BATTERY MANAGEMENT

DON LAYBOURN
AUTOMOTIVE BUSINESS DEVELOPMENT

AMF-AUT-T2812 | AUGUST 2017

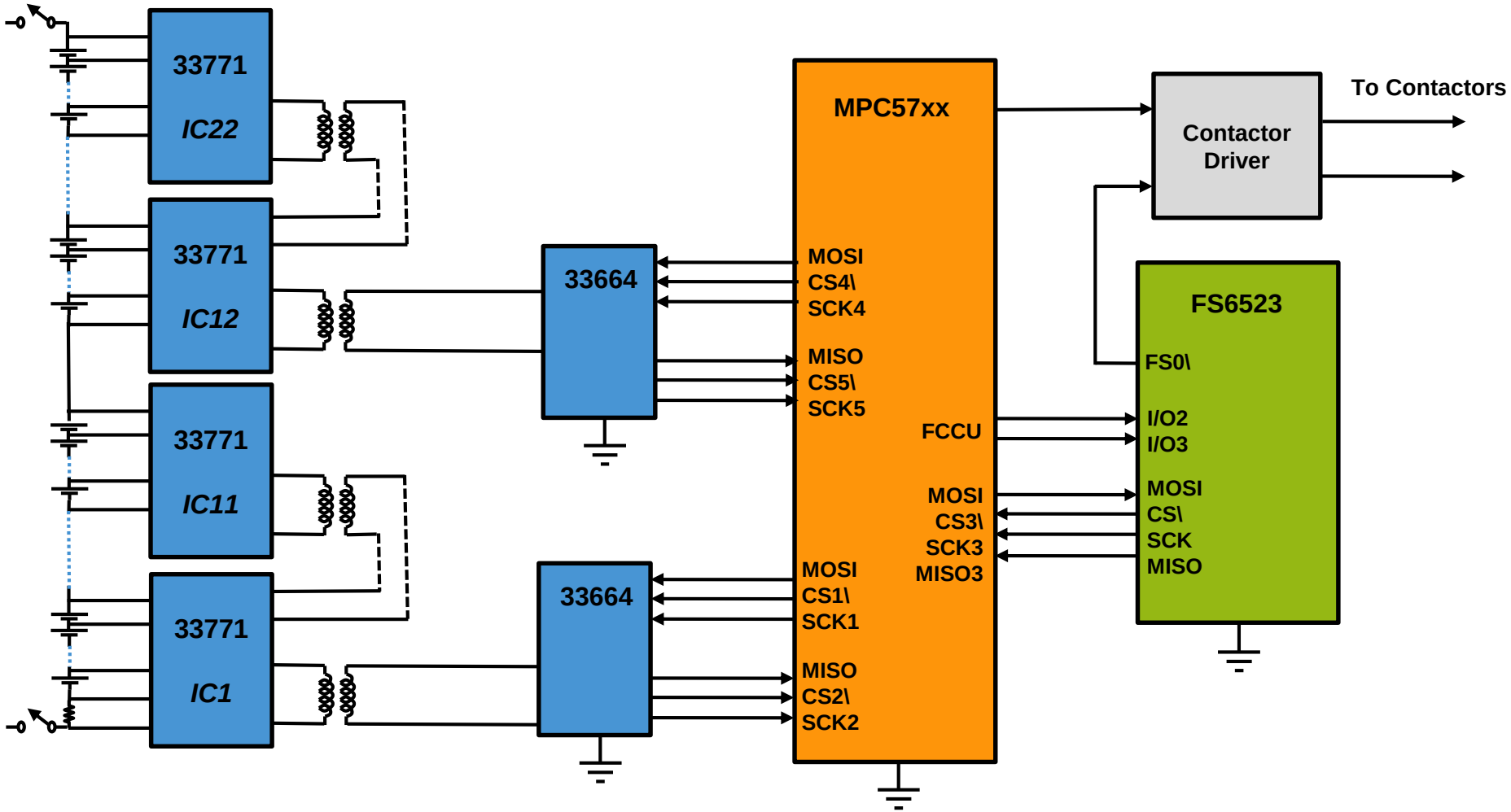
SECURE CONNECTIONS
FOR A SMARTER WORLD

AGENDA

- BMS Market
- Lithium-Ion Battery Overview
- NXP’s BMS Portfolio
- MC3377x / MC33664 Feature Set
- BMS Applications
- Enablement Tools

Battery Management System

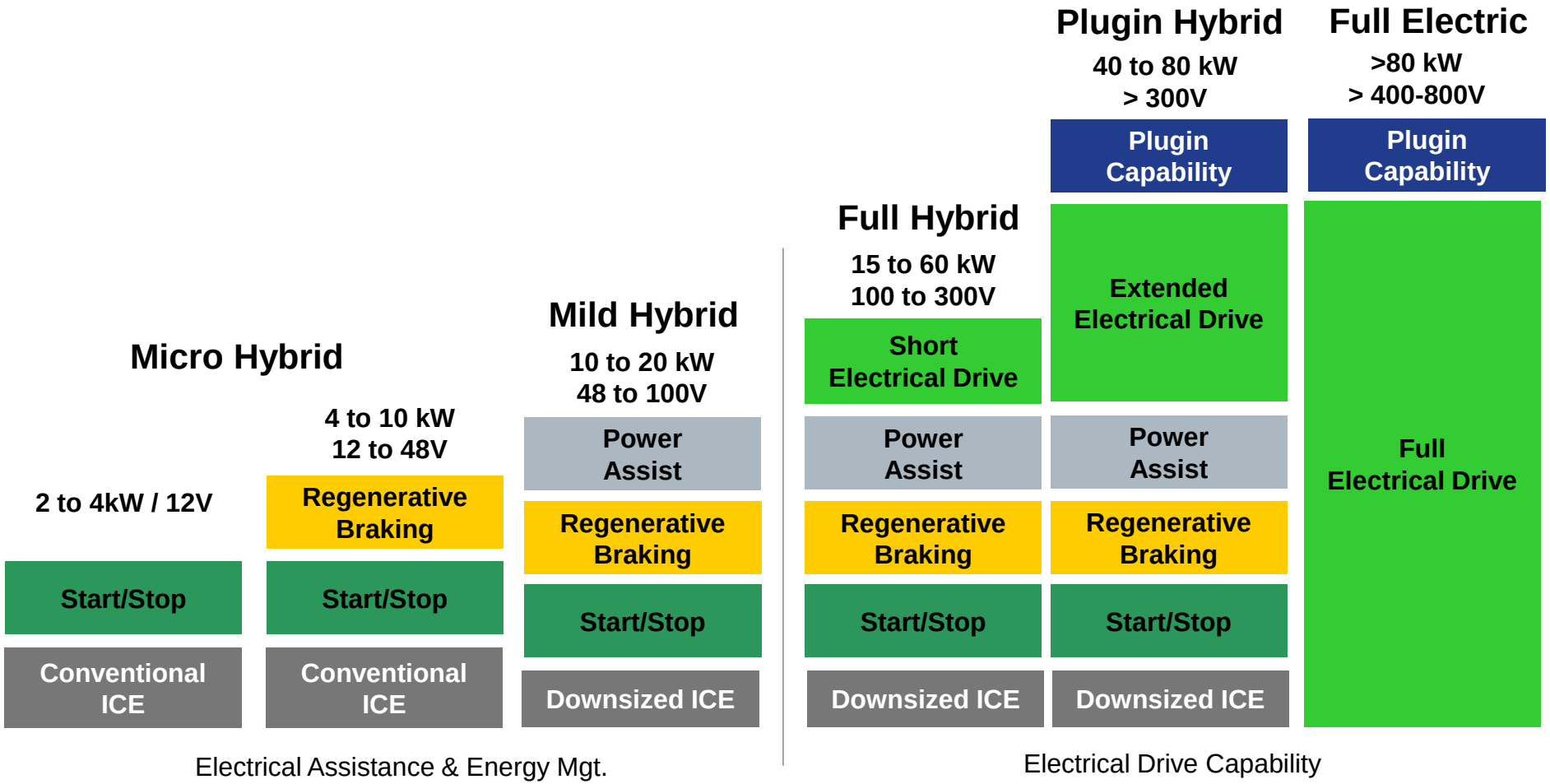
Measures Cell Voltage, Current & Temperature



01.

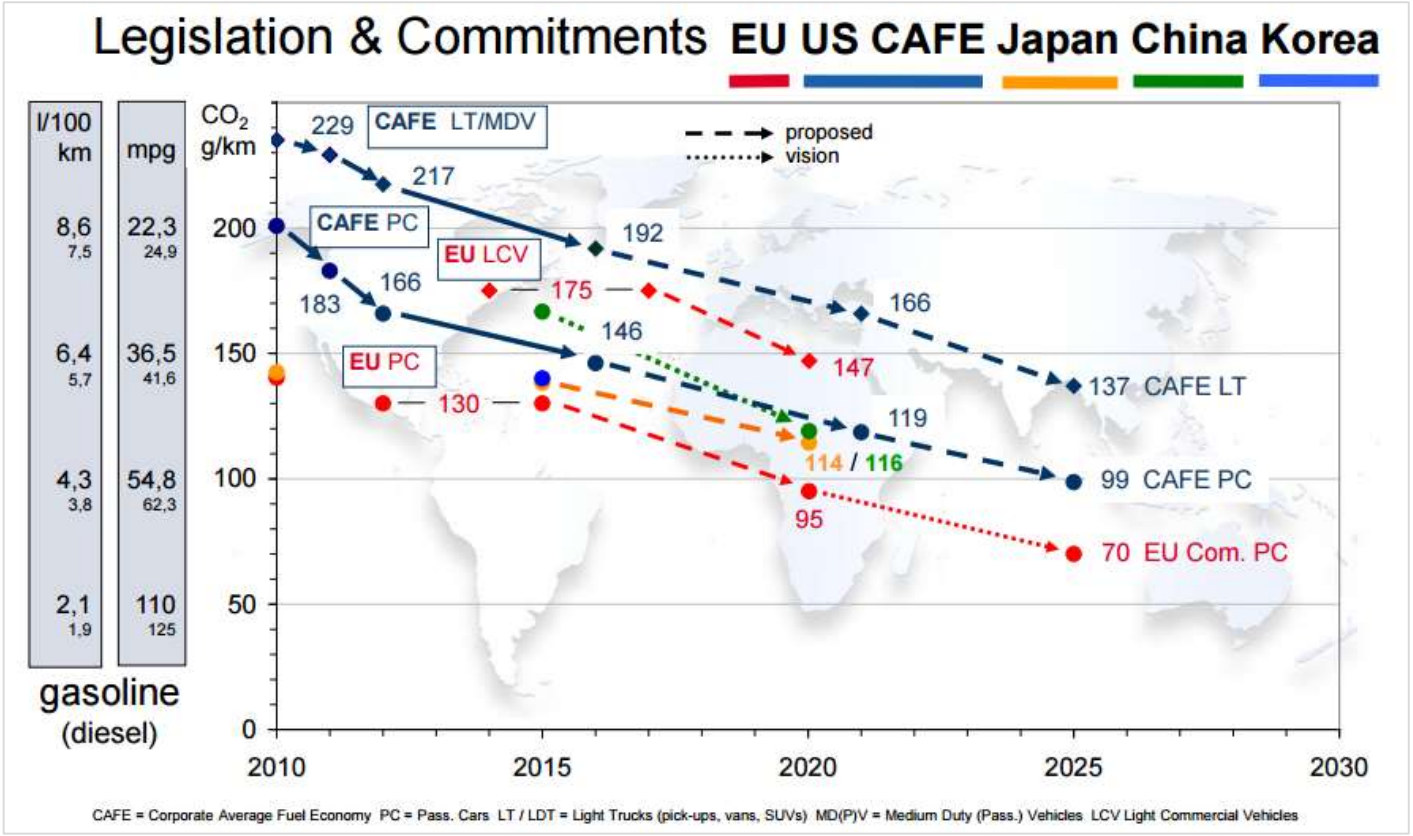
BMS MARKET

Types of ePowertrain Systems



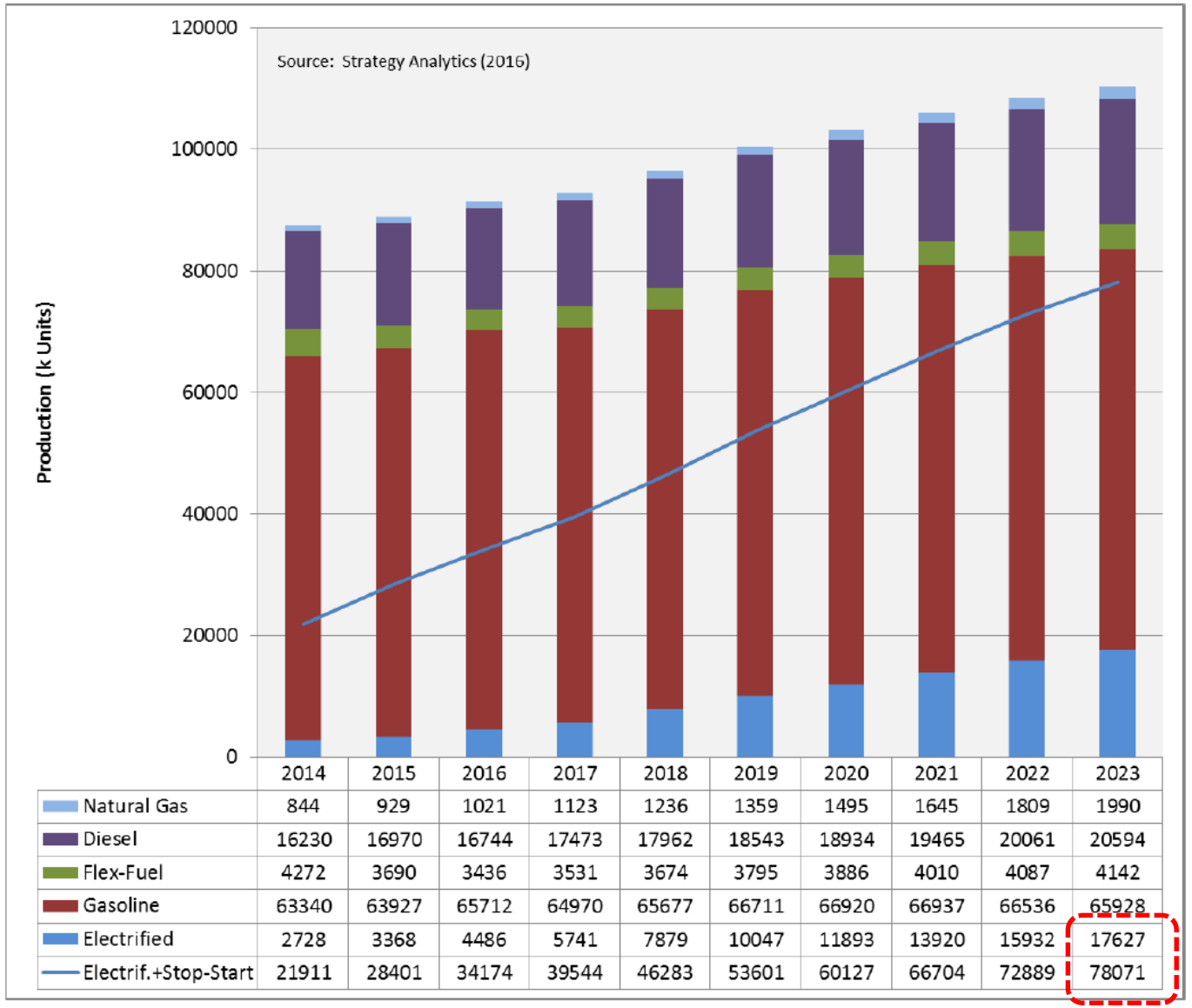
CO_2 & CAFE Standards Drive BMS Market Growth

