LOW POWER EMBEDDED DESIGN
PROJECT UPDATE #5

Team Name: WearTech

Team Mates:

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Executive Summary:

Part Selection

Battery	**GMB401215-45mAh**
PMU IC	**LT1965**
Processor	**EFR32BG121 – f1024**
Inductive Charging IC	**BQ5103B**
Battery Charger IC	**BQ24040**
Sensor	**BMA280**

As discussed, our project requires 2 Blue Gecko dev kits to act as devices in the mesh network.

On Schedule: Yes

Accomplishments:

- We have completed 70% of the schematics.
- Read about Bluetooth Mesh.
- Researched on features, components to be added to schematic to enable programming of your micro controller or SoC
- Work on the process of how to compile and download code to the board - the target board
- Investigated which signals will have test point
- Work on the Algorithm for the Machine Learning

Next week:

- Keep the work going in Schematics design for the circuit
- Start with the Layouts
- Energy spike calculation
- We need to work on Bluetooth Mesh
- Work on the Algorithm for the Machine Learning

1. **What features, components, will need to be added to your schematic to enable programming of your micro controller or SoC?**

According to the https://www.silabs.com/documents/login/data-sheets/efr32bg12-datasheet.pdf Datasheet :

3.11.1 Processor Core

The ARM Cortex-M processor includes a 32-bit RISC processor integrating the following features and tasks in the system:

- ARM Cortex-M4 RISC processor achieving 1.25 Dhrystone MIPS/MHz
- Memory Protection Unit (MPU) supporting up to 8 memory segments
- Up to 1024 kB flash program memory
- Up to 256 kB RAM data memory
- Configuration and event handling of all modules
- 2-pin Serial-Wire debug interface

2-Pin Serial-Wire debug interface is used by the EFR3BG12

But according to the https://www.silabs.com/documents/public/application-notes/an958-mcu-stk-wstk-guide.pdf

Table 2.1. Interface Capabilities and Features

Feature	20-pin Standard ARM Cortex Debug+ETM Connector	20-pin Simplicity Connector	Simplicity Debug Adapter Board Interfaces (Standard or Tag-Connect 10-pin cable)			Tag-Connect 6-pin Interface
			Mini Simplicity Connector	Cortex Debug Connector	ISA3 Packet Trace Port Connector[1]	
SWD (serial wire debug)	X		X	X	X	X
JTAG	X			X	X	
C2	X			X		
ETM (embedded trace module)	X					
AEM (advanced energy monitoring)		X	X			
PTI (packet trace interface)		X	X		X	
VCOM (virtual COM port)		X	X			
Virtual UART	X		X	X	X	X

Note:

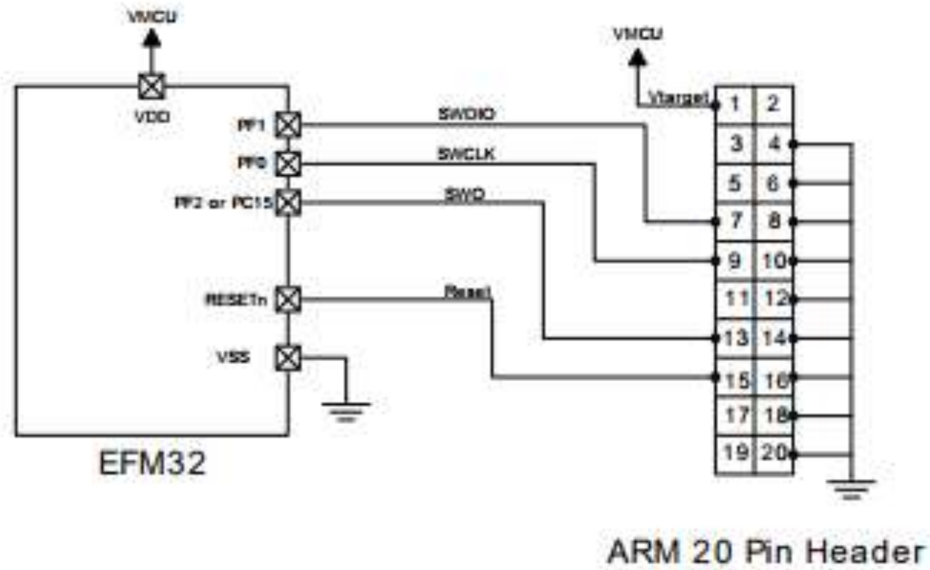
1. ISA3 Packet Trace Port Connector interface is not yet supported by the WSTK.

