LOW POWER EMBEDDED DESIGN

PMU/Capacitance Simulation Assignment

Team Name : WearTech

Team Mates:

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Part Kits Selection:

Battery: Li-ion Polymer Battery 401215-PCM
https://www.powerstream.com/lip/GMB401215-45mAh_With%20PCM_A0.pdf
PMU IC: LT1965 3.3V to 2.5V Regulator
http://www.linear.com/solutions/5342
Wireless Power IC: BQ51013B
Battery Charger: BQ24040
http://www.ti.com/lit/ds/symlink/bq51013b.pdf
Processor: Blue gecko BGM121 module
As discussed, our project requires 2 Blue Gecko dev kits to act as devices in the mesh network.
Sensor: BMA280

Resistance for the load (MCU at EM3):
The min current consumed is 0.133mA and it is constant consumption
With voltage is at 2.5v we have the resistance to be
V = I x R
R = V/I = 2.5/0.133m = 18.79kΩ ; since this is not a standard resistance=> considering 20kΩ

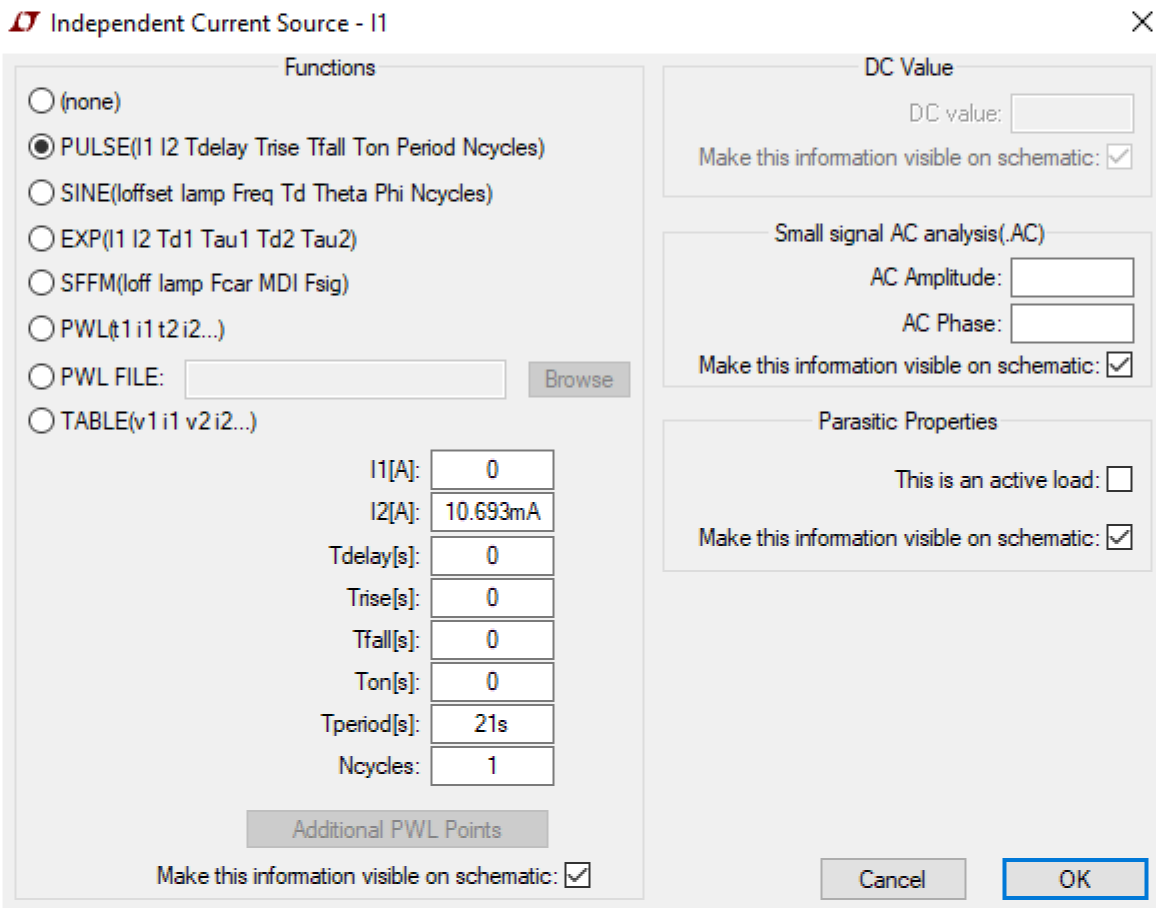
Decoupling capacitors:

Blue Gecko: According to hardware considerations, we have considered a decoupling capacitor (ceramic capacitor) of value 0.1 uF
Ref:https://www.silabs.com/documents/public/application-notes/an0002.1-efr32-efm32-series-1-hardware-design-considerations.pdf

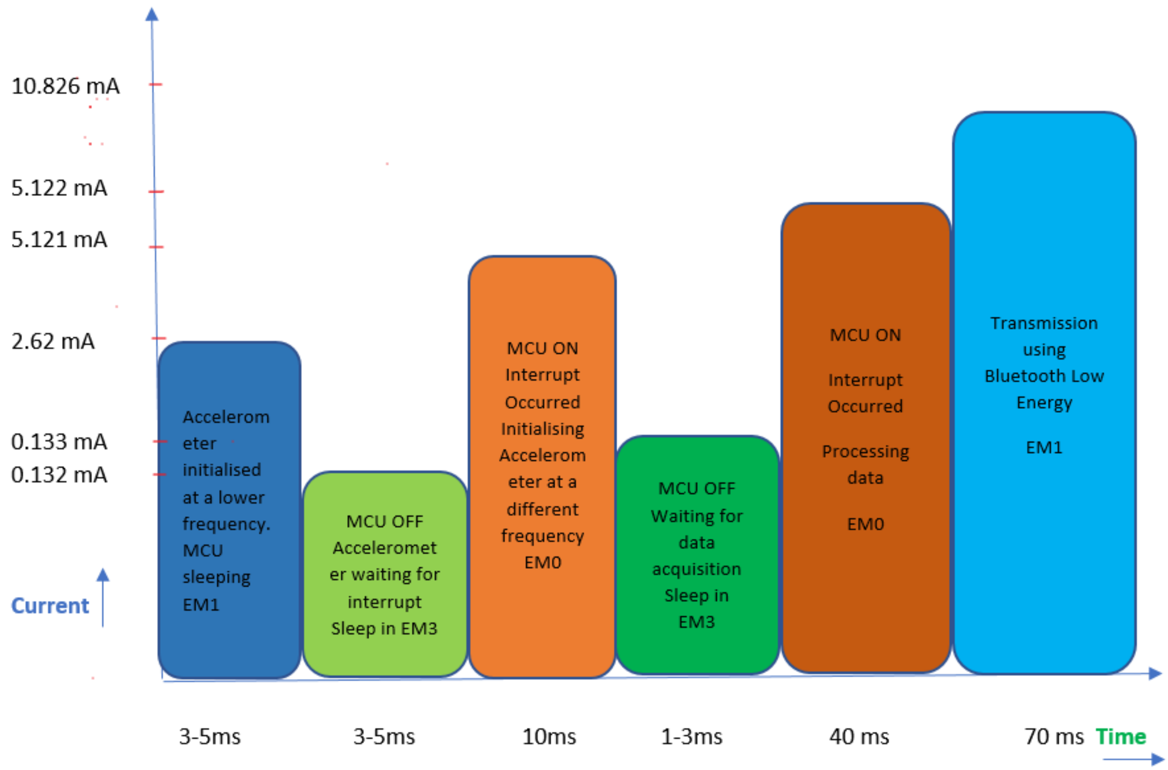
BMA280: We have considered a decoupling capacitor of 200 nF(0.2 uF).
Ref: http://www.mouser.com/ds/2/783/BST-BMA280-DS000-11_published-786496.pdf

