AN12969

Busbar design application note

Rev. 2 — 15 May 2023 **Application note**

Document Information

Information	Content
Keywords	MC33771x, busbar
Abstract	This application note describes how to connect busbars to NXP battery cell controllers.

Revision history

Rev	Date	Description
2	20230515	changed security status to public
1	20210108	initial version

1 Introduction

1.1 Definition of a busbar

In battery packs for electric mobility, a busbar is used to connect battery cells or modules. In automotive battery packs, busbars are used to connect battery modules together. Busbars are made of copper. In a schematic, a very small resistance represents the busbar. Busbars typically have very low impedance.

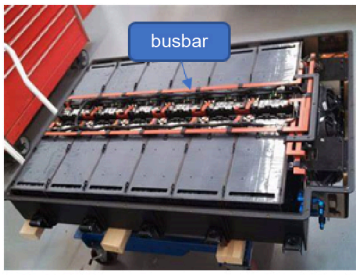

Figure 1. Busbar example

2 Busbar location determination

2.1 Conventional design requirement

If a cluster has fewer cells than the maximum number of cells, the usage of cell terminal pins CT_x and cell balancing pins CB_x has to fulfill some constraints. Stacked cells in an arrangement from 7 cells to 14 cells are described in Table 1.

Table 1. Arrangement when the cluster has fewer cells than the maximum number of cells for MC33771B/C

Cell	Stacked cells							
	14	13	12	11	10	9	8	7
1	CT_REF/CT_1	CT_REF/CT_1	CT_REF/CT_1	CT_REF/CT_1	CT_REF/CT_1	CT_REF/CT_1	CT_REF/CT_1	CT_REF/CT_1
2	CT_1/CT_2	CT_1/CT_2	CT_1/CT_2	CT_1/CT_2	CT_1/CT_2	CT_1/CT_2	CT_1/CT_2	CT_1/CT_2
3	CT_2/CT_3	CT_2/CT_3	CT_2/CT_3	CT_2/CT_3	CT_2/CT_3	CT_2/CT_3	CT_2/CT_3	CT_2/CT_3
4	CT_3/CT_4	CT_3/CT_4	CT_3/CT_4	CT_3/CT_4	CT_3/CT_4	CT_3/CT_4	CT_3/CT_4	CT_3/CT_4
5	CT_4/CT_5	CT_5/CT_6	CT_6/CT_7	CT_7/CT_8	CT_8/CT_9	CT_9/CT_10	CT_10/CT_11	CT_11/CT_12
6	CT_5/CT_6	CT_6/CT_7	CT_7/CT_8	CT_8/CT_9	CT_9/CT_10	CT_10/CT_11	CT_11/CT_12	CT_12/CT_13
7	CT_6/CT_7	CT_7/CT_8	CT_8/CT_9	CT_9/CT_10	CT_10/CT_11	CT_11/CT_12	CT_12/CT_13	CT_13/CT_14
8	CT_7/CT_8	CT_8/CT_9	CT_9/CT_10	CT_10/CT_11	CT_11/CT_12	CT_12/CT_13	CT_13/CT_14	
9	CT_8/CT_9	CT_9/CT_10	CT_10/CT_11	CT_11/CT_12	CT_12/CT_13	CT_13/CT_14		
10	CT_9/CT_10	CT_10/CT_11	CT_11/CT_12	CT_12/CT_13	CT_13/CT_14			
11	CT_10/CT_11	CT_11/CT_12	CT_12/CT_13	CT_13/CT_14				
12	CT_11/CT_12	CT_12/CT_13	CT_13/CT_14					
13	CT_12/CT_13	CT_13/CT_14						
14	CT_13/CT_14							

In summary, channel 5 to channel 11 could be short when the system needs fewer cells. Therefore, the busbar could assemble these channels.

2.2 The pattern of busbar arrangement

There are two possibilities to add the busbar.

- Busbar is assembled to one channel independently.