- **Car electrification megatrend**
  - Mandates for CO2 emission reduction & fuel efficiency
  - Diesel not clean & viable for CO2 reduction
- **Market growth**
  - BCC for power train electrification and renewable energy
  - 14 V BCC as Li-Ion replaces lead acid
  - 12V Lead acid battery sensor as start/stop function adoption
- **Key market sub-segments**
  - **Battery sensors**: for 12 V Lead-Acid
  - **Battery cell controllers**: for 14 V, 48 V & HV Li-Ion batteries



Global Demand by Powertrain Type

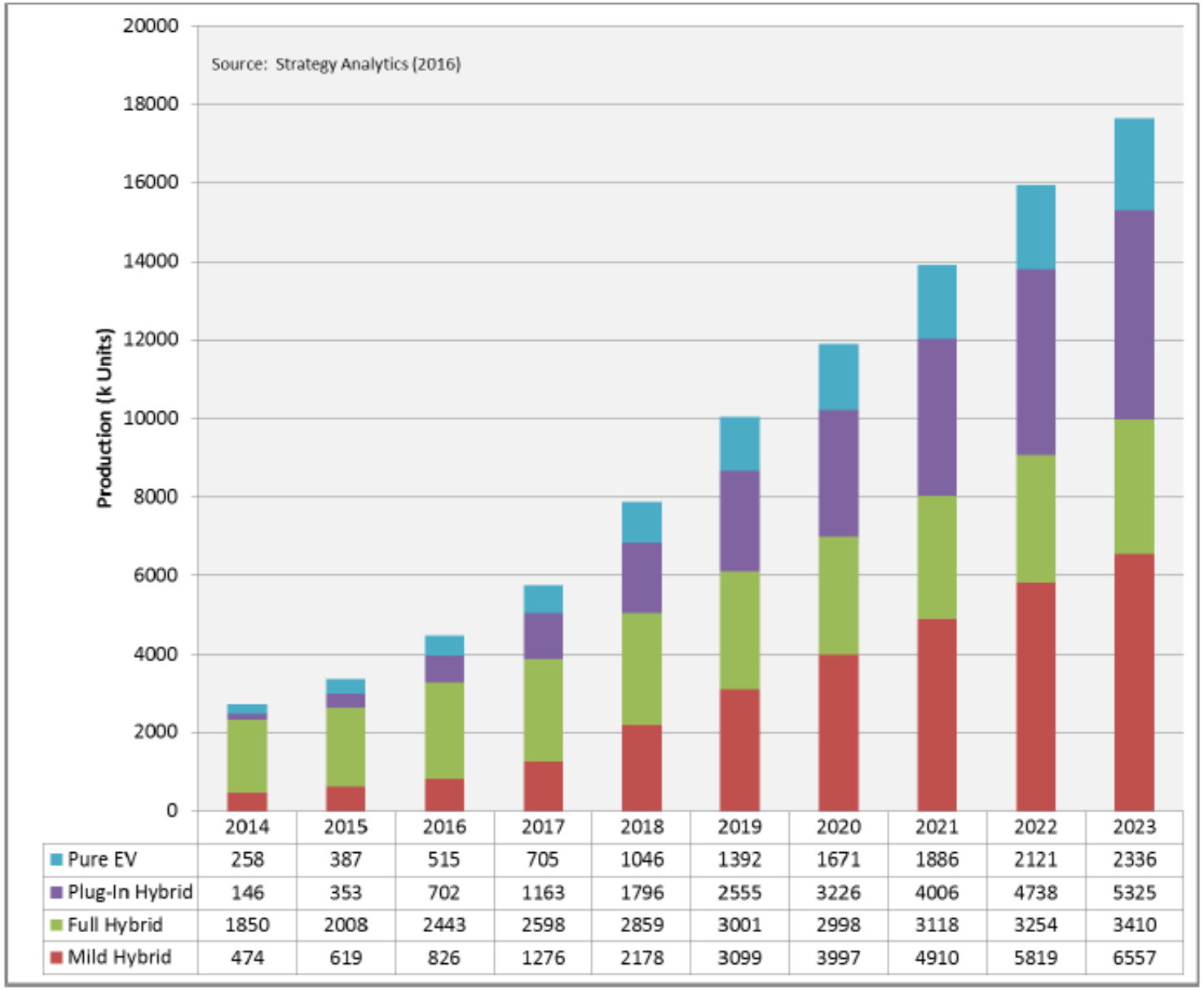
- Rapid adoption of Start/Stop Systems
  - Mostly 12V lead-acid today
  - 48V & 14V Li-Ion next gen
  - Lower cost step for small car segments
- PHEV, Plug-In EV
  - ICE used to charge smaller battery (series hybrid config)
    - Electric drive train with battery sized for 50 miles in EV mode.
- Full EV
  - Used in small car and performance car segments
  - Wider adoption expected as LI-Ion cell cost and reliability improve over time.



	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Natural Gas	844	929	1021	1123	1236	1359	1495	1645	1809	1990
Diesel	16230	16970	16744	17473	17962	18543	18934	19465	20061	20594
Flex-Fuel	4272	3690	3436	3531	3674	3795	3886	4010	4087	4142
Gasoline	63340	63927	65712	64970	65677	66711	66920	66937	66536	65928
Electrified	2728	3368	4486	5741	7879	10047	11893	13920	15932	17627
Electrif.+Stop-Start	21911	28401	34174	39544	46283	53601	60127	66704	72889	78071

xEV Forecast

- Does not include vehicles with Start / Stop system.



	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Pure EV	258	387	515	705	1046	1392	1671	1886	2121	2336
Plug-In Hybrid	146	353	702	1163	1796	2555	3226	4006	4738	5325
Full Hybrid	1850	2008	2443	2598	2859	3001	2998	3118	3254	3410
Mild Hybrid	474	619	826	1276	2178	3099	3997	4910	5819	6557

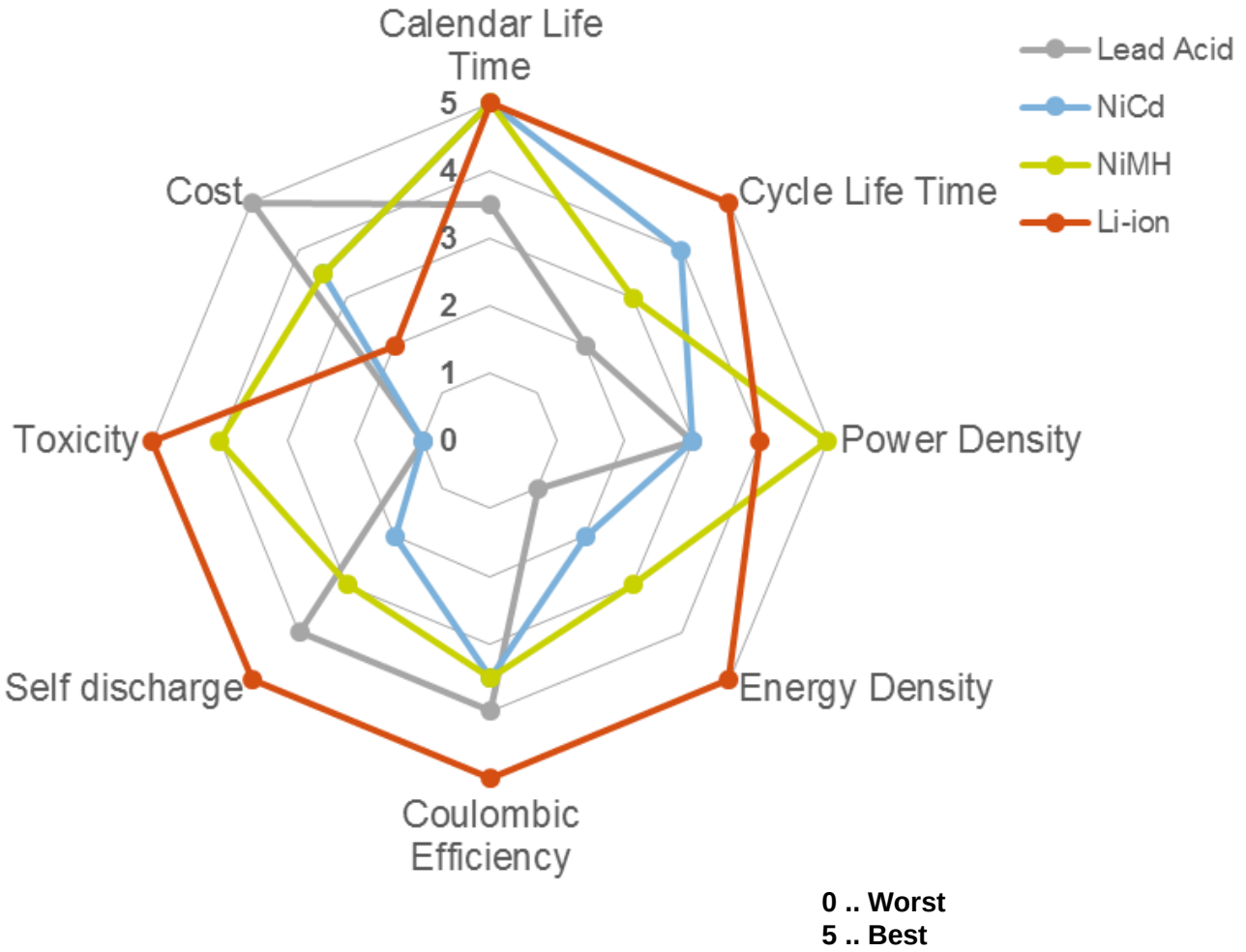
02.

LITHIUM-ION BATTERY OVERVIEW

Li-Ion Battery Examples

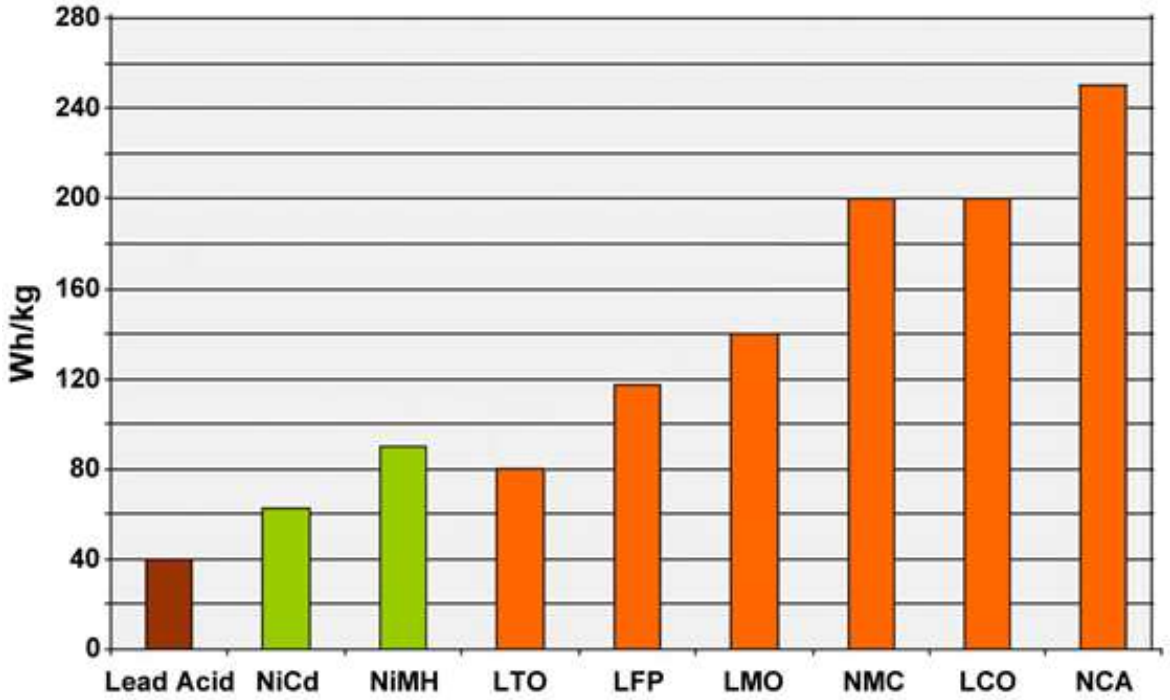
Lithium-Ion Batteries Performance

- **Common rechargeable batteries**
  - Lead-acid
  - NiCd
  - NiMH
  - Li-ion
- **Li-ion offers best general performance**
- **Rapidly growing volume of Li-ion**:
  - **Significant drop in cell cost (10~14% per year till 2020)**
    (JP Morgan & Morgan Stanley, June 2016)
  - **Significant improvement in product maturity**



