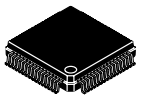


MC33771B_SDS

Battery cell controller IC

Rev. 6.0 — 22 June 2020 Product short data sheet

1 General description

The 33771 is a SMARTMOS lithium-ion battery cell controller IC designed for automotive applications, such as hybrid electric (HEV) and electric vehicles (EV) along with industrial applications, such as energy storage systems (ESS) and uninterruptible power supply (UPS) systems.

The device performs ADC conversions of the differential cell voltages and current, as well as battery coulomb counting and battery temperature measurements. The information is digitally transmitted through the Serial Peripheral Interface (SPI) or Transformer Isolation (TPL) to a microcontroller for processing.

2 Features

- 9.6 V ≤ V_{PWR} ≤ 61.6 V operation, 75 V transient
- 7 to 14 cells management
- Isolated 2.0 Mbps differential communication or 4.0 Mbps SPI
- Addressable on initialization
- 0.8 mV maximum total voltage measurement error
- Synchronized cell voltage/current measurement with coulomb count
- Total stack voltage measurement
- Seven GPIO/temperature sensor inputs
- 5.0 V at 5.0 mA reference supply output
- Automatic over/undervoltage and temperature detection routable to fault pin
- Integrated sleep mode over/undervoltage and temperature monitoring
- Onboard 300 mA passive cell balancing with diagnostics
- Hot plug capable
- Detection of internal and external faults, as open lines, shorts, and leakages
- Designed to support ISO 26262, up to ASIL D safety system
- Fully compatible with the MC33772 for a maximum of six cells
- Qualified in compliance with AEC–Q100

3 Simplified application diagram

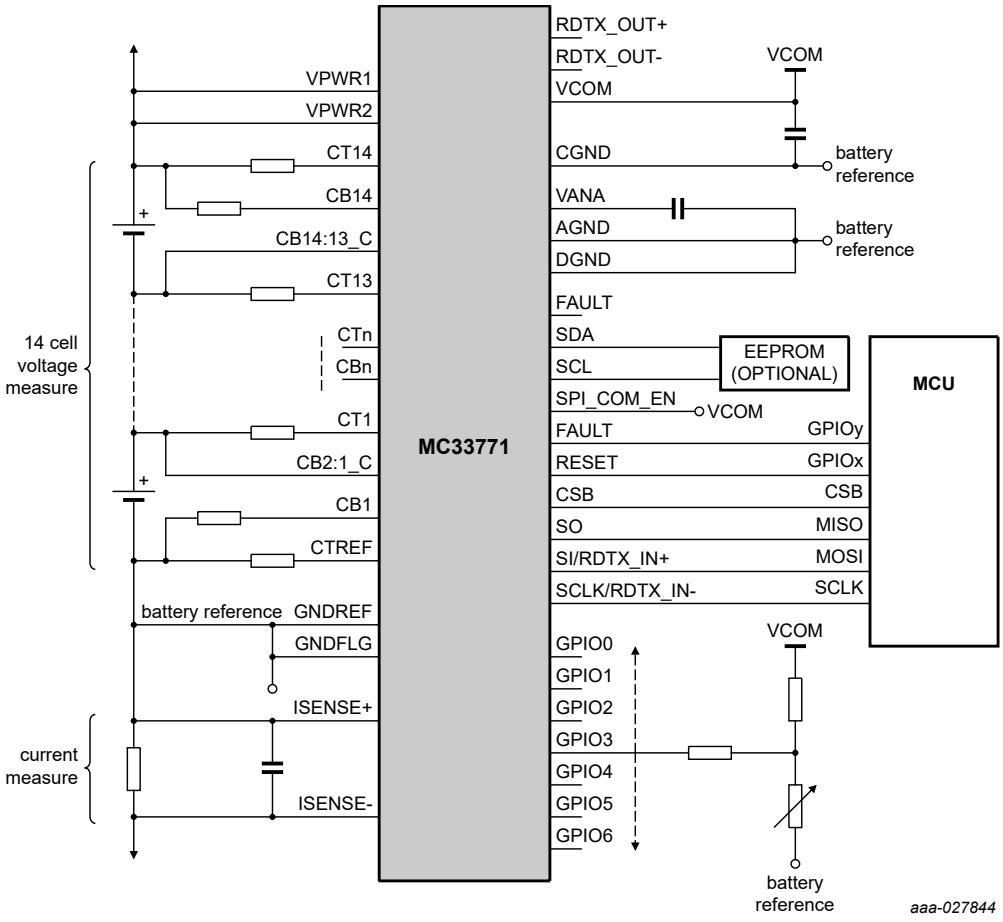


Figure 1. Simplified application diagram, SPI use case

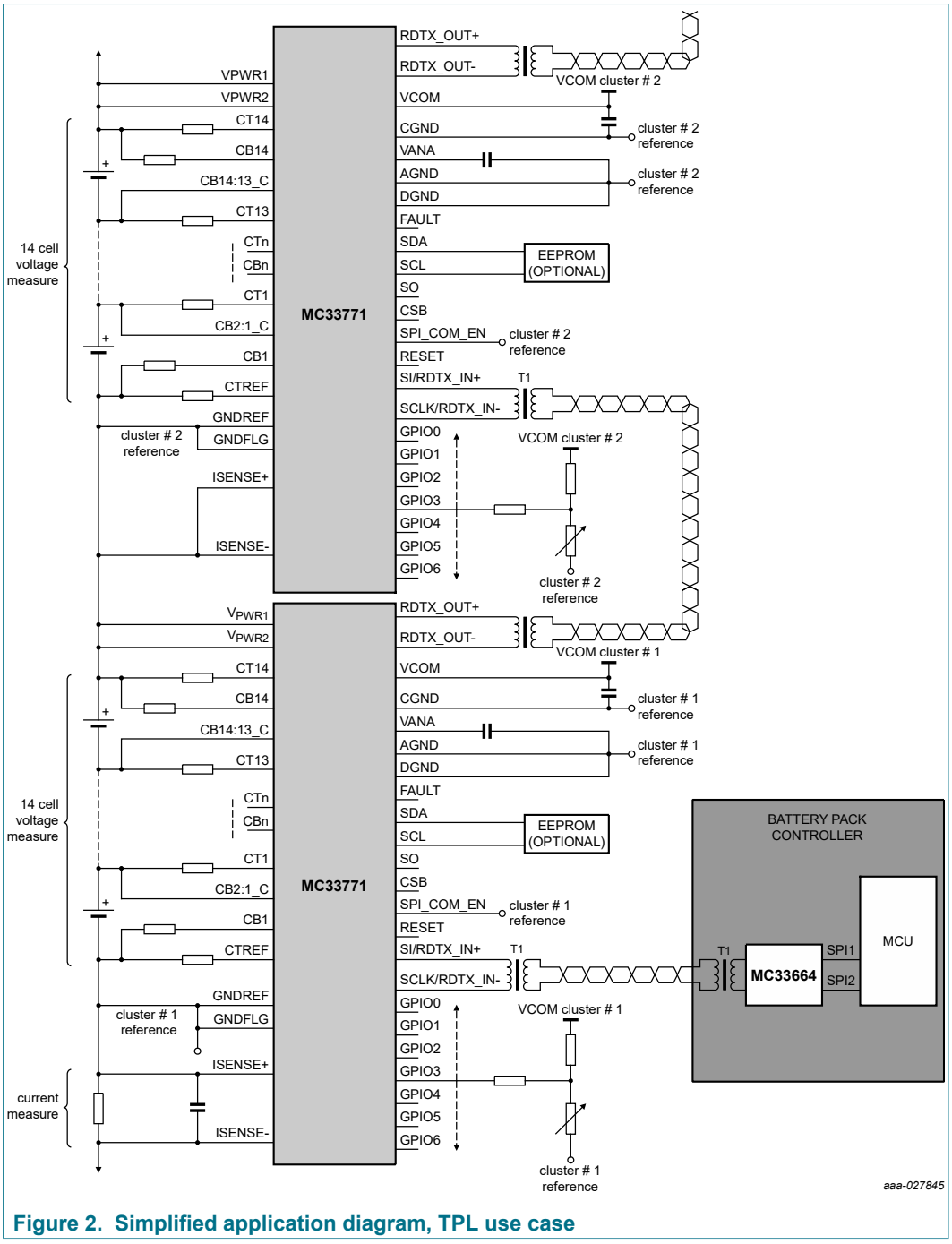


Figure 2. Simplified application diagram, TPL use case

4 Applications

- Automotive: 48 V and high-voltage battery packs
- E-bikes, e-scooters
- Energy storage systems
- Uninterruptible power supply (UPS)

5 Ordering information

5.1 Part numbers definition

MC33771B x y z AE/R2

Table 1. Part number breakdown

Code	Option	Description
x	S	x = S (SPI communication type)
	T	x = T (TPL communication type)
y	A	y = A (Advanced)
	B	y = B (Basic)
	P	y = P (Premium)
z	1	z = 1 (7 to 14 channels)
	2	z = 2 (7 to 8 channels)
	AE	Package suffix
	R2	Tape and reel indicator

5.2 Part numbers list

This section describes the part numbers available to be purchased along with their differences. Valid orderable part numbers are provided on the web. To determine the orderable part numbers for this device, go to http://www.nxp.com.