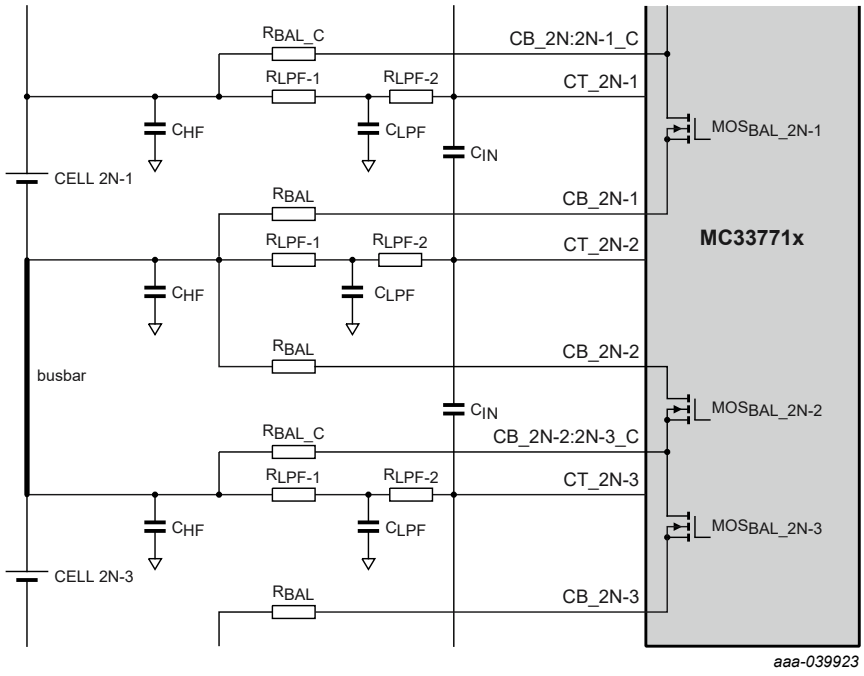

Figure 2. Busbar is connected to one channel independently

Advantage: The busbar is connected to one channel itself, it does not influence the accuracy of the adjacent cells.

Disadvantage: The busbar occupies one channel.

Note: *Negative voltage may be generated when the battery is discharged. The negative voltage limit for every channel is −0.3 V. If this voltage is exceeded, the measurement accuracy of adjacent channels would be influenced. In worst case, the device may be damaged. The user must control the busbar resistance and makes sure that in the worst case current condition, the drop is not higher than 0.3 V. If it is not possible, this option cannot be used.*

Note: *If the busbar occupies one channel as shown in Figure 2, CT_x OV/UV functional verification (SM01) must be disabled. Otherwise it triggers a false alarm.*

- Busbar and cell are assembled to the same channel.

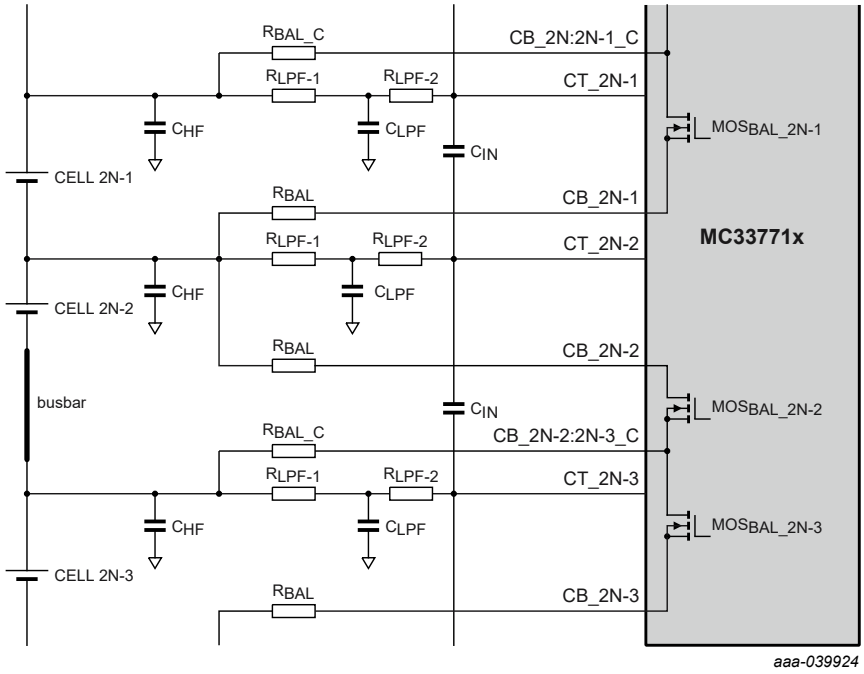

Figure 3. Busbar and cell are connected to the same channel

Advantage: The busbar does not occupy any channel.