We can select any of the above interfaces. We have chosen 20-pin Standard ARM Cortex Debug+ETM connector.

References:

- https://www.silabs.com/documents/public/application-notes/AN0043.pdf
- http://www.digikey.pt/Web%20Export/Supplier%20Content/EnergyMicro_914/PDF/energy-micro-an-an0002.pdf
- https://www.silabs.com/documents/public/application-notes/an958-mcu-stk-wstk-guide.pdf

Figure 2.1. Connecting the EFM32 to an ARM 20 pin debug header



The Serial Wire (SWD) interface is supported by all EFM32 and EZR32 Wireless MCU Series 0 devices. The SWD debug interface consists of the SWCLK (clock input) and SWDIO (data in/out) lines, in addition to the optional SWO (serial wire output). The SWO line is used for instrumentation trace and program counter sampling, and is not needed for programming and normal debugging. However, it can be valuable in advanced debugging scenarios, and it is therefore recommended to include this line in a design. The connection to an ARM 20-pin debug connector is shown in the following figure. Pins with no connection should be left unconnected.

Note: The Vtarget connection is not for supplying power. The debugger uses Vtarget as a reference voltage for the debugger's level translators

2. **Describe the process of how you will compile and download code to your board, the target board**

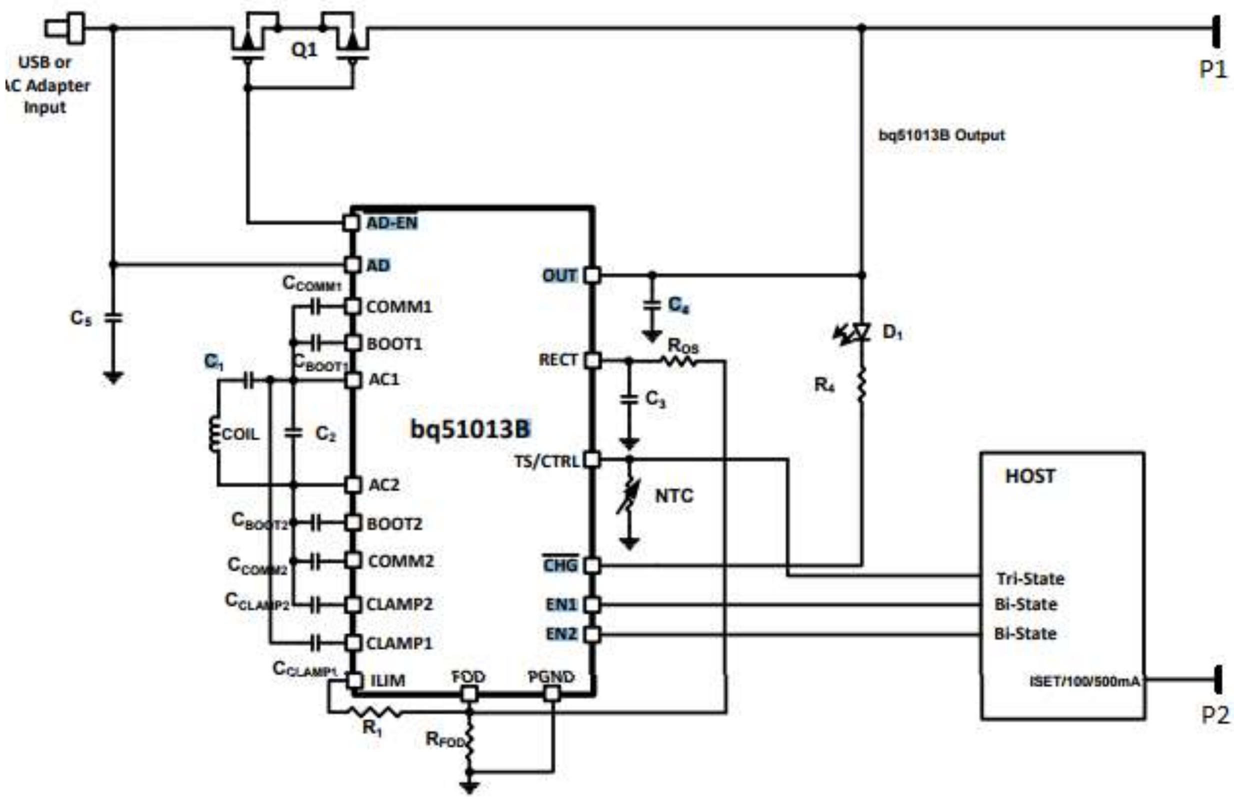
   We will be using Simplicity Studio 4-version to develop the firmware code. The code will be compiled in the Simplicity Studio 4. The generated executable is dumped to the board with the Debug Interface.