Lithium-Ion Cell Chemistries

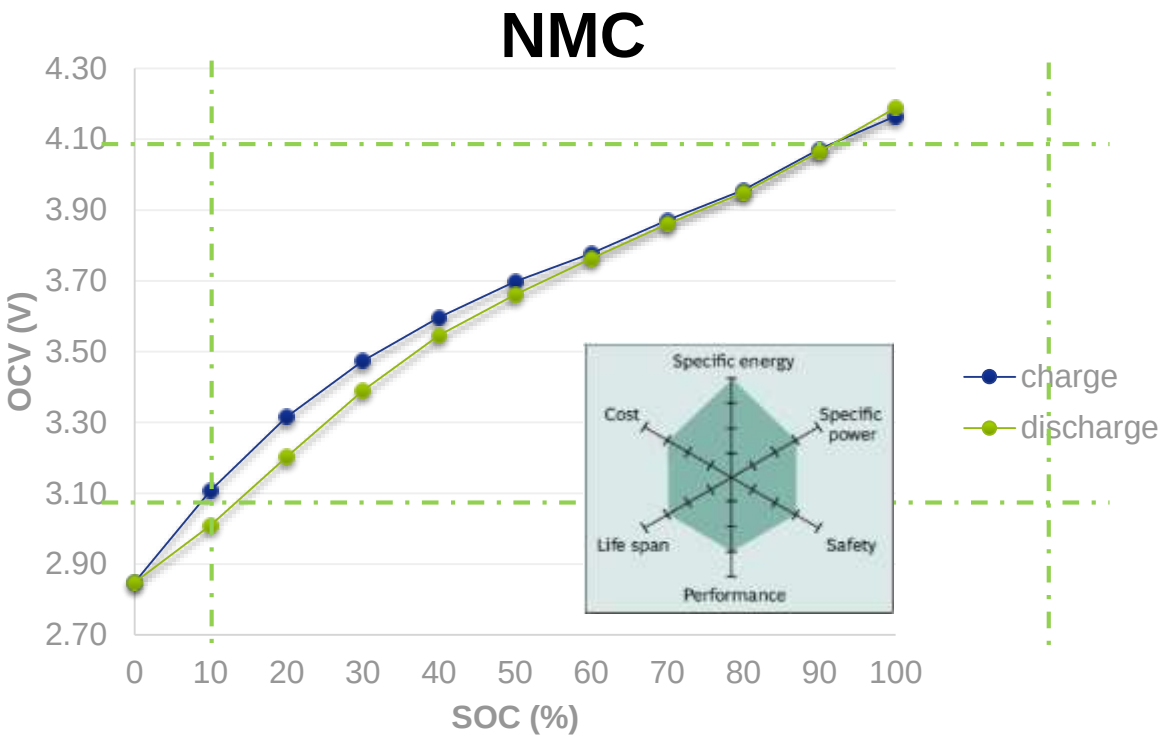
Name	Chemistry	Symbol	Nominal voltage	Full charge	Full discharge
LCO	Lithium Cobalt Oxide	$LiCoC_2$	**3.6V**	4.2V	3.0V
LMO	Lithium Manganese Oxide	$LiMn_2O_4$	**3.7V**	4.2V	3.0V
LFP	Lithium Iron Phosphate	$LiFePo_4$	**3.3V**	3.65V	2.5V
NCA	Lithium Nickel Cobalt Aluminum Oxide	$LiNiCoAlO_2$	**3.6V**	4.2V	3.0V
NMC	Lithium Nickel Manganese	$LiNiMnCoO_2$	**3.6V**	4.2V+	3.0V
LTO	Lithium Titanate	Li_2TiO_3	**2.4V**	2.85V	1.8V



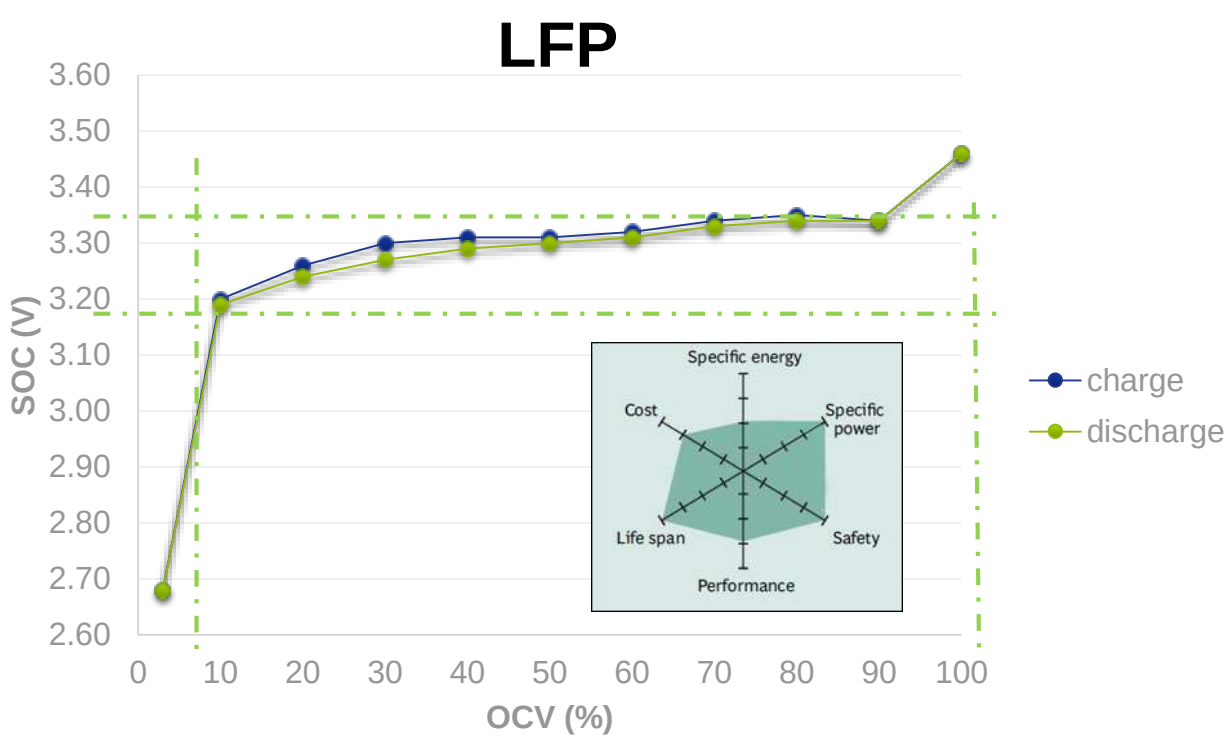
http://batteryuniversity.com/learn/article/types_of_lithium_ion

Open Circuit Voltage vs State of Charge

SOC accuracy depends on voltage measurement accuracy



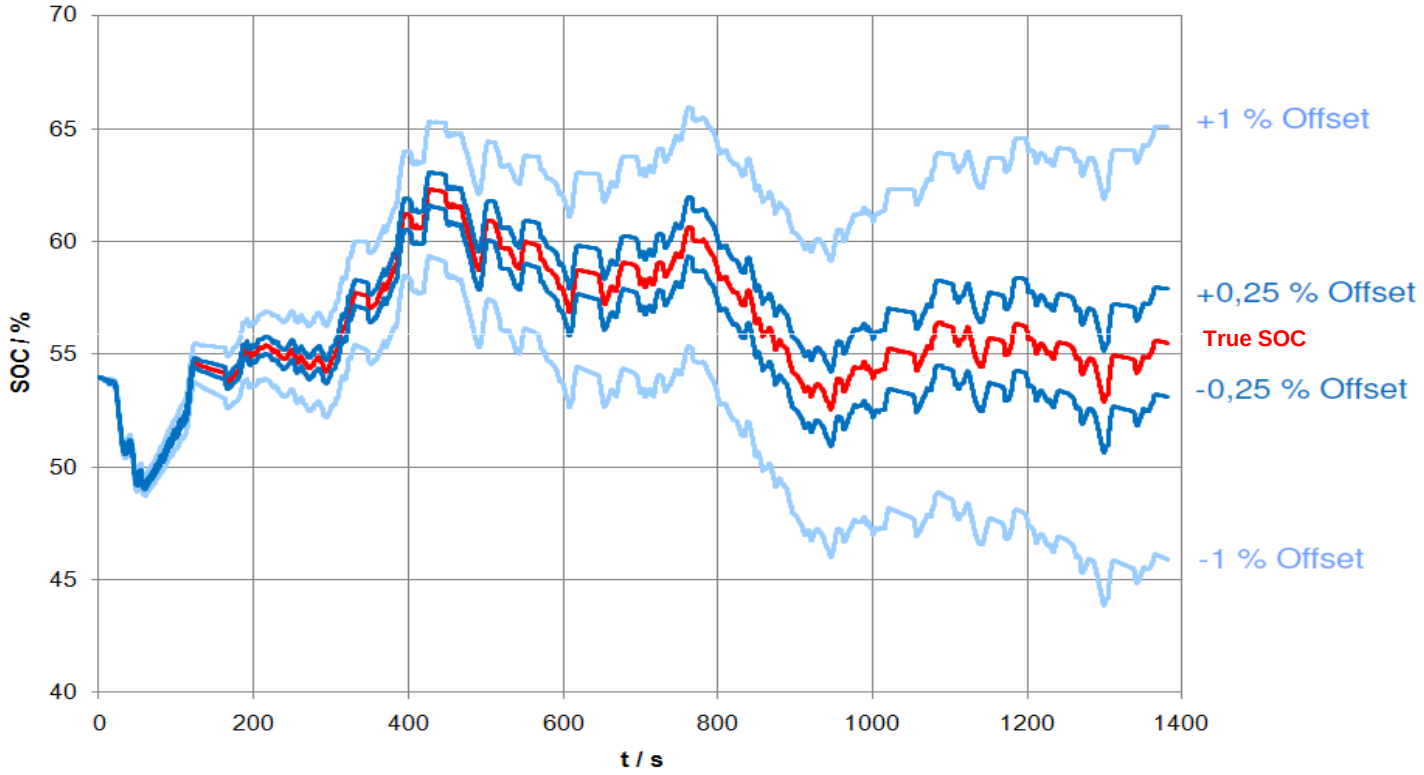
1V ≡ 80% SOC!
(12,5mV/1% SOC)



140mV ≡ 80%
SOC!
(1,75mV/1% SOC)

SOC Estimation

- Initial State of Charge estimation is necessary and needs to be accurate
- Then current is integrated by using the Coulomb counting function

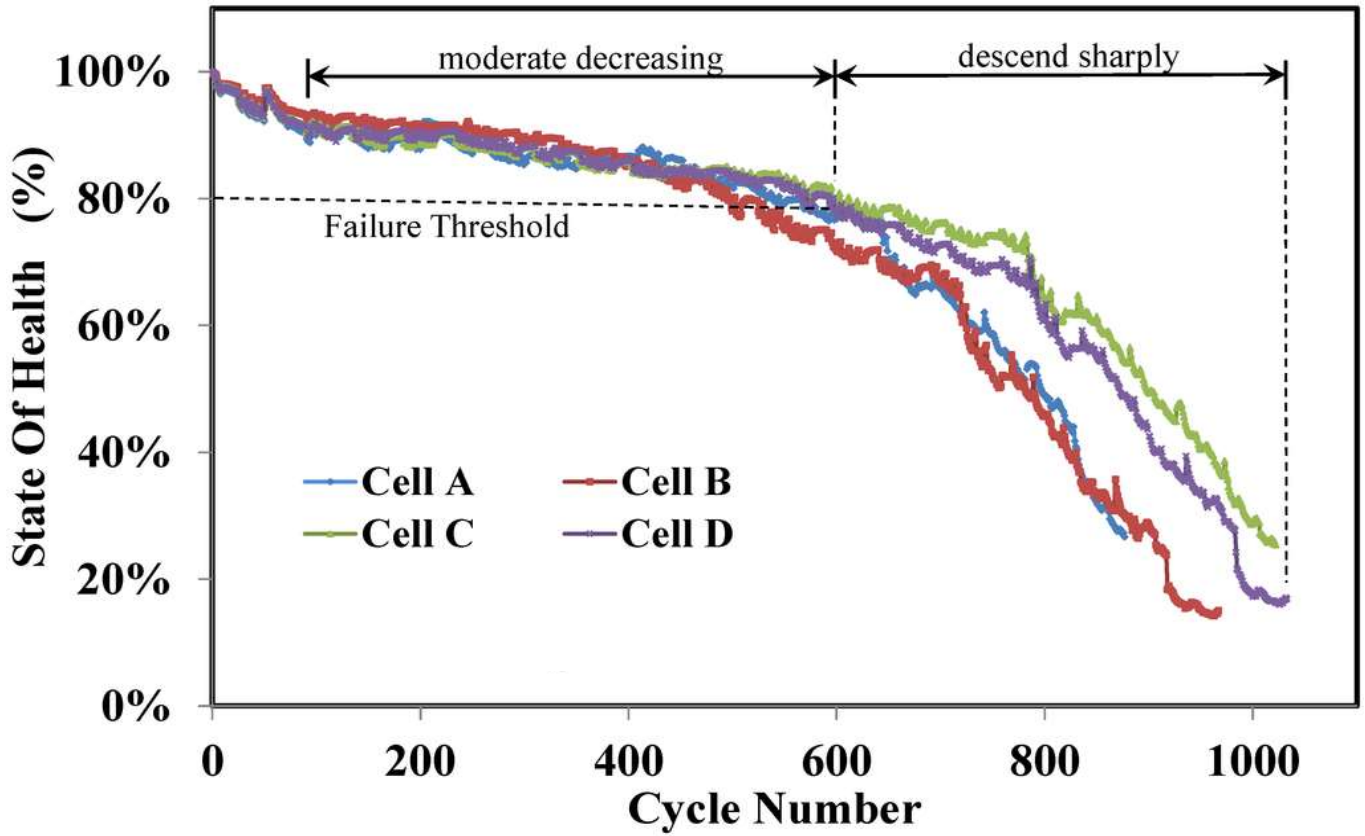


→ SOC accuracy depends on measurement accuracy of both current and voltage

SOH Estimation

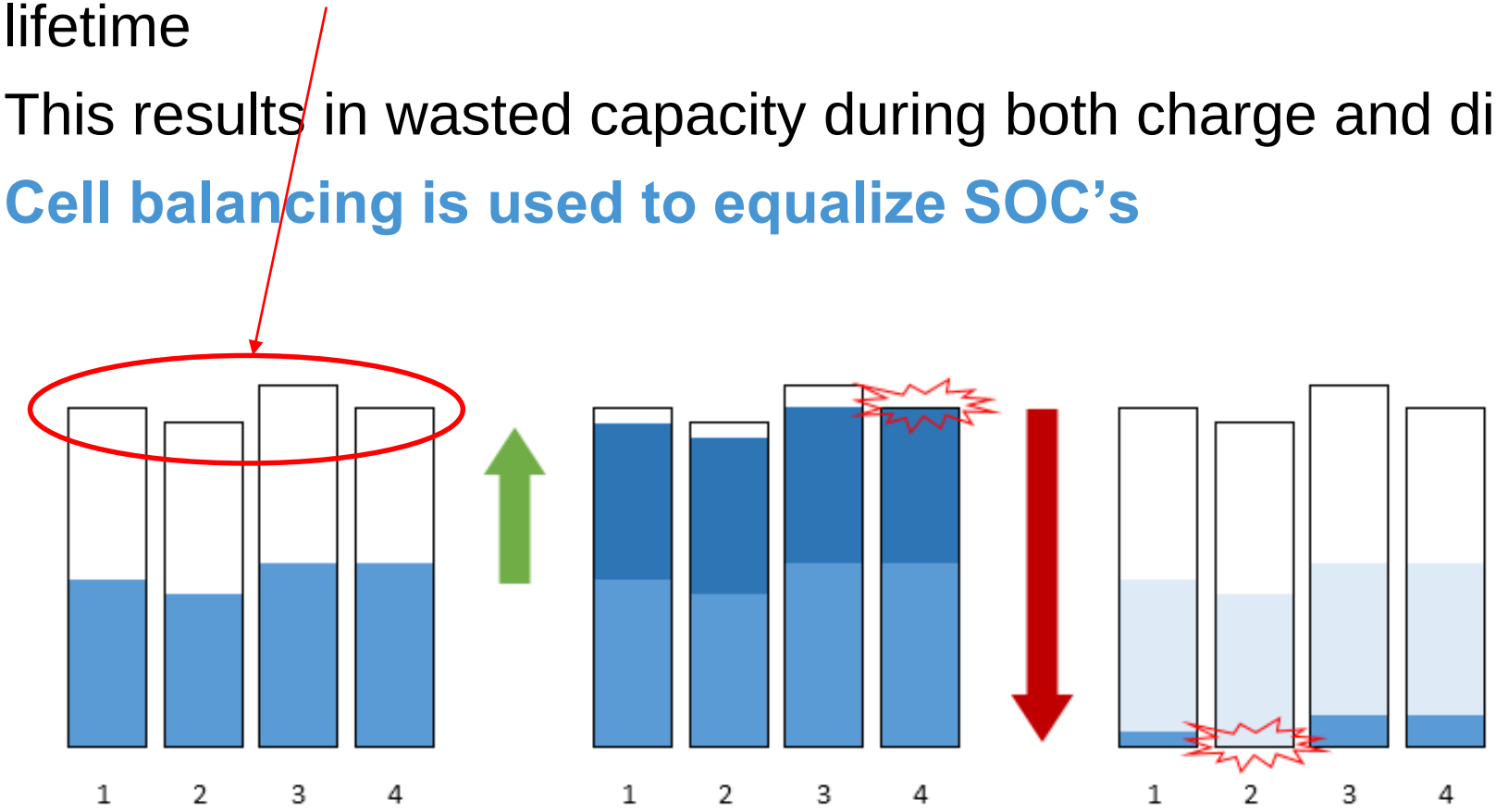
- State of Health = SOH
- Internal cell resistance is one of the many factors used to determine SOH
- SOH measurement requires a **good synchronization of current and voltage measurements (typ 100us)**

