Conversion of Cell Voltage Reading to the Corresponding I2C Reading

* ADC conversions using a 10 bit analog to digital converter
* $V_{\text{ref}} = 2.048\text{V}$

1. **Actual Cell Voltage Reading, $V_a$ (V)**
2. **Voltage Sensor**
   $$V_s = 4.096 - V_a$$
3. **ADC Conversion**
   $$V_v = \left(\frac{V_s}{V_{\text{ref}}}\right)\times(2^{10}-1)$$
4. **I2C Reading**
   $$V_v \rightarrow \text{Convert from decimal to hexadecimal}$$

Conversion of the I2C Reading of the Cell Voltage to Actual Cell Voltage

Actual Voltage Reading, $V_a = 4.096 - V_{\text{ref}} \times \left(\frac{V_v}{2^{10}-1}\right)$
Conversion of Cell Temperature Reading to the Corresponding I2C Reading

- ADC conversions using a 10 bit analog to digital converter
- \( V_{\text{ref}} = 2.048 \text{V} \)

\[
\text{Actual Temperature Reading } T \ (\degree\text{C})
\]

\[
T, \ \text{input to the temperature sensor}
\]

\[
\text{Temperature Sensor}
\]

\[
V_s = 0.01 \times T + 0.5
\]

\[
V_t (V), \ \text{output to the temperature sensor and input to the ADC channel of the PIC}
\]

\[
\text{ADC Conversion}
\]

\[
V_t = \left( \frac{V_s}{V_{\text{ref}}} \right) \times (2^{10} - 1)
\]

\[
\text{I2C Reading}
\]

\[
V_t \rightarrow \text{Convert from decimal to hexadecimal}
\]

Conversion of the I2C Reading of the Cell Temperature to Actual Cell Temperature

\[
\text{Actual Temperature Reading, } T = \frac{V_{\text{ref}} \times \left( \frac{V_t}{2^{10} - 1} \right) - 0.5}{0.01}
\]
Conversion of Charging Current Reading to the Corresponding I2C Reading

* ADC conversions using a 10 bit analog to digital convertor
* \( V_{\text{ref}} = 2.048V \)
* \( G = \) gain of op amp
* \( V_{\text{off}} = \) offset of op amp
* \( R = \) resistance of bar

Actual Charging Current Reading \( I_c \) (A)

\[ I_c, \text{ input to the current sensor} \]

Current Sensor

\[ V_s = (I_c \cdot R - V_{\text{off}}) \cdot G \]

\( V_s, (V), \text{ output to the current sensor and input to the ADC channel of the PIC} \)

ADC Conversion

\[ V_{ic} = \left( \frac{V_s}{V_{\text{ref}}} \right) \cdot ((2^{10})-1) \]

\( V_{ic} \rightarrow \text{Convert from decimal to hexadecimal} \)

I2C Reading

Conversion of the I2C Reading of the Charging Current to Actual Charging Current

\[ \text{Actual Charging Current Reading,} \ I_c = \left( \frac{V_{\text{ref}}}{G} \right) \cdot \left( \frac{V_{ic}}{2^{10} - 1} \right) + V_{\text{off}} \]
Conversion of Discharging Current Reading to the Corresponding I2C Reading

- ADC conversions using a 10 bit analog to digital converter
- \( V_{\text{ref}} = 2.048V \)
- \( G \) = gain of op amp
- \( V_{\text{off}} \) = offset of op amp
- \( R \) = resistance of bar

Actual Discharging Current Reading \( I_d \) (A)

\[ V_s = (I_d \cdot R - V_{\text{off}}) \cdot G \]

Current Sensor

\( V_s \) (V), output to the current sensor and input to the ADC channel of the PIC

ADC Conversion

\[ V_{\text{id}} = \left( \frac{V_s}{V_{\text{ref}}} \right) \cdot (2^{10} - 1) \]

