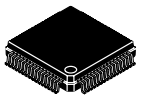


PB_MC33771C

Battery cell controller IC

Rev. 1.0 — 20 January 2020 Product brief

1 General description

The MC33771C 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 transmitted to MCU using one of the microcontroller interfaces (Serial Peripheral Interface (SPI) or Transformer physical layer (TPL)) of the IC.

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
- Bi-directional transceiver to support up to 63 nodes in daisy chain
- 0.8 mV maximum total voltage measurement error
- Synchronized cell voltage/current measurement with coulomb count
- Averaging of cell voltage measurements
- 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.
- Qualified in compliance with AECQ-100

3 Simplified application diagram

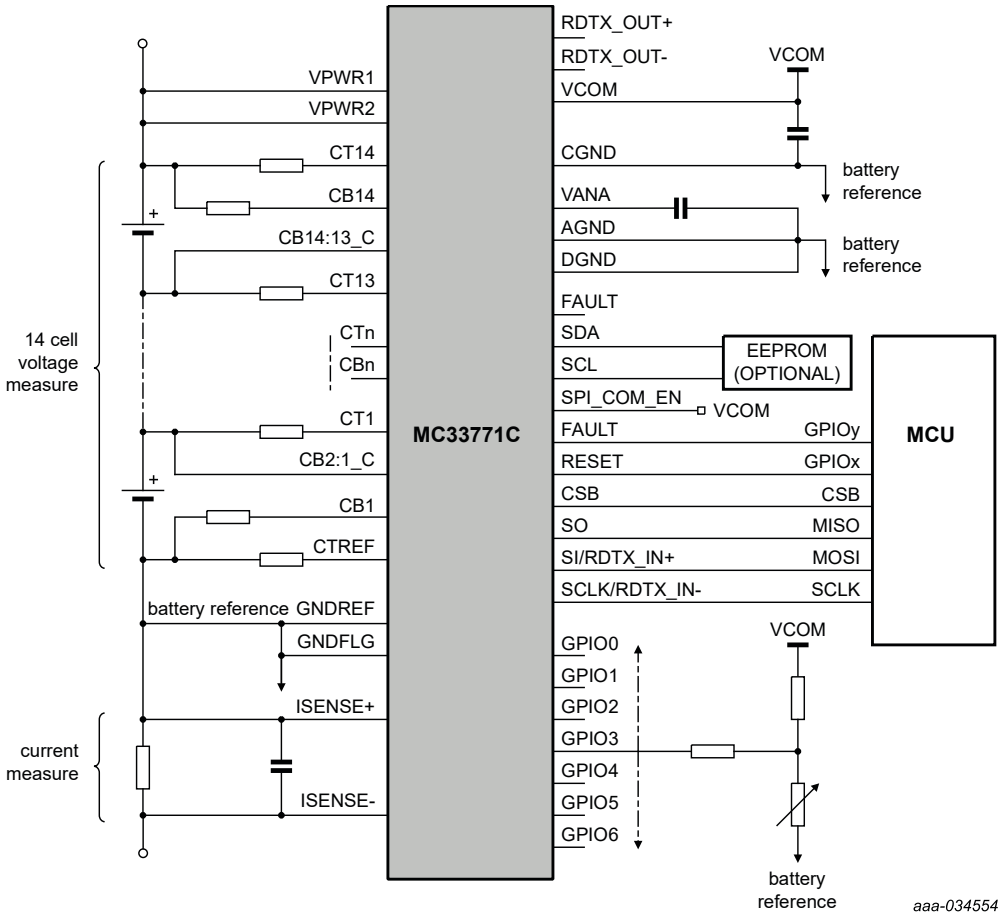


Figure 1. Simplified application diagram, SPI use case

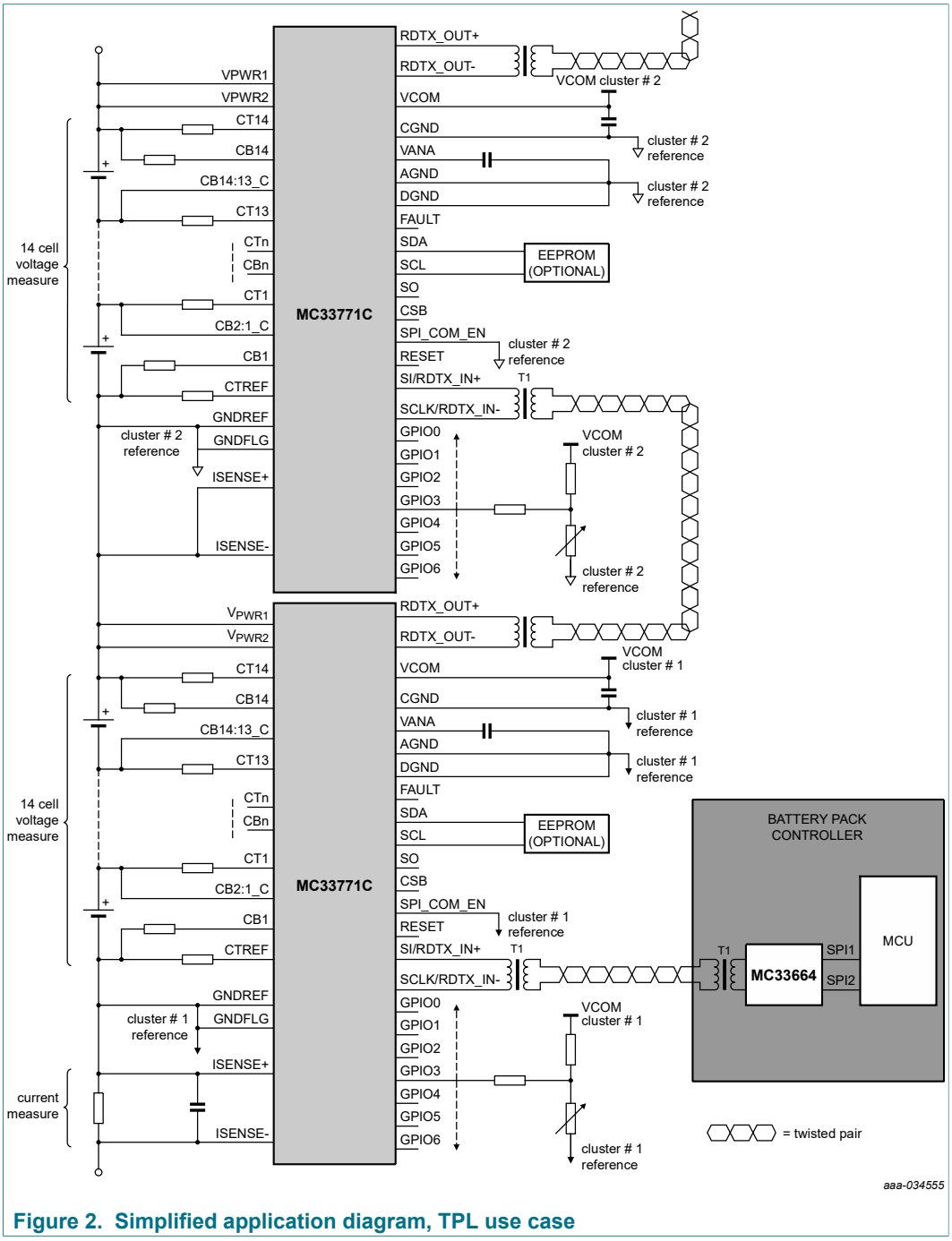


Figure 2. Simplified application diagram, TPL use case

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

MC33771C T/y z AE/R2

Table 1. Part number breakdown

Code	Option	Description
	T	TPL communication type
y	P	y = P (Premium with current measurement option)
	A	y = A (Advanced)
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
TPL differential communication protocol				
MC33771CTA1AE	7 to 14	Yes	Yes	No
MC33771CTA2AE	7 to 8	Yes	Yes	No

