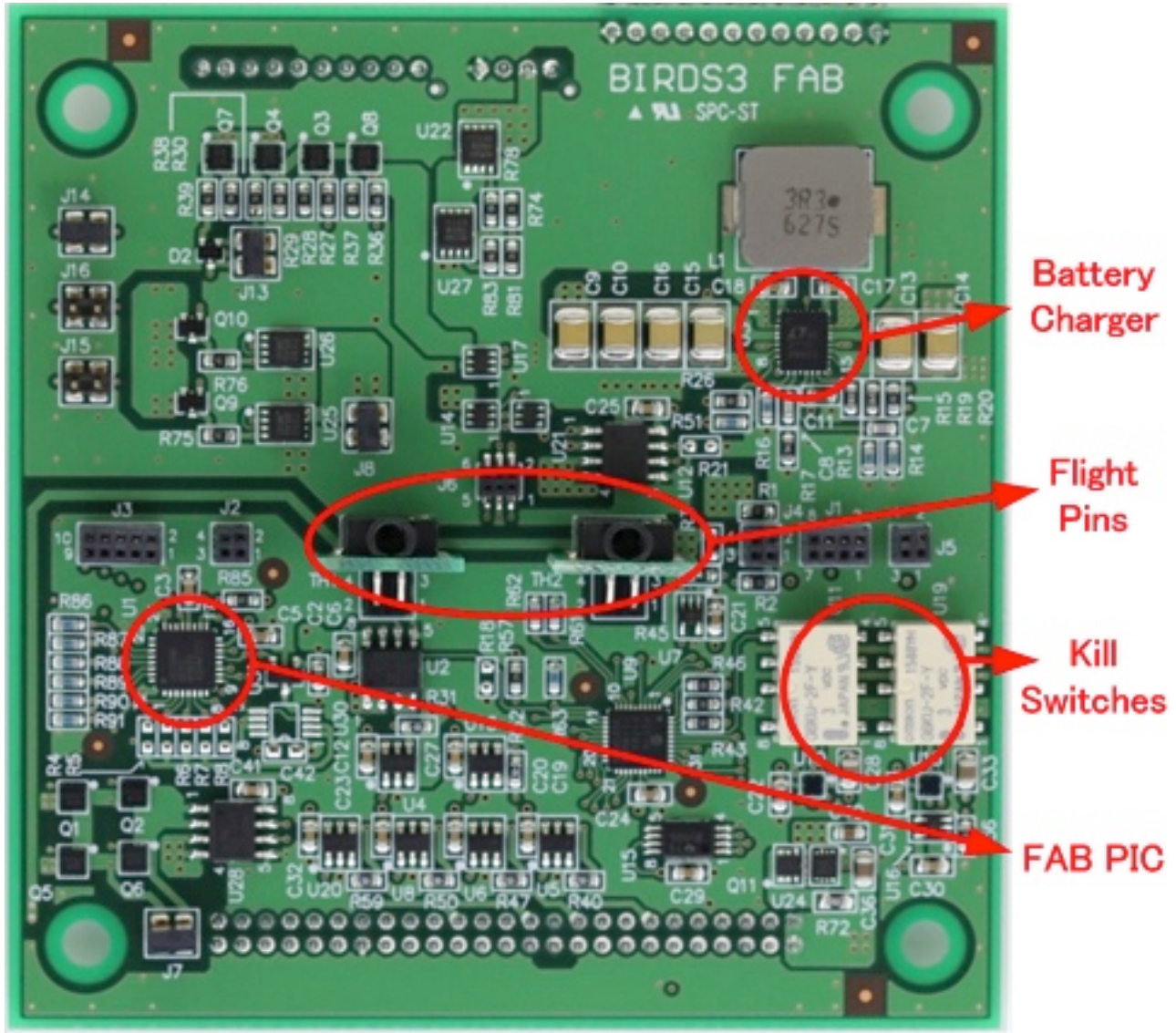
FAB, OBC Board Update for BIRDS-5

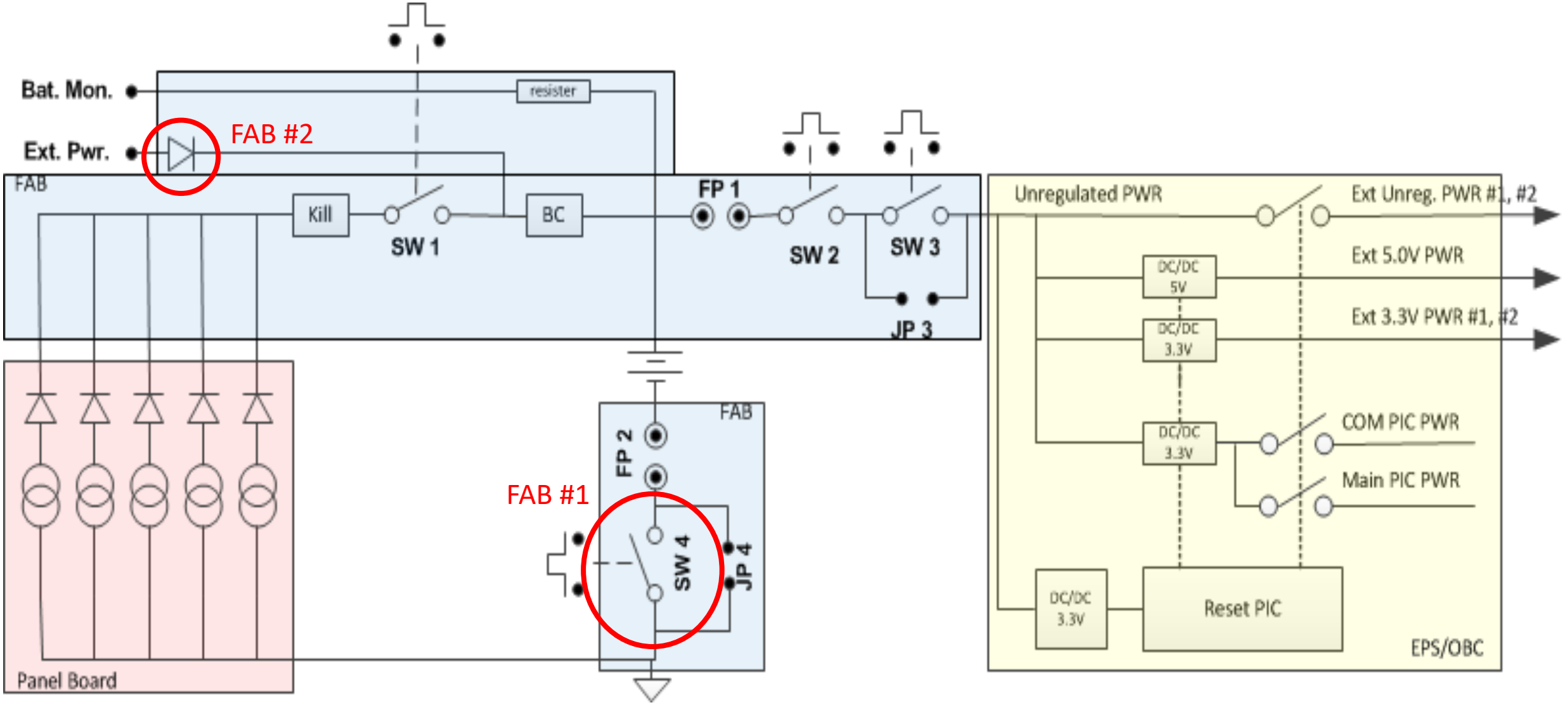
2020/OCT/02

Sangkyun Kim

FAB(Front Access Board)

