will appear in the *Benchmark Status* window.

6 References

- EEMBC ULPMark-CP <http://www.eembc.org/ulpbench/>
- MSP-EXP432P401R LaunchPad™ Development Kit User's Guide ([SLAU535](#))

Installing the USB Drivers

If this is the first time connecting the EnergyMonitor to the computer, the EnergyMonitor is an unrecognized USB device to that computer.

1. Click on *Next* and choose the option to manually locate USB drivers. The USB drivers are included in the ULPBench zip files: EEMBCmonitor_drivers.cat and EEMBCmonitor_drivers.inf.
2. If the message to locate drivers is not displayed, go to the Device Manager and locate the devices that are labeled EEMBC Application UART1 and EEMBC Energy Tool V1. Click on each to install the driver.
3. After starting the driver installation, Windows security displays a message that it cannot verify the publisher of this driver software. Click on *Install this driver software anyway*.
4. After Windows has successfully updated the driver software, close the update window.

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