Table 2. Advanced orderable part table

Temperature range is −40 to 105 °C
Package type is 64-pin LQFP-EP

Orderable part	Number of channels	OV/UV	Precision GPIO as temperature channels and OT/UT	Current channel or coulomb count
SPI communication protocol				
MC33771BSA1AE	7 to 14	Yes	Yes	No
MC33771BSA2AE	7 to 8	Yes	Yes	No
TPL differential communication protocol				
MC33771BTA1AE	7 to 14	Yes	Yes	No
MC33771BTA2AE	7 to 8	Yes	Yes	No

Table 3. Basic orderable part table

Temperature range is −40 to 105 °C
Package type is 64-pin LQFP-EP

Orderable part	Number of channels	OV/UV	Precision GPIO as temperature channels and OT/UT	Current channel or coulomb count
SPI communication protocol				
MC33771BSB1AE	7 to 14	Yes	No	No
MC33771BSB2AE	7 to 8	Yes	No	No
TPL differential communication protocol				
MC33771BTB1AE	7 to 14	Yes	No	No
MC33771BTB2AE	7 to 8	Yes	No	No

Table 4. Premium orderable part table

Temperature range is −40 to 105 °C
Package type is 64-pin LQFP-EP

Orderable part	Number of channels	OV/UV	Precision GPIO as temperature channels and OT/UT	Current channel or coulomb count
SPI communication protocol				
MC33771BSP1AE	7 to 14	Yes	Yes	Yes
MC33771BSP2AE	7 to 8	Yes	Yes	Yes
TPL differential communication protocol				
MC33771BTP1AE	7 to 14	Yes	Yes	Yes
MC33771BTP2AE	7 to 8	Yes	Yes	Yes

6 Pinning information

6.1 Pinout diagram

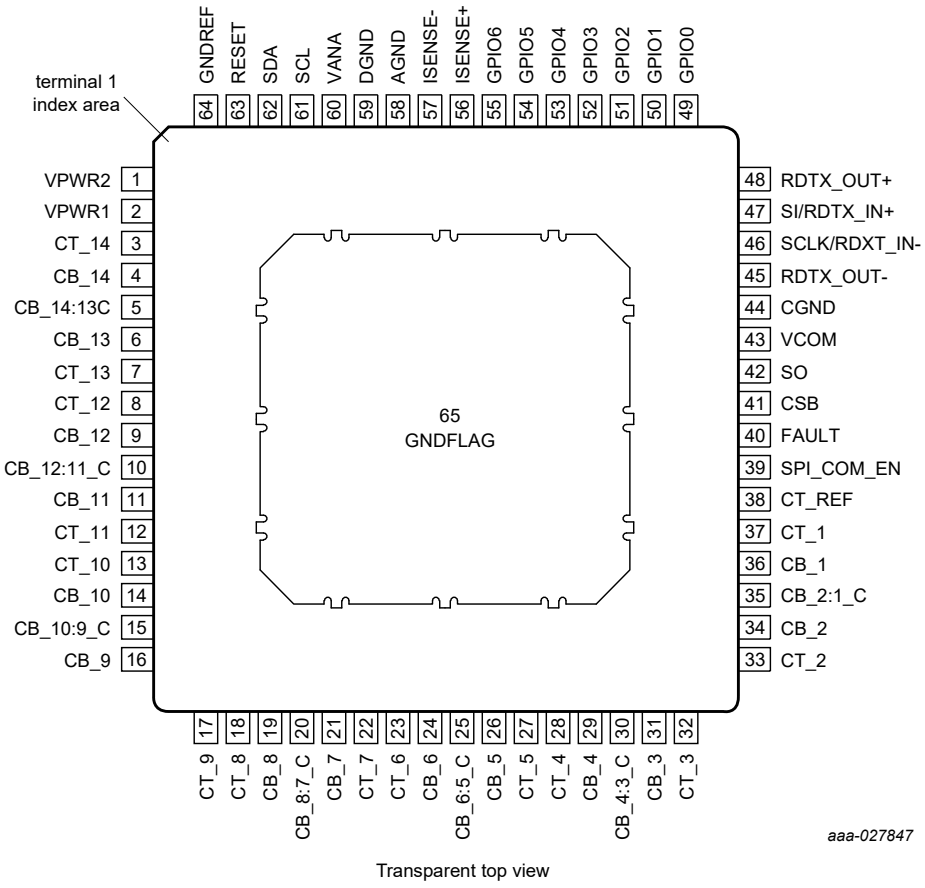


Figure 3. Pinout diagram

6.2 Pin definitions

Table 5. Pin definitions

Number	Name	Function	Definition
1	VPWR2	Input	Power input to the 33771
2	VPWR1	Input	Power input to the 33771
3	CT_14	Input	Cell pin 14 input. Terminate to LPF resistor.
4	CB_14	Output	Cell balance driver. Terminate to cell 14 cell balance load resistor.
5	CB_14:13_C	Output	Cell balance 14:13 common. Terminate to cell 14 and 13 common pin.
6	CB_13	Output	Cell balance driver. Terminate to cell 13 cell balance load resistor.
7	CT_13	Input	Cell pin 13 input. Terminate to LPF resistor.
8	CT_12	Input	Cell pin 12 input. Terminate to LPF resistor.

Number	Name	Function	Definition
9	CB_12	Output	Cell balance driver. Terminate to cell 12 cell balance load resistor.
10	CB_12:11_C	Output	Cell balance 12:11 common. Terminate to cell 12 and 11 common pin.
11	CB_11	Output	Cell balance driver. Terminate to cell 11 cell balance load resistor.
12	CT_11	Input	Cell pin 11 input. Terminate to LPF resistor.
13	CT_10	Input	Cell pin 10 input. Terminate to LPF resistor.
14	CB_10	Output	Cell balance driver. Terminate to cell 10 cell balance load resistor.
15	CB_10:9_C	Output	Cell balance 10:9 common. Terminate to cell 10 and 9 common pin.
16	CB_9	Output	Cell balance driver. Terminate to cell 9 cell balance load resistor.
17	CT_9	Input	Cell pin 9 input. Terminate to LPF resistor.
18	CT_8	Input	Cell pin 8 input. Terminate to LPF resistor.
19	CB_8	Output	Cell balance driver. Terminate to cell 8 cell balance load resistor.
20	CB_8:7_C	Output	Cell balance 8:7 common. Terminate to cell 8 and 7 common pin.
21	CB_7	Output	Cell balance driver. Terminate to cell 7 cell balance load resistor.
22	CT_7	Input	Cell pin 7 input. Terminate to LPF resistor.
23	CT_6	Input	Cell pin 6 input. Terminate to LPF resistor.
24	CB_6	Output	Cell balance driver. Terminate to cell 6 cell balance load resistor.
25	CB_6:5_C	Output	Cell balance 6:5 common. Terminate to cell 6 and 5 common pin.
26	CB_5	Output	Cell balance driver. Terminate to cell 5 cell balance load resistor.
27	CT_5	Input	Cell pin 5 input. Terminate to LPF resistor.
28	CT_4	Input	Cell pin 4 input. Terminate to LPF resistor.
29	CB_4	Output	Cell balance driver. Terminate to cell 4 cell balance load resistor.
30	CB_4:3_C	Output	Cell balance 4:3 common. Terminate to cell 4 and 3 common pin.
31	CB_3	Output	Cell balance driver. Terminate to cell 3 cell balance load resistor.
32	CT_3	Input	Cell pin 3 input. Terminate to LPF resistor.
33	CT_2	Input	Cell pin 2 input. Terminate to LPF resistor.
34	CB_2	Output	Cell balance driver. Terminate to cell 2 cell balance load resistor.