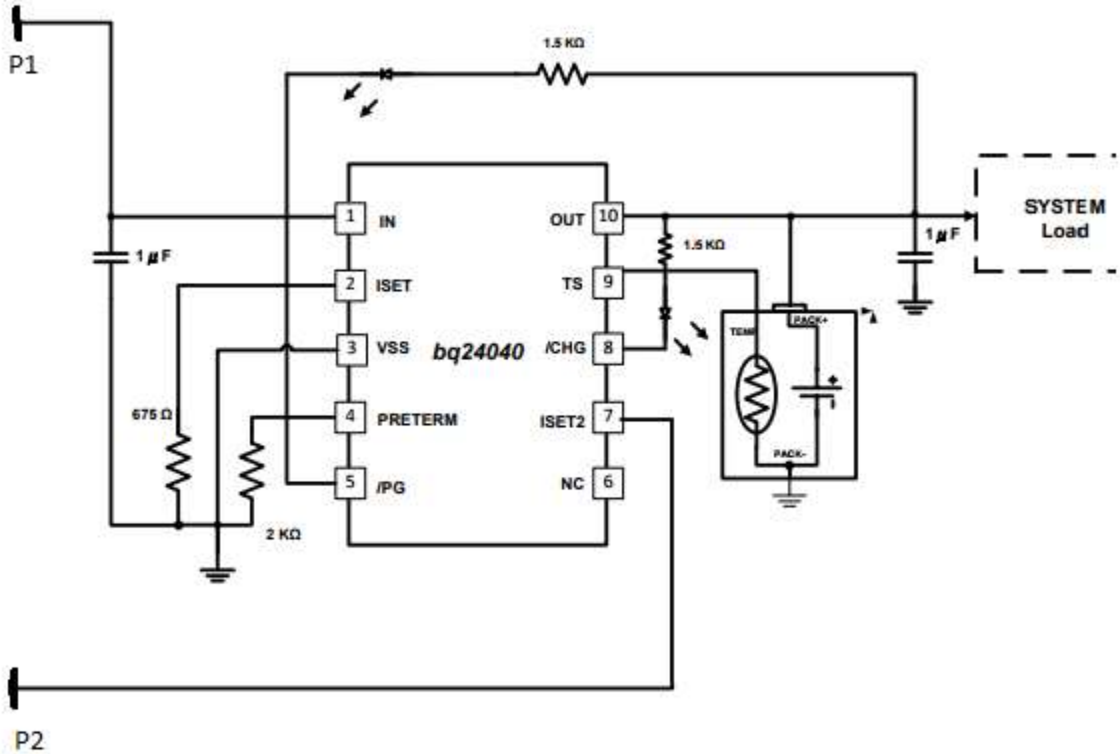
   1. Connect the appropriate pins for the debug Interface
   2. Open Simplicity Studio (Assuming that the code is already done)
   3. Connect the BlueGecko to the PC, Detect the Part-Number in the Simplicity studio.
   4. Compile the code and flash the executable generated to the board.