Table 3. 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
TPL differential communication protocol with current measurement option				
MC33771CTP1AE	7 to 14	Yes	Yes	Yes
MC33771CTP2AE	7 to 8	Yes	Yes	Yes

6 Pinning information

6.1 Pinout diagram

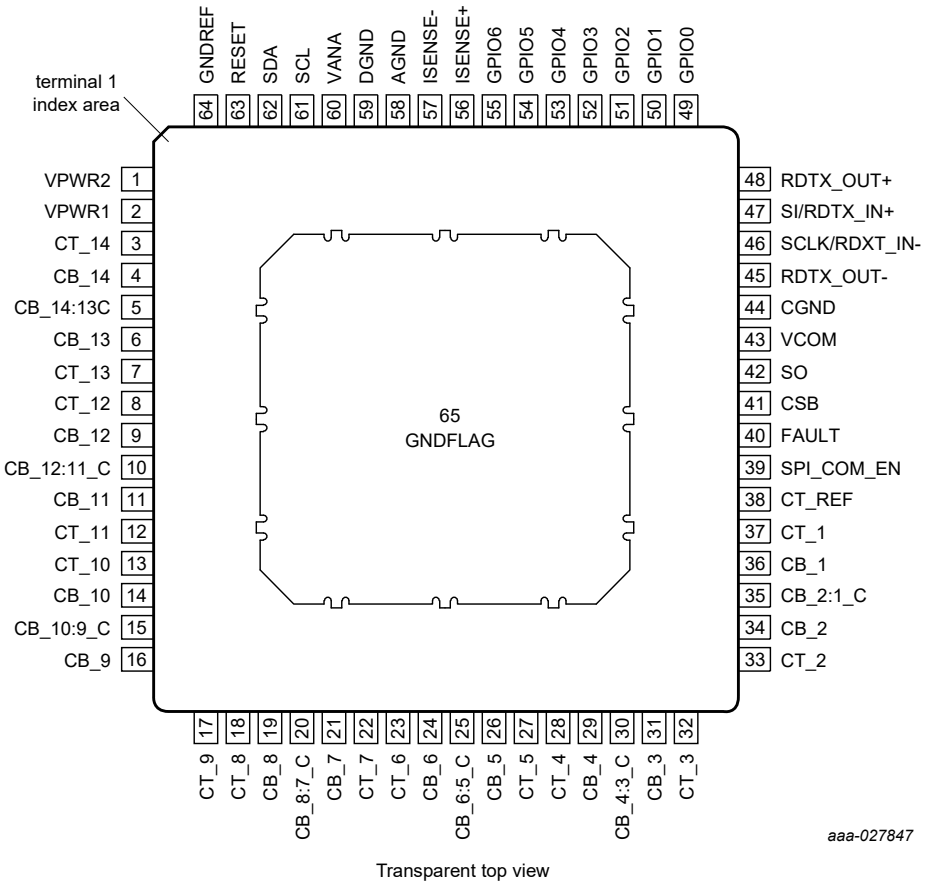


Figure 3. Pinout diagram

6.2 Pin definitions

Table 4. Pin definitions

Number	Name	Function	Definition
1	VPWR2	Input	Power input to the MC33771C
2	VPWR1	Input	Power input to the MC33771C
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 CB_14:13_C balance load resistor.
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 CB_12:11_C balance load resistor.
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 CB_10:9_C balance load resistor.
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 CB_8:7_C balance load resistor.
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 CB_6:5_C balance load resistor.
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 CB_4:3_C balance load resistor.
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 CB_2:1_C balance load resistor.
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
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 receive/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
61	SCL	I/O	I^2C clock
62	SDA	I/O	I^2C data
63	RESET	Input	RESET is an active high input. RESET has an internal pull down. If not used, it can be tied to GND.