$$SOH = \left(\frac{R_i}{R_0}\right) * 100$$

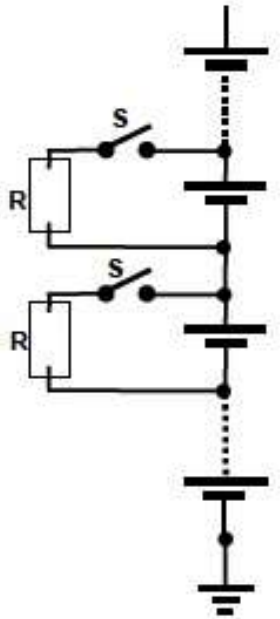


Cell Capacity / Charging Mismatch

- Slight mismatch in capacity during manufacturing, additional mismatch during lifetime
- This results in wasted capacity during both charge and discharge
- **Cell balancing is used to equalize SOC's**



Passive Cell Balancing



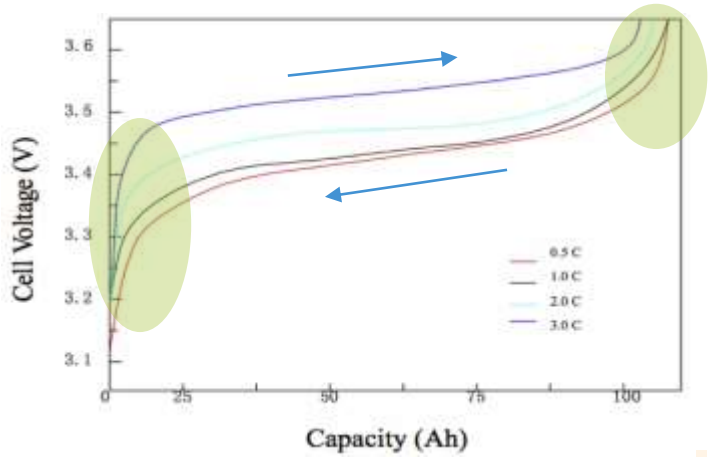
Lithium-Ion Battery Safety

- **Battery over-voltage (OV):** secondary chemical reactions triggered: battery overheating, smoke emission, inflaming or explosion are very likely. OV typically close to 4V.
- **Thermal runaway (OT):** can start a positive temperature feedback mechanism, with the same consequences as an OV. OT typically close to 60 °C.
- **Battery under-voltage (UV):** results in progressive breakdown of the electrodes substances. With LFP cells this may happen over a few cycles. UV typically close to 2V.
- **Battery over-current (OC):** may result in the melting of the battery contactors. Major safety issue: impossibility to open the contactors and inability to drive the system to the disabled safe state.
- **Battery under-temperature (UT):** loss of robustness of the contactors, reduction of the battery capability to provide current, dendrites. Need to limit current to avoid damage.

→ **Need to comply with stringent Safety standards (ISO26262 for Automotive)**

Main Functions of BMS systems

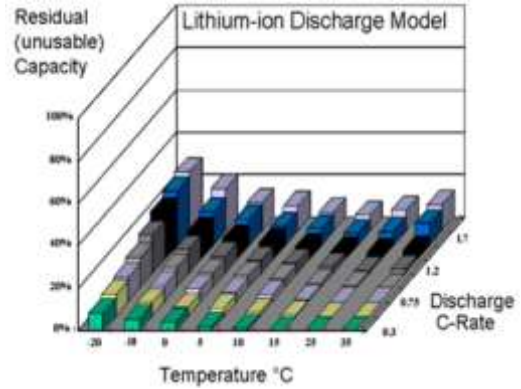
Guarantee Safety



Danger:
- Over voltage
- Extra heat
- Unstable chemical stage
- Thermal runaway=>fire/explosion
- Low temperature charge

V/I/T measurement
OV/UV/OT/UT detection

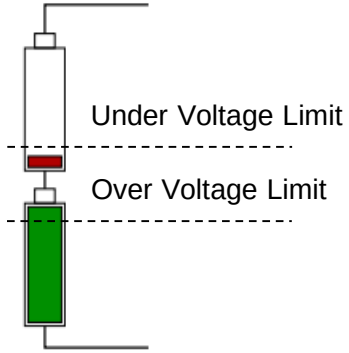
Guarantee Performance



Requirements:
- Safe & fast charging
- Discharge optimization
- State of charge (SOC) estimation
- State of health (SOH) estimation

V/I/T measurement
Coulomb counting
Internal resistance calculation

Guarantee Multi-cell Function



Challenges:
- Up to hundreds of cells
- Manufacture mismatch
- Capacity degradation
- Lifetime degradation

Cell balancing

03.

NXP’s BMS PORTFOLIO

NXP BMS Targeted Systems

Rechargeable Batteries

Highest Growth

Consumer | Industrial | Automotive

Single Cell Li-Ion 3.6V battery charger IC (see Power Management portfolio)

Li-Ion: 14V, 48V, High Voltage (→ 800V)

Telecom

Robotic

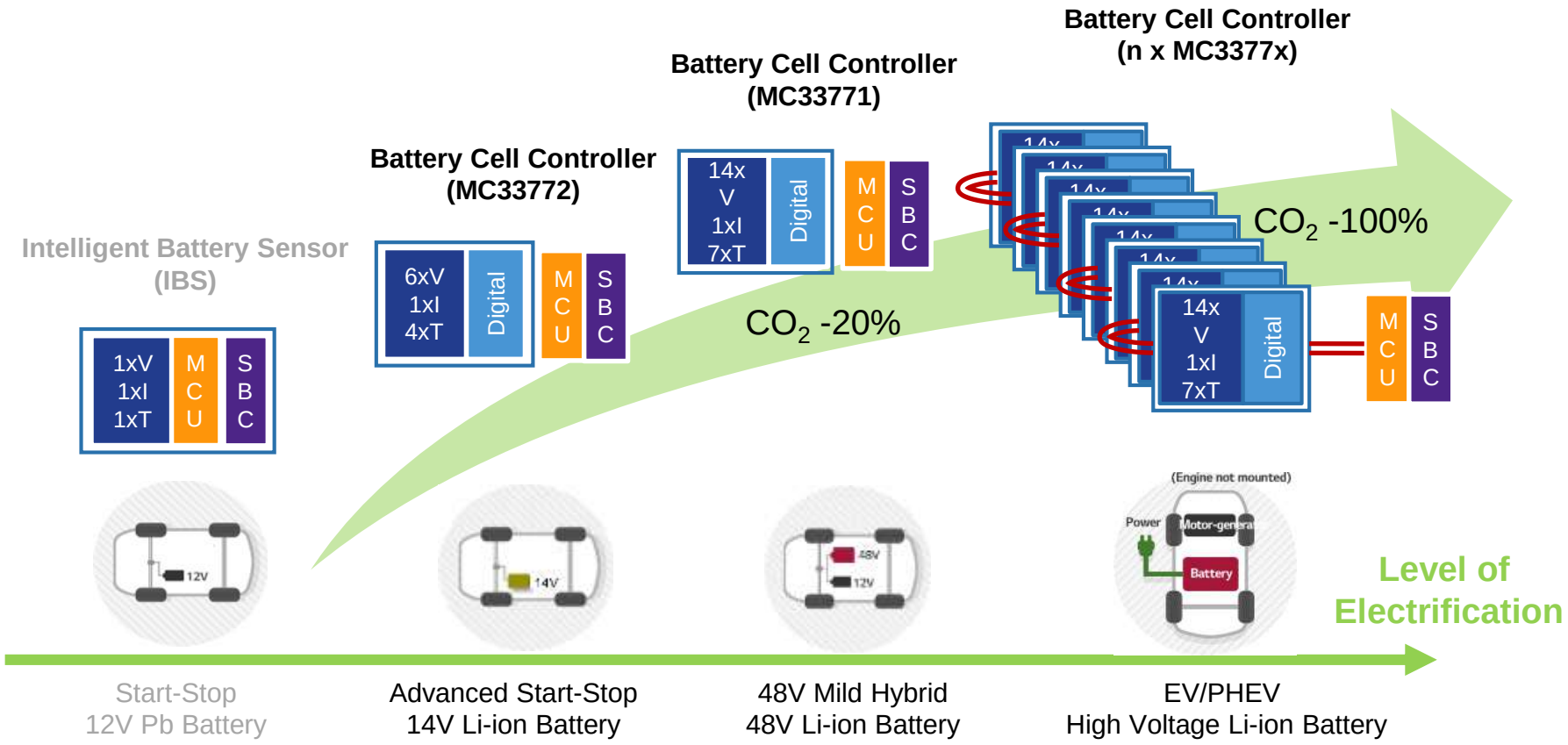
Smart Grid

Replacement

HEV/PHEV/EV

NXP's Scalable Battery Management Portfolio

Addresses all Battery Management Applications – Maximizes HW/SW reuse



MC33771B - 7 to 14 Cells Li-ion Battery Cell Controller

Differentiating Points

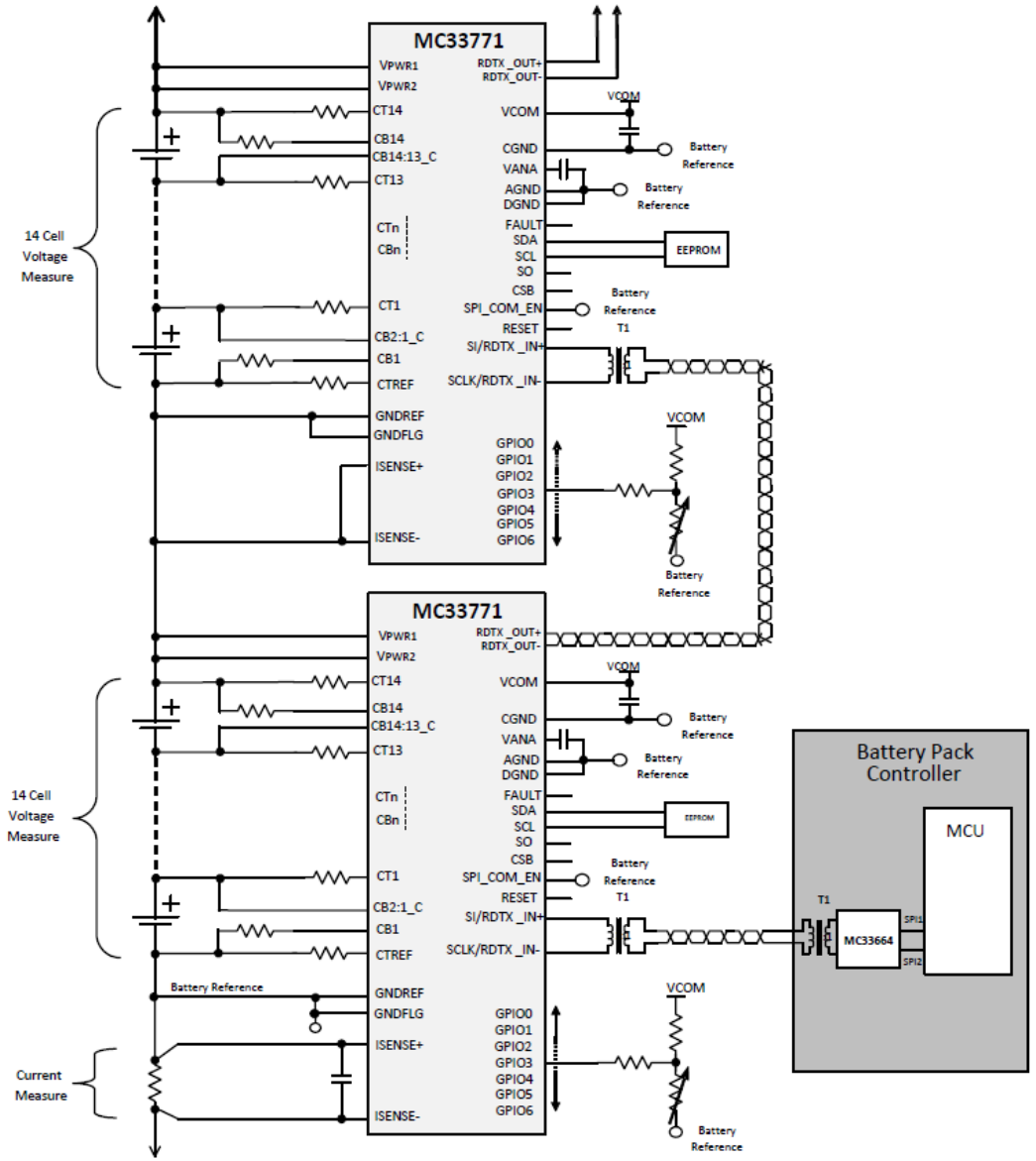
- **Single chip** 48 V battery control scalable to > 1000 V
- **ASIL-C** functional safety compliant
- **300 mA** cell balancing transistors and **0.5%** current sensors
- **Isolated 2 Mbps** differential communication or **4.0 Mbps SPI**
- >2.5x higher transformer coupled daisy chain isolation (3750 V)
- **Synchronized** cell I/V measurement with coulomb counter
- **2 mV** voltage measurement accuracy
- 65µs one shot synchronized cell impedance determination
- **Fast data acquisition**: 3.6 ms for 96 cells, 4.5 ms for 112 cells
- **Functional verification** & **diagnostics** supporting ISO26262
- Automotive robustness: ESD, EMC, **Hot plug**, AEC Q-100