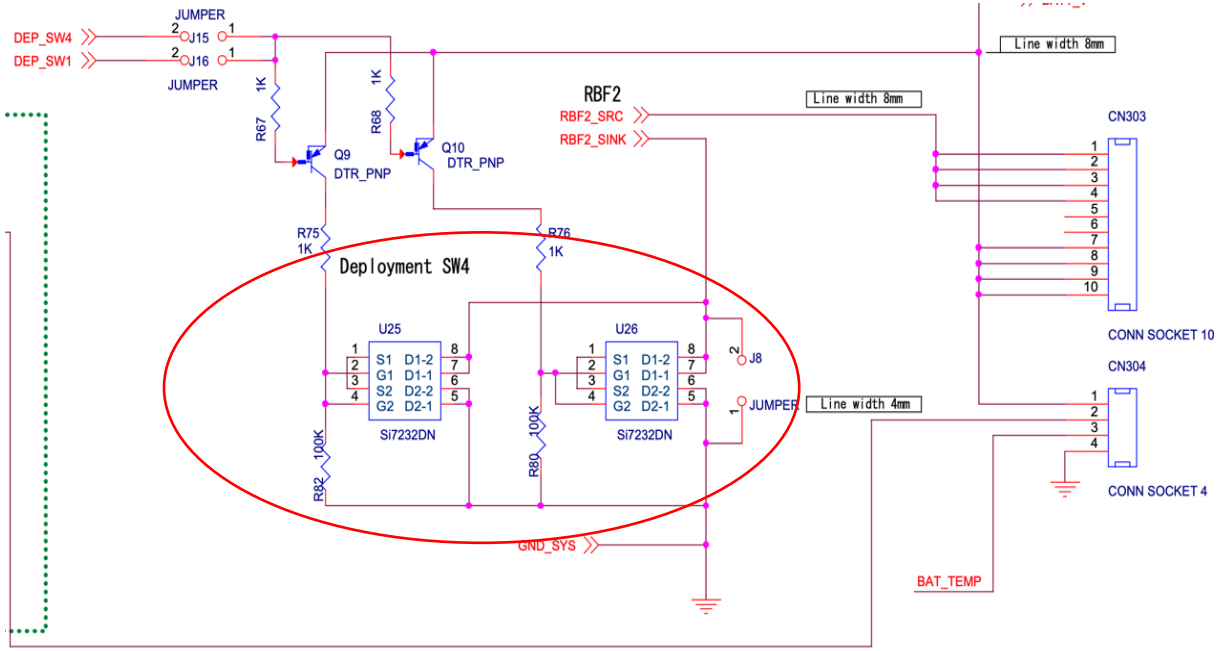


Block diagram of EPS, Update points of FAB

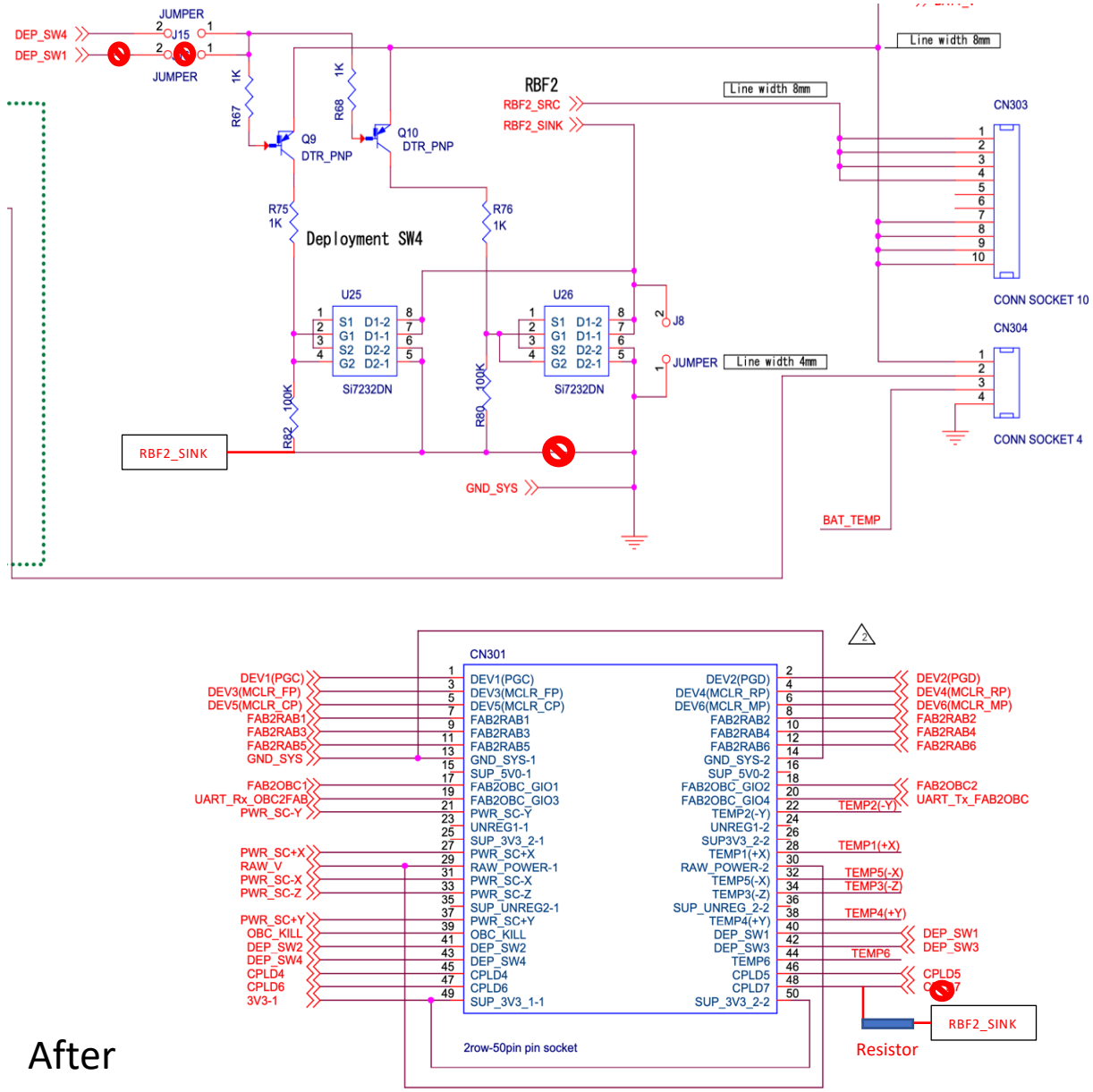


FAB #1 : MOSFET switch between BAT- and GND

- Change MOSFET gate control from GND_SYS to BAT- (RBF2_SINK)