Number	Name	Function	Definition
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 5. 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 6. 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_{REF} to GND	Cell terminal reference to ground	—	5	V
CT_N to GND	Cell terminal voltage to ground (N=1 to 4 or N=6 to 14)	—	(N+1) . 5	V
	Cell terminal voltage to ground (N=5)	—	27.5	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

Symbol	Description (rating)	Min	Max	Unit
CB_{2n} to GND	Cell balance voltage to GND (n=1 to 7)	—	(2n+1) . 5	V
CB_{2n+1} to GND	Cell balance voltage to GND (n=0 to 6)	—	(2n+1) . 5	V
$CB_{2n:2n-1\_C}$ to GND	Cell balance voltage to GND (n=1 to 6)	—	2n . 5	V
$CB_{N:N-1\_C}$ to CTn-1	Cell balance input to cell terminal input	−10	10	V
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
$I_{pin\_unpowered}$	Input current in a pin when the device is unpowered	–2	2	mA
V_{COMM}	Maximum voltage to pins RDTX_OUT+, RDTX_OUT–, SI/RDTX_IN+, SCLK/RDTX_IN-	−10.0	10.0	V
V_{ESD1}	ESD voltage			V
	Human body model (HBM)	—	±2000	
	Charge device model (CDM)	—	±500 [2]	
	Charge device model corner pins (CDM)	—	±750	
V_{ESD2}	ESD voltage (VPWR1, VPWR2, CTx, CBx, GPIOx, ISENSE+, ISENSE−, RDTX_OUT+, RDTX_OUT−, SI/RDTX_IN+, SCLK/ RDTX_IN−) versus all ground pins [3]			V
	Human body model (HBM)	—	±4000	
V_{ESD3}	ESD voltage (CTREF, CTx, CBx, GPIOx, ISENSE+, ISENSE−, RDTX_OUT+, RDTX_OUT−, SI/RDTX_IN+, SCLK/ RDTX_IN−) [4]			V
	IEC 61000-4-2, Unpowered (Gun configuration: 330Ω / 150pF)	—	±8000	
	HMM, Unpowered (Gun configuration: 330Ω / 150pF)	—	±8000	
	ISO 10605:2009, Unpowered (Gun configuration: 2 kΩ / 150pF)	—	±8000	
	ISO 10605:2009, Powered (Gun configuration: 2 kΩ / 150pF)	—	±8000	

[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] For CT_REF pin applicable limit is ±450 V.
[3] 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).
[4] These voltage values can be sustained only if ESD caps are used as described in MC33771C External Components

7.3 Thermal characteristics

Table 7. 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	[1]	−40	+150	
T_{STG}	Storage temperature		−55	+150	°C
T_{PPRT}	Peak package reflow temperature	[2] [3]	—	260	°C
Thermal resistance and package dissipation ratings					
$R_{\Theta JB}$	Junction-to-board (bottom exposed pad soldered to board) 64 LQFP EP	[4]	—	10	°C/W
$R_{\Theta JA}$	Junction-to-ambient, natural convection, single-layer board (1s) 64 LQFP EP	[5] [6]	—	59	°C/W
$R_{\Theta JA}$	Junction-to-ambient, natural convection, four-layer board (2s2p) 64 LQFP EP	[5] [6]	—	27	°C/W
$R_{\Theta JCTOP}$	Junction-to-case top (exposed pad) 64 LQFP EP	[7]	—	14	°C/W
$R_{\Theta JCBOTTOM}$	Junction-to-case bottom (exposed pad) 64 LQFP EP	[8]	—	0.97	°C/W
Ψ_{JT}	Junction to package top, natural convection	[9]	—	3	°C/W

[1] The user must ensure that the average maximum operating junction temperature (TJ) is not exceeded.
[2] 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.
[3] 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 and review parametrics.
[4] 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.
[5] 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.
[6] Per JEDEC JESD51-6 with the board (JESD51-7) horizontal.
[7] 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.
[8] Thermal resistance between the die and the solder pad on the bottom of the package based on simulation without any interface resistance.
[9] Thermal characterization parameter indicating the temperature difference between the package top and the junction temperature per JEDEC JESD51-2.

7.4 Electrical characteristics

Table 8. Static and dynamic electrical characteristics

Characteristics noted under conditions 9.6 V ≤ V_{PWR} ≤ 61.6V, −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	—	—	16	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 (T_A = 25 °C)	 — 64	 40 —	 — 108	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
$I_{LIM\_VCOM(OC)}$	VCOM current limit	65	—	140	mA
$R_{VCOM(SS)}$	VCOM sleep mode pull-down resistor	—	2.0	—	kΩ
t_{VCOM}	VCOM rise time (for V_{PWR} > 10V and CL = 2.2 µF (ceramic X7R only) in parallel with 220 pF)	—	—	440	µs
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
$I_{LIM\_VANA(OC)}$	VANA current limit	5.0	—	10	mA
R_{VANA_RPD}	VANA sleep mode pull-down resistor	—	1.0	—	kΩ

Symbol	Parameter	Min	Typ	Max	Unit
t_{VANA}	VANA rise time (CL = 47 nF ceramic X7R only)	—	—	400	µs
ADC1-A, ADC1-B					
$CTn_{(LEAKAGE)}$	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
$V_{ANx\_RATIO\_RES}$	ANx resolution in 15-bit MEAS_xxxx registers in ratiometric mode	—	VCOM. (30.51851)	—	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

Symbol	Parameter	Min	Typ	Max	Unit
V_{V_NOISE}	Conversion noise				µVrms
	13-bit resolution	—	1800	—	
	14-bit resolution	—	1000	—	
	15-bit resolution	—	600	—	
	16-bit resolution	—	400	—	
ADC2/current sense module					
V_{INC}	ISENSE+/ISENSE− input voltage (reference to AGND)	−300	—	300	mV
V_{IND}	ISENSE+/ISENSE− differential input voltage range	−150	—	150	mV
$V_{ISENSEX(OFFSET)}$	ISENSE+/ISENSE− input voltage offset error	—	—	0.5	µV
$I_{SENSEX(BIAS)}$	ISENSE+/ISENSE− input bias current	−100	—	100	nA
$I_{SENSE(DIF)}$	ISENSE+/ISENSE− differential input bias current	−5.0	—	5.0	nA
$I_{GAINERR}$	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) Balance on (shorted load)	—	0.55	—	
R_{PD_CB}	Output OFF open load detection pull-down resistor				kΩ
	Balance off, open load detect disabled	—	2.0	—	