I2C Reading

\( V_{\text{id}} \rightarrow \) Convert from decimal to hexadecimal

Conversion of the I2C Reading of the Discharging Current to Actual Discharging Current

\[
\text{Actual Discharging Current Reading, } I_d = \frac{V_{\text{ref}}}{G} \cdot \left( \frac{V_{\text{id}}}{2^{10} - 1} \right) + V_{\text{off}}
\]
Conversion of the I2C Reading of the Charging Coulomb Count to the Actual Charging Coulomb Count

* ADC conversions using a 10 bit analog to digital converter
* \( V_{\text{ref}} = 2.048V \)
* \( G = \) gain of op amp
* \( V_{\text{off}} = \) offset of op amp
* \( R = \) resistance of bar
* \( \Delta t = \) time between two current samples = 4ms = 0.004s
* \( \text{CCount}_c = 32 \) bit Charging Coulomb Count reading from the PIC
* \( N_c = 32 \) bit count of the number of times the sampled charging current was summed to get the coulomb count

We know,

\[
\text{Actual Charging Current, } I_c = \frac{(V_{\text{ref}}/R) \cdot (V_c/R) + V_{\text{off}}}{R} = \frac{(V_{\text{ref}}/R) \cdot (V_c/R) + V_{\text{off}}}{R}
\]

\[
\therefore I_c = \alpha \ast V_c + \beta, \quad \text{where } \alpha = \left( \frac{V_{\text{ref}}}{G \cdot (2^{10} - 1) \cdot R} \right), \quad \beta = \frac{V_{\text{off}}}{R}
\]

Over a period of time over which \( N_c \) number of charging current samples have been taken,

\[
\text{CCount}_c = \sum_{k=0}^{N_c} V_c(k)
\]

Now,

\[
\sum_{k=0}^{N_c} I_c(k) = \alpha \ast \text{CCount}_c + N_c \ast \beta
\]

\[
\text{Actual Charging Coulomb Count} = \sum_{k=0}^{N_c} I_c(k) \ast (\Delta t)
\]

\[
\therefore \text{Actual Charging Coulomb Count} = (\Delta t) \ast (\alpha \ast \text{CCount}_c + N_c \ast \beta)
\]
Conversion of the I2C Reading of the Discharging Coulomb Count to the Actual Discharging Coulomb Count

- ADC conversions using a 10 bit analog to digital converter
- $V_{ref} = 2.048V$
- $G = \text{gain of op amp}$
- $V_{off} = \text{offset of op amp}$
- $R = \text{resistance of bar}$
- $\Delta t = \text{time between two current samples} = 4\text{ms} = 0.004s$
- $\text{CCount}_d = 32\text{ bit Discharging Coulomb Count reading from the PIC}$
- $N_d = 32\text{ bit count of the number of times the sampled charging current was summed to get the coulomb count}$

We know,

$\begin{align*}
\text{Actual Discharging Current, } I_d &= \left(\frac{V_{ref}}{G}\right) \left(\frac{V_{id}}{R}\right) + V_{off} + \frac{V_{off}}{R} \\
\therefore \quad I_d &= \alpha \cdot V_{id} + \beta, \quad \text{where} \quad \alpha = \frac{V_{ref}}{G \cdot (2^{10} - 1) \cdot R}, \quad \beta = \frac{V_{off}}{R}
\end{align*}$

Over a period of time over which $N_d$ number of discharging current samples have been taken,

$\text{CCount}_d = \sum_{k=0}^{N_d} V_{id}(k)$

Now,

$\sum_{k=0}^{N_d} I_d(k) = \alpha \cdot \text{CCount}_d + N_d \cdot \beta$

$\text{Actual Discharging Coulomb Count} = \sum_{k=0}^{N_d} I_d(k) \times (\Delta t)$

$\therefore \quad \text{Actual Discharging Coulomb Count} = (\Delta t) \ast (\alpha \ast \text{CCount}_d + N_d \ast \beta)$