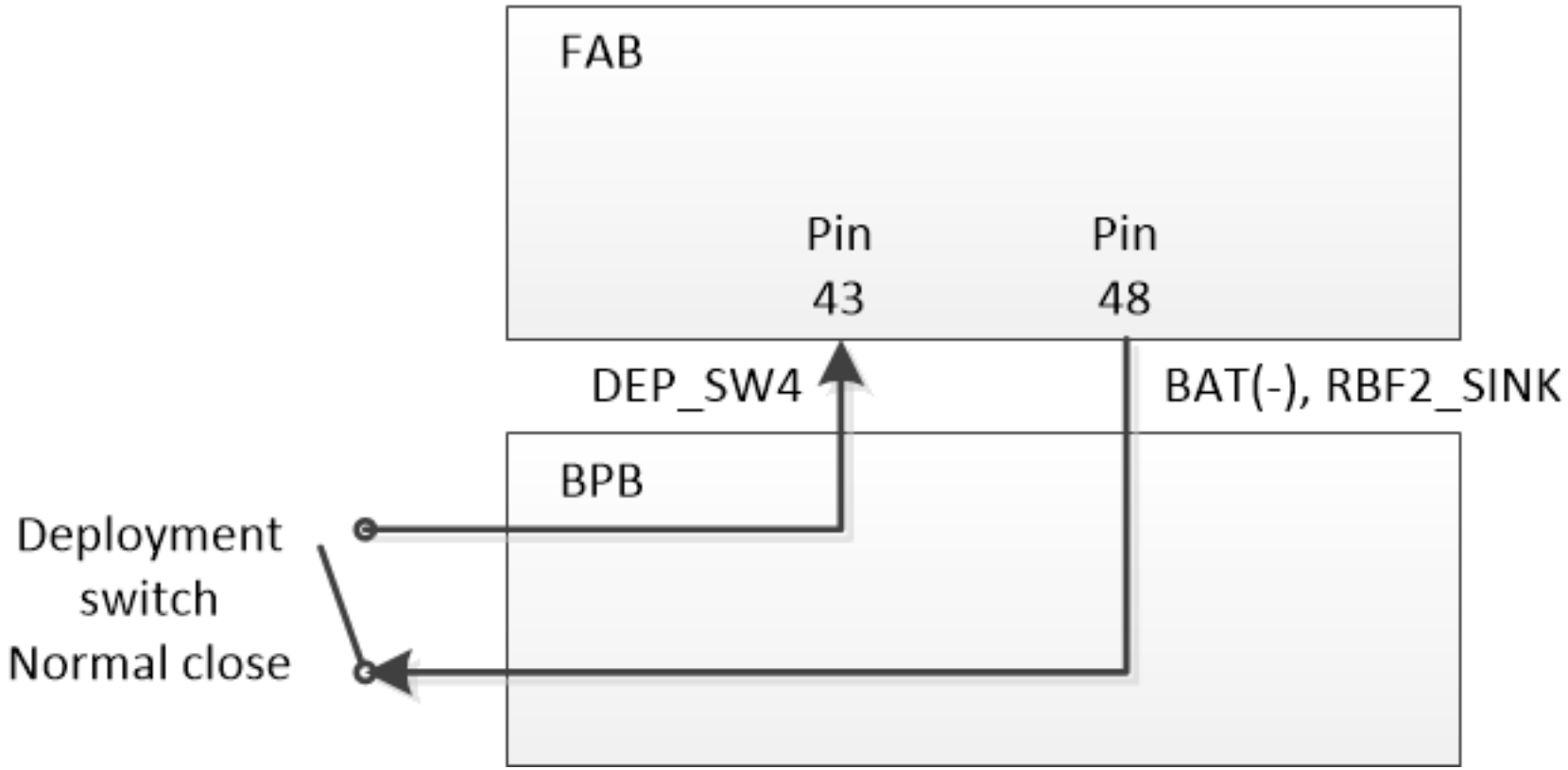


Before



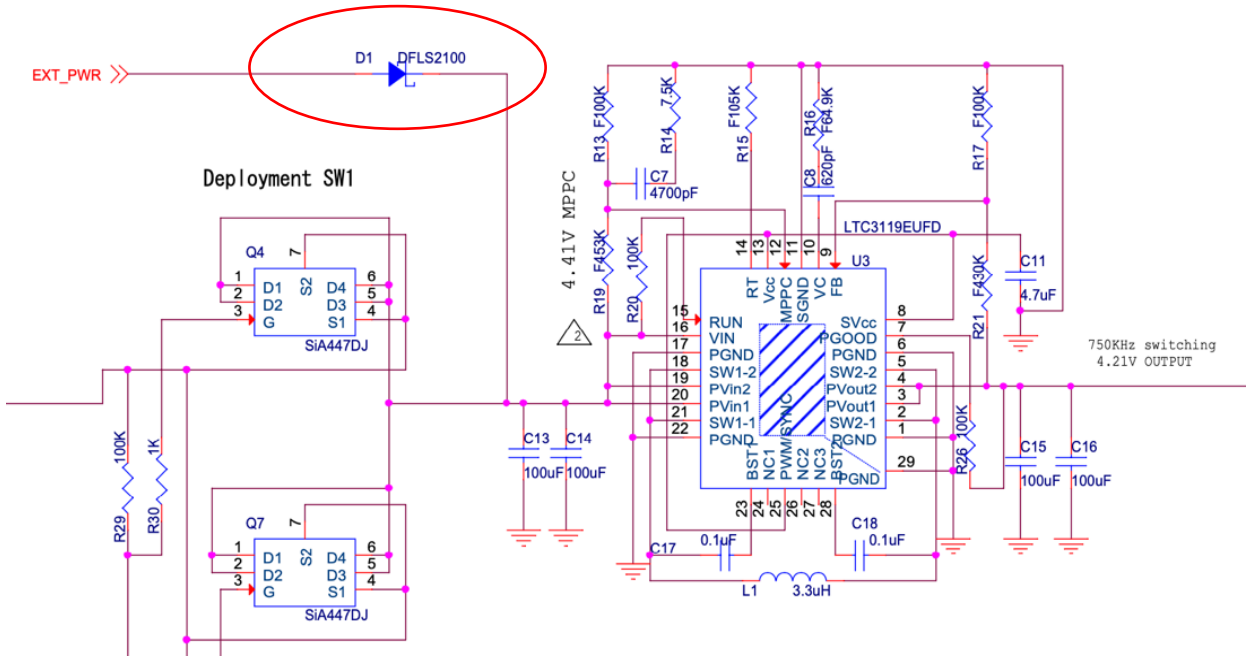
After

Wiring of MOSFET control signal

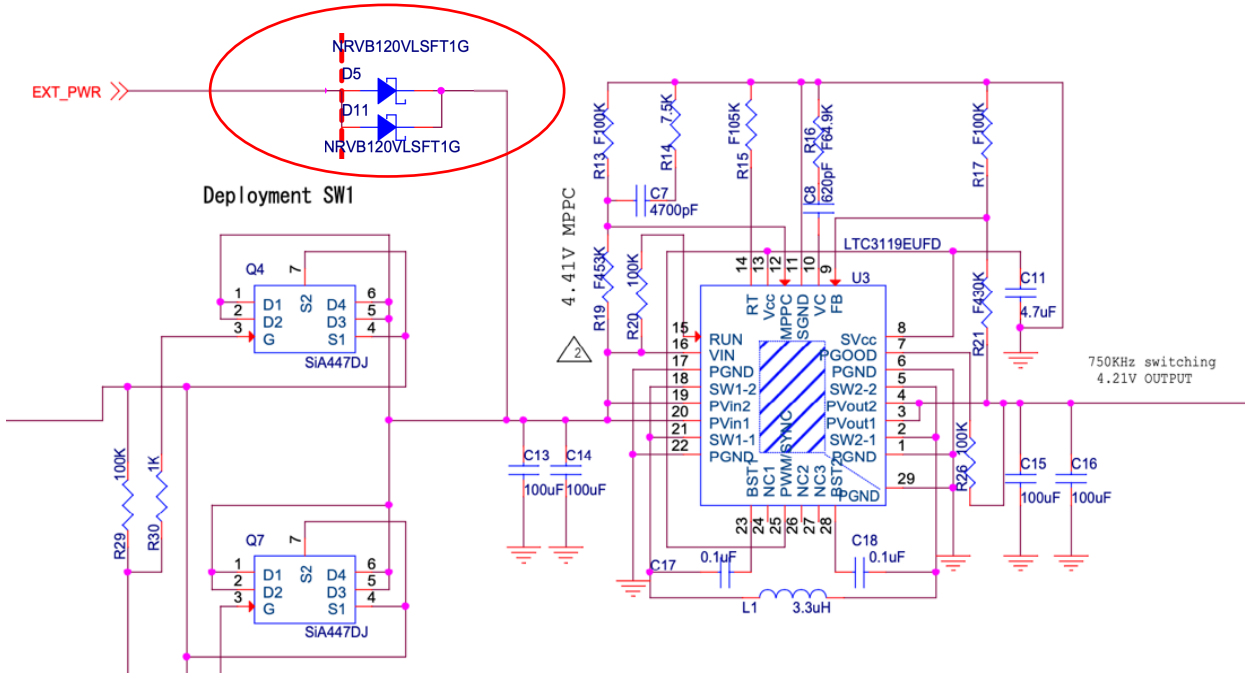


FAB #2 : Blocking diode for external power

- Change blocking diode for low voltage drop
- Portable USB battery(5V output) can be used for battery charging