Number	Name	Function	Definition
35	CB_2:1_C	Output	Cell Balance 2:1 common. Terminate to cell 2 and 1 common pin.
36	CB_1	Output	Cell balance driver. Terminate to cell 1 cell balance load resistor.
37	CT_1	Input	Cell pin 1 input. Terminate to LPF resistor.
38	CT_REF	Input	Cell pin REF input. Terminate to LPF resistor.
39	SPI_COM_EN	Input	SPI communication enable, pin must be high for the SPI to be active
40	FAULT	Output	Fault output dependent on user defined internal or external faults. If not used, it must be left open.
41	CSB	Input	SPI chip select
42	SO	Output	SPI serial output
43	VCOM	Output	Communication regulator output. Decouple with 2.2 µF ceramic.
44	CGND	Ground	Communication decoupling ground. Terminate to GNDREF
45	RDTX_OUT-	I/O	Receive/transmit output negative
46	SCLK/RDTX_IN-	I/O	SPI clock or receive/transmit input negative
47	SI/RDTX_IN+	I/O	SPI serial input or receiver/transmit input positive
48	RDTX_OUT+	I/O	Receive/transmit output positive
49	GPIO0	I/O	General purpose analog input or GPIO or wake-up or fault daisy chain
50	GPIO1	I/O	General purpose analog input or GPIO
51	GPIO2	I/O	General purpose analog input or GPIO or conversion trigger
52	GPIO3	I/O	General purpose analog input or GPIO
53	GPIO4	I/O	General purpose analog input or GPIO
54	GPIO5	I/O	General purpose analog input or GPIO
55	GPIO6	I/O	General purpose analog input or GPIO
56	ISENSE+	Input	Current measurement input+
57	ISENSE-	Input	Current measurement input−
58	AGND	Ground	Analog ground, terminate to GNDREF
59	DGND	Ground	Digital ground, terminate to GNDREF
60	VANA	Output	Precision ADC analog supply. Decouple with ceramic 47 nF ceramic capacitor to AGND.
61	SCL	I/O	I^2C clock
62	SDA	I/O	I^2C data

Number	Name	Function	Definition
63	RESET	Input	RESET is an active high input. RESET has an internal pull down. If not used, it can be tied to GND.
64	GNDREF	Ground	Ground reference for device. Terminate to reference of battery cluster.
65	GNDFLAG	Ground	Device flag. Terminate to lowest potential of battery cluster.

7 General product characteristics

7.1 Ratings and operating requirements relationship

The operating voltage range pertains to the VPWR pins referenced to the AGND pins.

Table 6. Ratings vs. operating requirements

Fatal range • Permanent failure might occur	Handling range – no permanent failure			Fatal range • Permanent failure might occur
	Lower limited operating range • No permanent failure, but IC functionality is not guaranteed	Normal operating range • 100 % functional	Upper limited operating range • IC parameters might be out of specification • Detection of V_{PWR} overvoltage is functional	
$V_{PWR} < -0.3$ V	7.6 V ≤ V_{PWR} < 9.6 V **Reset range:** –0.3 V ≤ V_{PWR} < 7.6 V	9.6 V ≤ V_{PWR} ≤ 61.6 V	61.6 V < V_{PWR} ≤ 75 V	75 V < V_{PWR}

In both upper and lower limited operating range, no information can be provided about IC performance. Only the detection of V_{PWR} overvoltage is guaranteed in the upper limited operating range.

Performance in normal operating range is guaranteed only if there is a minimum of seven battery cells in the stack.

7.2 Maximum ratings

Table 7. Maximum ratings

All voltages are with respect to ground unless otherwise noted. Exceeding these ratings may cause a malfunction or permanent damage to the device.

Symbol	Description (rating)	Min	Max	Unit
Electrical ratings				
VPWR1, VPWR2	Supply input voltage	−0.3	75	V
CT14	Cell terminal voltage	−0.3	75	V
VPWR to CT14	Voltage across VPWR1,2 pins pair and CT14 pin	−10	10.5	V
CT_N to CT_{N-1}	Cell terminal differential voltage [1]	−0.3	6.0	V
$CT_{N(CURRENT)}$	Cell terminal input current	—	±500	µA
CB_N to $CB_{N:N-1\_C}$ $CB_{N:N-1\_C}$ to CB_{N-1}	Cell balance differential voltage	—	10	V
CB_{N-1_C} to CTn-1	Cell balance input to cell terminal input	−10	+10	V

Symbol	Description (rating)	Min	Max	Unit
VISENSE	ISENSE+ and ISENSE– pin voltage	−0.3	2.5	V
VCOM	Maximum voltage may be applied to VCOM pin from external source	—	5.8	V
VANA	Maximum voltage may be applied to VANA pin	—	3.1	V
V_{GPIO0}	GPIO0 pin voltage	–0.3	6.5	V
V_{GPIOx}	GPIOx pins (x = 1 to 6) voltage	–0.3	VCOM + 0.5	V
V_{DIG}	Voltage I^2C pins (SDA, SCL)	–0.3	VCOM + 0.5	V
V_{RESET}	RESET pin	–0.3	6.5	V
V_{CSB}	CSB pin	–0.3	6.5	V
$V_{SPI\_COMM\_EN}$	SPI_COMM_EN	–0.3	6.5	V
V_{SO}	SO pin	–0.3	VCOM + 0.5	V
$V_{GPIO5,6}$	Maximum voltage for GPIO5 and GPIO6 pins used as current input	−0.3	2.5	V
FAULT	Maximum applied voltage to pin	−0.3	7.0	V
V_{COMM}	Maximum voltage to pins RDTX_OUT+, RDTX_OUT–, SI/RDTX_IN+, CLK/RDTX_IN–	−10.0	10.0	V
f_{SPI}	SPI frequency (SPI mode)	—	4.2	MHz
BR_{TPL}	Transformer communication bit rate (TPL mode)	1.9	2.1	Mbps
f_{TPL}	Transformer signal frequency (TPL mode)	3.8	4.2	MHz
V_{ESD}	ESD voltage Human body model (HBM) Charge device model (CDM) Charge device model corner pins (CDM)	 — — —	 ±2000 ±500 ±750	V
V_{ESD}	ESD voltage (VPWR1, VPWR2, CTx, CBx, GPIOx, ISENSE+, ISENSE−, RDTX_OUT+, RDTX_OUT−, SI/RDTX_IN+, SCLK/ RDTX_IN−) [2] Human body model (HBM)	 —	 ±4000	V
V_{ESD}	ESD voltage (CTREF, CTx, CBx, GPIOx, ISENSE+, ISENSE−, RDTX_OUT+, RDTX_OUT−, SI/RDTX_IN+, SCLK/ RDTX_IN−) IEC 61000-4-2, Unpowered (Gun configuration: 330Ω / 150pF) HMM, Unpowered (Gun configuration: 330Ω / 150pF) ISO 10605:2009, Unpowered (Gun configuration: 2 kΩ / 150pF) ISO 10605:2009, Powered (Gun configuration: 2 kΩ / 150pF)	 — — — —	 ±8000 ±8000 ±8000 ±8000	V

[1] Adjacent CT pins may experience an overvoltage that exceeds their maximum rating during OV/UV functional verification test or during open line diagnostic test. Nevertheless, the IC is completely tolerant to this special situation.

[2] ESD testing is performed in accordance with the human body model (HBM) (C_{ZAP} = 100 pF, R_{ZAP} = 1500 Ω), and the charge device model (CDM) (C_{ZAP} = 4.0 pF).

7.3 Thermal characteristics

Table 8. Thermal ratings

All voltages are with respect to ground unless otherwise noted. Exceeding these ratings may cause a malfunction or permanent damage to the device.

Symbol	Description (rating)		Min	Max	Unit
Thermal ratings					
	Operating temperature				°C
T_A	Ambient		−40	+105	
T_J	Junction		−40	+150	
T_{STG}	Storage temperature		−55	+150	°C
T_{PPRT}	Peak package reflow temperature	[1] [2]	—	260	°C
Thermal resistance and package dissipation ratings					
$R_{\Theta JB}$	Junction-to-board (bottom exposed pad soldered to board) 64 LQFP EP	[3]	—	10	°C/W
$R_{\Theta JA}$	Junction-to-ambient, natural convection, single-layer board (1s) 64 LQFP EP	[4] [5]	—	59	°C/W
$R_{\Theta JA}$	Junction-to-ambient, natural convection, four-layer board (2s2p) 64 LQFP EP	[4] [5]	—	27	°C/W
$R_{\Theta JCTOP}$	Junction-to-case top (exposed pad) 64 LQFP EP	[6]	—	14	°C/W
$R_{\Theta JCBOTTOM}$	Junction-to-case bottom (exposed pad) 64 LQFP EP	[7]	—	0.97	°C/W
ΨJT	Junction to package top, natural convection	[8]	—	3	°C/W

[1] Pin soldering temperature limit is for 10 seconds maximum duration. Not designed for immersion soldering. Exceeding these limits may cause a malfunction or permanent damage to the device.
[2] NXP's Package Reflow capability meets Pb-free requirements for JEDEC standard J-STD-020C. For Peak Package Reflow Temperature and Moisture Sensitivity Levels (MSL), go to www.nxp.com, search by part number (remove prefixes/suffixes) and enter the core ID to view all orderable parts (MC33xxxD enter 33xxx), and review parametrics.
[3] Thermal resistance between the die and the printed circuit board per JEDEC JESD51-8. Board temperature is measured on the top surface of the board near the package.
[4] Junction temperature is a function of die size, on-chip power dissipation, package thermal resistance, mounting site (board) temperature, ambient temperature, air flow, power dissipation of other components on the board, and board thermal resistance.
[5] Per JEDEC JESD51-6 with the board (JESD51-7) horizontal.
[6] Thermal resistance between the die and the case top surface as measured by the cold plate method (MIL SPEC-883 Method 1012.1), with the cold plate temperature used for the case temperature.
[7] Thermal resistance between the die and the solder pad on the bottom of the package based on simulation without any interface resistance.
[8] Thermal characterization parameter indicating the temperature difference between the package top and the junction temperature per JEDEC JESD51-2. When Greek letter (Ψ) is not available, the thermal characterization parameter is written as Psi-JT.