Symbol	Parameter	Min	Typ	Max	Unit
$I_{OUT(LKG)}$	Output leakage current Balance off, open load detect disabled at V_{DS} = 4.0 V	 —	 —	 1.0	µA
$R_{DS(on)}$	Drain-to-source on resistance I_{OUT} = 300 mA, T_J = 105 °C I_{OUT} = 300 mA, T_J = 25 °C I_{OUT} = 300 mA, T_J = −40 °C	 — — —	 — 0.5 0.4	 0.80 — —	Ω
I_{LIM_CB}	Driver current limitation	310	—	950	mA
t_{ON}	Cell balance driver turn on R_L = 15 Ω	 —	 350	 —	µs
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 after RESET	—	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 after RESET	—	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	—	5.0	—	kΩ
t_{GPIO0_WU}	GPIO0 WU de-glitch filter	—	50	—	µs

Symbol	Parameter	Min	Typ	Max	Unit
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
$t_{RESETFLT}$	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
Digital interface					
V_{FAULT_HA}	FAULT output (high active, IOH = 1.0 mA)	—	4.9	—	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_IN+)	—	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	—	—	80	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

Symbol	Parameter	Min	Typ	Max	Unit
t_{SYNC}	V/I synchronization time				µs
	ADC1-A,B at 13 bit, ADC2 at 13 bit	—	48.16	—	
	ADC1-A,B at 14 bit, ADC2 at 13 bit	—	53.50	—	
	ADC1-A,B at 15 bit, ADC2 at 13 bit	—	64.16	—	
	ADC1-A,B at 16 bit, ADC2 at 13 bit	—	85.50	—	
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
$t_{WAKE-UP}$	Power up duration	—	—	440	µs
t_{WAKE_DELAY}	Time between wake pulses	—	600	—	µs
t_{IDLE}	Idle timeout after POR	—	60	—	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_{EOC}	SOC to data ready (includes post processing of data, ADC_CFG[AVG]=0)	—	148	—	µs
	13-bit resolution	—	201	—	
	14-bit resolution	—	307	—	
	15-bit resolution	—	520	—	
	16-bit resolution				
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 (with ADC_CFG[AVG]=0):				ms
	13-bit resolution	—	4.67	—	
	14-bit resolution	—	4.73	—	
	15-bit resolution	—	4.83	—	
	16-bit resolution	—	5.05	—	
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 (with ADC_CFG[AVG]=0):				ms
	13-bit resolution	—	3.24	—	
	14-bit resolution	—	3.39	—	
	15-bit resolution	—	3.40	—	
	16-bit resolution	—	3.61	—	

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 (with ADC_CFG[AVG]=0): 13-bit resolution 14-bit resolution 15-bit resolution 16-bit resolution	 — — — —	 0.85 0.90 1.101 1.22	 — — — —	ms
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 (with ADC_CFG[AVG]=0): 13-bit resolution 14-bit resolution 15-bit resolution 16-bit resolution	 — — — —	 0.57 0.64 0.76 1.03	 — — — —	ms
$t_{I2C\_DOWNLOAD}$	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 $t_{WAVE\_DC\_BITx = 00}$	 —	 500	 —	µs
$t_{WAVE\_DC\_BITx}$	Daisy chain duty cycle off time $t_{WAVE\_DC\_BITx = 01}$	 —	 1.0	 —	ms
$t_{WAVE\_DC\_BITx}$	Daisy chain duty cycle off time $t_{WAVE\_DC\_BITx = 10}$	 —	 10	 —	ms
$t_{WAVE\_DC\_BITx}$	Daisy chain duty cycle off time $t_{WAVE\_DC\_BITx = 11}$	 —	 100	 —	ms
$t_{WAVE\_DC\_ON}$	Daisy chain duty cycle on time	—	500	—	µs
t_{COM_LOSS}	Time out to reset the IC in the absence of communication	—	1024	—	ms
SPI interface					
t_{SPI_TD}	Sequential data transfer delay in SPI mode (N)	1.0	—	—	µs
F_{SCK}	SCLK/RDTX_IN– frequency	—	—	4.0	MHz
t_{SCK_H}	SCLK/RDTX_IN– high time (A)	125	—	—	ns
t_{SCK_L}	SCLK/RDTX_IN– high time (B)	125	—	—	ns
t_{SCK}	SCLK/RDTX_IN− period (A+B)	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)	20	—	—	ns
t_{HOLD}	SCLK/RDTX_IN– hold time (P)	20	—	—	ns
t_{SI_SETUP}	SI/RDTX_IN+ setup time (F)	40	—	—	ns
t_{SI_HOLD}	SI/RDTX_IN+ hold time (G)	40	—	—	ns
t_{SO_VALID}	SO data valid, rising edge of SCLK/RDTX_IN− to SO data valid (I)	—	—	40	ns
t_{SO_EN}	SO enable time (H)	—	—	40	ns
$t_{SO\_DISABLE}$	SO disable time (K)	—	—	40	ns
t_{CSB_LEAD}	CSB lead time (L)	100	—	—	ns
t_{CSB_LAG}	CSB lag time (M)	100	—	—	ns