3. **Which signals will have test points?**
   SPI GPIO pins from BMA 280, i2c from all the PMUs, PMU – battery-MCU input-Accelerometer Input- Inductive IC output (To check the voltage)
   In reference to the Question4 diagram, we will have signals at P1, at AC1 & AC2, at the USB adapter, at AD-EN, at the Battery (pin 10 from bq24040), at the load.
   At the SPI pins from BMA and the corresponding pins in MCU.

4. **Provide alternative charging method of the energy source other than the energy harvester**

   Inductive Charging:
   Since we could not simulate the Inductive charging and the battery charger, we have shown our approach for the application/implementation of the Inductive charging:
   Reference: http://www.ti.com/lit/ds/symlink/bq51013b.pdf





Note: P1& P2 from both the Figures are to be connected.

The $\overline{\text{AD-EN}}$ pin of BQ51013B controls the Q1 switch, the alternative energy source is a USB/AC adapter connected to the Q1 switch. Depending on the $\overline{\text{AD-EN}}$, the energy source can be chosen from the USB/AC Adapter or from the Indutcive Charging IC.

5. **Backup solution to charge the energy storage element in the event that the Energy Harvester circuity is not functional**

Our Energy Harvester is an Inductive charger, if not functional we can switch back to the USB/AC adapter charger.

6. **What is the maximum charging current allowed by the PMU circuitry?**

For BQ51013B:

			MIN	MAX	UNIT
V_{IN}	Input voltage	RECT	4	10	V
I_{IN}	Input current	RECT		500	mA
I_{OUT}	Output current	OUT		500	mA
$I_{AD\text{-}EN}$	Sink current	$\overline{\text{AD-EN}}$		1	mA
I_{COMM}	COMM sink current	COMM		500	mA
T_J	Junction temperature		0	125	°C

For BQ24040:

$I_{IN-USB-CL}$	USB input I-Limit 100mA	ISET2 = Float; R_{ISET} = 825Ω	85	92	100	mA
	USB input I-Limit 500mA, bq24040, bq24045	ISET2 = High; R_{ISET} = 825Ω	430	462	500	mA
	USB input I-Limit 380mA, bq24041	ISET2 = High; R_{ISET} = 825Ω	350	386	420	mA
ISET SHORT CIRCUIT TEST						
R_{ISET_SHORT}	Highest Resistor value considered a fault (short). Monitored for Iout>90mA	R_{ISET}: 540Ω → 250Ω, Iout latches off. Cycle power to Reset.	280		500	Ω
I_{OUT_CL}	Maximum OUT current limit Regulation (Clamp)	V_{IN} = 5V, V_{OUT} = 3.6V, V_{ISET2} = Low, R_{ISET}: 540Ω → 250Ω, I_{OUT} latches off after $t_{DGL-SHORT}$	1.05		1.4	A

7. What is the maximum charging current allowed by the energy storage unit?

Charge current 充电电流	标准充电 Standard charge： 0.2C 快速充电 Rapid charge： 0.5C

The battery is a LiPo 45mAH battery. Nominal of 40mAH capacity.

The Rapid charge of 0.5C => 0.5*40mA = 20mA

The standard charge current of 0.2C => 0.2*40mA = 8mA

8. What will the maximum current of the jump start power source be set to?

9. Where will with jump start power and ground signals connect to?

The solution being used satisfies the condition of required voltage hence we do not need a jump start power source.