Disadvantage: When large current goes through the busbar, the voltage drop on busbar influences the accuracy of the channel.

2.3 Special design requirements

As a system requirement, some users may add a busbar to the channel that is out of the range of channel 5 to channel 11. For this application, the condition to add a busbar should be listed in detail. The most important limitation for busbar location is the voltage requirement of every CT_x pin. If the voltage cannot satisfy the requirement, the accuracy of CT_x may be impacted. The voltage requirement is listed in Table 2.

Table 2. Voltage requirement of every MC33771x pin

MC33771x pin	Minimum voltage to AGND (V)	Minimum absolute voltage to VPWR (V)
CT_REF	-	-
CT_1	-	-
CT_2	1.9	-
CT_3	1.9	-
CT_4	4.8	-
CT_5	-	-
CT_6	-	-
CT_7	-	-
CT_8	-	-
CT_9	-	-

Table 2. Voltage requirement of every MC33771x pin*...continued*

MC33771x pin	Minimum voltage to AGND (V)	Minimum absolute voltage to VPWR (V)
CT_10	-	-
CT_11	-	6
CT_12	-	4
CT_13	-	-
CT_14	-	-

The user should configure the busbar based on the application cell voltages, making sure that the conditions in Table 2 are met in all cases. Typical battery operation voltage ranges are shown in Table 3.

Table 3. Voltage range of battery

Technology	Acronym	Nominal voltage (V)	Full charge voltage (V)	End of discharge voltage (V)
$LiNiMnCoO_2$	NMC	3.6 to 3.7	4.2	2.5 to 3.0
$LiNiCoAlO_2$	NCA	3.6	4.2	2.7
$LiFePO_4$	LFP	3.2	3.6	2.0
$LiCoO_2$	LCO	3.7	4.2	2.4
Li_2TiO_3	LTO	2.4	3 to 3.9	1.5
$LiMn_2O_4$	LMO	3.0	3.5	2.0

3 Busbar installation during battery pack assembly

To avoid damaging the battery cell controller (BCC) during the installation, all the busbars of the battery must be connected first. Then the MC33771x could be plugged in.

Table 4. Busbar configuration examples

MC33771x	3 × 3 cells	3 × 4 cells	2 × 6 cells	13 cells
Position between pin CT_14 and pin CT_13	module 3 cell 3	module 3 cell 4	module 2 cell 6	module 1 cell 13
Position between pin CT_13 and pin CT_12	module 3 cell 2	module 3 cell 3	module 2 cell 5	module 1 cell 12
Position between pin CT_12 and pin CT_11	module 3 cell 1	module 3 cell 2	module 2 cell 4	module 1 cell 11
Position between pin CT_11 and pin CT_10	busbar	module 3 cell 1	module 2 cell 3	module 1 cell 10
Position between pin CT_10 and pin CT_9	module 2 cell 3	busbar	module 2 cell 2	module 1 cell 9
Position between pin CT_9 and pin CT_8	module 2 cell 2	module 2 cell 4	module 2 cell 1	module 1 cell 8
Position between pin CT_8 and pin CT_7	module 2 cell 1	module 2 cell 3	busbar	module 1 cell 7
Position between pin CT_7 and pin CT_6	0 Ω	module 2 cell 2	module 1 cell 6	module 1 cell 6
Position between pin CT_6 and pin CT_5	0 Ω	module 2 cell 1	module 1 cell 5	module 1 cell 5
Position between pin CT_5 and pin CT_4	0 Ω	busbar	0 Ω	0 Ω
Position between pin CT_4 and pin CT_3	busbar	module 1 cell 4	module 1 cell 4	module 1 cell 4
Position between pin CT_3 and pin CT_2	module 1 cell 3	module 1 cell 3	module 1 cell 3	module 1 cell 3
Position between pin CT_2 and pin CT_1	module 1 cell 2	module 1 cell 2	module 1 cell 2	module 1 cell 2
Position between pin CT_1 and pin CT_REF	module 1 cell 1	module 1 cell 1	module 1 cell 1	module 1 cell 1

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