3G/4G Communicational Booster Pack

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Abstract: *In this project, mainly we are focusing on developing a new booster pack that works with a 3G/4G module. To develop a booster pack we are using an industrial grade open source hardware called MangOH Red designed to address common IoT pain points and deliver 90% of our prototype out-of-the-box so we can focus our time and resources building the next killer IoT application and bringing our products to market sooner. We are using a CF3 module of WP series (wp7502), which is a 4G module, manufactured by a sierra wireless company. This module is built using a Legato platform and uses its own APIs to operate and execute. Basically, nowadays IoT plays important role in the society hence this helps for quick prototyping and provides an easy way for requirements of the Internet of Things. This concept mainly involves the implementation of serial communication between client and server using MangOH and MSP430 [11] [12].*

Keywords: *APIs, MSP430, GSM,CF3, LP, IoT.*

I. INTRODUCTION

The microcontroller is a computer system on a chip that does a job. It contains an integrated processor, memory, and programmable input output peripherals which are used to interact with chips. MSP430 is one of the most important aspects of the hardware. The MSP430 is the simplest microcontroller in TI. It is a product of Texas Instruments. The MSP430 was introduced in the late 1990s, although its ancestry goes back to the 4-bit TSS400. In summary, it is a particularly straight forward 16-bit processor with a Von-Neumann architecture, designed for low-power applications. The CPU is often described as a reduced instruction set computer (RISC) but this is if unimportant and is considered in the section "Reflections on the CPU and Instruction Set". Both the address and data buses are 16 bits wide. The registers in the CPU are also all 16 bits wide and can be used interchangeably for either data or addresses. This makes the MSP430 simpler than an 8-bit processor with 16-bit addresses [1] [2].

The figure1 shows a block diagram of the MSP430. The main features are

➤ On the left are the CPU and its supporting hardware, including the clock generator. The emulation, JTAG interface, and Spy-Bi-Wire are used to communicate with a desktop computer when downloading a program and for debugging.

➤ The main blocks are linked by the memory address bus (MAB) and memory data bus (MDB).

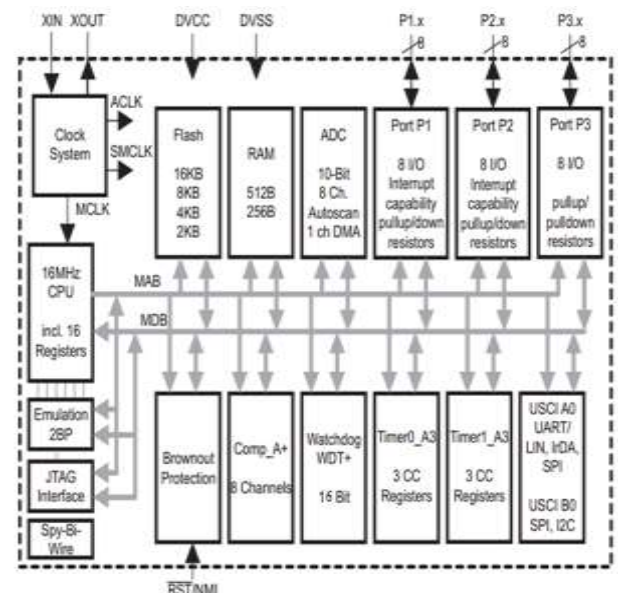➤ These devices have flash memory and 128 bytes of RAM.

Fig 1: Block Diagram of MSP430 Architecture

➢ Six blocks are shown for peripheral functions. All MSP430s include input/output ports, Timer A, and a watchdog timer. The universal serial interface (USI) and sigma delta analog-to-digital converter are particular features of this device.

➢ The brownout protection comes into action if the supply voltage drops to a dangerous level [2].