Hence total capacitance = 0.3 uF

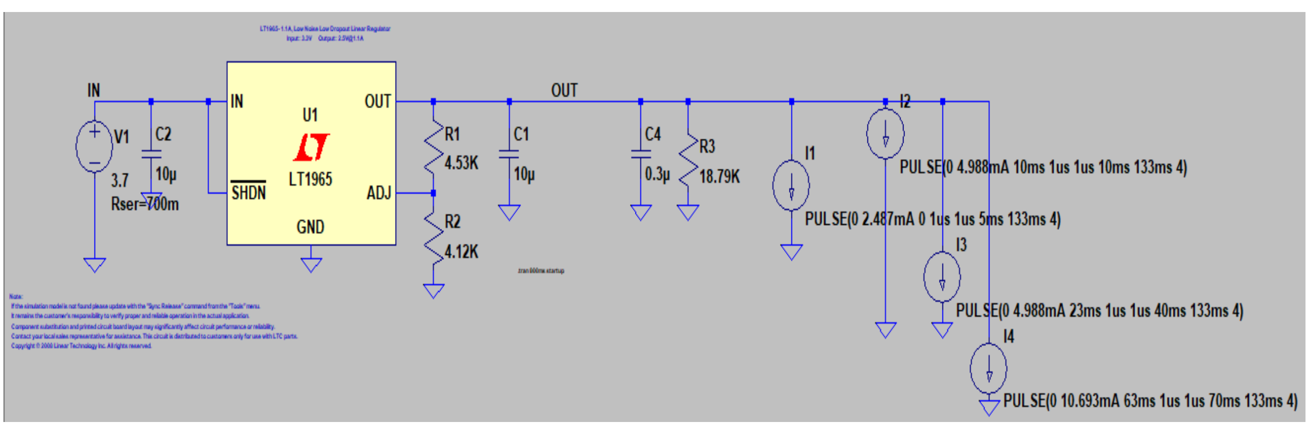
Simulation process example:



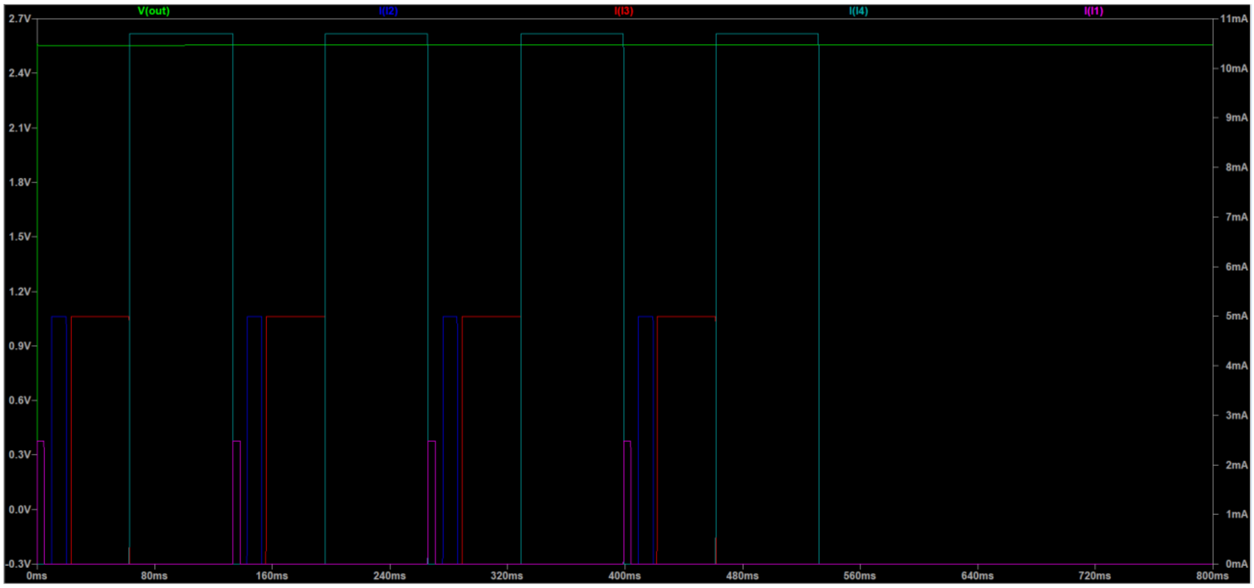
Use Case Model (Energy vs Current):



Design of dynamic load circuit with nominal voltage of 3.7 V:



Simulation of dynamic load with multiple current sinks:



Ripple of PMU IC from datasheet:

Ripple Rejection	$V_{IN} - V_{OUT} = 1.5V$ (AVG), $V_{RIPPLE} = 0.5V_{P-P}$, $f_{RIPPLE} = 120Hz$, $I_{LOAD} = 0.75A$

The Ripple from the PMU is 0.5Vp-p
At 120Hz.