7.4 Electrical characteristics

Table 9. Static and dynamic electrical characteristics

Characteristics noted under conditions 9.6 V ≤ V_{PWR} ≤ 61.6 V, −40 °C ≤ T_A ≤ 105 °C, GND = 0 V, unless otherwise stated. Typical values refer to V_{PWR} = 56 V, T_A = 25 °C, unless otherwise noted.

Symbol	Parameter	Min	Typ	Max	Unit
Power management					
$V_{PWR(FO)}$	Supply voltage				V
	Full parameter specification	9.6	—	61.6	

Symbol	Parameter	Min	Typ	Max	Unit
I_{VPWR}	Supply current (base value) Normal mode, cell balance OFF, ADC inactive, SPI communication inactive, IVCOM = 0 mA Normal mode, cell balance OFF, ADC inactive, TPL communication inactive, IVCOM = 0 mA	 — —	 5.4 8.0	 — —	mA
$I_{VPWR(TPL\_TX)}$	Supply current adder when TPL communication active	—	50	—	mA
$I_{VPWR(CBON)}$	Supply current adder to set all 14 cell balance switches ON	—	0.97	—	mA
$I_{VPWR(ADC)}$	Delta supply current to perform ADC conversions (addend) ADC1-A,B continuously converting ADC2 continuously converting	 — —	 3.0 1.4	 — —	mA
$I_{VPWR(SS)}$	Supply current in sleep mode and in idle mode, communication inactive, cell balance off, cyclic measurement off, oscillator monitor on SPI mode (25 °C) TPL mode (25 °C)	 — —	 40 68	 — —	µA
$I_{VPWR(CKMON)}$	Clock monitor current consumption	—	5	—	µA
$V_{PWR(OV\_FLAG)}$	V_{PWR} overvoltage fault threshold (flag)	—	65	—	V
$V_{PWR(LV\_FLAG)}$	V_{PWR} low-voltage warning threshold (flag)	—	12	—	V
$V_{PWR(UV\_POR)}$	V_{PWR} undervoltage shutdown threshold (POR)	—	8.5	—	V
$V_{PWR(HYS)}$	V_{PWR} UV hysteresis voltage	—	200	—	mV
$t_{VPWR(FILTER)}$	V_{PWR} OV, LV filter	—	50	—	µs
VCOM power supply					
V_{COM}	VCOM output voltage	—	5.0	—	V
I_{VCOM}	VCOM output current allocated for external use	—	—	5.0	mA
$V_{COM(UV)}$	VCOM undervoltage fault threshold	—	4.4	—	V
V_{COM_HYS}	VCOM undervoltage hysteresis	—	100	—	mV
$t_{VCOM(FLT\_TIMER)}$	VCOM undervoltage fault timer	—	10	—	µs
$t_{VCOM(RETRY)}$	VCOM fault retry timer	—	10	—	ms
$V_{COM(OV)}$	VCOM overvoltage fault threshold	5.4	—	5.9	V
$I_{LIM(OC)}$	VCOM current limit	65	—	140	mA
$R_{VCOM(SS)}$	VCOM sleep mode pull-down resistor	—	2.0	—	kΩ
VANA power supply					
V_{ANA}	VANA output voltage (not used by external circuits) Decouple with 47 nF X7R 0603 or 0402	 —	 2.65	 —	V
$V_{ANA(UV)}$	VANA undervoltage fault threshold	—	2.4	—	V
V_{ANA_HYS}	VANA undervoltage hysteresis	—	50	—	mV
$V_{ANA(FLT\_TIMER)}$	VANA undervoltage fault timer	—	11	—	µs
$V_{ANA(OV)}$	VANA overvoltage fault threshold	—	2.8	—	V
$t_{VANA(RETRY)}$	VANA fault retry timer	—	10	—	ms
$I_{LIM(OC)}$	VANA current limit	5.0	—	10	mA
R_{VANA_RPD}	VANA sleep mode pull-down resistor	—	1.0	—	kΩ
t_{VANA}	VANA rise time (CL = 47 nF ceramic X7R only)	—	—	100	µs
ADC1-A, ADC1-B					

Symbol	Parameter	Min	Typ	Max	Unit
$CTn_{(LEAKAGE)}$	Cell terminal input leakage current (except in SLEEP mode when cell balancing is ON)	—	10	—	nA
$CTn_{(FV)}$	Cell terminal input current - functional verification	—	0.365	—	mA
CT_N	Cell terminal input current during conversion	—	50	—	nA
R_{PD}	Cell terminal open load detection pull-down resistor	—	950	—	Ω
V_{VPWR_RES}	VPWR terminal measurement resolution	—	2.44141	—	mV/LSB
V_{VPWR_RNG}	VPWR terminal measurement range	9.6	—	75	V
$VPWR_{TERM\_ERR}$	VPWR terminal measurement accuracy	−0.5	—	0.5	%
V_{CT_RNG}	ADC differential input voltage range for CTn to CTn-1	0.0	—	4.85	V
$V_{CT\_ANx\_RES}$	Cell voltage and ANx resolution in 15-bit MEAS_xxxx registers	—	152.58789	—	µV/LSB
$V_{ERR33RT}$	Cell voltage measurement error V_{CELL} = 3.3 V, T_A = 25 °C	−0.8	±0.4	0.8	mV
V_{ERR}	Cell voltage measurement error 0.1 V ≤ V_{CELL} ≤ 4.8 V, −40 °C ≤ T_A ≤ 105 °C (or −40 °C ≤ T_J ≤ 125 °C)	—	±0.7	—	mV
V_{ERR_1}	Cell voltage measurement error 0 V ≤ V_{CELL} ≤ 1.5 V, −40 °C ≤ T_A ≤ 60 °C (or −40 °C ≤ T_J ≤ 85 °C)	—	±0.4	—	mV
V_{ERR_2}	Cell voltage measurement error 1.5 V ≤ V_{CELL} ≤ 2.7 V, −40 °C ≤ T_A ≤ 60 °C (or −40 °C ≤ T_J ≤ 85 °C)	—	±0.4	—	mV
V_{ERR_3}	Cell voltage measurement error 2.7 V ≤ V_{CELL} ≤ 3.7 V, −40 °C ≤ T_A ≤ 60 °C (or −40 °C ≤ T_J ≤ 85 °C)	—	±0.5	—	mV
V_{ERR_4}	Cell voltage measurement error 3.7 V ≤ V_{CELL} ≤ 4.3 V, −40 °C ≤ T_A ≤ 60 °C (or −40 °C ≤ T_J ≤ 85 °C)	—	±0.7	—	mV
V_{ERR_5}	Cell voltage measurement error 1.5 V ≤ V_{CELL} ≤ 4.5 V, −40 °C ≤ T_A ≤ 105 °C (or −40 °C ≤ T_J ≤ 125 °C)	—	±0.7	—	mV
V_{ANx_ERR}	Magnitude of ANx error in the entire measurement range: Ratiometric measurement Absolute measurement after soldering and aging, input in the range [1.0, 4.5] V Absolute measurement after soldering and aging, input in the range [0, 4.85] V, for −40 °C < T_A < 60 °C) Absolute measurement after soldering and aging, input in the range [0, 4.85] V, for −40 °C < T_A < 105 °C)	 — — −8.0 −11	 — — — —	 16 10 8.0 11	mV
t_{VCONV}	Single channel net conversion time 13-bit resolution 14-bit resolution 15-bit resolution 16-bit resolution	 — — — —	 6.77 9.43 14.75 25.36	 — — — —	µs
V_{V_NOISE}	Conversion noise 13-bit resolution 14-bit resolution 15-bit resolution 16-bit resolution	 — — — —	 1800 1000 600 400	 — — — —	µVrms
ADC2/current sense module					
V_{INC}	ISENSE+/ISENSE− input voltage (reference to AGND)	−300	—	300	mV