Symbol	Parameter	Min	Typ	Max	Unit
TPL interface (MCU)					
t_{MCU_RES}	Time between two consecutive message request transmitted by MCU	4.0	—	—	µs
t_{WU_Wait}	Time the MCU shall wait after sending first wake-up message per 33771 IC	0.75	—	—	ms
TPL interface (33771)					
t_{TPL_TD}	Sequential data transfer delay in TPL mode	4.0	—	—	µs
t_{TPL}	Transmit pulse duration	—	210	—	ns
t_{port_delay}	Port delay introduced by each repeater in 33771	—	—	0.95	µs
t_{RES}	Slave response after read command	—	5.0	—	µs
$V_{RDTX\ INTH}$	Differential receiver threshold	—	580	—	mV
t_{EOM}	Message timeout duration	—	250	—	µs

7.5 Timing diagrams

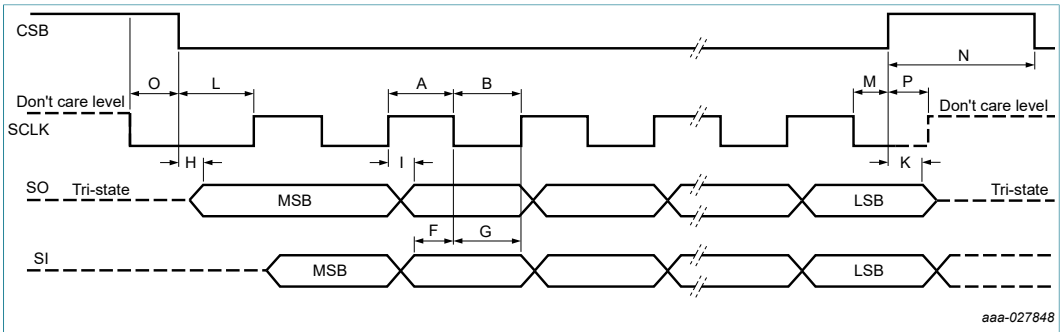


Figure 4. Low-voltage SPI interface timing

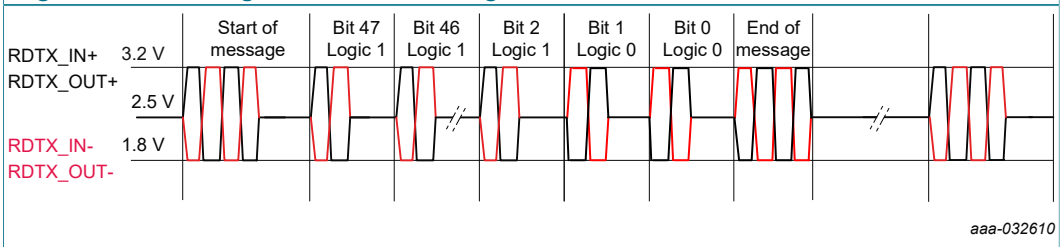


