LTC3: Battery Charging Schematic Numbers for LTC3, LT8490

Objective: To review and clarify component value choices for the LT8490 schematic in the LTC3 system for PSAS.

Basic Parameters

Stage 2 Charging Voltage: 33.6V
Maximum Charging Current: 10A
Maximum Pre-charge/Trickle Current: 1A
Maximum Input Current: 10A
Switching Frequency: 202 kHz

Table of Chosen Values

Input Feedback Resistor Network

R_{FBIN1}	93.1 kΩ
R_{FBIN2}	7.68 kΩ
R_{DACI1}	3.32 kΩ
R_{DACI2}	16.5 kΩ
C_{DACI}	33 μF

Output Feedback Resistor Network

R_{FBOUT1}	294 kΩ
R_{FBOUT2}	10.2 kΩ
R_{DACO1}	57.6 kΩ
R_{DACO2}	1.5 kΩ
C_{DACO}	.18 μF

Current Limiting

R_{SENSE1}	5 mΩ
R_{SENSE2}	5 mΩ
R_{IMON_OUT}	243 kΩ
R_{IOW}	27.1 kΩ
C_{IMON_OUT}	10 nF

Input Feedback Resistor Network

The Input Feedback network is essentially what tells the LT8490 the present input voltage and current from the solar panel, and tells the LT8490 the maximum input voltage to accept. The true maximum input voltage is defined as

$$V_{X1} = V_{X2} - 3.3 \cdot \left(\frac{R_{FBIN1}}{R_{DAC1} + R_{DAC2}} \right),$$

where

$$V_{X2} = 1.205 \cdot \left[\frac{R_{FBIN1}}{R_{DACI1} + R_{DACI2}} + \left(\frac{R_{FBIN1}}{R_{FBIN2}} \right) + 1 \right].$$

We want V_{X1} to be as close to 6V as possible, which is accomplished by iterating over multiple values of R_{FBIN1}, R_{FBIN2}, R_{DAC1}, and R_{DAC2}. Given our values, V_{X1} is 5.971V, giving a percent error of .48% from the ideal value of 6. This means that the LT8490 sees a maximum input voltage of 21.47V.

Due to the nature of the iterative process, some component values were not chosen based on their closest real resistor value, but rather the value that would get V_{X1} as close to 6V as possible. More information can be found on page 14 of the LT8490 datasheet.

The equation for R_{FBIN1} can be found on page 14 of the LT8490 datasheet, and is described by

$$R_{FBIN1} = 100k \bullet \left[\frac{1 + \left(\frac{4.470V}{V_{MAX} - 6V} \right)}{1 + \left(\frac{5.593}{V_{MAX} - 6V} \right)} \right] \Omega$$

When we set our V_{MAX} to the short circuit voltage of the solar panel, which is 21.7V, we get a value of 94.7 kΩ for R_{FBIN1}. The chosen resistor value is 93.1 kΩ.

The equation for R_{DAC2} can be found on page 14 of the LT8490 datasheet, and is described by

$$R_{DACI2} = 2.75 \bullet \left(\frac{R_{FBIN1}}{V_{MAX} - 6V} \right) \Omega$$

Given our R_{FBIN1} value of 94.7 kΩ and our V_{MAX} of 21.7V, we get a R_{DACI2} value of 16.59 kΩ. The chosen resistor value is 16.5 kΩ.

The equation for R_{FBIN2} can be found on page 14 of the LT8490 datasheet, and is described by

$$R_{FBIN2} = \frac{1}{\left(\frac{1}{100k - R_{FBIN1}} \right) - \left(\frac{1}{R_{DACI2}} \right)} \Omega$$

Given our R_{FBIN1} value of 94.7 kΩ and our R_{DACI2} value of 16.59 kΩ, our resulting R_{FBIN2} value is 7.808kΩ. The chosen R_{FBIN2} value is 7.68 kΩ.

The equation for R_{DACI1} can be found on page 14 of the LT8490 datasheet, and is described by

$$R_{DACI1} = 0.2 \bullet R_{DACI2} \Omega$$

Given our R_{DACI2} value of 16.59 kΩ, the resulting R_{DACI1} value is 3.318 kΩ. The chosen R_{DACI1} value is 3.32 kΩ.

The equation for C_{DACI} can be found on page 14 of the datasheet and is described by

$$C_{DACI} = \frac{1}{1000 \bullet R_{DACI1}} F$$

Given our R_{DACI1} value of 3.318 kΩ, we get a C_{DACI} value of .301 μF. The chosen C_{DACI} value is .33 μF.

Output Feedback Resistor Network

The Output Feedback Resistor Network determines the maximum output voltage of the LT8490, which determines stage 3 charging voltage of the LiPo cells. The accuracy of this network is critical to fully charging the batteries. The true stage 3 voltage is described by

$$V_{X3} = \left(\frac{R_{FBOUT1}}{R_{DACO1} + R_{DACO2}}\right) \bullet (X - 1.89),$$

where

$$X = 1.211 \bullet \left[1 + \left(\frac{R_{DACO1} + R_{DACO2}}{R_{FBOUT2}}\right) + \left(\frac{R_{DACO1} + R_{DACO2}}{R_{FBOUT1}}\right)\right].$$

We want V_{X3} to be as close as possible to 33.6 V. With our chosen resistor values, our stage 3 voltage is 33.225 V. This is a 1.04% error from the ideal value of 33.6 V. These values were chosen by iterating over multiple real resistor values.