10. Insuring that there is enough energy / current to program the flash of the MCU. How much current will the programming of the MCU flash require?

As per the data sheet:

Page erase current[4]	I_{ERASE}		—	—	1.6	mA
Write current[4]	I_{WRITE}		—	—	3.8	mA

11. How much current will the energy storage element and the PMU be able to provide?

PMU IC:

$I_{OUT(RANGE)}$	Programmed Output "fast charge" current range	$V_{OUT(REG)} > V_{OUT} > V_{LOWV}$; V_{IN} = 5V, ISET2=Lo, R_{ISET} = 540 to 10.8kΩ	10		1000	mA

$I_{OUT\_FAST\_CHG}$ = 540mA; $I_{OUT\_PRE\_CHG}$ = 108mA; I_{OUT_TERM} = 54mA

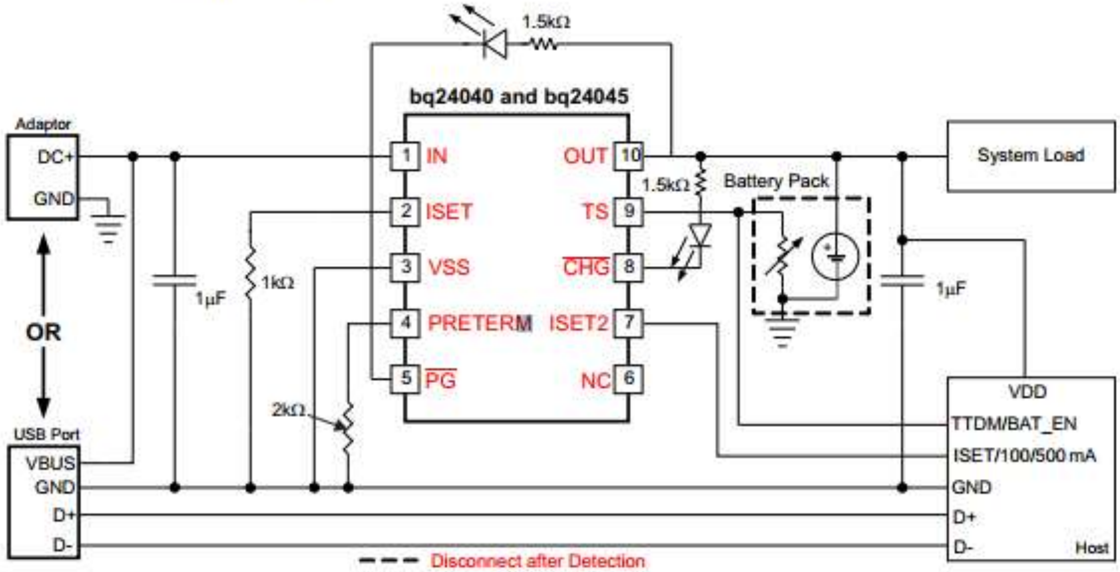


Figure 15. Typical Application Circuit: bq24040 and bq24045

For a typical USB charged PM, the bq24040 gives ≈500mA(MAX) of fast charge current, but generally in ideal conditions it provvides a 1000mA of charge current (MAX)

Battery:

Discharge Current 放电电流	Standard Discharge: 0.5C 标准放电电流：0.5C Max Discharge: 1C 最大放电电流： 1C

The battery is a LiPo 45mAH battery. Nominal of 40mAH capacity.
Thus a standard discharge current of 20mA and a max discharge of 40mA.

Since the MCU just needs a max of 3.8mA to flash the program, The powerpath control in the BQ51013B ensures that power supply to the load is not compromised in the absence of a battery and the battery takes over when the USB power supply isn't available.

12. **What are the connection points to enable external power to digital / MCU portion of the board**

As per our design, we do not have any external enable mechanism to power the MCU portion of the board.