Questions:

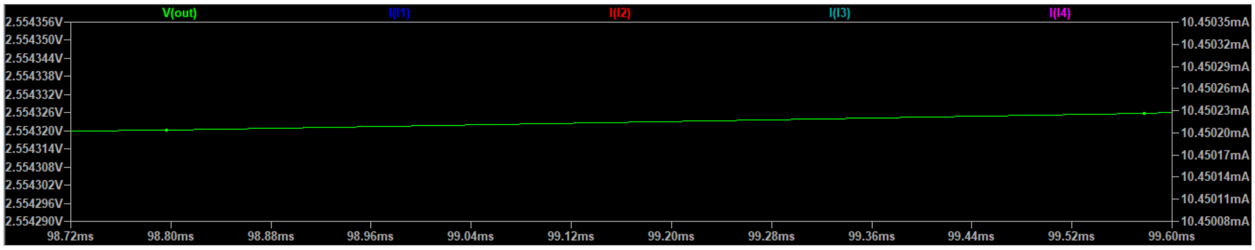
Vin= min = 3.3V
Vin = max = 4.2 V

1.What is the voltage ripple of your design before the step function load?

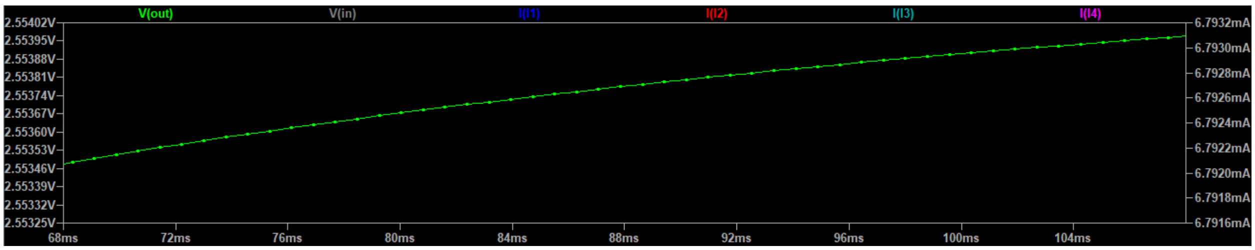
For Step Down Current load function:

From EM1-BLE to EM1 max current step down 8.206mA
a.At Vin = min

.6mV



b. At Vin = max



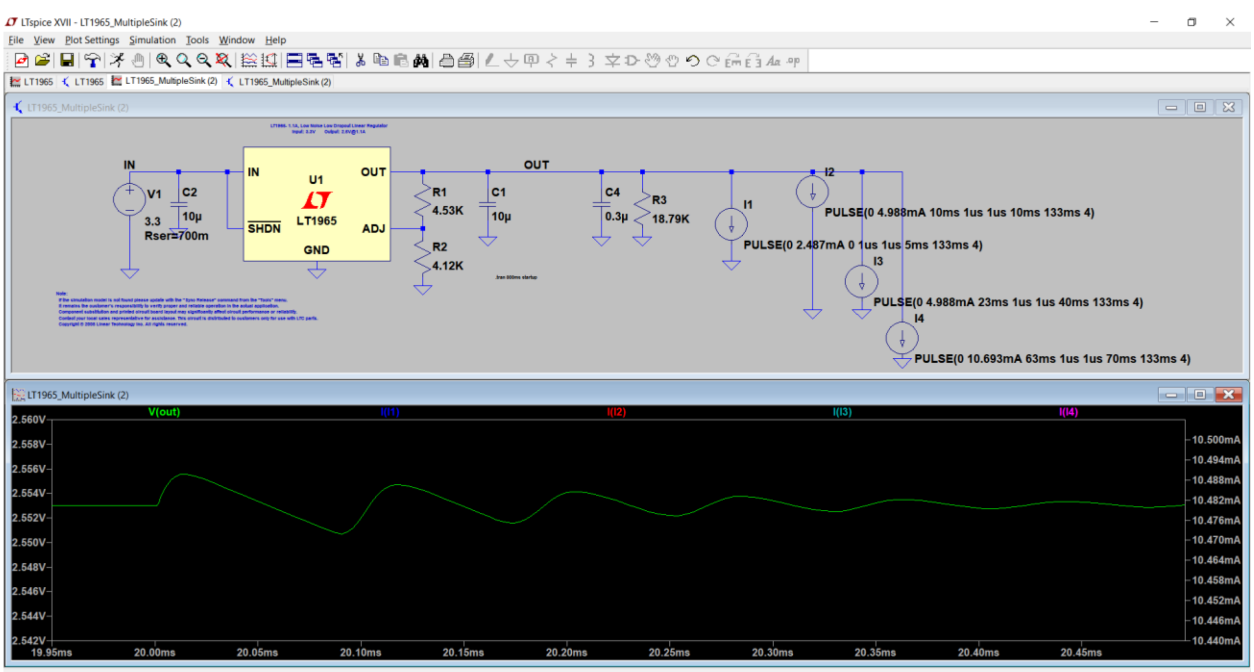
0.5mV of Ripple before the dynamic load

For Step Up Current load function:

From EM0-Sensor(5.122 mA) interrupt to EM1-BLE (10.826 mA)

