PWM Period

$$T_{PWM} = (PR2+1) \times 4 \times T_{OSC} \times (TMR2\,Prescale\,Value)$$

$$PR2 = 255$$
$$TMR2\,Prescale = 1$$
$$T_{OSC} = \frac{1}{F_{OSC}} = \frac{1}{4 \times 10^{6}} = 250 \times 10^{-9}$$

$$T_{PWM} = (255+1) \times 4 \times 250 \times 10^{-9} \times 1$$

$$T_{PWM} = 256 \times 1 \times 10^{-6} = 256\,us$$

PWM Frequency

$$f = \frac{1}{T_{PWM}}$$

$$f = \frac{1}{256 \times 10^{-6}} = 3.906\,KHz$$

PWM Average Voltage

$$V_{AVG} = (Duty\,Cycle\,Ratio) \times V_{HIGH}$$

$$V_{HIGH} = 5V$$

$$Duty\,Cycle\,Ratio = \frac{CCPR}{4 \times (PR2+1)}$$

$$CCPR = 10\,bit\,PWM\,Period\,Register$$

$$V_{AVG} = \frac{CCPR}{1024} \times 5$$

$$V_{AVG} \times 1024 = CCPR \times 5$$

$$CCPR = \frac{V_{AVG} \times 1024}{5}$$

Low Pass Filter Cut-off Frequency

$$fc = \frac{1}{2 \times \pi \times R \times C}$$

$$fc = 1\,Hz$$
$$C = 1\,uF$$

$$R = \frac{1}{2 \times \pi \times fc \times C}$$

$$R = \frac{1}{2 \times \pi \times 1 \times 1 \times 10^{-6}} = 159\,K\Omega$$

$$V_F = V_{AVG}$$

$$V_{FMAX} = V_{HIGH}$$

AOP Feedback Resistor (R2) for a Gain β of 3.2 times

$$\beta = 1 + \frac{R1}{R2}$$

$$\beta - 1 = \frac{R1}{R2}$$

$$R2 = \frac{R1}{\beta - 1}$$

$$\beta = 3.2$$
$$R1 = 2.2\,K\Omega$$
$$R2 = ?$$

$$R2 = \frac{2.2 \times 10^3}{(3.2 - 1)} = \frac{2.2 \times 10^3}{2.2} = 1\,K\Omega$$

AOP Ouput Voltage

$$V_{AOP} = V_F \times \beta$$

$$V_{AOPMAX} = V_{FMAX} \times \beta = 5 \times 3.2 = 16\,V$$

Power Supply Output Voltage

$$V_{OUT}=V_{AOP}$$

$$V_{OUTMAX}=V_{AOPMAX}$$

$$V_{OUT}=\frac{CCPR}{1024}\times V_{ON}\times\beta$$

$$V_{OUT}=\frac{CCPR}{1024}\times 5\times 3.2$$

$$V_{OUT}\times 1024=CCPR\times 16$$

$$CCPR=64\times V_{OUT}$$

ADC

$$V_{REF}=2.048\,V$$
$$RES=10\,bits$$
$$ADRES=ADC\,Result$$

$$ADRES=\frac{V_{ANALOG}}{V_{REF}}\times 2^{RES}$$

$$ADRES\times V_{REF}=V_{ANALOG}\times 2^{RES}$$

$$V_{ANALOG}=\frac{V_{REF}}{2^{RES}}\times ADRES$$

Voltage Divider Resistors

$$V_S=16\,V$$
$$V_{OUT}=V_{REF}=2.048$$
$$R1=4.7\,K\Omega$$
$$R2=?$$

$$V_{OUT}=\frac{R2}{R1+R2}\times V_S$$

$$V_{OUT}\times(R1+R2)=V_S\times R2$$
$$V_{OUT}\times R1+V_{OUT}\times R2=V_S\times R2$$

$$V_{OUT}\times R1=V_S\times R2-V_{OUT}\times R2$$

$$V_{OUT}\times R1=R2\times(V_S-V_{OUT})$$

$$R2=\frac{V_{OUT}\times R1}{V_S-V_{OUT}}$$

$$R2=\frac{2.048\times 4700}{16-2.048}$$

$$R2=689.9\,\Omega$$

Voltmeter

$$V=\frac{V_S}{2^{RES}}\times ADRES$$

$$V=\frac{18}{1024}\times ADRES$$

Shunt Resistor

$$R_{SHUNT}=1\,\Omega$$

$$I_{LOAD}=I_{SHUNT}=2\,A$$

$$V_{MAX}=R_{SHUNT}\times I_{LOAD}=1\times 2=2\,V$$

$$P_{SHUNT}=V_{MAX}\times I_{LOAD}=2\times 2=4\,W$$

Ammeter

$$I_{SHUNT}=\frac{V_{SHUNT}}{R_{SHUNT}}$$

$$V_{SHUNT}=V_{ANALOG}$$

$$I_{SHUNT}=\frac{\frac{V_{REF}}{2^{RES}}\times ADRES}{R_{SHUNT}}$$

$$I_{SHUNT}=\frac{\frac{2.048}{1024}\times ADRES}{1}$$

$$I_{SHUNT}=\frac{2.048}{1024}\times ADRES$$

$$I_{SHUNT}=V_{SHUNT}=V_{ANALOG}$$