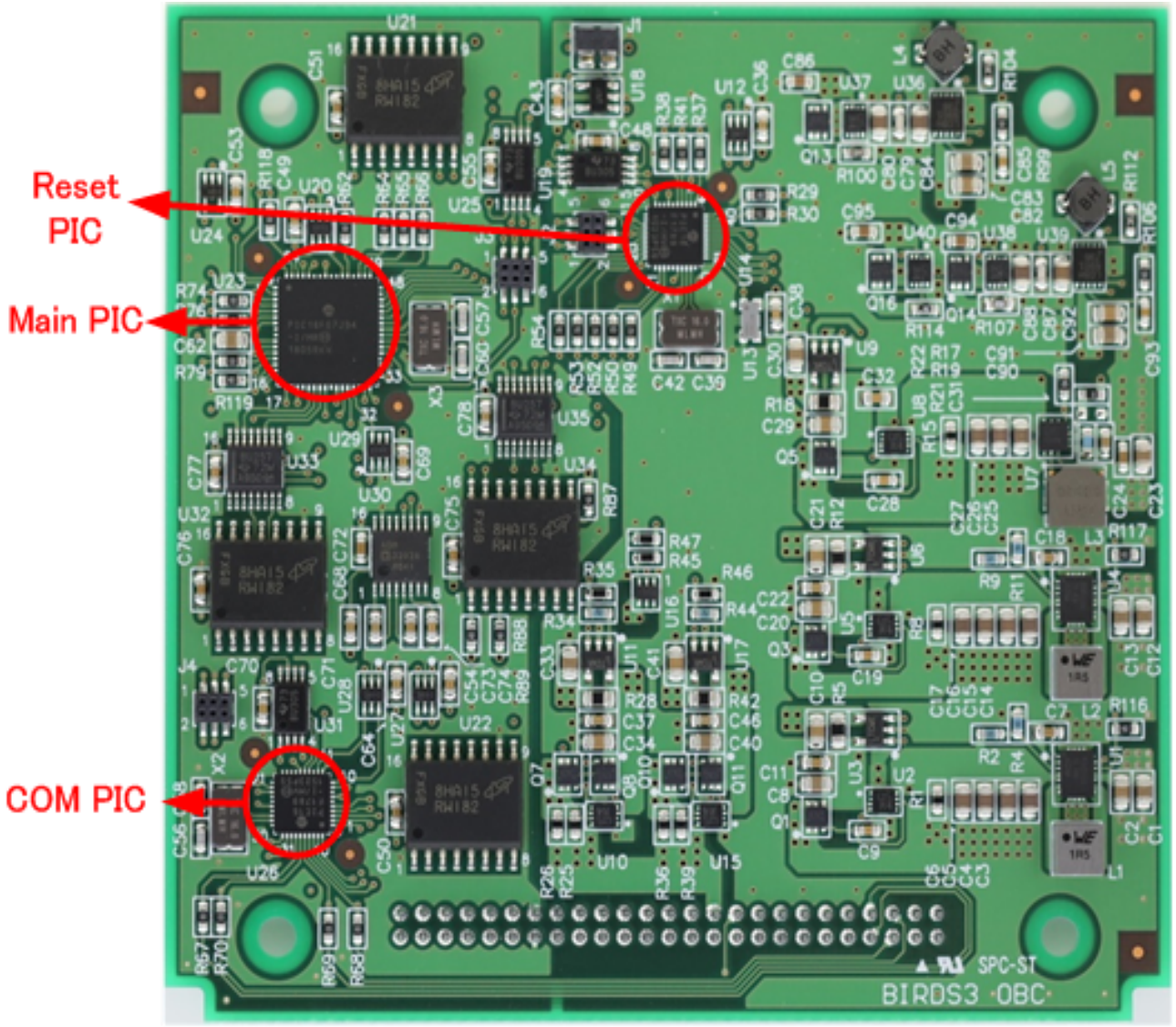


Before



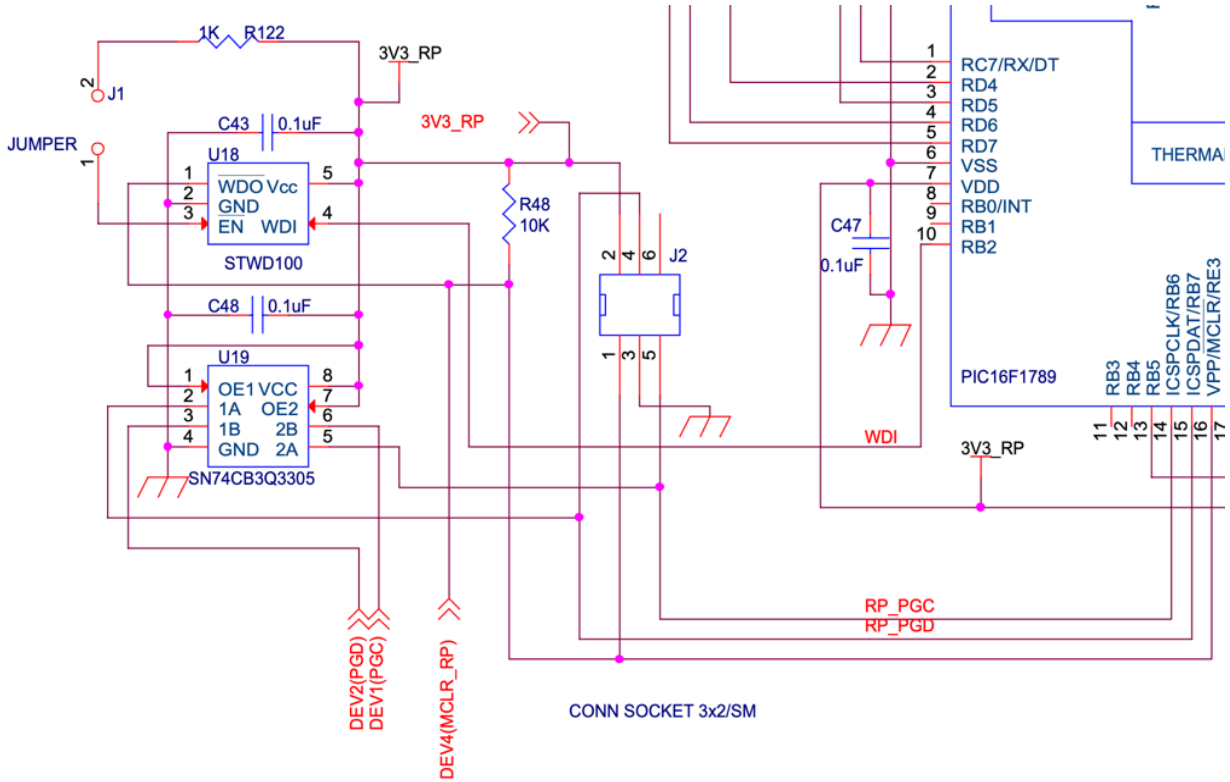
After

OBC(On Board Computer) board

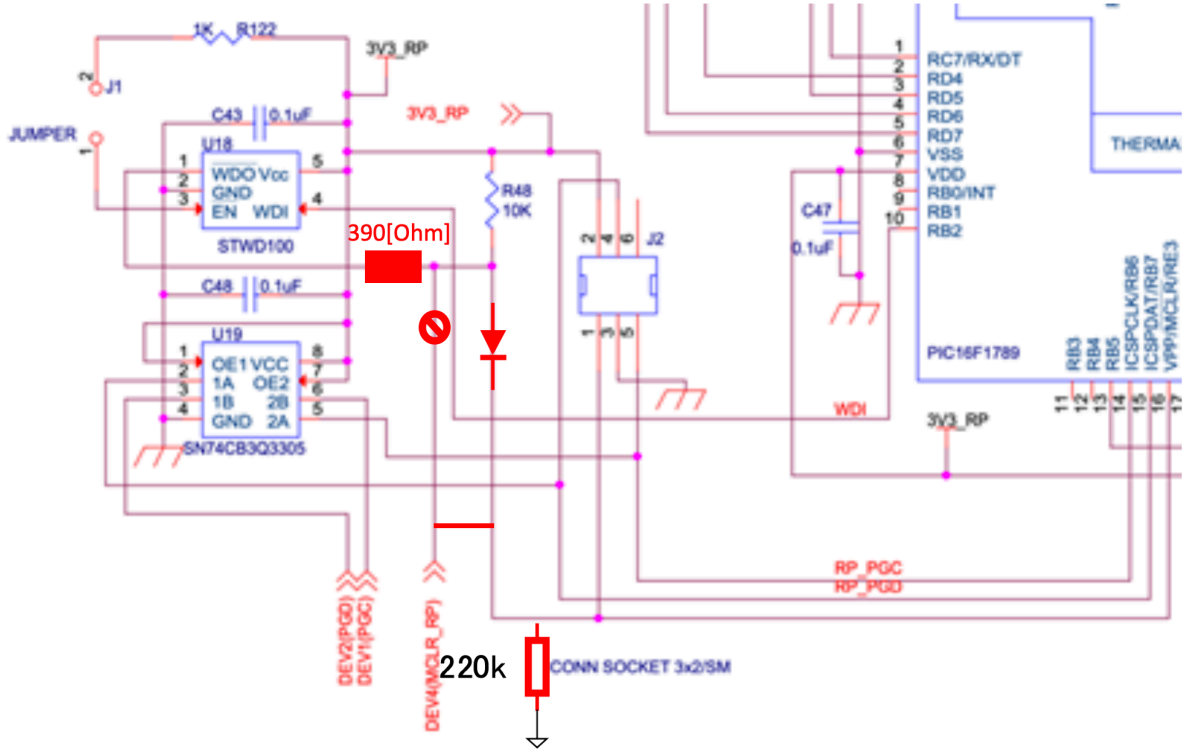


OBC #1 : Reset PIC programing with watchdog

- Put resistor on the outputp of watchdog avoiding disturbance from watchdog during the programming of Reset PIC