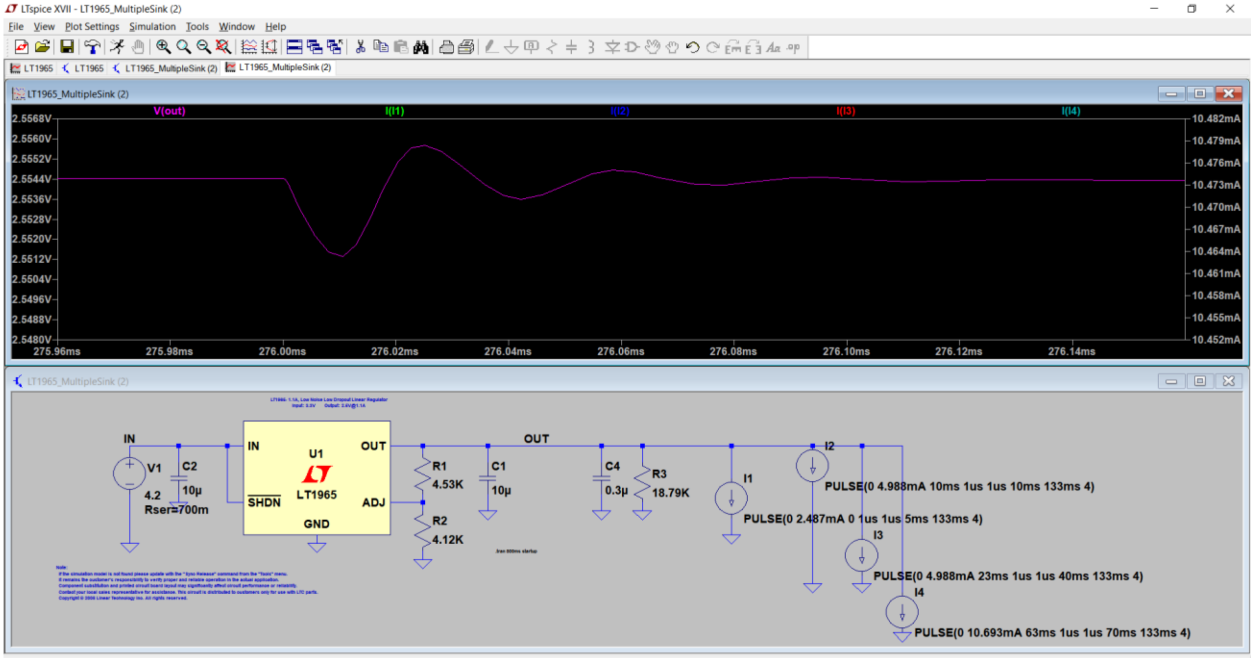
a. At Vin = min = 3.3

5.39 mV of ripple



b. At Vin = max= 4.2

4.2 mV of ripple



2.Does the voltage and its ripple before the step load meet the IC specifications of your circuits in terms of specified ripple or minimum voltage of the ICs?

a. At Vin = min => 3.3V

The circuit acts as a voltage regulator giving a 2.5V typical as the output with Max 0.5Vp-p Ripple.
For the Min Vin for the IC, the output voltage and the Ripple simulated is within the IC specifications for both Step up load and Step down load.

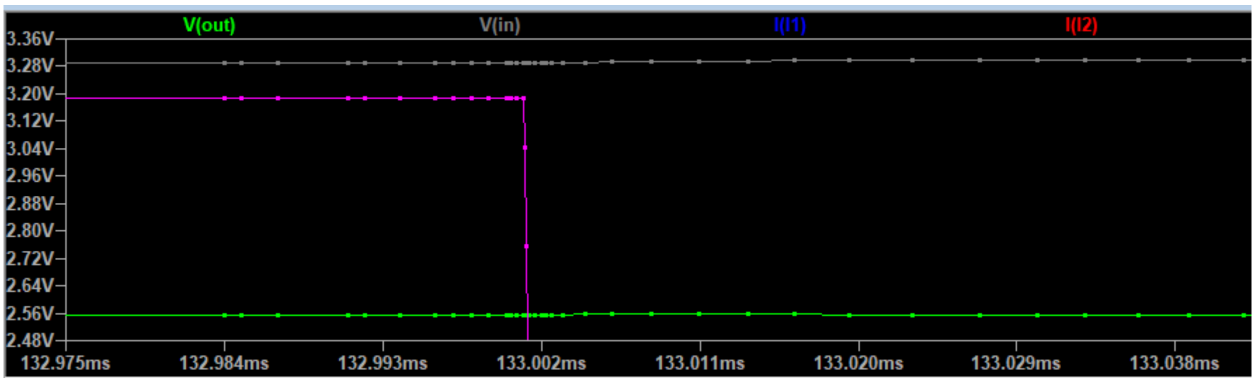
b.At Vin = max => 4.2V

The circuit acts as a voltage regulator giving a 2.5V typical as the output with Max 0.5Vp-p Ripple.
For the Min Vin for the IC, the output voltage and the Ripple simulated is within the IC specifications for both Step up load and Step down load.

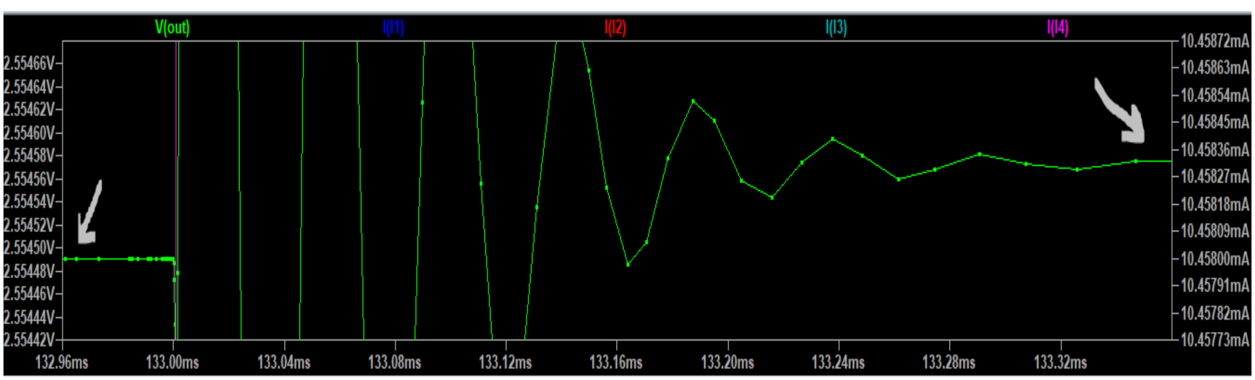
3.Does the output voltage dip when the dynamic step load is added? What is this minimum out voltage of the power supply or Vdd of the system while the power supply voltage is drooping?