Symbol	Parameter	Min	Typ	Max	Unit
V_{IND}	ISENSE+/ISENSE− differential input voltage range	−150	—	150	mV
$V_{ISENSEX(OFFSET)}$	ISENSE+/ISENSE− input voltage offset error	—	—	0.5	µV
$I_{GAINERR}$	ISENSE error including nonlinearities	−0.5	—	0.5	%
I_{ISENSE_OL}	ISENSE open load injected current	—	130	—	µA
V_{ISENSE_OL}	ISENSE open load detection threshold	—	460	—	mV
V_{2RES}	Current sense user register resolution	—	0.6	—	µV/LSB
V_{PGA_SAT}	PGA saturation half-range				mV
	Gain = 256	—	4.9	—	
	Gain = 64	—	19.5	—	
	Gain = 16	—	78.1	—	
	Gain = 4	—	150.0	—	
V_{PGA_ITH}	Voltage threshold for PGA gain increase				mV
	Gain = 256	—	—	—	
	Gain = 64	—	2.344	—	
	Gain = 16	—	9.375	—	
	Gain = 4	—	37.50	—	
V_{PGA_DTH}	Voltage threshold for PGA gain decrease				mV
	Gain = 256	—	4.298	—	
	Gain = 64	—	17.188	—	
	Gain = 16	—	68.750	—	
	Gain = 4	—	—	—	
t_{AZC_SETTLE}	Time to perform auto-zero procedure after enabling the current channel	—	200	—	µs
t_{ICONV}	ADC conversion time including PGA settling time				µs
	13 bit resolution	—	19.00	—	
	14 bit resolution	—	21.67	—	
	15 bit resolution	—	27.00	—	
	16 bit resolution	—	37.67	—	
V_{I_NOISE}	Noise error at 16-bit conversion	—	3.01	—	µVrms
V_{I_NOISE}	Noise error at 13-bit conversion	—	8.33	—	µVrms
ADC_{CLK}	ADC2 and ADC1-A,B clocking frequency	—	6.0	—	MHz
Cell balance drivers					
$V_{DS(CLAMP)}$	Cell balance driver VDS active clamp voltage	—	11	—	V
$V_{OUT(FLT\_TH)}$	Output fault detection voltage threshold				V
	Balance off (open load)	—	0.55	—	
	Balance on (shorted load)				
R_{PD_CB}	Output OFF open load detection pull-down resistor				kΩ
	Balance off, open load detect disabled	—	2.0	—	
$I_{OUT(LKG)}$	Output leakage current				µA
	Balance off, open load detect disabled at V_{DS} = 4.0 V	—	—	1.0	
$R_{DS(on)}$	Drain-to-source on resistance				Ω
	I_{OUT} = 300 mA, T_J = 105 °C	—	—	0.80	
	I_{OUT} = 300 mA, T_J = 25 °C	—	0.5	—	
	I_{OUT} = 300 mA, T_J = −40 °C	—	0.4	—	
I_{LIM_CB}	Driver current limitation (shorted resistor)	310	—	950	mA
t_{CB_AUTOP}	CB_AUTO_PAUSE timing	—	4.0	—	µs
t_{ON}	Cell balance driver turn on				µs
	R_L = 15 Ω	—	350	—	

Symbol	Parameter	Min	Typ	Max	Unit
t_{OFF}	Cell balance driver turn off R_L = 15 Ω	— 	200 	— 	µs
$t_{BAL\_DEGLICTH}$	Short/open detect filter time	—	20	—	µs
Internal temperature measurement					
IC_TEMP1_ERR	IC temperature measurement error	−3.0	—	3.0	K
IC_TEMP1_RES	IC temperature resolution	—	0.032	—	K/LSB
TSD_TH	Thermal shutdown	—	170	—	°C
TSD_HYS	Thermal shutdown hysteresis	—	10	—	°C
Default operational parameters					
$V_{CTOV(TH)}$	Cell overvoltage threshold (8 bits), typical value is default value after reset	0.0	4.2	5.0	V
$V_{CTOV(RES)}$	Cell overvoltage threshold resolution	—	19.53125	—	mV/LSB
$V_{CTUV(TH)}$	Cell undervoltage threshold (8 bits), typical value is default value after reset	0.0	2.5	5.0	V
$V_{CTUV(RES)}$	Cell undervoltage threshold resolution	—	19.53125	—	mV/LSB
$V_{GPIO\_OT(TH)}$	GPIOx configured as ANx input overtemperature threshold from POR	—	1.16	—	V
$V_{GPIO\_OT(RES)}$	Temperature voltage threshold resolution	—	4.8828125	—	mV/LSB
$V_{GPIO\_UT(TH)}$	GPIOx configured as ANx input undertemperature threshold from POR	—	3.82	—	V
$V_{GPIO\_UT(RES)}$	Temperature voltage threshold resolution	—	4.8828125	—	mV/LSB
General purpose input/output GPIOx					
V_{IH}	Input high-voltage (3.3 V compatible)	2.0	—	—	V
V_{IL}	Input low-voltage (3.3 V compatible)	—	—	1.0	V
V_{HYS}	Input hysteresis	—	100	—	mV
I_{IL}	Input leakage current Pins tristate, V_{IN} = V_{COM} or AGND	 −100	 —	 100	nA
I_{IDL}	Differential Input Leakage Current GPIO 5,6 GPIO 5,6 configured as digital inputs for current measurement	 −30	 —	 30	nA
V_{OH}	Output high-voltage I_{OH} = −0.5 mA	V_{COM} − 0.8	—	—	V
V_{OL}	Output low-voltage I_{OL} = +0.5 mA	—	—	0.8	V
V_{ADC}	Analog ADC input voltage range for ratiometric measurements	AGND	—	V_{COM}	V
$V_{OL(TH)}$	Analog input open pin detect threshold	—	0.15	—	V
R_{OPENPD}	Internal open detection pull-down resistor	3.8	5.0	—	kΩ
t_{GPIO0_WU}	GPIO0 WU de-glitch filter	—	50	—	µs
t_{GPIO0_FLT}	GPIO0 daisy chain de-glitch filter both edges	—	20	—	µs
t_{GPIO2_SOC}	GPIO2 convert trigger de-glitch filter	—	2.0	—	µs
t_{GPIOx_DIN}	GPIOx configured as digital input de-glitch filter	2.5	—	5.6	µs
Reset input					
V_{IH_RST}	Input high-voltage (3.3 V compatible)	2.0	—	—	V
V_{IL_RST}	Input low-voltage (3.3 V compatible)	—	—	1.0	V
V_{HYS}	Input hysteresis	—	0.6	—	V

Symbol	Parameter	Min	Typ	Max	Unit
$t_{RESETFLT}$	RESET de-glitch filter	—	100	—	µs
R_{RESET_PD}	Input logic pull down (RESET)	—	100	—	kΩ
SPI_COM_EN input					
V_{IH}	Input high-voltage (3.3 V compatible)	2.0	—	—	V
V_{IL}	Input low-voltage (3.3 V compatible)	—	—	1.0	V
V_{HYS}	Input hysteresis	—	450	—	mV
$R_{SPI\_COM\_EN\_PD}$	Input pull-down resistor (SPI_COM_EN)	—	100	—	kΩ
Bus switch for TPL communication					
RX_{TERM}	Bus termination resistor (open resistor when bus switch is closed)	—	150	—	Ω
Remark: If the bus switch is closed, then the termination resistor is open, else the termination resistor is connected. At the end of the daisy chain, the switch must be open, so that the transmission line is properly terminated.					
Digital interface					
V_{FAULT_HA}	FAULT output (high active, IOH = 1.0 mA)	4.0	4.9	6.0	V
I_{FAULT_CL}	FAULT output current limit	3.0	—	40	mA
R_{FAULT_PD}	FAULT output pull-down resistance	—	100	—	kΩ
V_{IH_COMM}	Voltage threshold to detect the input as high SI/RDTX_IN+, SCLK/RDTX_IN–, CSB, SDA, SCL (NOTE: needs to be 3.3 V compatible)	—	—	2.0	V
V_{IL_COMM}	Voltage threshold to detect the input as low SI/RDTX_IN+, SCLK/RDTX_IN–, CSB, SDA, SCL	0.8	—	—	V
V_{HYS}	Input hysteresis SI/RDTX_IN+, SCLK/RDTX_IN−, CSB, SDA, SCL	—	80	—	mV
I_{LOGIC_SS}	Sleep state input logic current CSB	−100	—	100	nA
R_{SCLK_PD}	Input logic pull-down resistance (SCLK/RDTX_IN–, SI/RDTX+)	—	20	—	kΩ
R_{I_PU}	Input logic pull-up resistance to V_{COM} (CSB, SDA, SCL)	—	100	—	kΩ
I_{SO_TRI}	Tristate SO input current 0 V to V_{COM}	−2.0	—	2.0	µA
V_{SO_HIGH}	SO high-state output voltage with $I_{SO(HIGH)}$ = −2.0 mA	V_{COM} − 0.4	—	—	V
V_{SO_LOW}	SO, SDA, SLK low-state output voltage with $I_{SO(HIGH)}$ = −2.0 mA	—	—	0.4	V
CSB_{WU_FLT}	CSB wake-up de-glitch filter, low to high transition	—	50	—	µs
System timing					
t_{CELL_CONV}	Time needed to acquire all 14 cell voltages and the current after an on demand conversion 13-bit resolution 14-bit resolution 15-bit resolution 16-bit resolution	 — — — —	 59 80 123 208	 — — — —	µs
t_{SYNC}	V/I synchronization time ADC1-A,B at 13 bit, ADC2 at 13 bit ADC1-A,B at 14 bit, ADC2 at 13 bit ADC1-A,B at 15 bit, ADC2 at 13 bit ADC1-A,B at 16 bit, ADC2 at 13 bit	 — — — —	 48.16 53.50 64.16 85.50	 — — — —	µs