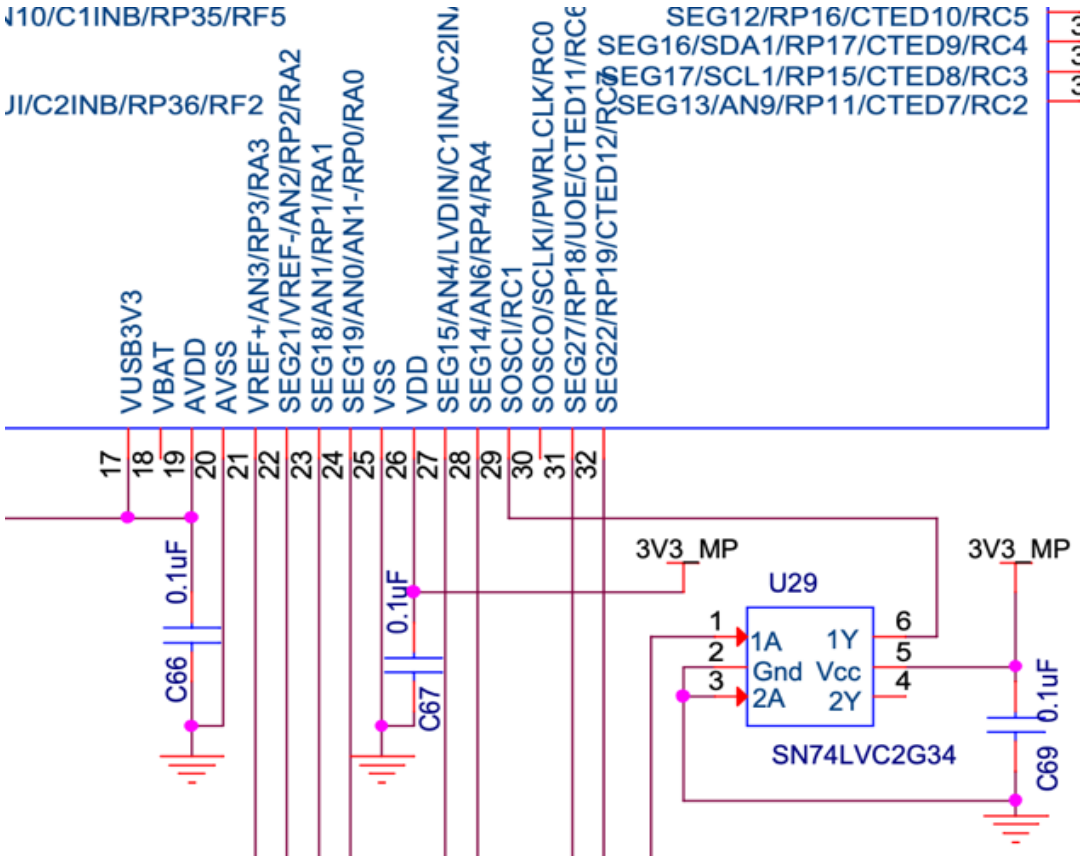
Before



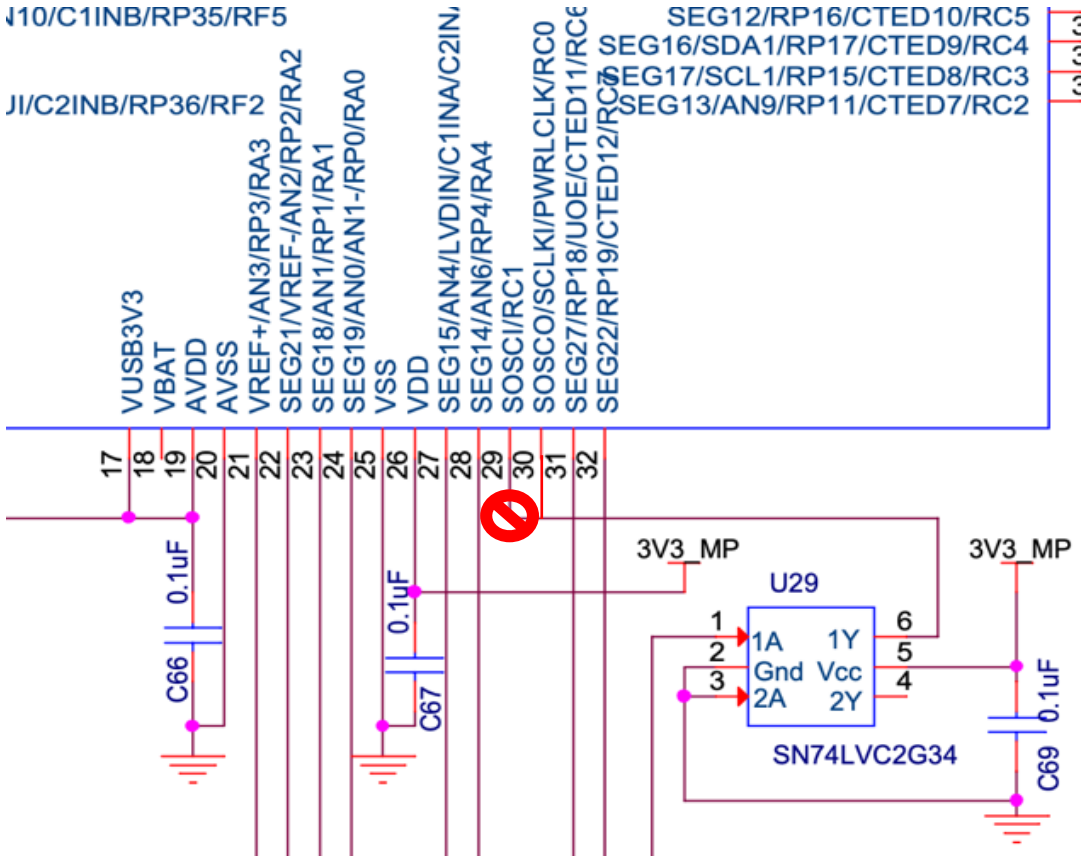
After

OBC #2 : Secondary clock input of Main PIC

- Secondrary clock input goes to SCLKI(pin30)