Figure 5. Transformer communication signaling

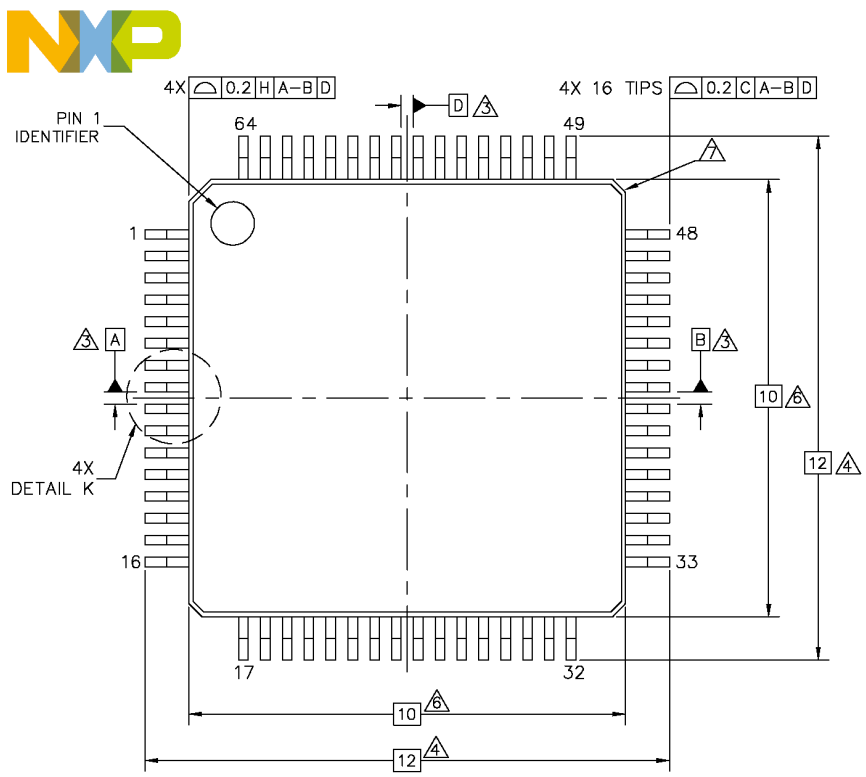
8 Packaging

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 9. Package outline

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



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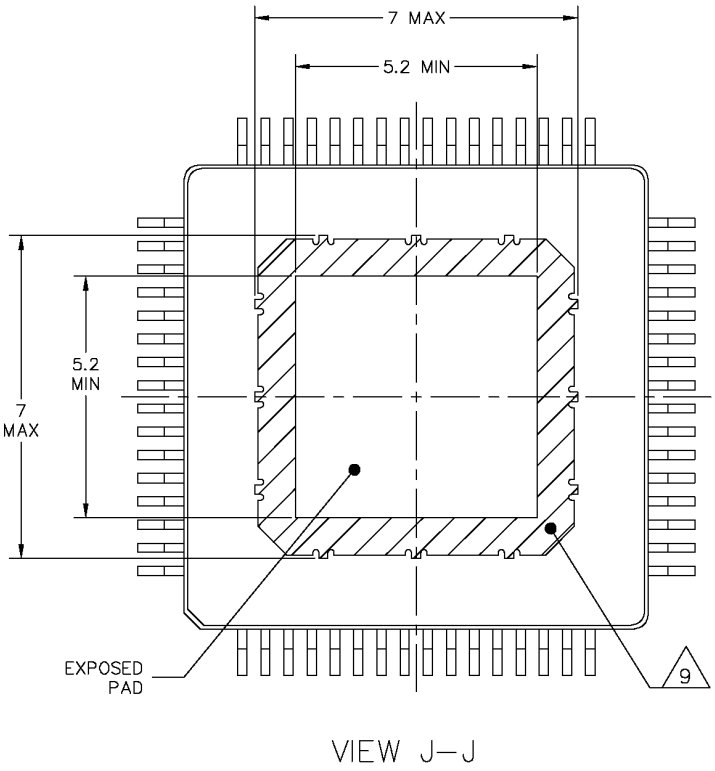
TITLE: LQFP, 10 X 10 X 1.4 PKG, 0.5 PITCH, 64LD, 6.1 x 6.1 EXPOSED PAD	DOCUMENT NO: 98ASA10763D	REV: E
	STANDARD: JEDEC MS-026 BCD	
	SOT1510-2	29 JUN 2018

Figure 6. Package outline



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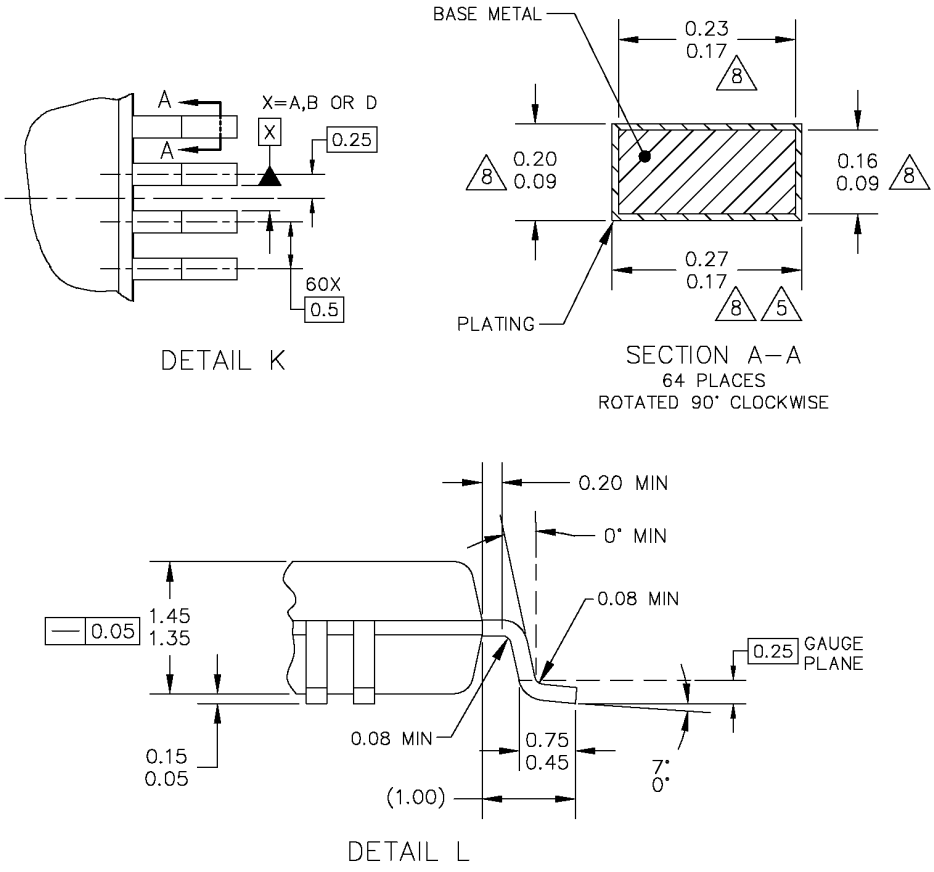
	STANDARD: JEDEC MS-026 BCD	
	SOT1510-2	29 JUN 2018

Figure 7. Package outline



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	STANDARD: JEDEC MS-026 BCD	
	SOT1510-2	29 JUN 2018