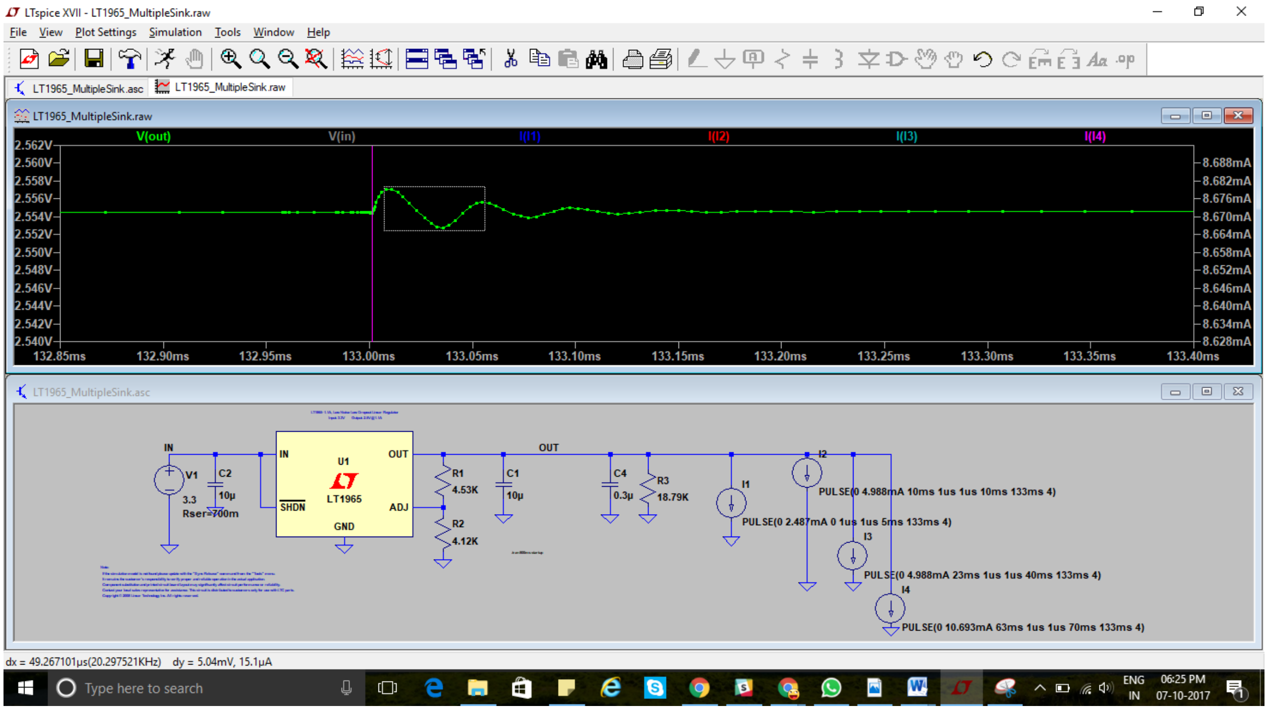
a.At Vin = min

Yes, the voltage was increased of about 0.1mV. The Supply Voltage was about 3.28V to the PMU IC from the battery.
The PMU IC would be giving approximately 2.5V output.



Note: The silver line indicates the stabilized voltage change





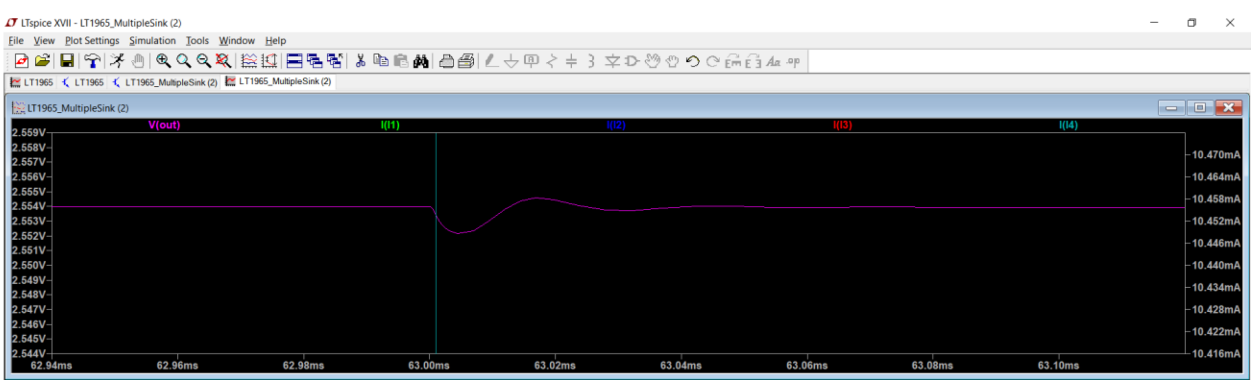
5mV is the ripple which is within the specifications of 0.5Vp-p

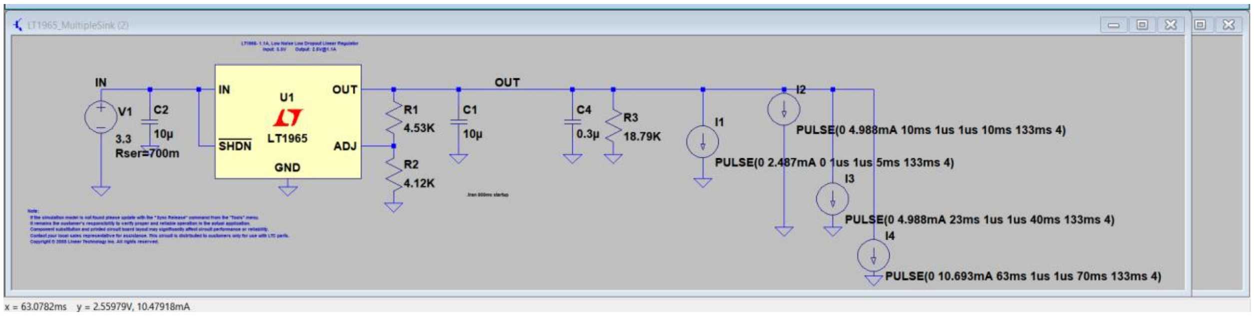
When the dynamic load is added there is a dip in the voltage, the min value is 2.553V, the appropriate voltage supplied by the battery is 3.296V
The Stabilized output voltage of the battery before the dynamic load was 2.5544V
Thus, there is a variation of 2.5544-2.553 = 0.0014V => 1.4mV which is within the specifications.

Dynamic current step up load:

Yes, there was a voltage dip with dynamic step up load.

Below screenshot shows the voltage dip when there is dynamic current step up load i.e when the load switches from EM0- Accelerometer interrupt to EM1-BLE transmission.