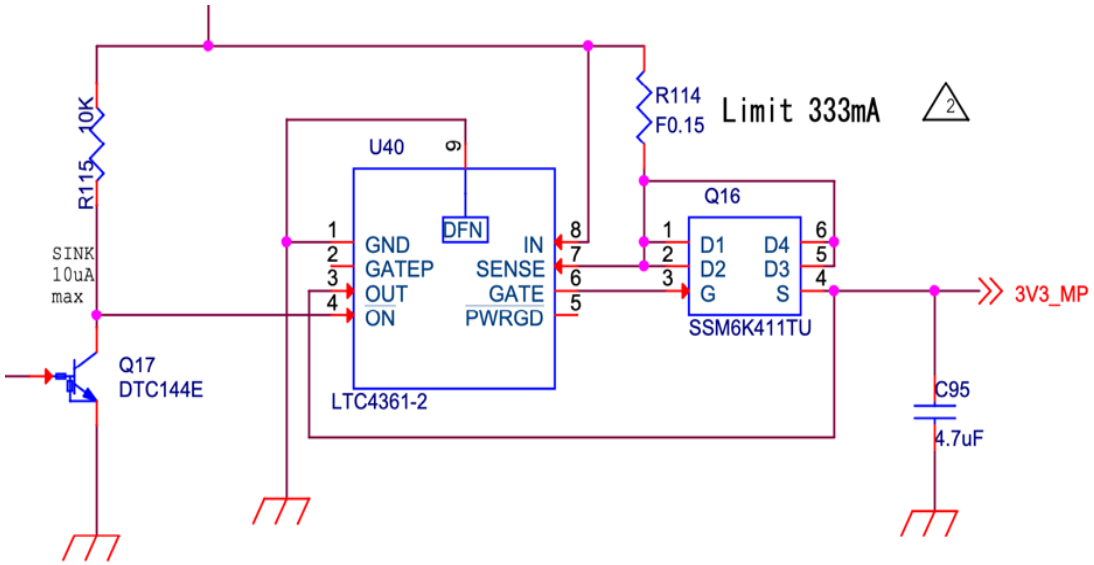
Before



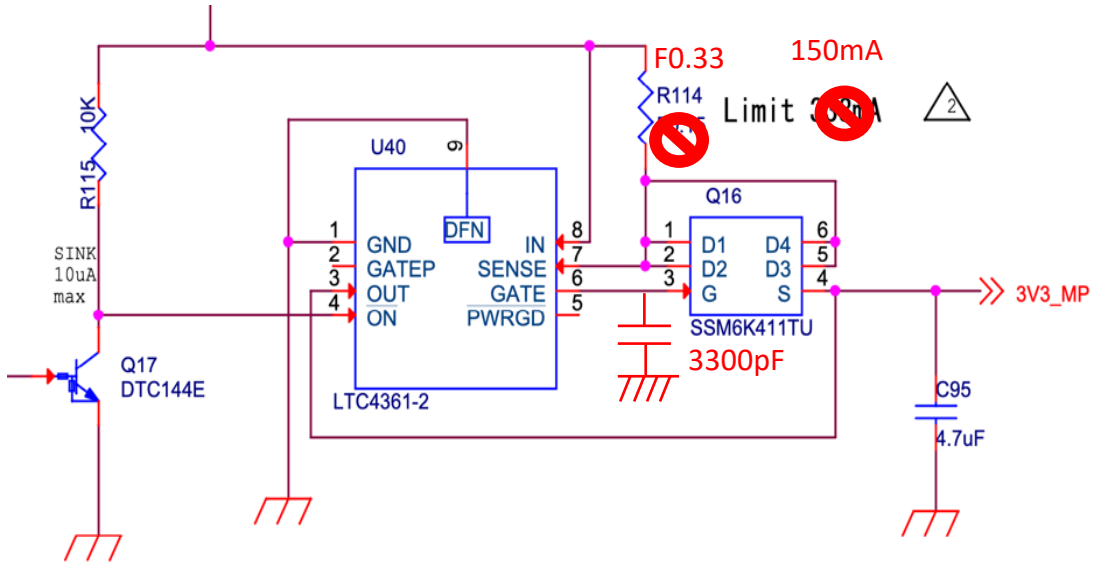
After

OBC #3 : OCP of Main PIC

- Change OCP level to 150mA, BecauseSEL current was 180mA
- Add capacitor on the gate line to avoid false proection



Before



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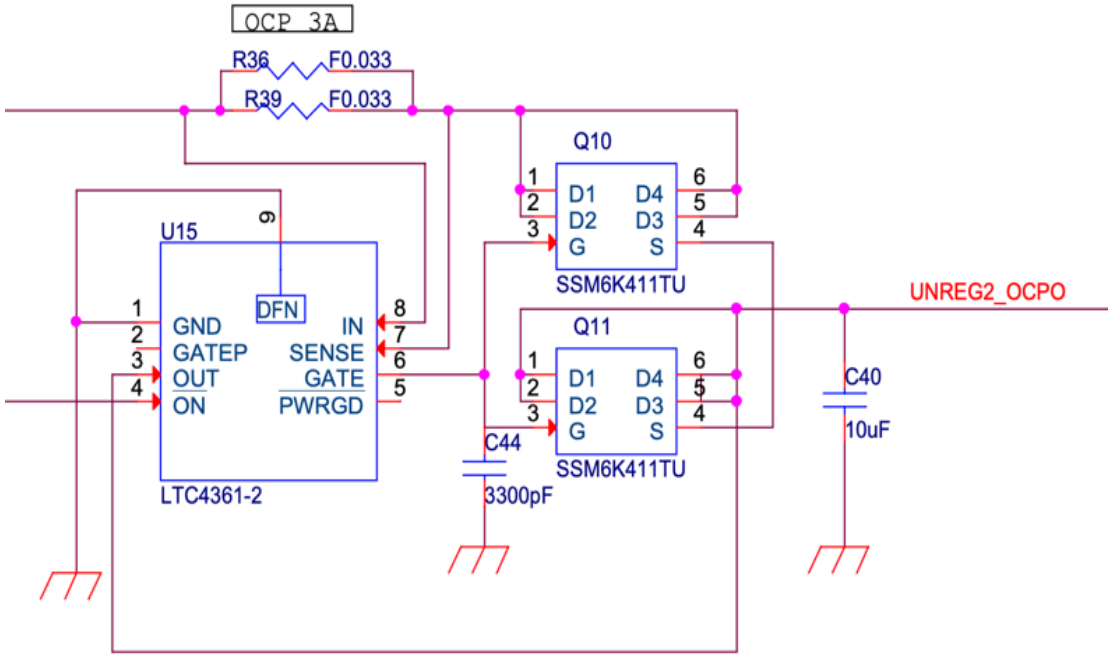
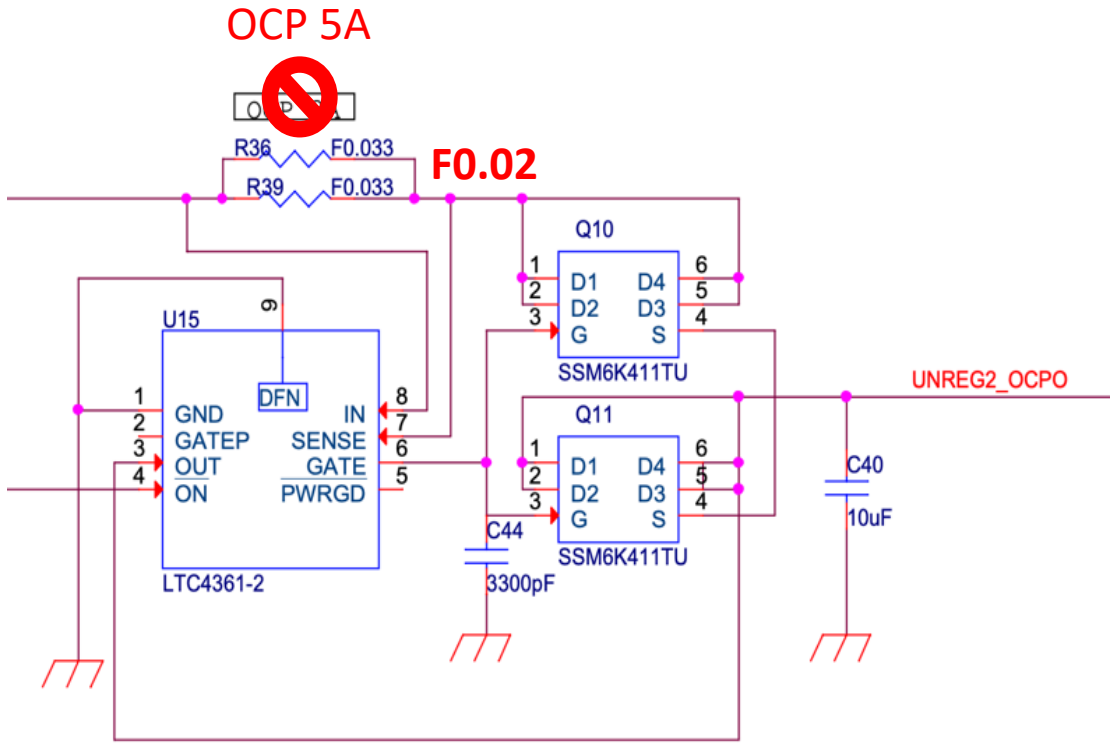
OBC #4 : OCP of UNREG2