A. Launchpads and Booster Pack

Launch Pad is nothing but a development kit developed by Texas Instruments. MSP430 Launchpads are

Ultra-low-power mixed signal microcontrollers. The MSP430 LaunchPad Development Kit now has USB! The MSP-EXP430F5529LP (or the "F5529 LaunchPad") is an inexpensive and simple development kit for the MSP430F5529 USB microcontroller. It offers an easy way to start developing on the MSP430, with on-board emulation for programming and debugging as well as buttons and LEDs for a simple user interface. Rapid prototyping is simplified by the 40-pin Booster Pack plug-in module headers, which support a wide range of available Booster Packs. We can quickly add features like wireless connectivity, graphical displays, environmental sensing, and much more. This includes the MSP430 USB Descriptor Tool, which quickly customizes any combination of USB interfaces and automatically generates USB descriptors for those interfaces [12] [13].
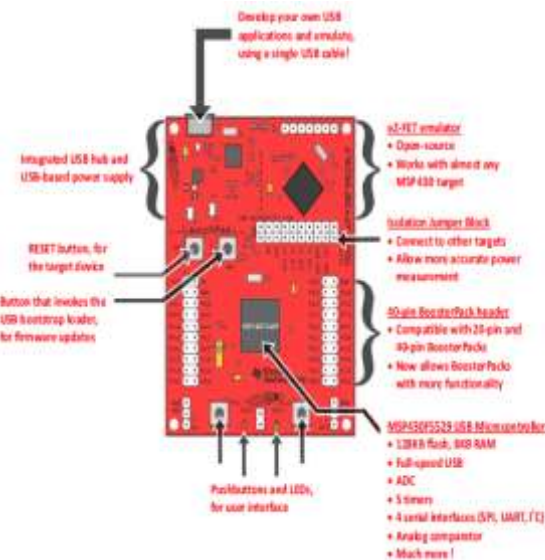

Fig 2: MSP430F5529 LaunchPad

Application-specific Booster Pack is the plug-in modules allow you to explore a broad range of applications, including capacitive touch, wireless sensing, LED lighting control, and more [12] [14].

➢ More than 80 Booster Pack modules are available from both Texas Instruments and third parties.

➢ Available in 20- and 40-pin variants as per requirements.

➢ Stack multiple Booster Pack modules onto a single LaunchPad kit to further enhance the functionality of the design.

Fig 3: General View of Booster Pack

II. MangOH RED

MangOH is industrial-grade open source hardware designed to address common IoT pain points and deliver 90% of the prototype out-of-the-box so it helps to focus our time and resources building the next killer IoT application and bringing the products to market sooner.

The workflow of MangOH is based on following factors,

➢ **Idea:** If we got an idea for an IoT product, MangOH provides all the resources that we need to turn our idea into reality.

➢ **Prototype:** With 90% of the hardware and software development done already, MangOH allows you to focus on the development effort on getting to market faster by rapidly iterating the product concept.

➢ **Product:** With the hard work of industrial-grade IoT design, MangOH provides the fastest and most cost-effective workflow from prototype to product.

Fig 4: MangOH RED

The above image represents the MangOH Red board that consist the hardware features as follows [15]:

1. **CF3 socket**: MangOH Red connects to any 2G, 3G or 4G LTE mobile networks in the world with the CF3 based wireless modules from Sierra Wireless.

2. **SIM Card Slot**: This slot allows to utilize the Smart SIM card and its Connectivity Service that delivers multi-operator coverage, superior data service quality, and resilience to outages.

3. **IoT Expansion Card Connector**: The IoT Expansion card connector helps to add any combination of wired, wireless and sensor technologies to the board.

4. **Wi-Fi and Bluetooth:** With Wi-Fi and Bluetooth connectivity built-in, it helps to develop wireless products without any expertise in connecting to mobile or PAN networks.

5. **Built-in IMU and Sensors:** MangOH Red is equipped with an inertial measurement unit (accelerometer and gyroscope) as well as built-in sensors for temperature, light and air pressure.

6. **Cortex®-M4 with RTOS:** The Cortex-M4 processor runs real-time operating system—process real-time applications data as it comes in with minimum delays.

7. **Audio Jack:** The built-in audio jack allows MangOH Red to make two-way voice calls.

8. **USB Connectivity to a Console:** Start writing your software immediately with the open-source Legato Linux platform, fully integrated on MangOH Red. Simply connect the board to a console via USB connector.

