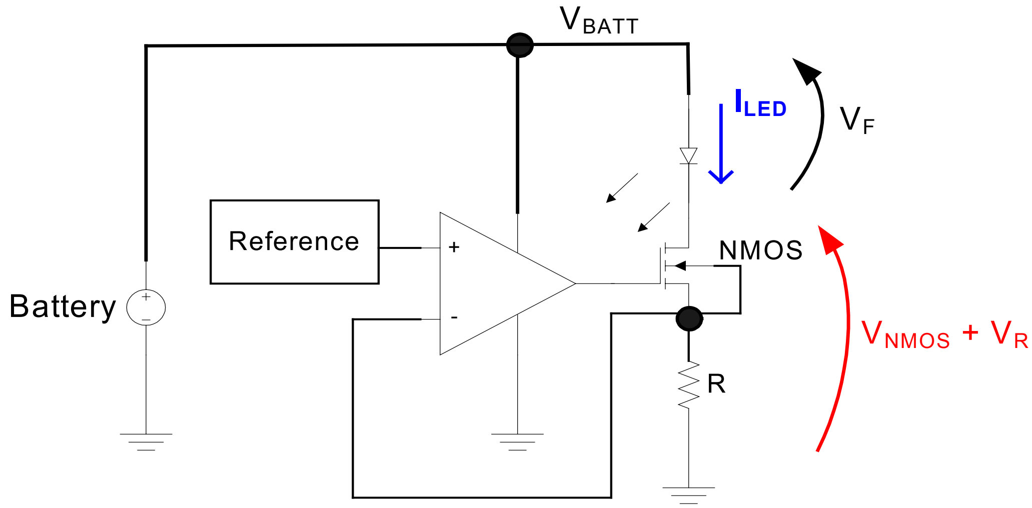
Three common methods of driving one LED with a single battery in a portable device are compared. The LED forward voltage V_F is fixed for a given $I_{LED.}$

1 - Old Fashioned Scheme - One method is to use a "Reference" voltage and a traditional OpAmp with a power FET (NMOS) and a resistor R as shown below.



The current is set by the "Reference" voltage via the OpAmp, NMOS transistor, and resistor R.

Assuming current in the OpAmp and "Reference" is negligible, the power out of the battery is simply

$$P_{BATT} = I_{LED}*V_{BATT}$$

The minimum battery voltage for this setup is

$$V_{BATT\,|\,Min} = V_F + V_{NMOS} + V_R$$

A lower value of V_F would reduce the minimum value of battery

$$P_{NMOS\&R} = P_{BATT} - P_{LED} = I_{LED}*(V_{NMOS} + V_R)$$

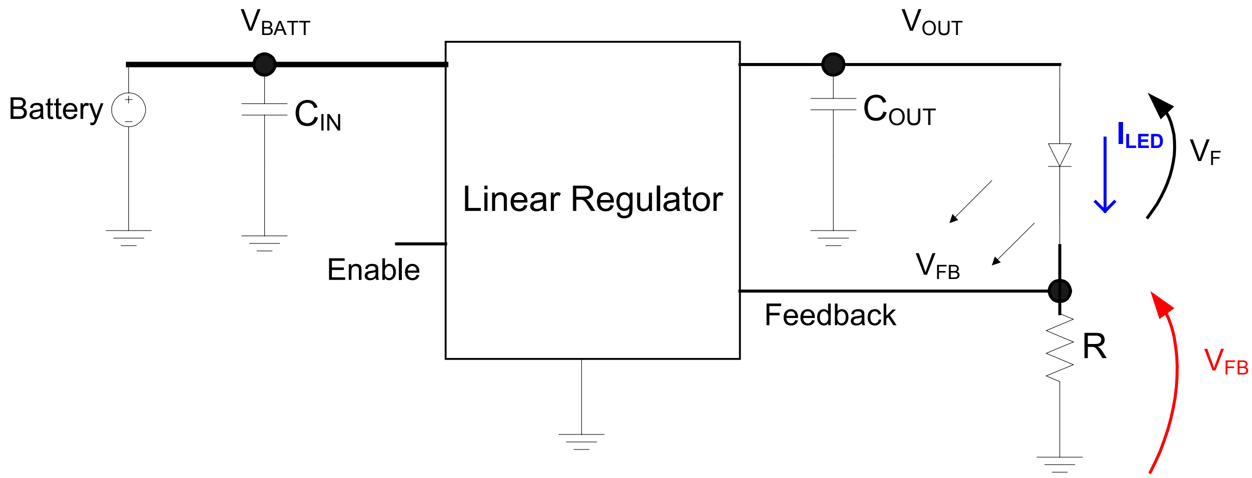
At the maximun battery voltage, the power loss in the NMOS and resistor R is at its maximum. As the battery voltage drops, the heat generated in the NMOS and resistor R is reduced. Power loss drops as the battery voltage drops.