Product Features

- **9.6 V ≤ VPWR ≤ 61.6 V** operation, 70V transient
- **7 to 14x** differential cell voltage + **stack voltage** measurement
- **7x** ADC + GPIO + temperature sensor Inputs
- Low power modes
- 64 pin QFP package
- Low-level drivers to simplify SW development

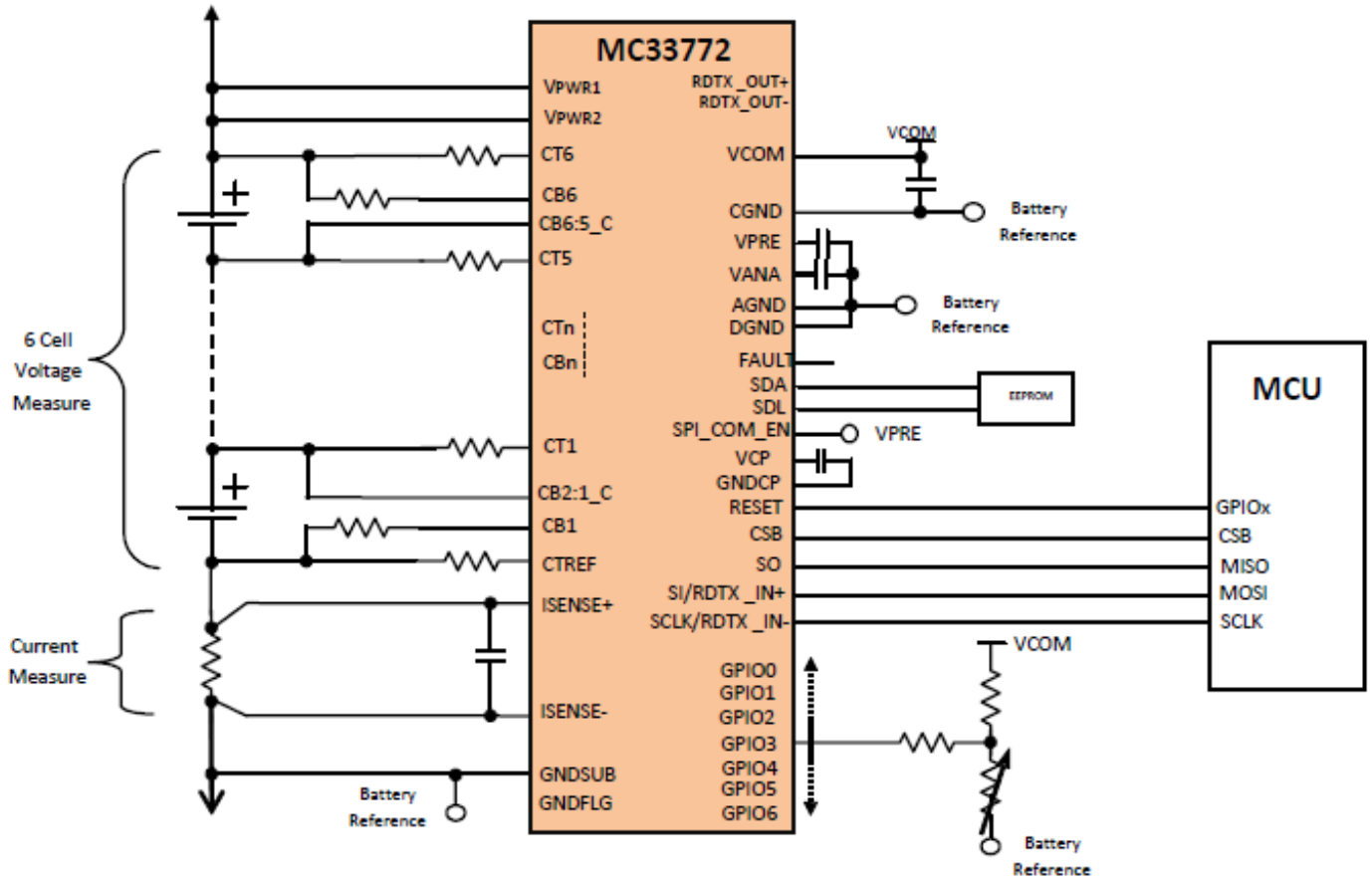
Typical Applications

- 48 V and High Voltage EV battery system
- Energy storage systems (ESS)
- Uninterrupted power supply (UPS)
- E-bikes, E-scooters



MC33772 – 3 to 6 Cells Li-Ion Battery Cell Controller

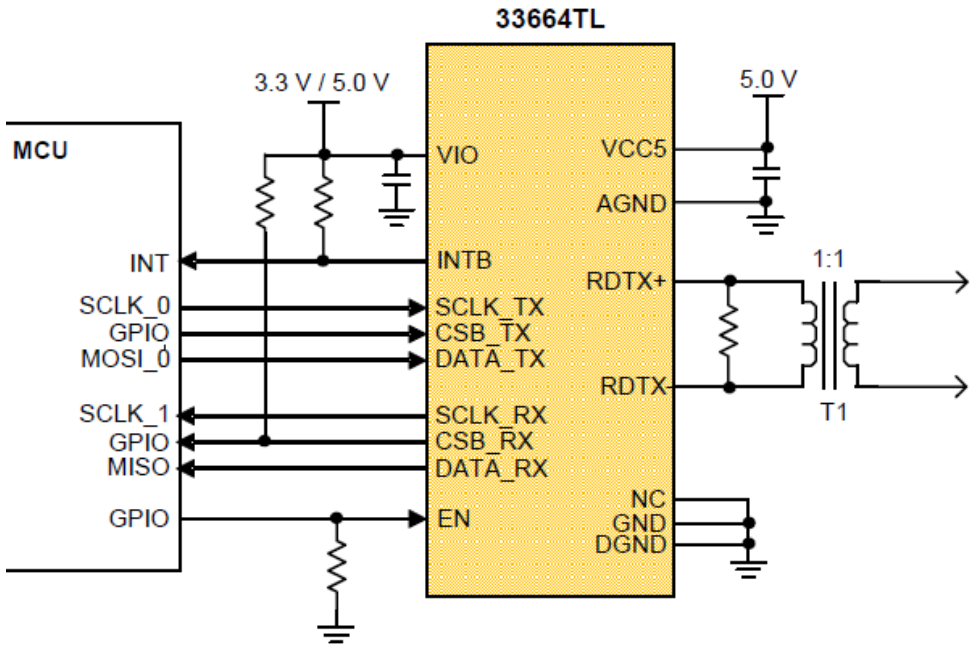
- Operating Voltage:
  - **5 V ≤ V_{PWR} ≤ 30 V Operation, 42 V Transient (for SPI communication)**
  - **7 V ≤ V_{PWR} ≤ 30 V Operation, 42 V Transient (for TPL communication)**
- 4.0 Mbps SPI or Isolated 2 Mbps Differential Communication
- **3 to 6 Cells Voltage Measurement Channels**
- Total Stack Voltage Measurement
- Current sensor with ±0.5% accuracy from mA to kA
- Coulomb Counter (in low-power mode as well)
- 7 x ADC/GPIO/Temperature sensor inputs
- 5.0 V @ 5mA Reference Supply Output
- Integrated Sleep Mode Over/Under Voltage & Temperature Monitoring
- Over/Under Voltage, Over/Under Temperature Fault Verification
- Onboard Passive Cell Balancing with Diagnostics and balancing timers
- Open Cell Terminal Detection
- Internal Diagnostics
- Hot Plug Capable
- Operational Low Power Mode
- **48-LEAD LQFP-EP**
- Temp range: -40°C to 125°C
- AEC-Q100 Automotive Qualified
- EMC/ESD Robustness

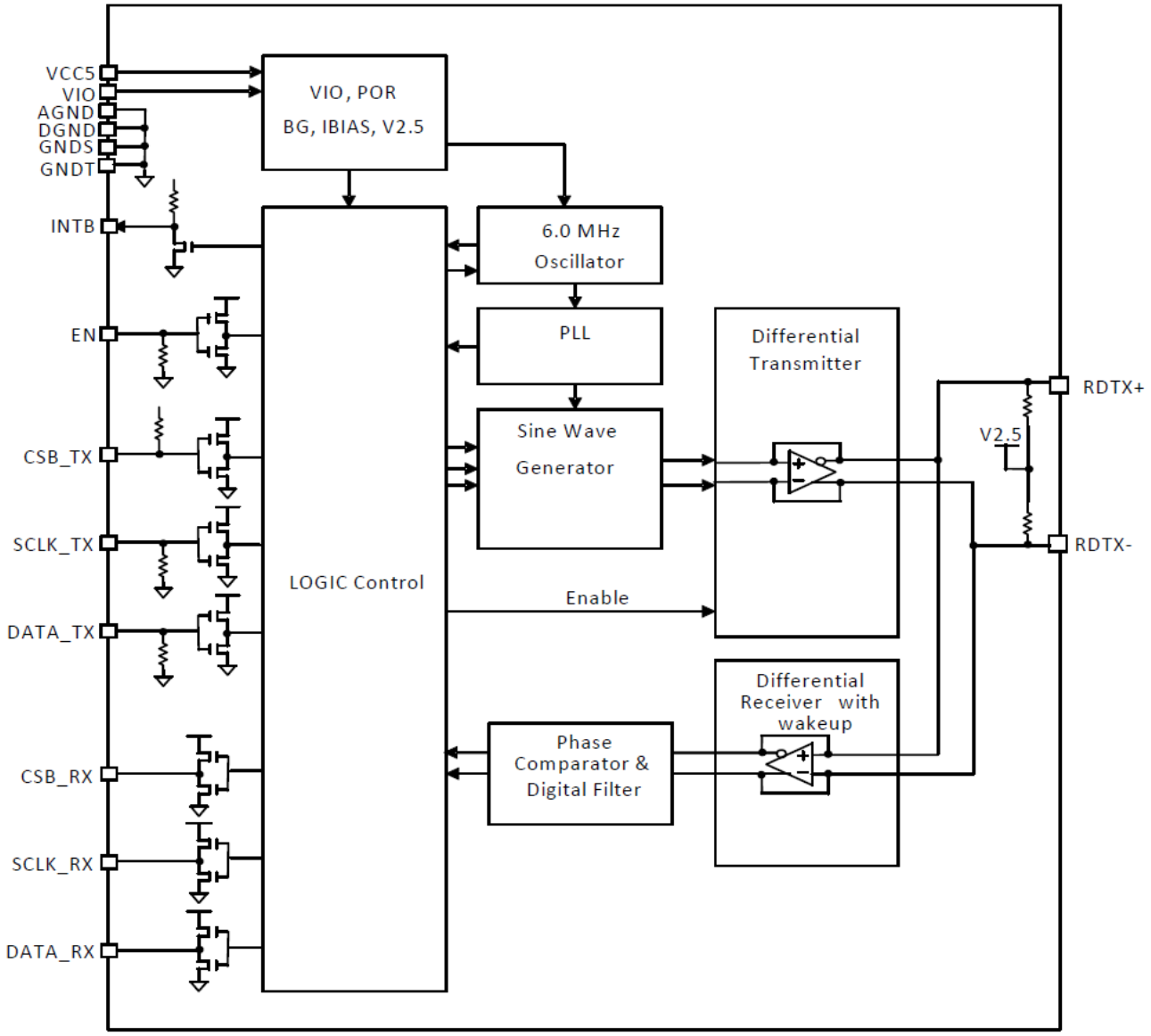


MC33664ATL Transformer Physical Layer

Features:

- 2Mpbs Isolated Network Communication Rate
- Dual SPI Architecture for Message Confirmation
- Robust Conducted and Radiated Immunity with Wake-up
- 3.3V and 5.0V Compatible Logic Thresholds
- Engineered for 5 Meter, 15 Node System
- Low Current Sleep Mode with Automatic Wake-up
- Sine Wave Transmission for low Radiated Emission





Products Overview - Battery Cell Controller | Isolated Communication

Premium

MC3377xySP (SPI comm)
MC3377xyTP (TPL comm)

- Precise differential cell voltage measurement
- Cell OV/UV,
- Synchronized current measurement
- Coulomb Count
- Cell balancing
- Temp measurement, O/U temperature
- Functional verification & diagnostics
- Communication:
  - 2 MHz half duplex differential
  - SPI 4 MHz
- Package:
  64/48-ld LQFP EP
- Temp range:
  -40 C to +105C

Advanced

MC3377xySA (SPI comm)
MC3377xyTA (TPL comm)

- Precise differential cell voltage measurement
- Cell OV/UV,
- ~~Synchronized current measurement~~
- ~~Coulomb Count~~
- Cell balancing
- Temp measurement, O/U temperature
- Functional verification & diagnostics
- Communication:
  - 2 MHz half duplex differential
  - SPI 4 MHz
- Package:
  64/48-ld LQFP EP
- Temp range:
  -40 C to +105C

Basic

MC3377xySB (SPI comm)
MC3377xyTB (TPL comm)

- Precise differential cell voltage measurement
- Cell OV/UV,
- ~~Synchronized current measurement~~
- ~~Coulomb Count~~
- ~~Cell balancing~~
- ~~Temp measurement, O/U temperature~~
- Functional verification & diagnostics
- Communication:
  - 2 MHz half duplex differential
  - SPI 4 MHz
- Package:
  64/48-ld LQFP EP
- Temp range:
  -40 C to +105C

Current

MC33772yTC (TPL comm)

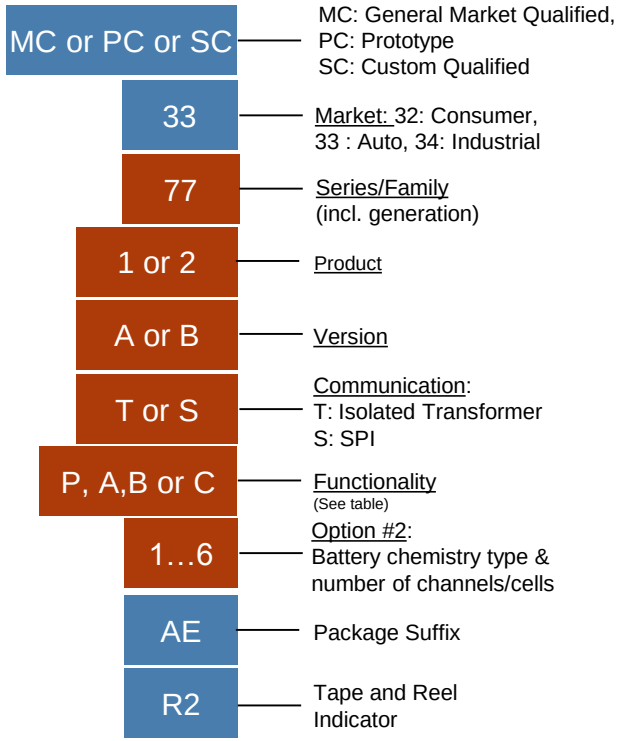
- ~~Precise differential cell voltage measurement~~
- ~~Cell OV/UV~~,
- Synchronized current measurement
- Coulomb Count
- ~~Cell balancing~~
- Temp measurement, O/U temperature
- Functional verification & diagnostics
- Communication:
  - 2 MHz half duplex differential
  - ~~SPI 4 MHz~~
- Package:
  48-ld LQFP EP
- Temp range:
  -40 C to +105C