Figure 8. Package outline

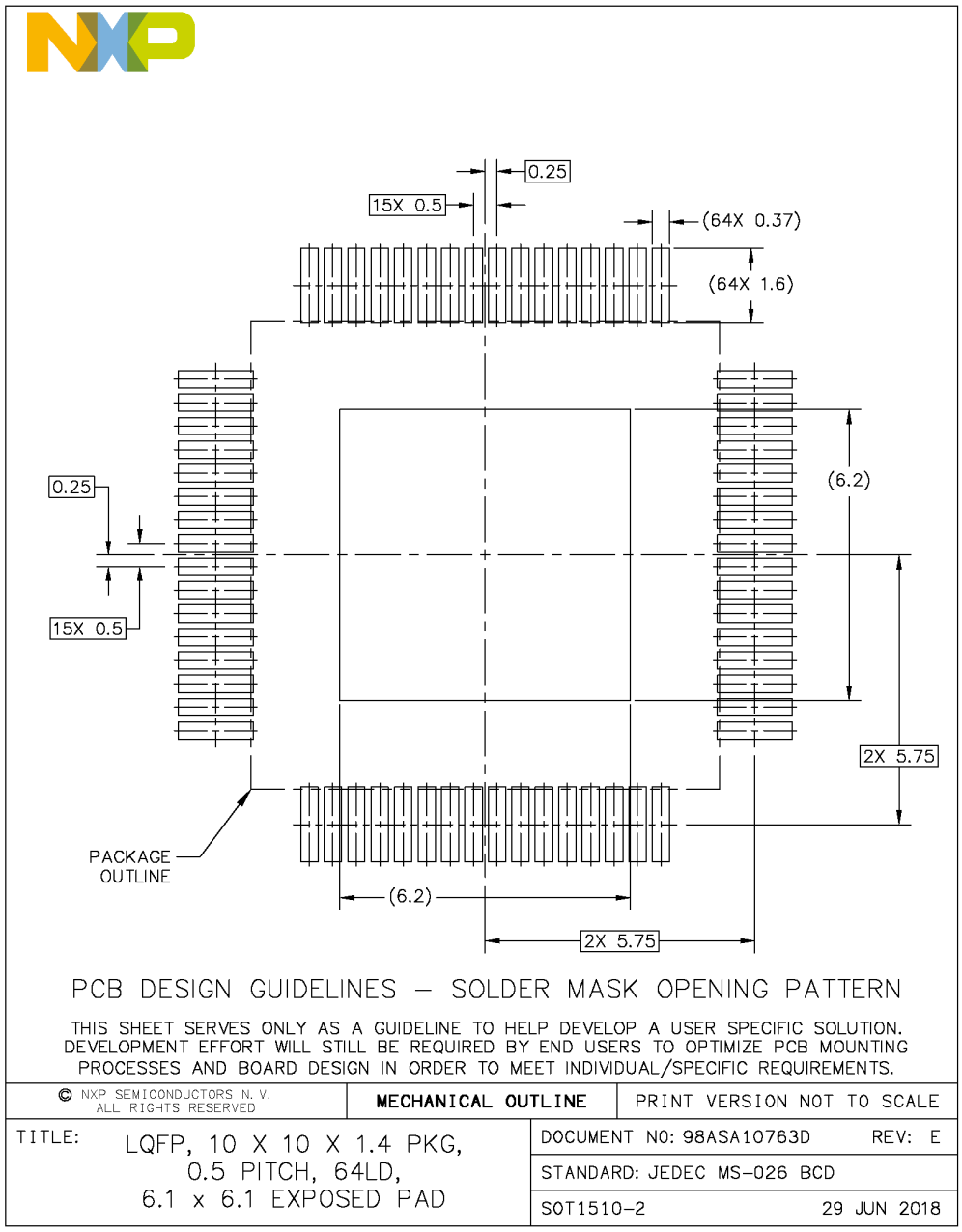

Figure 9. Package outline

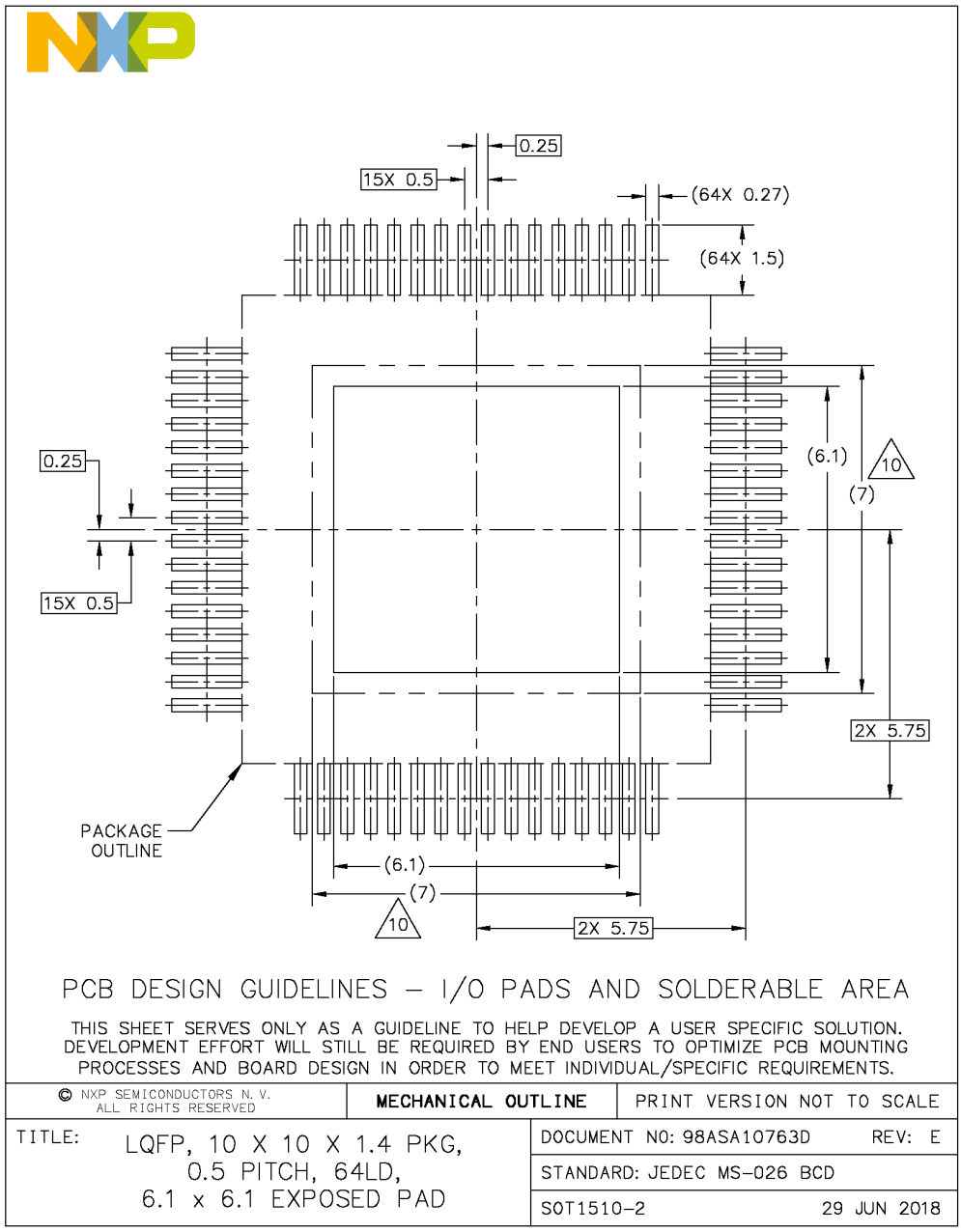

Figure 10. Package outline

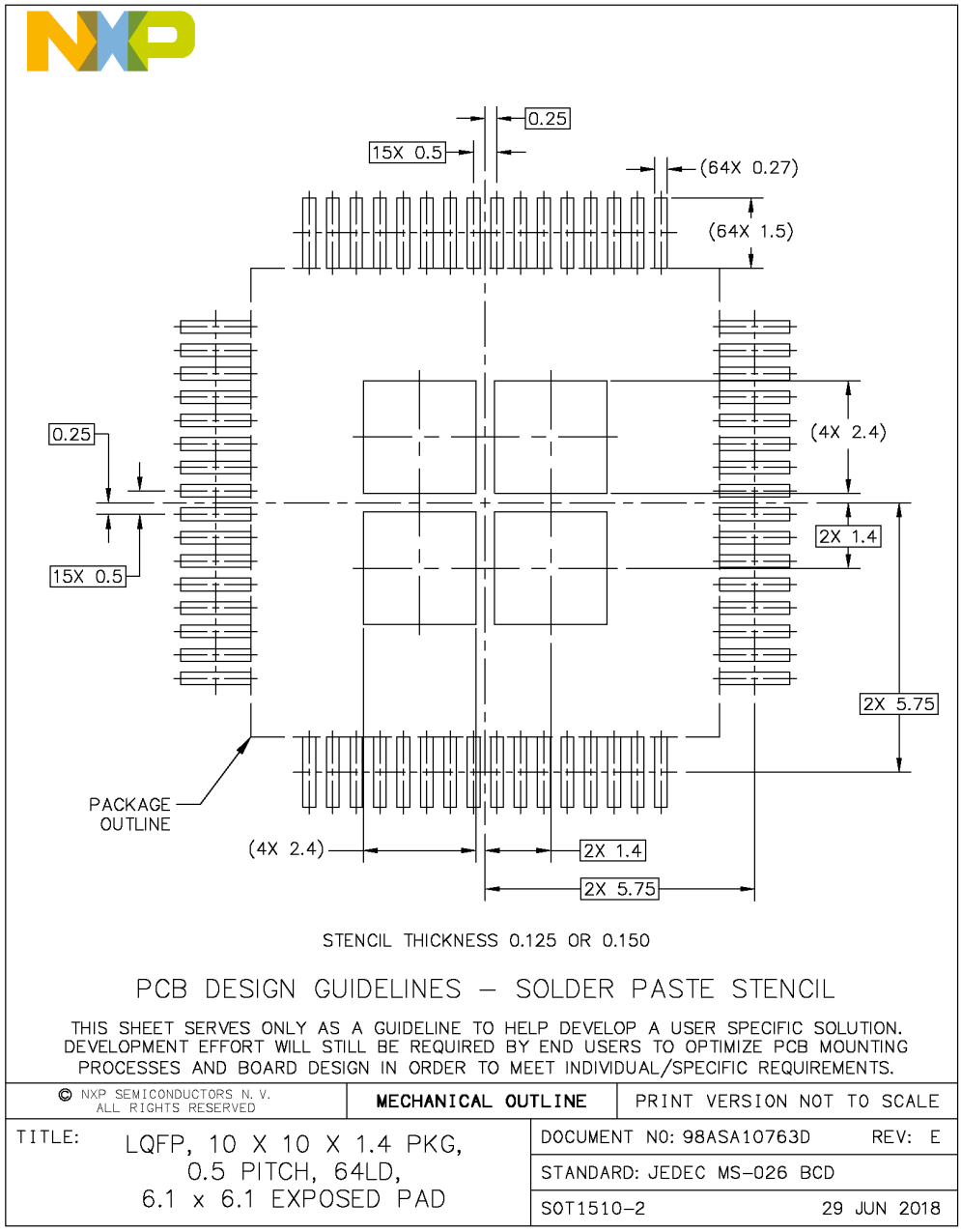

Figure 11. Package outline

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 REPRESENTS POSSIBLE MOLD FLASH ON EXPOSED PAD.
10. KEEP OUT ZONE REPRESENTS AREA ON PCB THAT MUST NOT HAVE ANY EXPOSED METAL (EG. TRACE/VIA) FOR PCB ROUTING DUE TO THE POSSIBILITY OF SHORTING TO TIE BAR/EXPOSED PAD.

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	STANDARD: JEDEC MS-026 BCD	
	SOT1510-2	29 JUN 2018

Figure 12. Package outline

9 References

Following are URLs where you can obtain information on related NXP products and application solutions:

[1] **Product summary page for RD33771CNTREVM: HV Battery management system reference design** — http://www.nxp.com/products/RD33771CNTREVM

[2] **Product summary page for MC33664: Isolated Network High-Speed Transceiver** — http://www.nxp.com/products/MC33664

[3] **Product summary page for MC33771: 14-Channel Li-ion Battery Cell Controller IC** — http://www.nxp.com/products/MC33771C

[4] **Product summary page for UJA1169: Mini high-speed CAN companion system basis chip** — https://www.nxp.com/products/power-management/system-basis-chips/mini-system-basis-chips-sbcs/mini-high-speed-can-companion-system-basis-chip:UJA1169LTK

[5] **Product summary page for S32K144: 32-bit Automotive General Purpose Microcontroller** — https://www.nxp.com/products/processors-and-microcontrollers/arm-microcontrollers/s32k-32-bit-automotive-general-purpose-microcontrollers:S32K

[6] **Support page for S32DS-PA: S32DS-ARM: S32 Design Studio for Arm** — https://www.nxp.com/design/software/development-software/s32-design-studio-ide/s32-design-studio-for-arm:S32DS-ARM

[7] **NXP DocStore** — docstore.nxp.com

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