- Increase OCP level of UNREG2 : 5 [A]
- Change the value of R36, R39 to F0.02



Before



After

Antenna deployment safety connector

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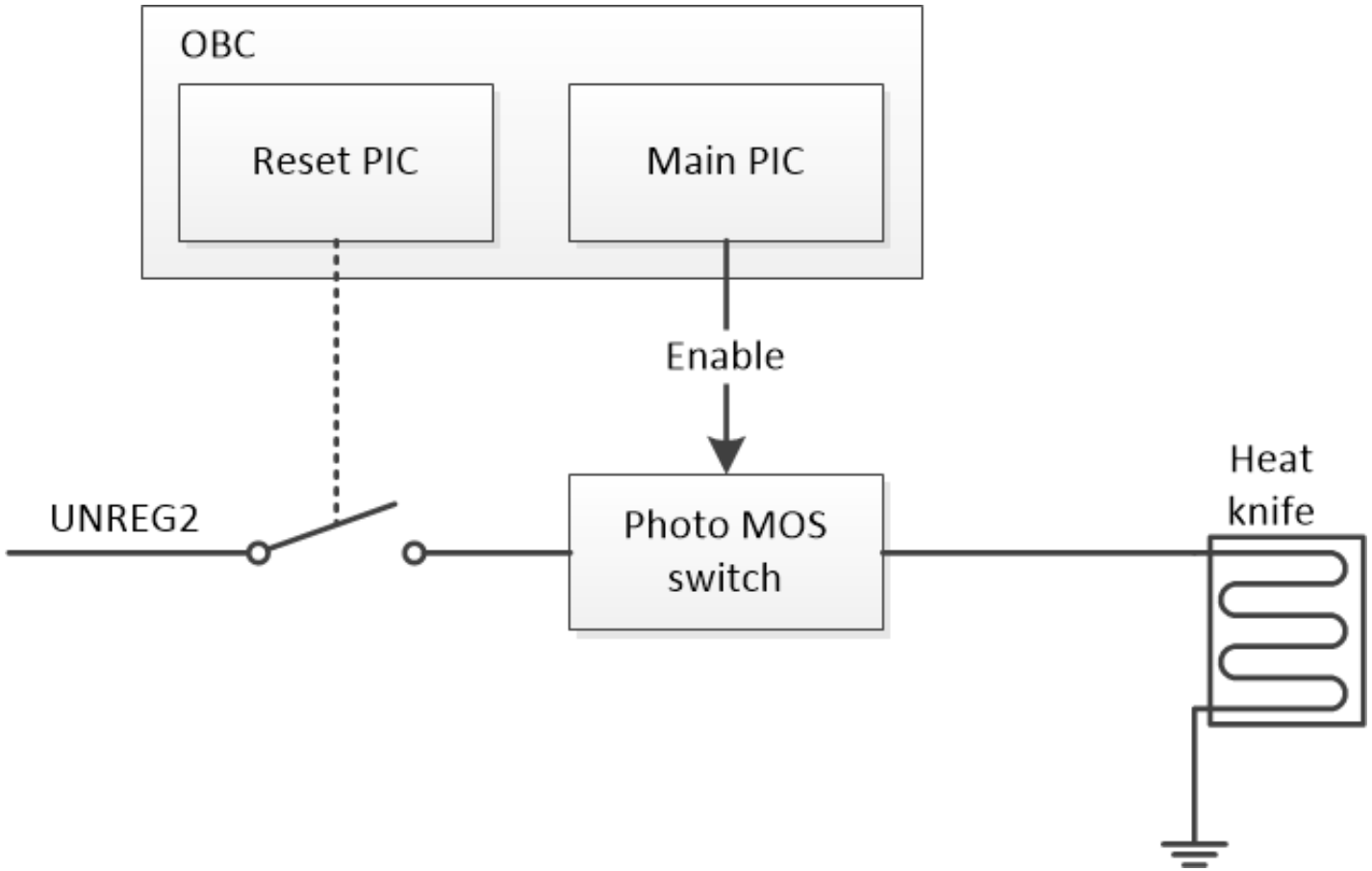
Reson of safety system for antenna deployment

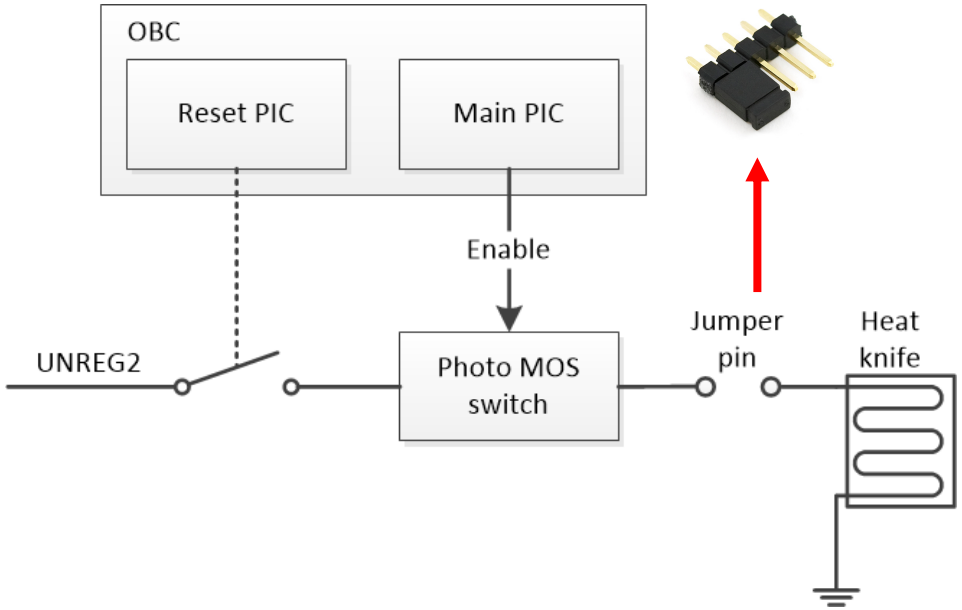
- Satellite needs to be power on for S/W update
- Antenna deployment is activated more than 30 minutes in final configuration automatically
- After accepatnce vibration test of FM, satellites needs to keep its configuration. Antenna deployment is not acceptable
- Reason 1 : S/W needs to be updated with many reasons until the last moment of delivery
- Reason 2 : Sometimes, Battery charging work make accidental antenna deployment because of human error
- A safety system is required to avoid the accidental antenna deployment