Due to the nature of the iterative process, some component values were not chosen based on their closest real resistor value, but rather the value that would get V_{X3} as close to 33.6 V as possible. This process is described on page 17 of the LT8490 datasheet.

The equation for R_{FBOUT1} can be found on page 17 of the LT8490 datasheet, and is described by

$$R_{FBOUT1} = R_{FBOUT2} \bullet \left[V_{S2} \bullet \left(\frac{1.241}{1.211} - 0.128\right) - 1\right] \Omega.$$

R_{FBOUT2} is a chosen resistor value, with recommended values 4.99 kΩ and 49.9 kΩ. Our chosen R_{FBOUT2} value is 10.2 kΩ. Given our chosen R_{FBOUT2} value of 10.2 kΩ and our stage 2 voltage limit of 33.6 V (V_{S2}), our calculated R_{FBOUT1} is 291.12 kΩ. The chosen R_{FBOUT1} value is 294 kΩ.

The equation for R_{DACO2} can be found on page 17 of the LT8490 datahseet, and is described by

$$R_{DACO2} = \frac{R_{FBOUT1} \bullet R_{FBOUT2} \bullet 0.833}{\left(R_{FBOUT2} \bullet V_{S2} \bullet \frac{1.241}{1.211}\right) - R_{FBOUT2} - R_{FBOUT1}} \Omega.$$

Given our R_{FBOUT1} value of 291.12 kΩ, our R_{FBOUT2} value of 10.2 kΩ, and our V_{S2} of 33.6 V, the resulting R_{DACO2} value is 53.14 kΩ. The chosen R_{DACO2} value is 57.6 kΩ.

The equation for R_{DACO1} can be found on page 17 of the LT8490 datahseet, and is described by

$$R_{DACO1} = 0.2 \cdot R_{DACO2} \Omega$$

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Given our R_{DACO2} value of 53.14 kΩ, we get an R_{DACO1} value of 10.68 kΩ. The chosen value of R_{DACO1} is 11.5 kΩ.

The equation for C_{DACO} can be found on page 17 of the LT8490 datasheet, and is described by

$$C_{DACO} = \frac{1}{500 \cdot R_{DACO1}} F$$

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Given our R_{DACO1} value of 10.68 kΩ, the resulting C_{DACO} value is .174 µF. The chosen value of C_{DACO} is .18 µF.

Input Current Limiting

Because our design incorporates a DC Lab Supply power input option, input current limiting is necessary. Current limiting is accomplished by adjusting the value of R_{SENSE1} which measures the input current from either the lab supply or the solar panel. The voltage across R_{SENSE1} affects the voltage on the IMON_IN pin, dropping the V_C voltage, and thus reducing the input current. More information can be found on page 19 of the LT8490 datasheet.

The equation to determine R_{SENSE1} can be found on page 19 of the LT8490 datasheet and is described by

$$R_{SENSE1} = \frac{1000 \cdot \left(\frac{1.208V}{21k\Omega} - 7\mu A \right)}{I_{IN(MAX)}} = \frac{0.0505}{I_{IN(MAX)}} \Omega$$

.

Given our desired $I_{IN(MAX)}$ of 10 A, the resulting R_{SENSE1} value is 5.05 mΩ. The chosen R_{SENSE1} value is 5 mΩ.

Charge Current Limiting

The maximum charging current is configured by a network dependent on R_{SENSE2}. The current passing through R_{SENSE2} is measured and a voltage drop across IMON_OUT is created. When the IMON_OUT voltage is above 1.208 V, V_C is reduced, and thus the charging current is limited. More information can be found on page 18 of the LT8490 datasheet.

The equation to determine R_{SENSE2} can be found on page 19 of the LT8490 datasheet and is described by

$$R_{SENSE2} = \frac{0.0497}{I_{OUT(MAX)}}\Omega$$

Given our $I_{OUT(MAX)}$ of 10 A, the resulting R_{SENSE2} value is 4.97 mΩ. The chosen value for R_{SENSE2} is 5 mΩ.

The equation to determine R_{IMON_OUT} can be found on page 19 of the LT8490 datasheet, and is described by

$$R_{IMON\_OUT} = \frac{1208}{I_{OUT(MAXSO)} \bullet R_{SENSE2}}\Omega$$

Given our value of 4.97 mΩ for R_{SENSE2} and 1 A for $I_{OUT(MAXSO)}$ (pre-charge current maximum), the resulting value for R_{IMON_OUT} is 241.6 kΩ. The chosen value is 243 kΩ.

The equation for R_{IOW} can be found on page 19 of the LT8490 datasheet, and is described by

$$R_{IOW} = \frac{24.3k \bullet R_{IMON\_OUT}}{R_{IMON\_OUT} - 24.3k}\Omega$$

Given our R_{IMON_OUT} value of 241.6 kΩ, the resulting R_{IOW} value is 27.01 kΩ. The chosen R_{IOW} value is 27.1 kΩ.

The values for R_{IOR} and C_{IMON_OUT} are given as 3.01 kΩ and 10 nF are given in the LT8490 datasheet on page 19.

Temperature Sensing

Temperature sensing is accomplished using the TEMPSENSE pin on the LT8490. With the AV_{DD} pin, a voltage divider is created between an 11.5 kΩ resistor and a 10 kΩ, ß = 3380 NTC thermistor. The voltage on the TEMPSENSE pin then tells the LT8490 the battery temperature.