Minimum out voltage is 2.552167 V

Therefore, voltage droop = 1.83 mV < 0.5 * Vp-p

Hence, this is within the IC specifications

The stabilized voltage in EM0 before dynamic step up load = 2.55399 V

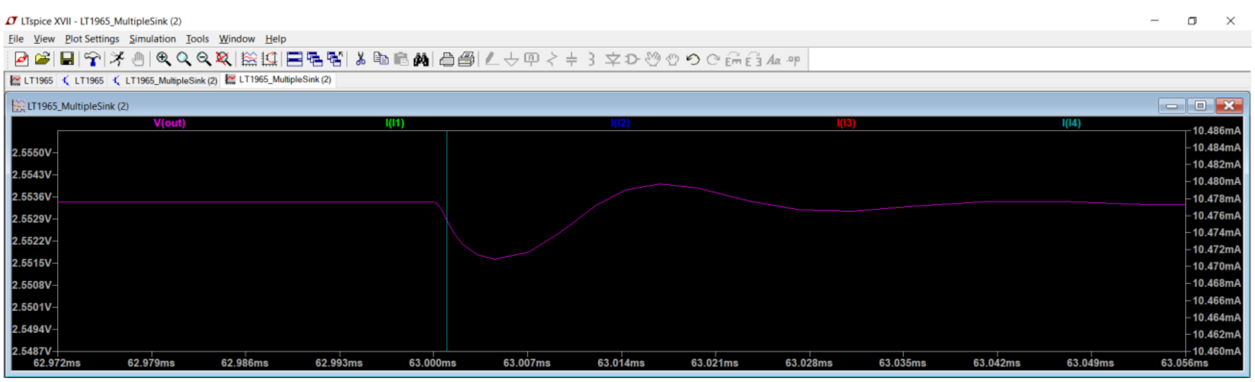
The stabilized voltage in EM1 after dynamic step up load = 2.55394 V

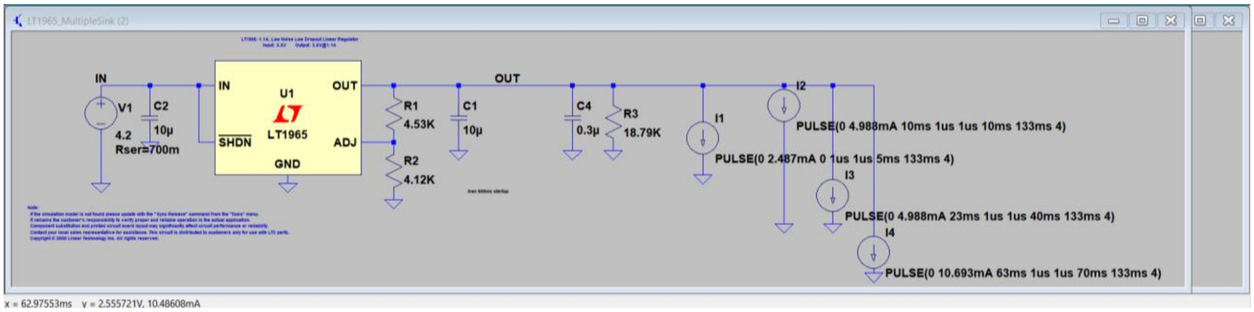
b. At Vin = max i.e Vin = 4.2 V

Dynamic current step up function load:

Yes, there was a voltage dip with dynamic step up load.

Below screenshot shows the voltage dip when there is dynamic current step up load i.e when the load switches from EM0- Accelerometer interrupt to EM1-BLE transmission.





Minimum out voltage is 2.5516 V

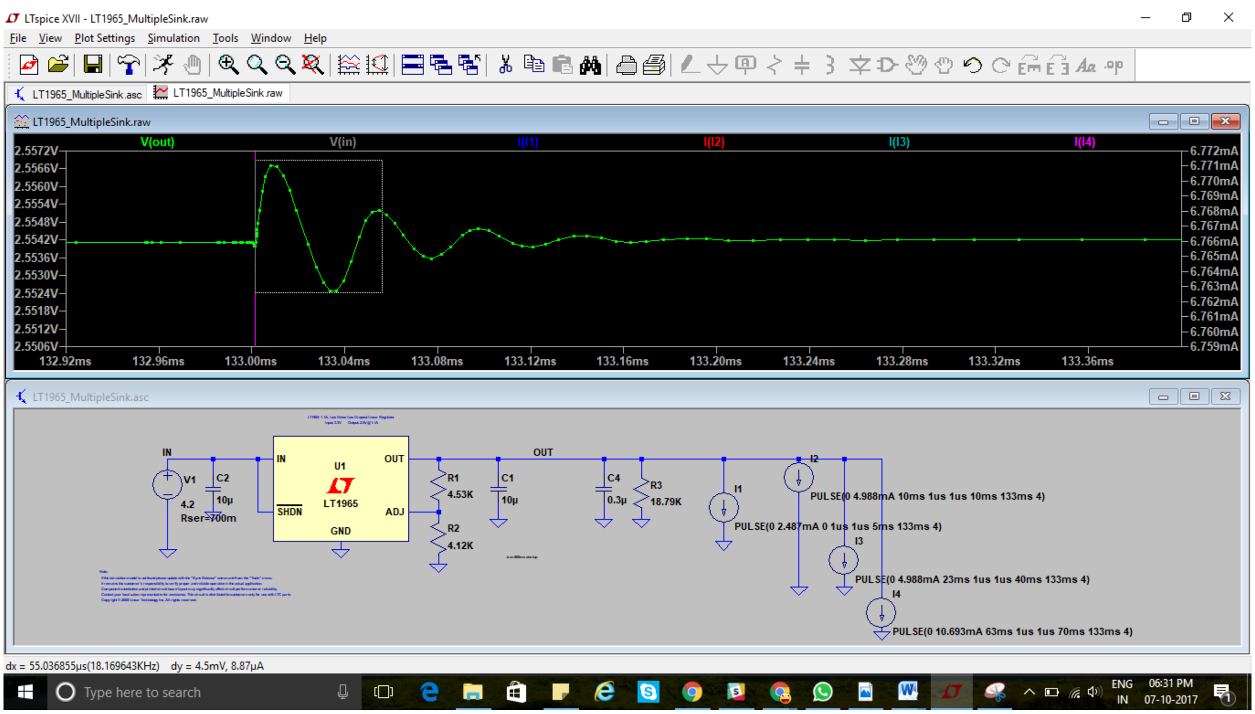
Therefore, voltage droop = 1.8 mV < 0.5*Vp-p