9. **Micro SD Slot:** MangOH Red offers a micro SD slot for easy off-line updates and storage.

10. **Battery Connector**: The board can operate on single cell Lithium polymer, DC power supply or USB. There is a battery charger for charging the battery as well.

11. **Raspberry Pi Shield Connector:** It has 26 pins Raspberry Pi-compatible connector, where we can connect multiple HATs (Hardware Attached to Top) to the design.MangOH also helps to build low-power IoT applications that can run for 10 years on a battery with the newest and smallest MangOH platform and send IoT sensor data to the cloud.

III. SENDING SENSOR DATA TO AIRVANTAGE CLOUD USING MANGOH RED

An airvantage cloud is a Machine (M2M) cloud used to deploy and manage large M2M applications. It provides secure two way communication between connected devices and the enterprise. Airvantage is much more than an IoT application enablement platform. It is purpose built to provide all of the platform services we need to build unique, global wireless IoT Services.
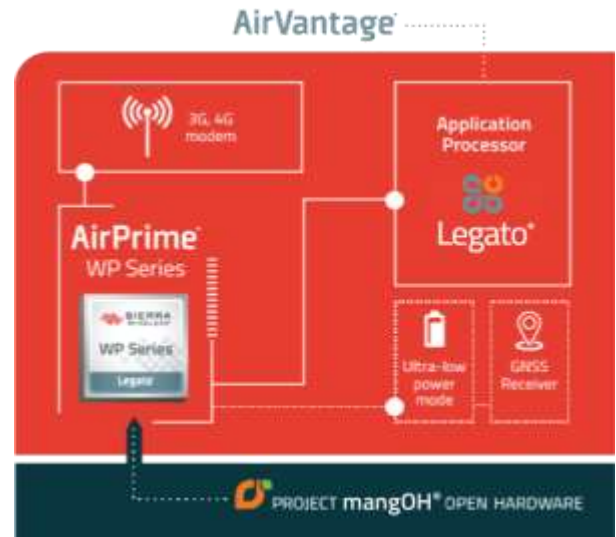

Fig 5: Block Diagram of WP Series Features and Benefits

The above diagram explains the following features:
- ARM core application processor with dedicated flash and RAM running legato enhances security, reduces system complexity and lowers overall BOM (Bill of Materials).
- GNSS receiver enables tracking and location-based services.
- Ultra low power mode reduces power consumption.
- Open hardware reference enables rapid prototyping.

It is a secure device to cloud architecture with Airvantage pre-integrated into the legato platform. Airvantage connectivity management interface is the single place to order, track and manage all of the sierra wireless SIM cards and connectivity subscription. It provides all of the building blocks including wireless connectivity management, wireless device management, application enablement services for all to connect the machine to mobile.

The procedure of sending sensor data to Airvantage includes
- Building an app.
- Build and install the legato platform and MangOH Red platform on a target.
- Connect to the IoT cloud (This step includes a register to the Airvantage cloud).
- Connect to Airvantage (this step includes to read the given data and send it to a cloud indication of communication process).

IV. INTERFACING MSP430 WITH MANGOH RED

Here in this project, we are dealing with the case in which both MSP430 and MangOH Red are totally different in their design and characteristics and also which uses different platforms and operating systems. Here MangOH Red is built using the legato platform and works in the Linux software whereas MSP430 works in Windows OS (Operating System).
Mainly in this project, we are concentrating on interfacing the MSP430 and MangOH Red that establishes serial communication which helps to develop our idea into a prototype and then to a product [6].
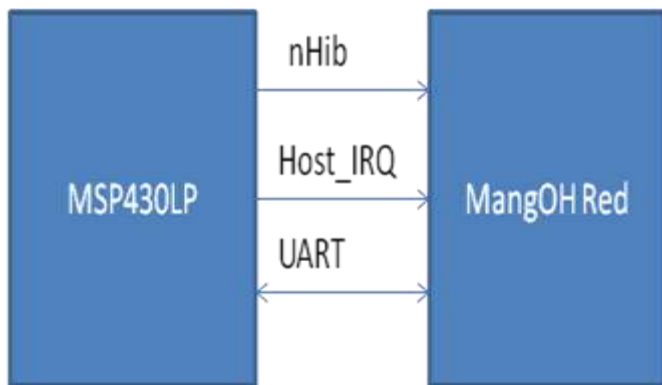
A. BLOCK DIAGRAM