Current antenna deployment system

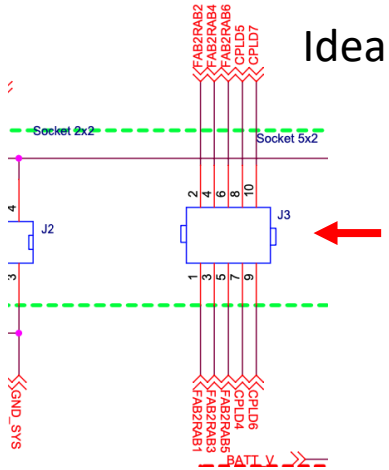


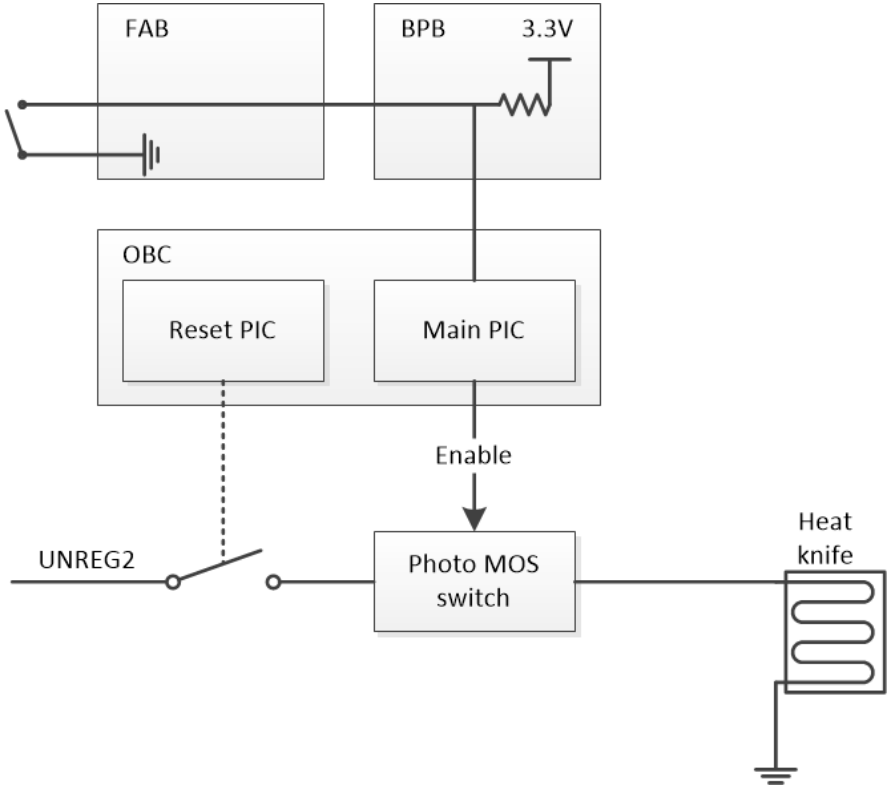
Ideas for the safety system of antenna deployment

Idea #1 : Jumper pin on power line



Idea #2 : Jumper pin on ext. DIO signal





Idea #3 : Other ideas

How to know satellite position

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Satellite position on the orbit

- Measurement : Measue the positaion directly
  - GPS(Global Positioning System)
  - GPS Antenna has to point the direction of GPS satellites
  - GPS receiver has to lock the signals of GPS satellites, more than 4 satellites
  - Accuracy : 10 – 100[m]
- Estimation(Propagation) : Calculate the position of satellite at the moment(time)
  - Calculate the position of satellite using propagation algorithm
  - GS(Ground Station) software uses SGP4 algorithm with TLE information, usually
  - TLE(Two Line Elements) has 6 elements of orbit with additional data
  - SGP4(Simplified General Perturbation 4) is propagation algorithm using TLE, Sample code is available
  - Accuracy : 1 – 20 [km]

Position of ISS

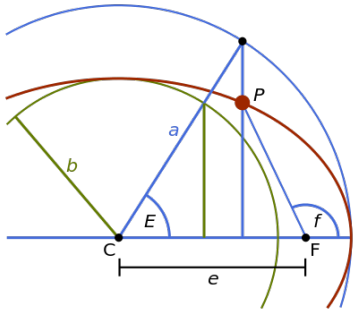
- Satellite has no significant change for its velocity
- Can be estimated its position based on time

Orbit

- Orbital elements, 6 elements
  - Eccentricity, e : Shape of the ellipse
  - Semimajor axis, a : The sum of the periapsis and apoapsis distance divide by two
  - Incilination, i : Vertical tilt of the ellipse with respect to the reference plane
  - Longitude of the ascending node, Ω : horizontal orient of the ascending node with vernal point
  - Argument of periapsis, ω : Angle measured from the ascending node to the periapsis
  - Anomaly, υ : Position of the body at a specific time(epoch)
- Anomaly
  - Mean anomaly, M : Hypothetical circular orbit
  - Eccentric anomaly, E : From the center of ellipse
  - True anomaly, υ or f : From the focus of ellipse

$$M = E - e \sin E$$

$$\tan \nu = \frac{\sin E \sqrt{1 - e^2}}{\cos E - e}$$



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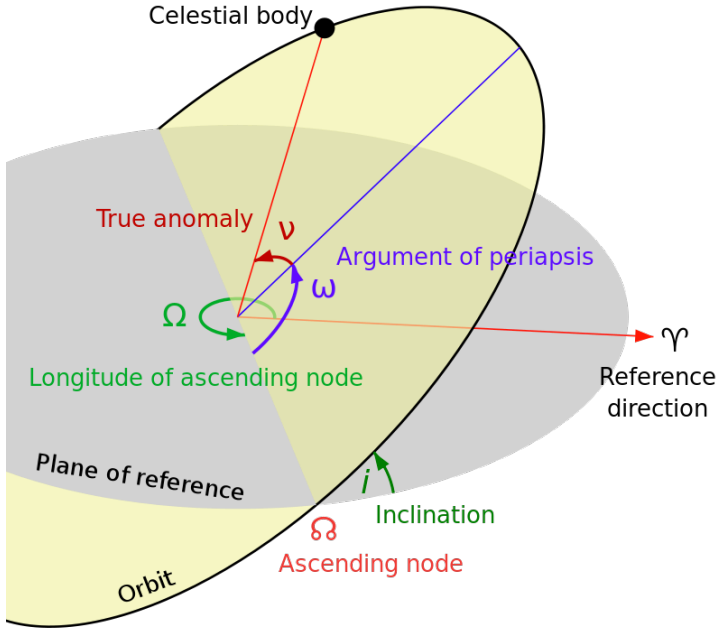

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Satellite Position

- From the orbital 6 elements
  - Calculate true anomaly
  - Calculate the distance r
  - Calculate the position using angle conditions of the orbital elements
- SGP4
  - Using TLE(Two Line Element), 6 elements + additional information
  - Better accuracy than 6 elements, usually 1km initial error, error is increasing 1 – 3 km per day
  - Sample code is available (https://celestrak.com/software/tskelso-sw.asp)
  - Heavier than orbital 6 elements on the orbit calculation
- GPS
  - 10 – 100 [m] accuracy
  - Space model needs wide Doppler shift tracking, and accurate time management
  - Continuous output is not available without attitude control
  - Power consumption and its price are decreasing now, but still not easy for small satellite

TLE

- Provided by NORAD
  - https://www.celestrak.com/NORAD/elements/

7	19–20	Epoch Year (last two digits of year)	08
8	21–32	Epoch (day of the year and fractional portion of the day)	264.51782528

```
ISS (ZARYA)
1 25544U 98067A   08264.51782528 -.00002182  00000-0 -11606-4 0  2927
2 25544  51.6416 247.4627 0006703 130.5360 325.0288 15.72125391563537
```

Field	Columns	Content	Example
1	01–01	Line number	2
2	03–07	Satellite number	25544
3	09–16	Inclination (degrees)	51.6416
4	18–25	Right ascension of the ascending node (degrees)	247.4627
5	27–33	Eccentricity (decimal point assumed)	0006703
6	35–42	Argument of perigee (degrees)	130.5360
7	44–51	Mean Anomaly (degrees)	325.0288
8	53–63	Mean Motion (revolutions per day)	15.72125391
9	64–68	Revolution number at epoch (revolutions)	56353
10	69–69	Checksum (modulo 10)	7

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$$n = \frac{2\pi}{T}$$

$$n^2 = \frac{\mu}{a^3}$$

$$\mu = 3.98600442 \times 10^{14} [m^3 sec^{-2}]$$

$$a = \sqrt[3]{\frac{\mu}{n^2}}$$

$$M = M_0 + n\Delta t$$

Satellite position from 6 elements

- Flow of calculation
  - Calculate eccentric anomaly from mean anomaly by iterative method
  - Calculate true anomaly using the eccentric anomaly and eccentricity
  - Calculate the distance from focus of ellipse using the eccentric anomaly, eccentricity, and major radius
  - Calculate the position using the angle condition of orbital elements

$$E_t = E_{t-1} - \frac{E_{t-1} - e\sin E_{t-1} - M}{1 - e\cos E_{t-1}}, until\ E_t - E_{t-1} is\ small\ enough$$

$$\upsilon = atan2(\sin E\sqrt{1-e^2}, \cos E - e)$$

$$r = \sqrt{(a(\cos E - e)^2 + (a\sin E\sqrt{1-e^2})^2}$$

$$\begin{bmatrix} r_x \\ r_y \\ r_z \end{bmatrix} = \begin{bmatrix} r(\cos\Omega\cos(\omega+\upsilon) - \sin\Omega\cos i\sin(\omega+\upsilon)) \\ r(\sin\Omega\cos(\omega+\upsilon) + \cos\Omega\cos i\sin(\omega+\upsilon)) \\ r\sin i\sin(\omega+\upsilon) \end{bmatrix}$$