Hence, this is within the IC specifications

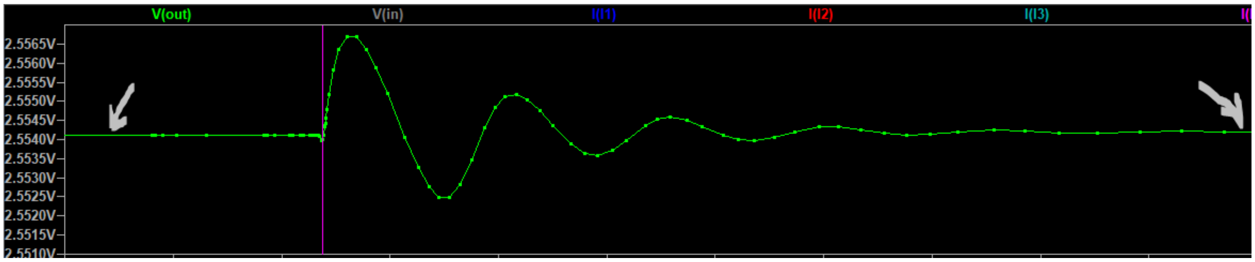
The stabilized voltage in EM0 before dynamic step up load = 2.5534 V

The stabilized voltage in EM1 after dynamic step up load = 2.5533 V

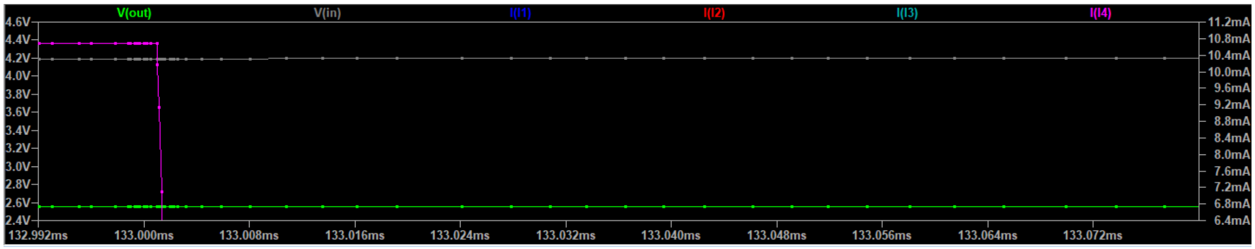
For Step Down Load: Vin: Max : 4.2V

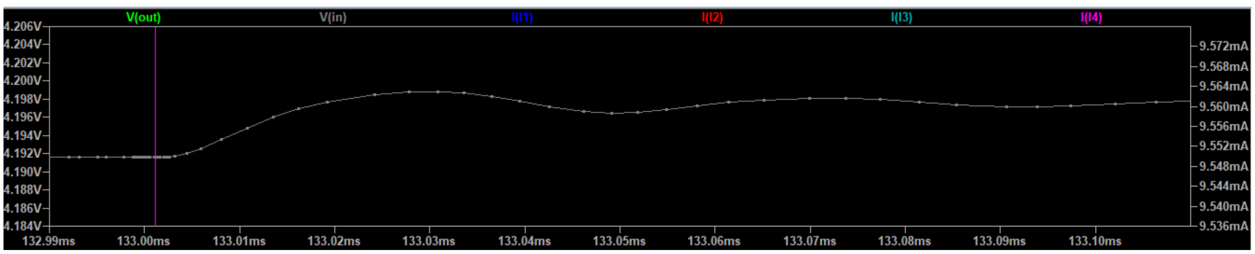


The ripple voltage is about 4.5mV, there is a voltage raise of about 1mV indicated by the arrows for step down function.



Vdd:



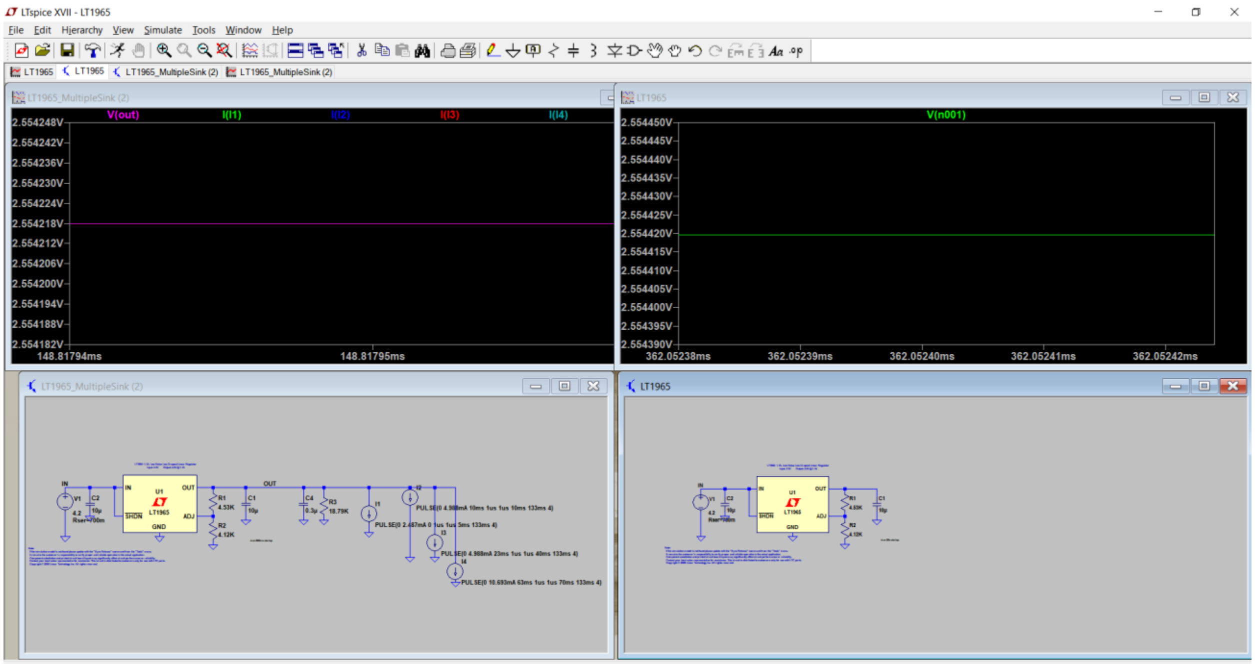


The Vdd was increased to about 5mV to 4.198v

When the dynamic load is added, a voltage dropped to about 2.5522V, the stabilised voltage before the variation was 2.55407V

The difference of about 1.87mV
Which is within the specifications of 0.5Vp-p ripple.