Half Duplex Differential PHY

MC33664ATL1

- Differential transformer driver / receiver
- Bus and MCU wake-up
- SAFE output (Fail-Safe implementation)
- Operating voltage down to 3.5 V (cranking)
- On-board oscillator
- Analog bit filter
- Package:
  16-ld LQFP EP
- Temp range:
  -40 C to +105C

Battery Cell Controllers: Part Numbering



Functionality & Communication

P/N	Precise differential cell voltage measurement		Temperature		Cell balancing	Current Channel	Couloumb Counter	Communication	
	CTx	Cell OV/UV	Measurement	OT/UT				SPI	Half Duplex differential
MC3377xyTP	x	x	x	x	x	x	x	x	x
MC3377xySP	x	x	x	x	x	x	x	x	NO
MC3377xyTA	x	x	x	x	x	NO	NO	x	x
MC3377xySA	x	x	x	x	x	NO	NO	x	NO
MC3377xyTB	x	x	NO	NO	NO	NO	NO	x	x
MC3377xySB	x	x	NO	NO	NO	NO	NO	x	NO
MC33772yTC	NO	NO	x	x	NO	x	x	x	x

Battery Chemistry Type & Number of Cells

Option #2	Chemistry type	No of Channels / Cells	
		MC33771	MC33772
1	NMC (N)	14	6
2		8	4
3	LFP (F)	14	6
4		8	4
5	LTO (T)	14	6
6		8	4

Examples

MC33771ATP1 → 14 channel, NMC, revA, Current Sensor, TPL
MC33771ATA1 → 14 channel, NMC, revA, NO Current Sensor, TPL
MC33771ASP3 → 14 channel, LFP, revA, Current Sensor, SPI
MC33771ATP6 → 8 channel, LTO, revA, Current Sensor, TPL
MC33771ATA6 → 8 channel, LTO, revA, NO Current Sensor, TPL

MC33772ASP5 → 6 channel, LTO, revA, Current Sensor, SPI
MC33772ASP2 → 4 channel, NMC, revA, Current Sensor, SPI
MC33772ATA1 → 6 channel, NMC, revA, NO Current Sensor, TPL

MC33772ATC → Current Sensor meas, TPL, NO Cell Meas/ Balancing

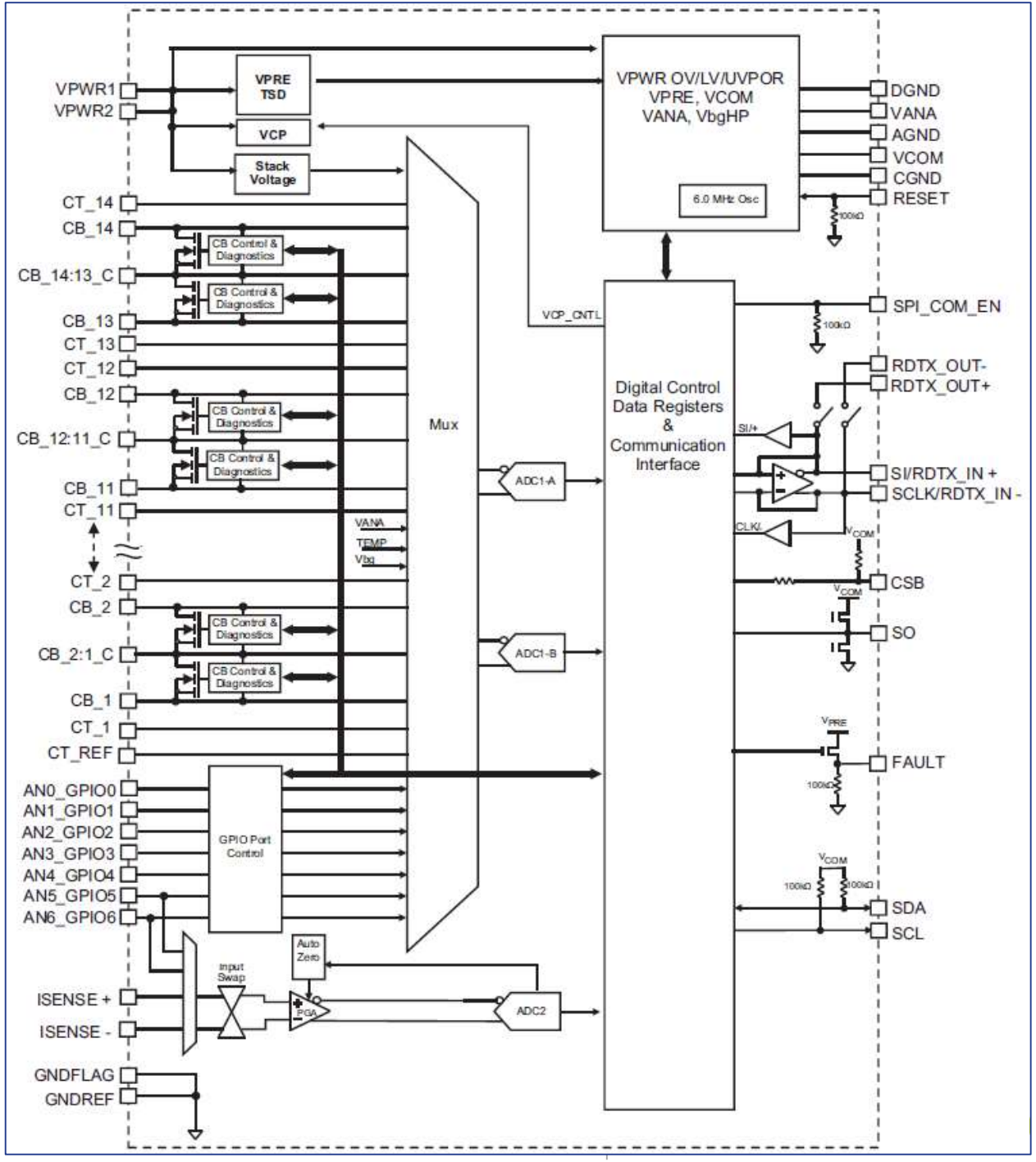
04.

MC33771 / MC33664 Feature Set

33771 Block Diagram

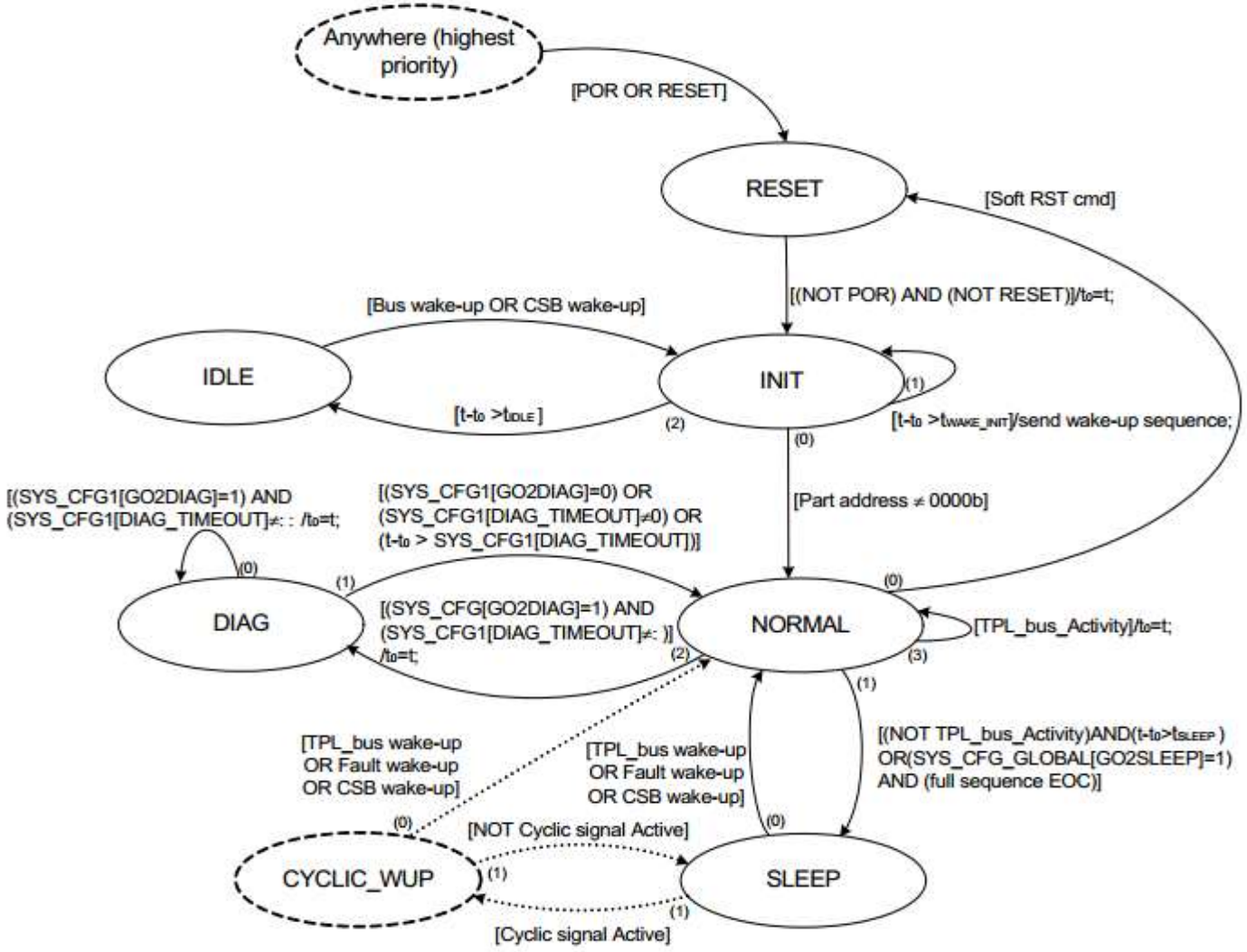
Features

- 9.6 V ≤ VPWR ≤ 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
- 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/under voltage and temperature detection routable to fault pin
- Integrated sleep mode over/under voltage 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
- Single chip ASIL C capable
- Fully compatible with the MC33772 for a maximum of six cells



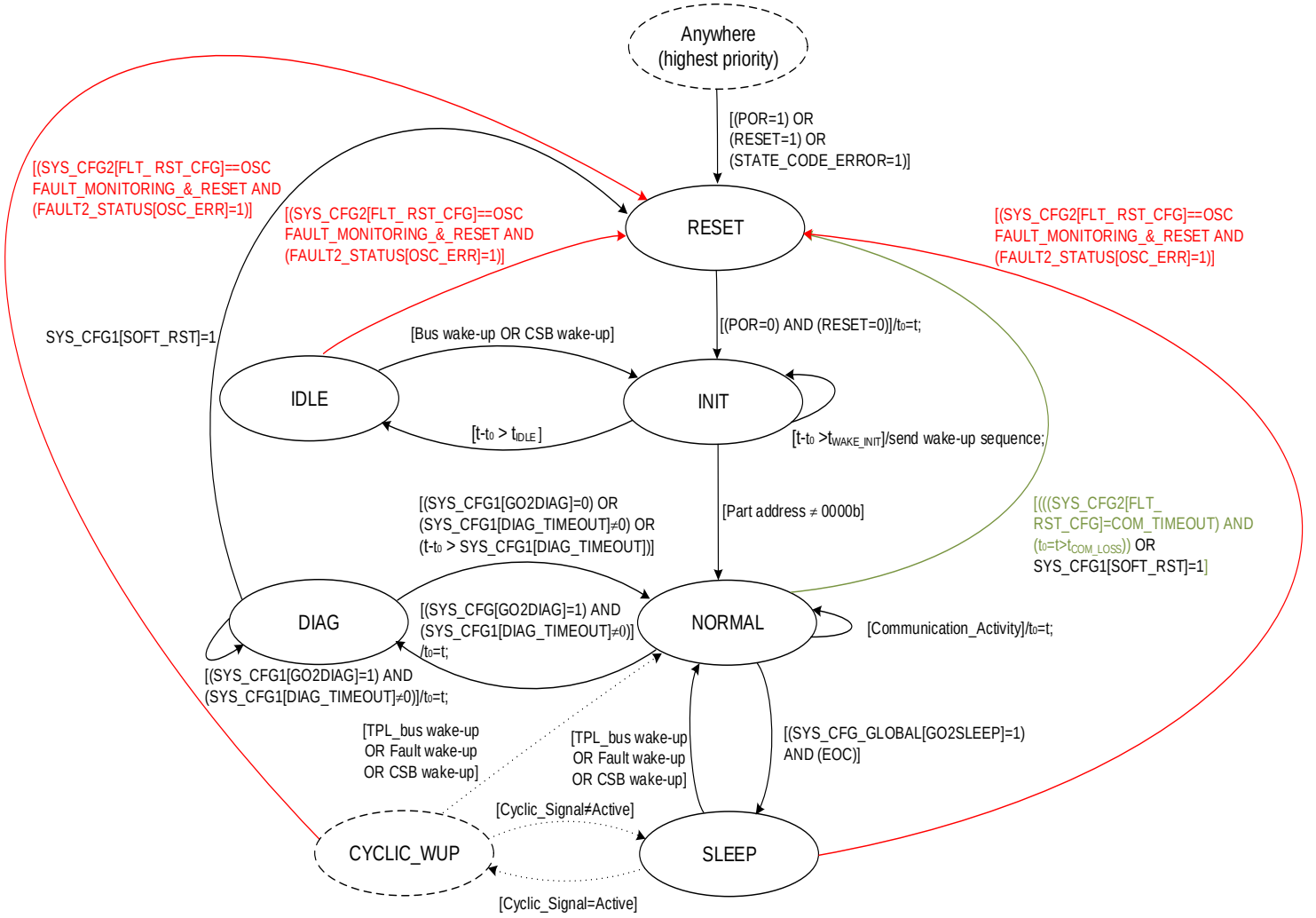
Modes of Operation revA

- **IDLE Mode**
  - No messages are recognized, only a valid wake-up lets the device transition from IDLE mode to INIT mode.
- **Normal mode**
  - The 33771 performs communication, ADC conversions, etc…
- **Sleep mode**
  - OV, UV, OT, UT and OC circuitry can remain cyclically active
  - When any fault happen (such as OV /UV/OT/UT/OC), then BCC can perform a bus wake-up
- **Diagnostic mode**
  - Used to perform regular self-diagnostics of the IC