Symbol	Parameter	Min	Typ	Max	Unit
t_{SYNC}	V/I synchronization time				µs
	ADC1-A,B at 13 bit, ADC2 at 14 bit	—	52.14	—	
	ADC1-A,B at 14 bit, ADC2 at 14 bit	—	57.48	—	
	ADC1-A,B at 15 bit, ADC2 at 14 bit	—	68.14	—	
	ADC1-A,B at 16 bit, ADC2 at 14 bit	—	89.48	—	
t_{SYNC}	V/I synchronization time				µs
	ADC1-A,B at 13 bit, ADC2 at 15 bit	—	62.12	—	
	ADC1-A,B at 14 bit, ADC2 at 15 bit	—	65.46	—	
	ADC1-A,B at 15 bit, ADC2 at 15 bit	—	76.12	—	
	ADC1-A,B at 16 bit, ADC2 at 15 bit	—	97.46	—	
t_{SYNC}	V/I synchronization time				µs
	ADC1-A,B at 13 bit, ADC2 at 16 bit	—	120.51	—	
	ADC1-A,B at 14 bit, ADC2 at 16 bit	—	117.84	—	
	ADC1-A,B at 15 bit, ADC2 at 16 bit	—	112.51	—	
	ADC1-A,B at 16 bit, ADC2 at 16 bit	—	113.39	—	
$t_{VPWR(READY)}$	Time after VPWR connection for the IC to be ready for initialization	—	—	5.0	ms
$t_{WAKE-UP}$	Sleep mode to normal mode device ready				µs
	Wake-up from fault	—	—	400	
	Wake-up from GPIO	—	—	400	
	Wake-up from network	—	—	400	
	Wake-up from CSB	—	—	400	
	Sleep mode to normal mode time after TPL bus wake-up	—	—	1.0	ms
t_{WAKE_DELAY}	Time between wake pulses	—	600	—	µs
t_{IDLE}	Idle timeout after POR	—	60	—	s
t_{WAKE_INIT}	Wake-up signaling timeout after POR	—	0.65	—	s
$t_{BALANCE}$	Cell balance timer range	0.5	—	511	min
t_{CYCLE}	Cyclic acquisition timer range	0.0	—	8.5	s
t_{FAULT}	Fault detection to activation of fault pin				µs
	Normal mode	—	—	56	
t_{DIAG}	Diagnostic mode timeout	0.047	1.0	8.5	s
t_{EOC}	SOC to data ready (includes post processing of data)				µs
	13-bit resolution	—	148	—	
	14-bit resolution	—	201	—	
	15-bit resolution	—	307	—	
	16-bit resolution	—	520	—	
t_{SETTLE}	Time after SOC to begin converting with ADC1-A,B	—	12.28	—	µs
t_{SYS_MEAS1}	Time needed to send an SOC command and read back 96 cell voltages, 48 temperatures, 1 current, and 1 coulomb counter and ADC1-A,B configured as follows:				ms
	13-bit resolution	—	3.73	—	
	14-bit resolution	—	3.78	—	
	15-bit resolution	—	3.89	—	
	16-bit resolution	—	4.10	—	
t_{SYS_MEAS2}	Time needed to send an SOC command and read back 96 cell voltages, 1 current, and 1 coulomb counter and ADC1-A,B configured as follows:				ms
	13-bit resolution	—	2.64	—	
	14-bit resolution	—	2.69	—	
	15-bit resolution	—	2.80	—	
	16-bit resolution	—	3.01	—	

Symbol	Parameter	Min	Typ	Max	Unit
t_{CLST_TPL}	Time needed to send an SOC command and read back 14 cell voltages, 7 temperatures, 1 current, and 1 coulomb counter with TPL communication working at 2.0 Mbps and ADC1-A,B configured as follows:				ms
	13-bit resolution	—	0.79	—	
	14-bit resolution	—	0.85	—	
	15-bit resolution	—	0.95	—	
	16-bit resolution	—	1.16	—	
t_{CLST_SPI}	Time needed to send an SOC command and read back 14 cell voltages, 7 temperatures, 1 current, and 1 coulomb counter with SPI communication working at 4.0 Mbps and ADC1-A,B configured as follows:				ms
	13-bit resolution	—	0.48	—	
	14-bit resolution	—	0.54	—	
	15-bit resolution	—	0.64	—	
	16-bit resolution	—	0.86	—	
$t_{I2C\_DOWNLOAD}$	Time to download EEPROM calibration after POR	—	—	1.0	ms
t_{I2C_ACCESS}	EEPROM access time, EEPROM write (depends on device selection)	—	5.0	—	ms
$t_{WAVE\_DC\_BITx}$	Daisy chain duty cycle off time				µs
	$t_{WAVE\_DC\_BITx = 00}$	—	500	—	
$t_{WAVE\_DC\_BITx}$	Daisy chain duty cycle off time				ms
	$t_{WAVE\_DC\_BITx = 01}$	—	1.0	—	
$t_{WAVE\_DC\_BITx}$	Daisy chain duty cycle off time				ms
	$t_{WAVE\_DC\_BITx = 10}$	—	10	—	
$t_{WAVE\_DC\_BITx}$	Daisy chain duty cycle off time				ms
	$t_{WAVE\_DC\_BITx = 11}$	—	100	—	
$t_{WAVE\_DC\_ON}$	Daisy chain duty cycle on time	—	500	550	µs
t_{COM_LOSS}	Time out to reset the IC in the absence of communication	—	1024	—	ms
SPI interface					
F_{SCK}	CLK/RDTX_IN– frequency [1]	—	—	4.0	MHz
t_{SCK_H}	SCLK/RDTX_IN– high time (A) [1]	125	—	—	ns
t_{SCK_L}	SCLK/RDTX_IN– high time (B) [1]	125	—	—	ns
t_{SCK}	SCLK/RDTX_IN− period (A+B) [1]	250	—	—	ns
t_{FALL}	SCLK/RDTX_IN− falling time	—	—	15	ns
t_{RISE}	SCLK/RDTX_IN− rising time	—	—	15	ns
t_{SET}	SCLK/RDTX_IN− setup time (O) [1]	20	—	—	ns
t_{HOLD}	SCLK/RDTX_IN– hold time (P) [1]	20	—	—	ns
t_{SI_SETUP}	SI/RDTX_IN+ setup time (F) [1]	40	—	—	ns
t_{SI_HOLD}	SI/RDTX_IN+ hold time (G) [1]	40	—	—	ns
t_{SO_VALID}	SO data valid, rising edge of SCLK/RDTX_IN− to SO data valid (I) [1]	—	—	40	ns
t_{SO_EN}	SO enable time (H) [1]	—	—	40	ns
$t_{SO\_DISABLE}$	SO disable time (K) [1]	—	—	40	ns
t_{CSB_LEAD}	CSB lead time (L) [1]	100	—	—	ns
t_{CSB_LAG}	CSB lag time (M) [1]	100	—	—	ns
t_{TD}	Sequential data transfer delay (N) [1]	1.0	—	—	µs