Simulation for with & without Dynamic load:



The circuits as shown above:

Voltage when there is no dynamic load: 2.5542 V (Image on the right)

Voltage when there is dynamic load: 2.5542 V (Image on the left)

Hence there is no change in the voltage when a dynamic load is added to the circuit.

The min voltage when the power supply is drooping is 2.53 V which is within the specifications of the IC.

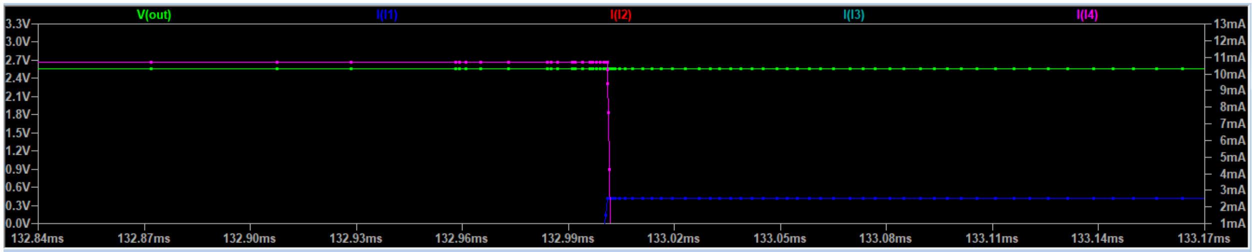
4. Does this minimum voltage due to the current load step meet the IC specifications of your circuit in terms of specified ripple or minimum voltage of the ICs?

Step Down Function:
EM1 BLE to EM1 (Accelerometer Config)

a. At Vin = min

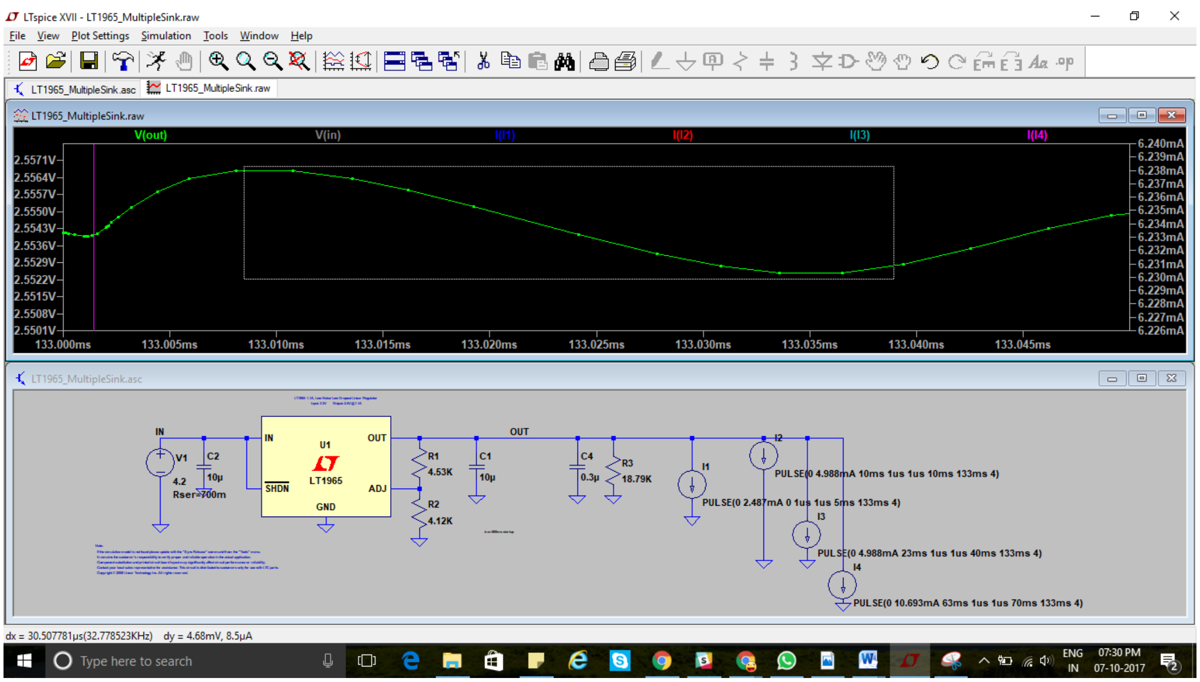
Yes, the ripple of the IC is 0.5Vp-p => which is within the ripple from the simulation. The Min Voltage of the IC is 2.425V; the simulated output from the step function load is within the range of the PMU output voltage (Vmin-2.425 to Vmax-2.575)

LT1965-2.5, V_{IN} = 3V, I_{LOAD} = 1mA		2.462	2.5	2.538	V
LT1965-2.5, 3.5 < V_{IN} < 20V, 1mA < I_{LOAD} < 1.1A	●	2.425	2.5	2.575	V



b. At Vin = max

Yes, the ripple of the IC is 0.5Vp-p => which is within the ripple from the simulation. The Min Voltage of the IC is 2.425V; the simulated output from the step function load is within the range of the PMU output voltage (Vmin-2.425 to Vmax-2.575)
The ripple voltage after the step down is 4.68mV



Step Up Function:

EM0 Accelerometer Interrupt to EM1 BLE transmission

a. At Vin = min

Yes, the ripple of the IC is 0.5Vp-p => which is within the ripple from the simulation. The Min Voltage of the IC is 2.5521V; the simulated output from the step function load is within the range of the PMU output voltage (Vmin-2.5521 to Vmax-2.554)

b. At Vin = max

Yes, the ripple of the IC is 0.5Vp-p => which is within the ripple from the simulation. The Min Voltage of the IC is 2.5516V; the simulated output from the step function load is within the range of the PMU output voltage (Vmin-2.5516 to Vmax-2.553)

5. If changes were made to meet the system requirements, you must re-simulate and provide data for both before and after the circuit change

No changes were made for the system requirements, all the calculations were accurate. Note: We have not simulated the PMU IC (BQ24040**) or the Inductive IC (**BQ51013B**) charger as we were not able to find the simulation modules for both of the ICs. We had mentioned it earlier in the class on Friday-6th Sept 2017.**

6. Does the design meet your system and component requirement

Yes.