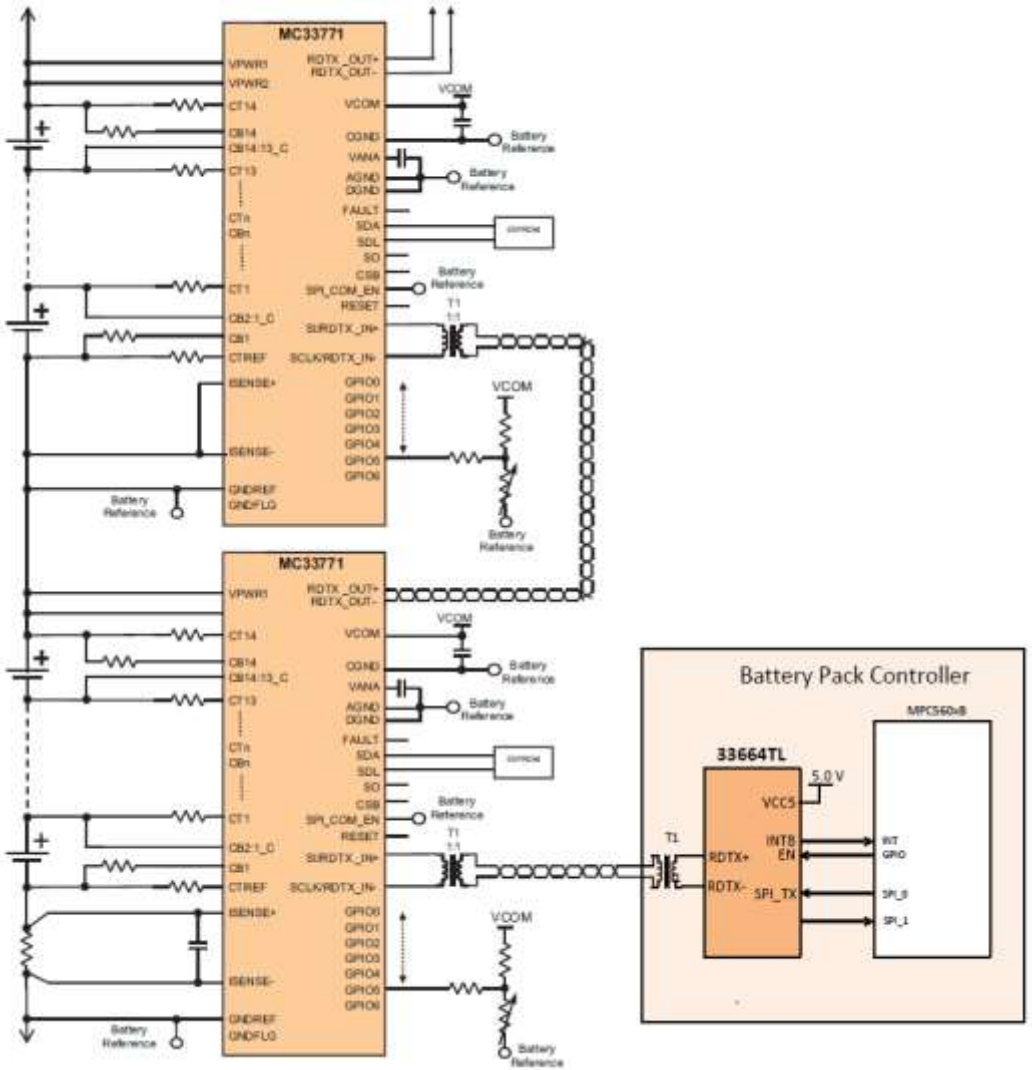
Modes of Operation revB

- Loss of Communications
  - Device resets if no TPL comm during a specified interval.
  - This mode is an optional addition to revA.
- Oscillator Monitor
  - Device resets of 100kHz osc is out of range.

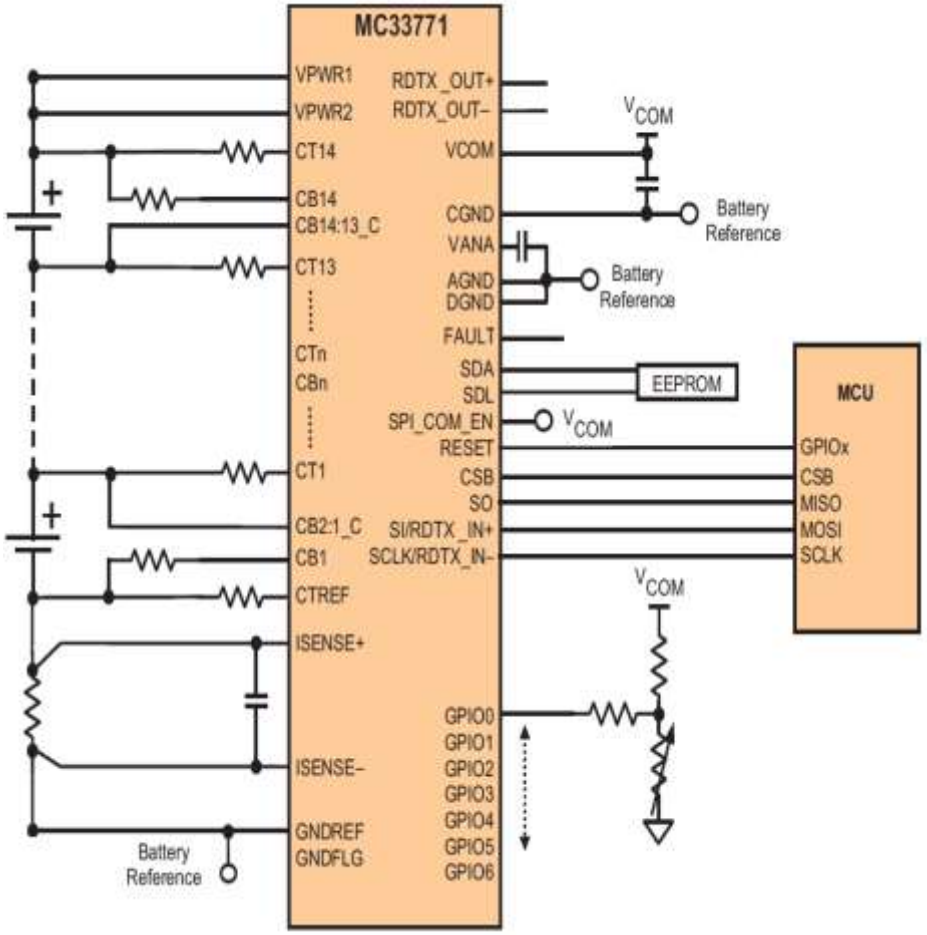


MC33771 – Connectivity Options

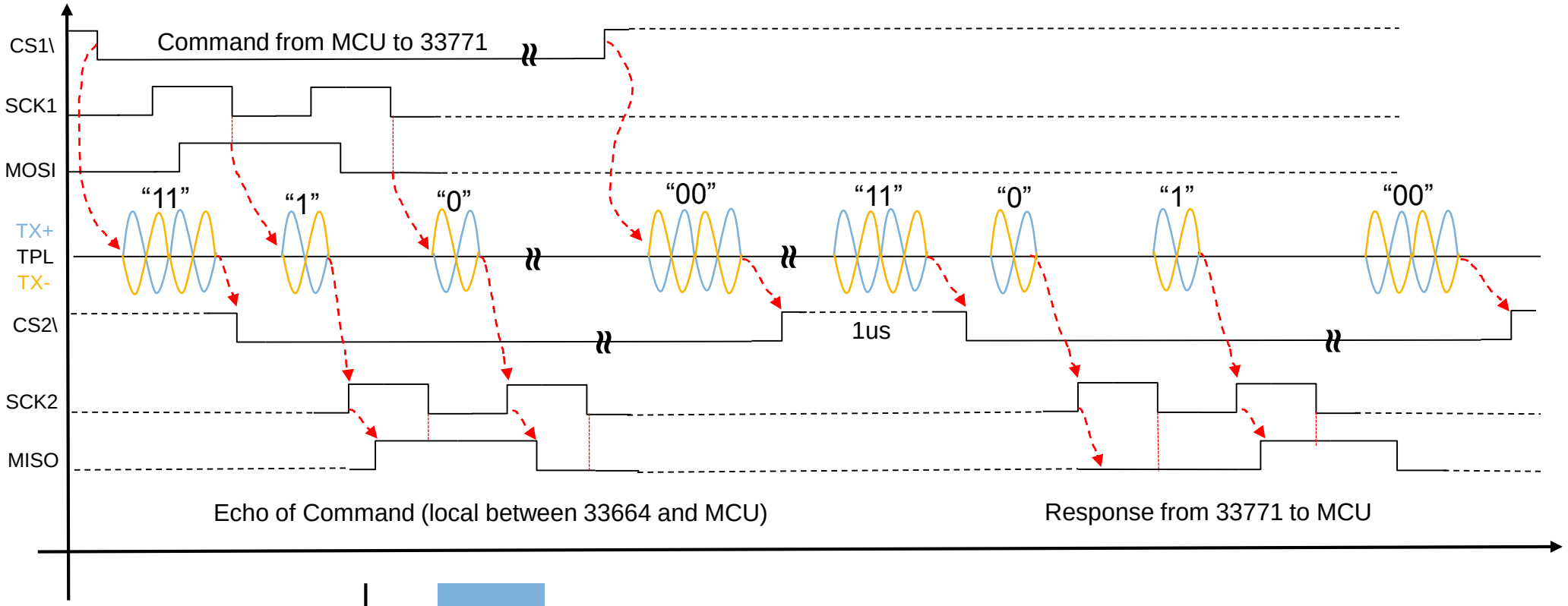
HV Daisy Chain Solution

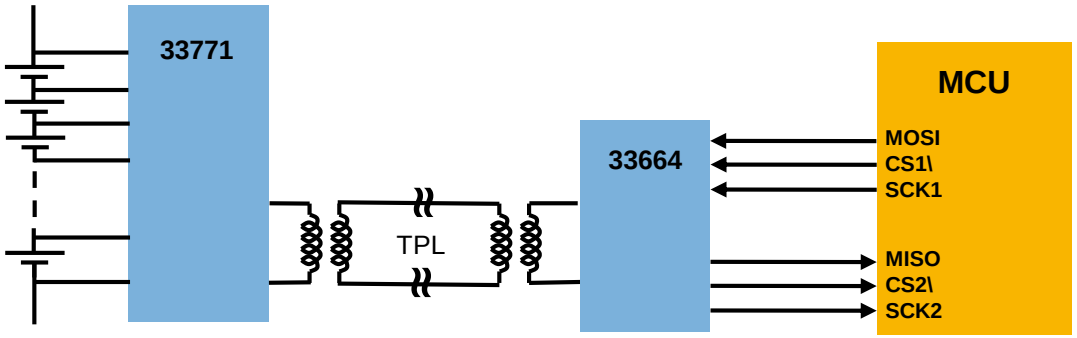


LV SPI Solution



TPL Communication Translation

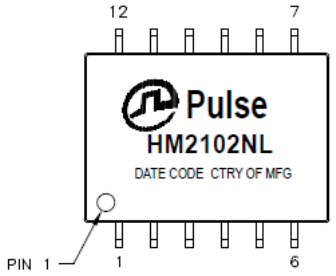


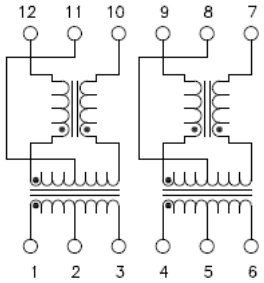


Recommended Transformer for Isolated Communications

RoHS COMPLIANT

Pulse Electronics
www.pulseelectronics.com





SCHEMATIC

ELECTRICAL CHARACTERISTICS AT +25°C UNLESS OTHER SPECIFIED
(FOR REFERENCE ONLY. USED FOR CUSTOMER INFORMATION.)

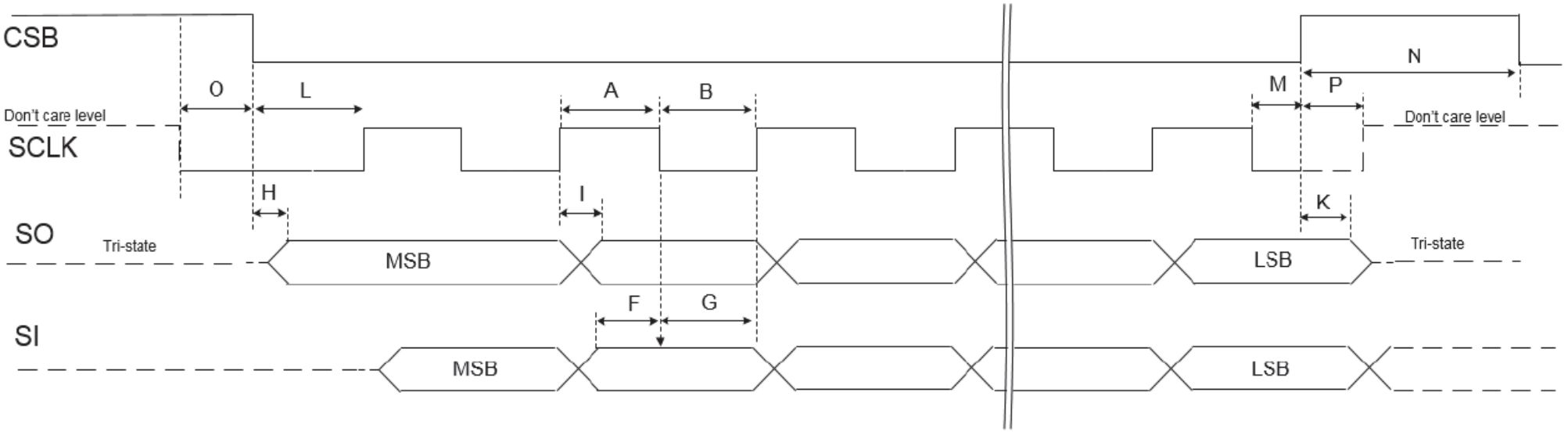
PARAMETER	SPECIFICATIONS	
QUALIFICATION	PER AEC-Q200	
OPERATING TEMPERATURE	-40°C TO 125 °C	
TURNS RATIO	1.00 ± 2%	
POLARITY	PER SCHEMATIC	
DC RESISTANCE	TRANSFORMER SIDE	CM CHOKE SIDE
	0.45 OHMS MAX	0.85 OHMS MAX
INDUCTANCE (OCL) AT 100 kHz, 100 mV (-40°C TO +125°C)	150 uH MIN, 370 uH MAX	
INSERTION LOSS	0.25 dB MAX @ 4 MHz	
RETURN LOSS (Z OUT = 100 OHM ±15%)	20 dB MIN @ 4 MHz	
CROSSTALK, ADJACENT CHANNELS	-50 dB MIN @ 4 MHz	
COMMON MODE REJECTION RATIO	1 - 10 MHz	10-1000 MHz
	-35 dB MIN	-20 dB MIN
INPUT - OUTPUT ISOLATION	4300 VDC OR 3100 VAC FOR 60 SECONDS	
WORKING VOLTAGE	1600 VDC FOR 15 YEARS	