Fig 6: Block Diagram of Interfacing Process

The above diagram represents the block diagram of interfacing the MSP430 with MangOH Red. Here we are communicating the boards using UART communication which is asynchronous serial communication in nature. Communication starts when the data is being transmitted from the transmitter pin of MSP430. As per the data being transmitted the interrupt IRQ (interrupt request) is enabled that to inform the MangOH Red that the event had been occurred and respond to the event occurred. In return, the MangOH Red reads and writes the data and displays the output on the output window based on the requirement. When the LaunchPad is in the power off mode the nHib mode helps the launch pad to stay in a low power mode [2] [3].

B. HARDWARE SETUP

To setup the hardware the following steps has to be followed
1. First set the two boards with the basic setup like jumper connection, dip switches etc.
2. Use 3 Micro USB Cables, two cables to connect CF3 USB connector and console USB connector of MangOH to USB port on Dev machine, another one cable is used to connect to the USB port of MSP430.
3. As per the pin configuration, connect a wire from MSP430 UART transmitter pin to a UART transmitter pin on IoT expansion card of MangOH Red.
4. Connect the ground to both development kit.

C. PROCEDURAL STEPS TO INTERFACE THE MSP430 WITH MangOH RED

Here we are trying to communicate using UART communication, in MangOH before communicating we have to install a Minicom software by using a command terminal window which helps to build the UART communication. It uses different IDE's and API's based on their requirements. For example
- Communicating with client and server.
- Authentication login
- Setting up Wi-Fi and so on.

Before starting with the procedure we need to open the serial monitor which is used to read and display the data through the USB port. Here in this, the serial monitor is nothing but the terminal window used in the Linux OS.

The procedural steps include as follows,
1. To connect using the UART ports connect a Serial to USB cable to your target and install a serial communications program like Minicom. Install Minicom on your dev machine:
   ### $ sudo apt-get install minicom
2. Connect using Minicom to the USB Port that your device is plugged into:
   ### $ minicom -D /dev/ttyS0

After the above steps, the Minicom app gets installed and allow us to the log in procedure. To log in as a root user use the command.
$ ssh root@192.168.2.2

Enter the password and open the serial monitor to read and display the data. After this, in CCS the codes are compiled and build with error free. Before running the target code use the command in terminal window to communicate with the baud rate 115200 by using
microcom –E/dev/tty HS0 –s 115200

After this step, run the code in CCS, the data being transmitted from the MSP430 is stored in the transmitter buffer of MangOH and it starts communicating and displays the output at the UART console continuously. This is how the communication takes place. Later this data is sent to a cloud using Airvantage cloud [12].

V. COMMUNICATION BETWEEN MSP430 AND AIRVANTAGE CLOUD

In this section, the readings of sensor connected to MSP430 will be sent to Airvantage cloud service using MangOH Red. The steps are as follows:

1. Set up the connection as shown in the figure below, the figure explains that the data that has to be sent is dumped into the MSP430 using CCS. The dumped data information is transmitted to MangOH through the transmitter.

Fig 7: Interconnection between MSP430 and MangOH Red

Through serial UART communication, MangOH receives the readings of the sensor data. This received reading is then sent to an Airvantage cloud by creating an app.

2. The procedure to read the sensor value is as follows
   - Open the terminal window, login to the board, in order to boot the board uses SSH command (refer chapter 6.1). Check the app status and check whether the app created is installed and running. If the app is installed, to read and display the sensor readings on the console window use the following command.

 # cat /dev/ttyHS0

Finally, the sensor readings appear on the console window and this is sent to a cloud.

VI.CONCLUSION

Using an open hardware source we can try our idea to convert into a prototype and then to a product. This includes various types of operating system, different API, and different IDEs helps to communicate through UART serial communication and sends a data to the cloud.

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