Symbol	Parameter	Min	Typ	Max	Unit
TPL interface					
$V_{RDTX\ INTH}$	Differential receiver threshold	—	580	—	mV
$V_{RDTX\ INHYS}$	Differential receiver threshold hysteresis	—	100	—	mV
t_{RES}	Slave response after write command (echo)	—	2.35	—	µs

[1] See Figure 4

7.5 Timing diagrams

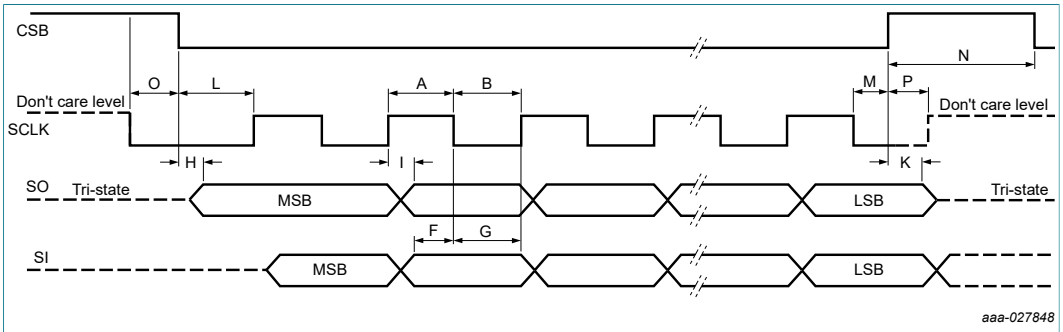


Figure 4. Low-voltage SPI interface timing

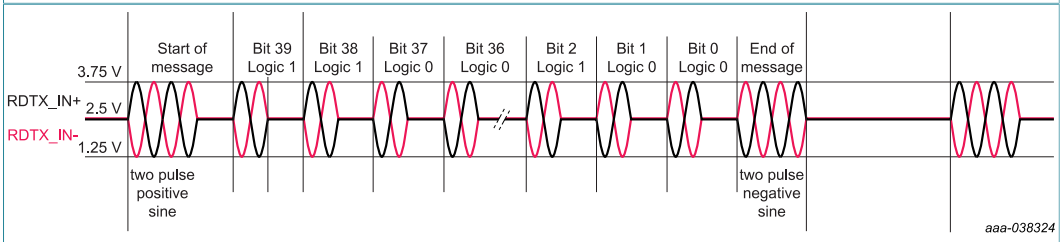


Figure 5. Transformer communication signaling

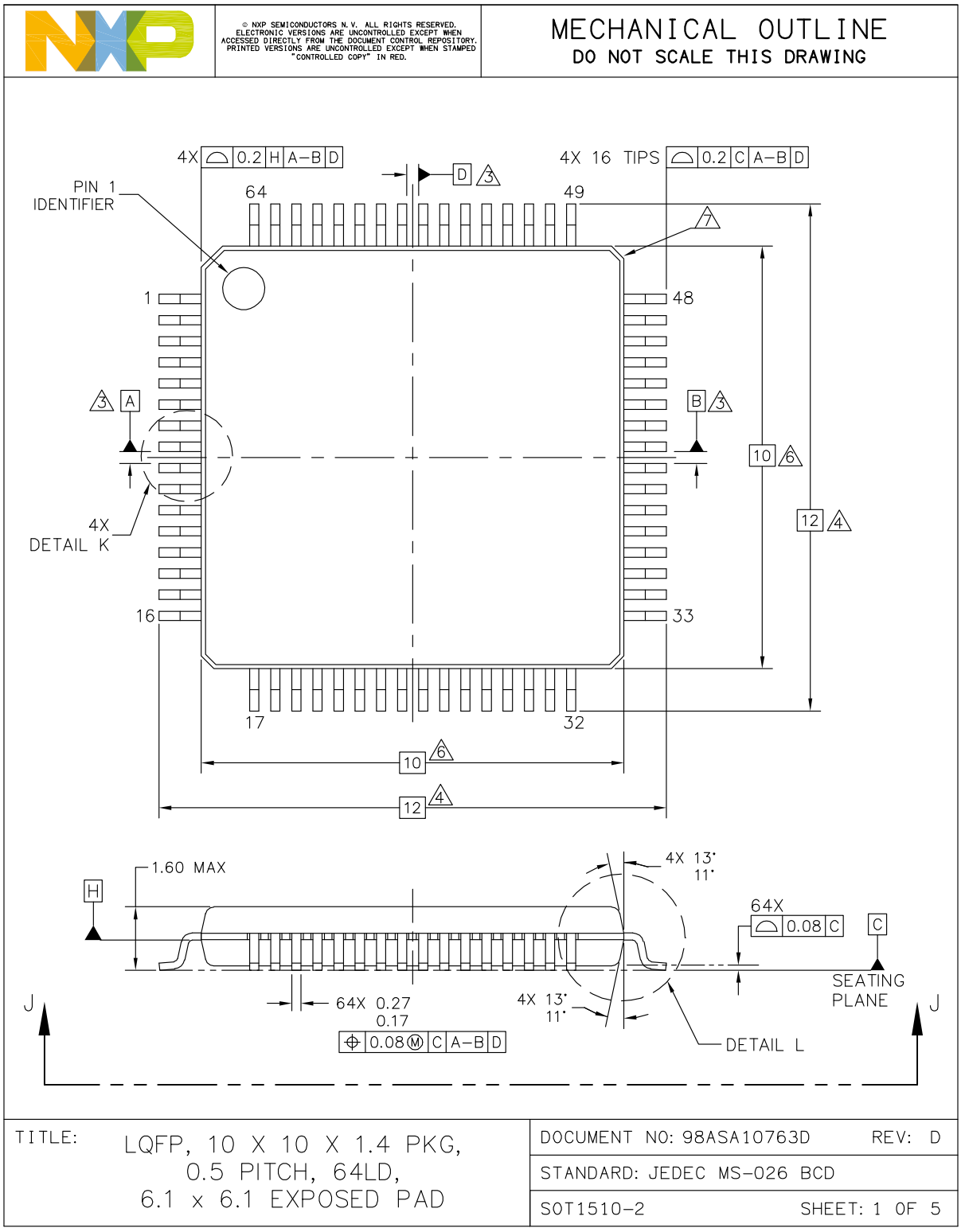
8 Packaging

8.1 Package mechanical dimensions

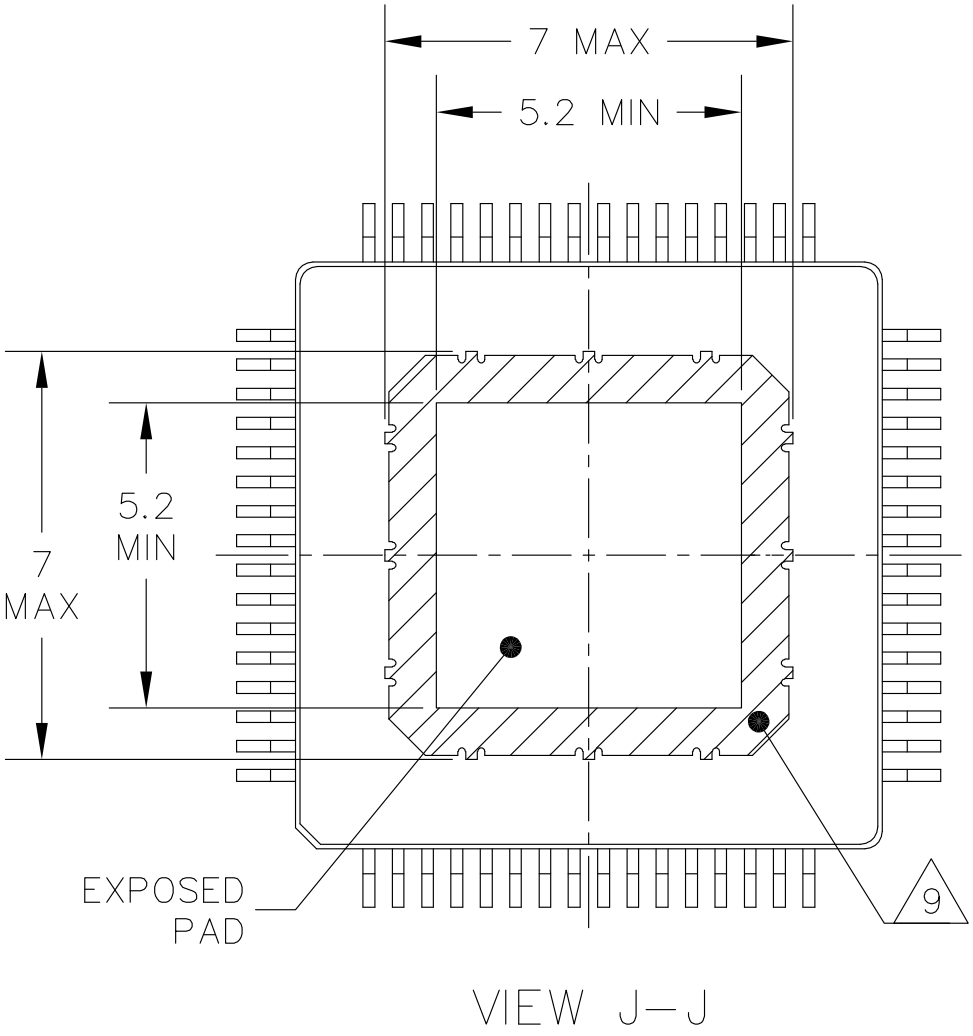
Package dimensions are provided in package drawings. To find the most current package outline drawing, go to www.nxp.com and perform a keyword search for the drawing's document number.