The operating time can be approximated from the battery capacity (in mAHr) and I_{LED}.

Operating_Time in Hours = (Battery_Capacity in mAHr) / (I_{LED} in mA)

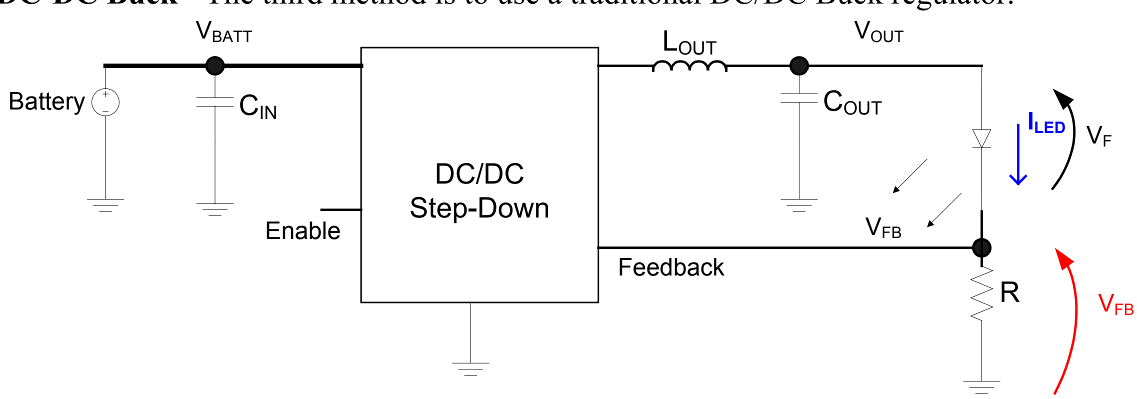
Forward voltage of the LED has no effect on power savings (or reduced heat) in the system. Total power loss is simply a function of LED current. So, for a 2100mAHr battery and a single LED at 700mA, total operating time can be approximated at 3 hours (180 minutes).

2- LDO As Driver - The second method is to use a simple Linear or LDO Regulator connected directly to the battery as shown below.



Since I_{LED} is provided by the battery, total power delivered to the system is the same as the previous method (V_{BATT} * I_{LED}), assuming power used by the Linear or LDO Regulator is negligible. Since V_F is fixed for a constant I_{LED}, the rest of the power is wasted in the feedback resistor R and inside the regulator itself. Again, lowering V_F does not save any power or battery life in this case.

3 – DC-DC Buck - The third method is to use a traditional DC/DC Buck regulator.



Current in the LED is set similarly to a Linear (or LDO) Regulator with resistor R and is

$$I_{LED} = V_{FB} / R$$

But, for a typical DC/DC with an efficiency of η and power output of V_{OUT}*I_{LED}, input power into the DC/DC is:

$$P_{BATT} = (V_{OUT} * I_{LED}) / \eta$$

Current out of a battery for a 100% efficienct DC/DC would be:

$$I_{BATT} = (V_{OUT} * I_{LED}) / V_{BATT}$$

The current out of the battery is the lowest when battery voltage is at its maximum value, and it increases as the battery voltage is reduced.

So, wasted power in the system is power loss in the DC/DC, and power lost in the feedback resistor (I_{LED}*V_{FB}). So, lowering the value of V_F and V_{FB} is crucial for this particular case in order to save power.

To maximize operating time:

- Use an LED with lowest forward voltage to reduce power loss and increase operating range
- Use the Lowest possible feedback voltage for the regulator to minimize power loss in the feedback resistor
- Use an efficient regulator when appropriate (depends on value of V_F)

Operating Time vs. LED Forward Voltage

- LED @ 350mA

□Linear Solution vs. DC/DC
□Black: Linear
□Red: V_{FB} = 600mV
□Blue: V_{FB} = 50mV

Operating Time Vs. Forward Voltage VF(x) for 1050mAHr