Table 10. Package Outline

Package	Suffix	Package outline drawing number
64-pin LQFP-EP	AE	98ASA10763D



MECHANICAL OUTLINE
DO NOT SCALE THIS DRAWING

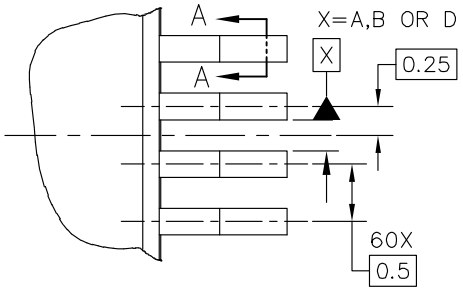


VIEW J–J

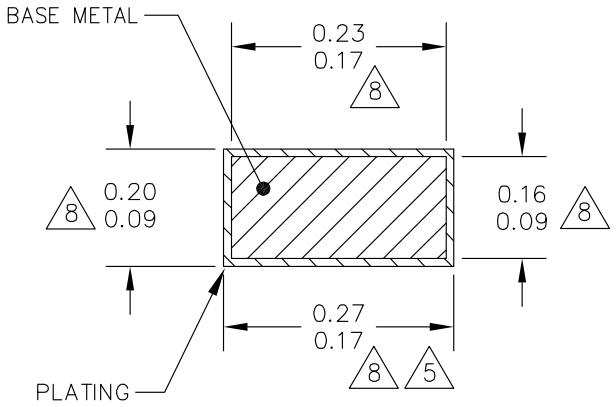
TITLE: LQFP, 10 X 10 X 1.4 PKG, 0.5 PITCH, 64LD, 6.1 x 6.1 EXPOSED PAD	DOCUMENT NO: 98ASA10763D	REV: D
	STANDARD: JEDEC MS-026 BCD	
	SOT1510-2	SHEET: 2

MECHANICAL OUTLINE

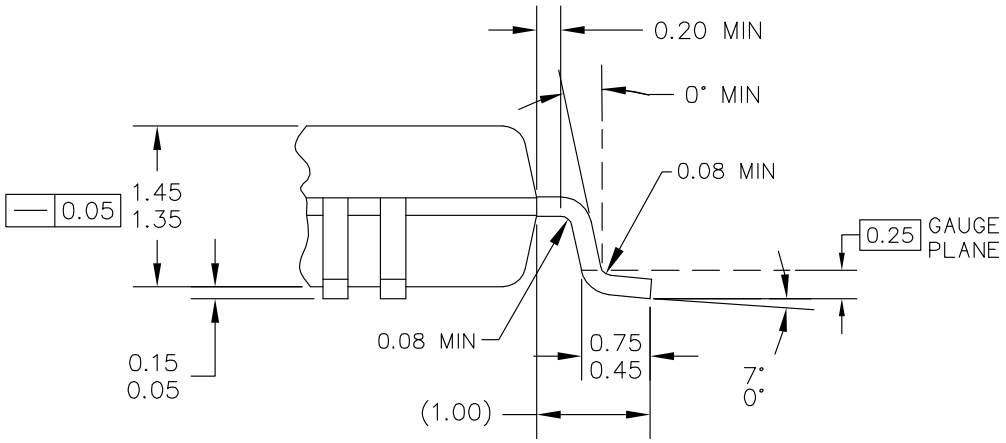
DO NOT SCALE THIS DRAWING



DETAIL K



SECTION A–A
64 PLACES
ROTATED 90° CLOCKWISE



DETAIL L

TITLE: LQFP, 10 X 10 X 1.4 PKG, 0.5 PITCH, 64LD, 6.1 x 6.1 EXPOSED PAD	DOCUMENT NO: 98ASA10763D REV: D
	STANDARD: JEDEC MS-026 BCD
	SOT1510-2 SHEET: 3

MECHANICAL OUTLINE
DO NOT SCALE THIS DRAWING

NOTES:

1. DIMENSIONS ARE IN MILLIMETERS.
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M–1994.
3. DATUMS A, B AND D TO BE DETERMINED AT DATUM PLANE H.
4. DIMENSIONS TO BE DETERMINED AT SEATING PLANE C.
5. DIMENSION DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL NOT CAUSE THE LEAD WIDTH TO EXCEED THE MAXIMUM DIMENSION BY MORE THAN 0.08 MM. DAMBAR CANNOT BE LOCATED ON THE LOWER RADIUS OR THE FOOT. MINIMUM SPACE BETWEEN PROTRUSION AND ADJACENT LEAD OR PROTRUSION 0.07 MM.
6. DIMENSIONS DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS 0.25 MM PER SIDE. DIMENSIONS ARE MAXIMUM PLASTIC BODY SIZE DIMENSIONS INCLUDING MOLD MISMATCH.
7. EXACT SHAPE OF EACH CORNER IS OPTIONAL.
8. THESE DIMENSIONS APPLY TO THE FLAT SECTION OF THE LEAD BETWEEN 0.10 MM AND 0.25 MM FROM THE LEAD TIP.
9. HATCHED AREA TO BE KEEP OUT ZONE FOR PCB ROUTING.

TITLE: LQFP, 10 X 10 X 1.4 PKG, 0.5 PITCH, 64LD, 6.1 x 6.1 EXPOSED PAD	DOCUMENT NO: 98ASA10763D REV: D
	STANDARD: JEDEC MS-026 BCD
	SOT1510-2 SHEET: 4

Figure 6. Package outline

9 Revision history

Table 11. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
MC33771BSDS v.6.0	20200622	Product data sheet	—	MC33771BSDS v.5.0
Modifications:	Updated to align with full data sheet, MC33771B v.6.0			
MC33771BSDS v.5.0	20180502	Technical data	—	MC33771BSDS v.1
Modifications:	Updated to align with full data sheet, MC33771B v.5.0			
MC33771BSDS v.1	20180419	Product preview	—	—

10 Legal information

10.1 Data sheet status

Document status[1][2]	Product status[3]	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
Preliminary [short] data sheet	Qualification	This document contains data from the preliminary specification.
Product [short] data sheet	Production	This document contains the product specification.

[1] Please consult the most recently issued document before initiating or completing a design.
[2] The term 'short data sheet' is explained in section "Definitions".
[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL http://www.nxp.com.

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Tables

Tab. 1. Part number breakdown 4
Tab. 2. Advanced orderable part table 5
Tab. 3. Basic orderable part table 5
Tab. 4. Premium orderable part table 5
Tab. 5. Pin definitions 6
Tab. 6. Ratings vs. operating requirements 9
Tab. 7. Maximum ratings 9
Tab. 8. Thermal ratings 11
Tab. 9. Static and dynamic electrical characteristics ... 11
Tab. 10. Package Outline 20
Tab. 11. Revision history 25

Figures

Fig. 1. Simplified application diagram, SPI use case 2
Fig. 2. Simplified application diagram, TPL use case 3
Fig. 3. Pinout diagram 6
Fig. 4. Low-voltage SPI interface timing 19
Fig. 5. Transformer communication signaling 19
Fig. 6. Package outline 24

Contents

1 General description 1
2 Features 1
3 Simplified application diagram 2
4 Applications 3
5 Ordering information 4
5.1 Part numbers definition 4
5.2 Part numbers list 5
6 Pinning information 6
6.1 Pinout diagram 6
6.2 Pin definitions 6
7 General product characteristics 9
7.1 Ratings and operating requirements relationship 9
7.2 Maximum ratings 9
7.3 Thermal characteristics 11
7.4 Electrical characteristics 11
7.5 Timing diagrams 19
8 Packaging 20
8.1 Package mechanical dimensions 20
9 Revision history 25
10 Legal information 26

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