PRELIMINARY

PRODUCT DESCRIPTION	TLA DRAWING	PS DRAWING	SHEET	PART NO.	DATASHEET REV.
TRANSFORMER/CMC,DUAL,4.3kV,SMT	HM2102NL-P3	PS-0023.002-A	2 OF 2	HM2102NL	G

E-MAIL: PRODINFONETWORK@PULSEELECTRONICS.COM(US), ASIA@PULSEELECTRONICS.COM(Asia) PHONE: USA:858 674 8100, GERMANY:49 7032 78060, SINGAPORE:65 6287 8998, SHANGHAI:86 21 62787060, TAIWAN:886 3 4356768

MC33771 SPI Communication



- Up to 4MHz operation
- Input data latched on falling edge of SCLK
- Output data changes on rising edge of SCLK
- 40bit message frame

Command & Response Frame Format

Command

Memory Data	Master/Slave	Memory Address	Device Address (Cluster ID)	Command				CRC
Bit[39:24]	Bit[23]	Bit[22:16]	Bit[15:12]	Bit[11]	Bit[10]	Bit[9]	Bit[8]	Bit[7:0]

bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
TAG_ID				SOC	PGA_GAIN			CC_RST	DIS_CH_COMP	ADC1_A_DEF		ADC1_B_DEF		ADC2_DEF	
				EOC_N	PGA_GAIN_S			0							

Response

Memory Data	Master/Slave	Memory Address	Physical Address (Cluster ID)	Tag ID		CRC
Bit[39:24]	Bit[23]	Bit[22:16]	Bit[15:12]	Bit[11:10]	Bit[9:8]	Bit[7:0]
Memory Data	1	Memory Address	CID	Tag ID		Bit[7:0]

Cell Measurement

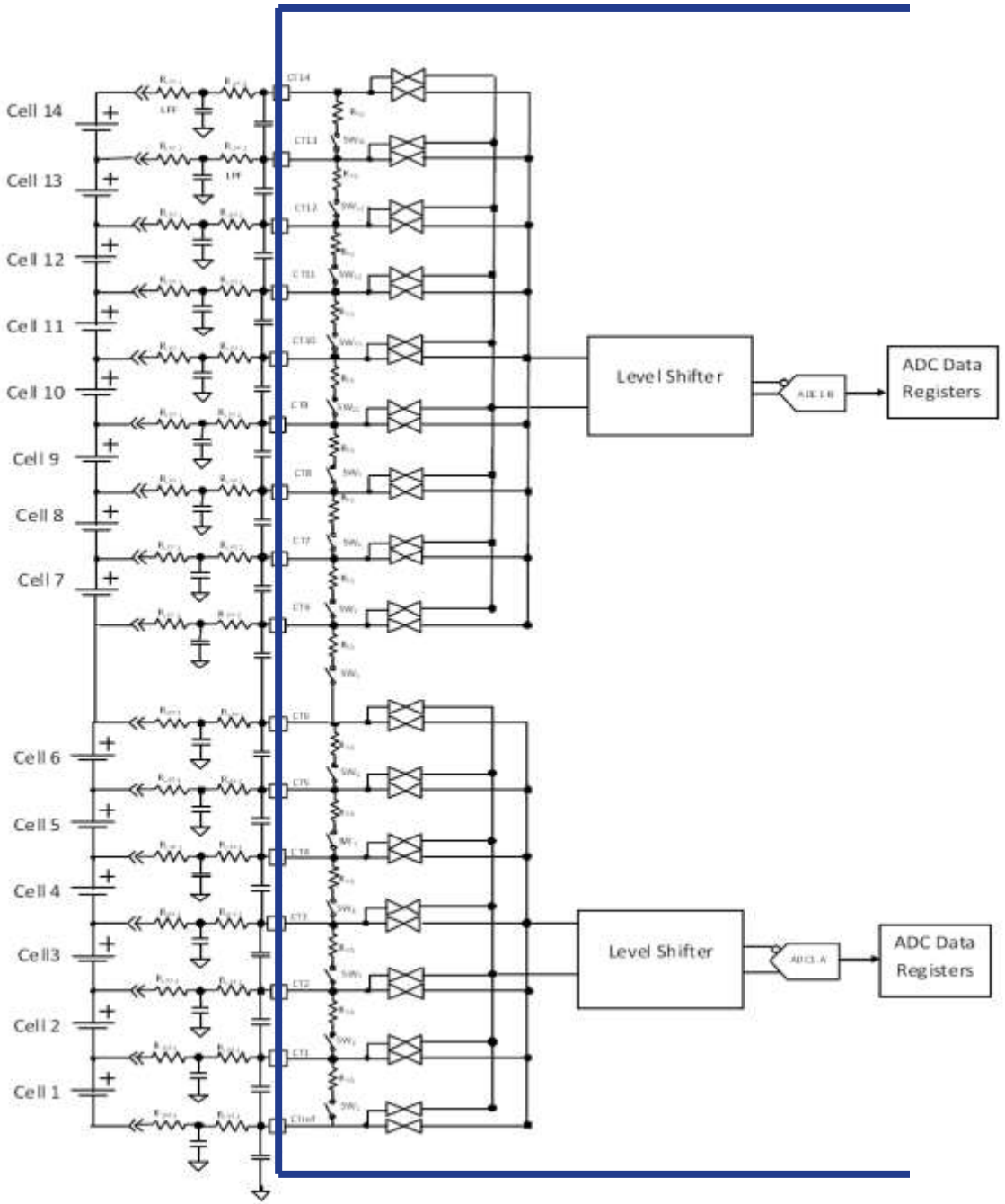
Two ADC's have selectable 13-Bit to 16-Bit resolution to support measurement resolution versus acquisition speed requirements

Stack voltage measurement possible between VPWR & GND. Verify cell voltage sum equals stack voltage

Conversion command and measurement data are synchronized with Tag ID's

Selectable cell measurement thresholds for sleep mode wake up

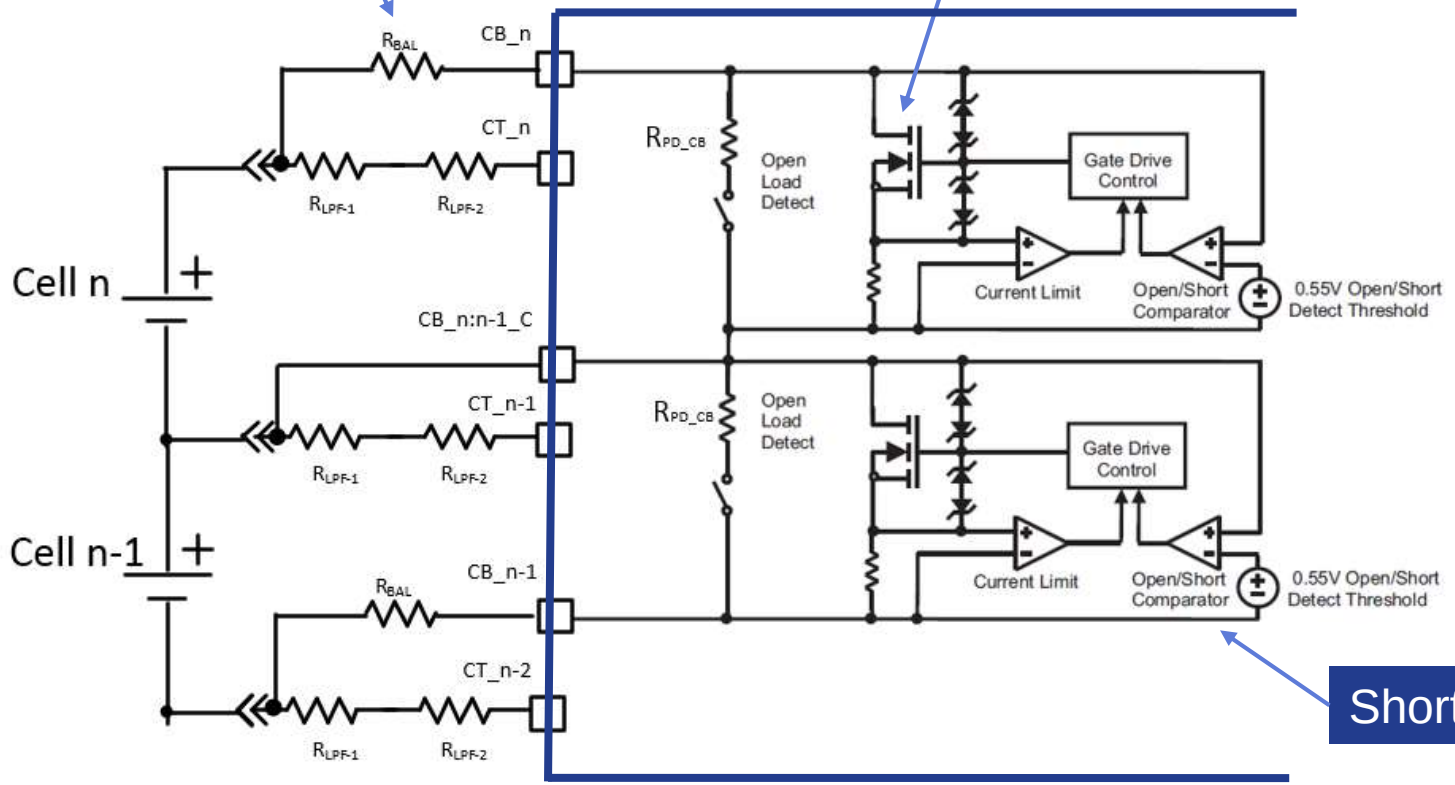
Measurement chain verification made available with separate internal references at cell inputs and ADC inputs



Cell Balancing

Energy dissipated across external resistor

300mA, 750mΩ Integrated MOSFET



Cell balance in sleep mode

Short & open detection

Cell balance timer 30sec-511min

Cell balance voltage thresholds

Cell balance auto pause during CT measurement

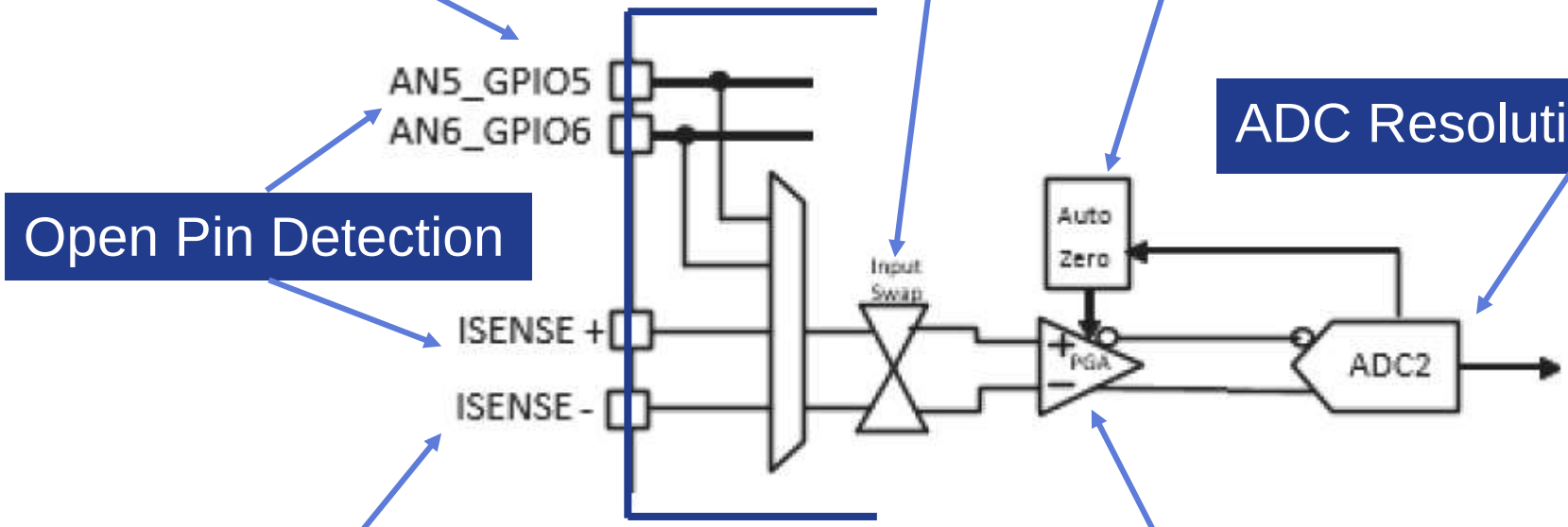
Current Measurement

Measures current flowing in both directions

Redundant Current Sense Inputs

Input Offset Cancellation

ADC Resolution 0.6uV/LSB



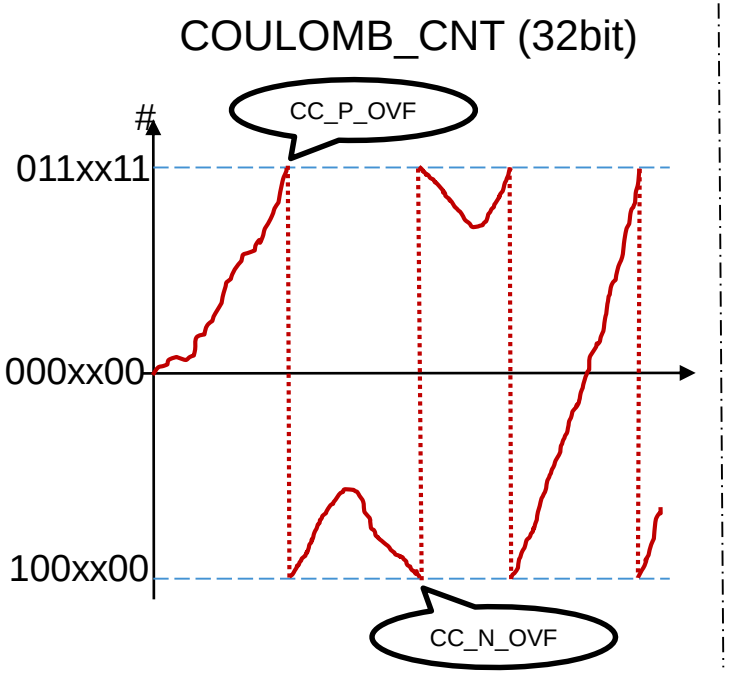
Open Pin Detection

±150mV Input Range

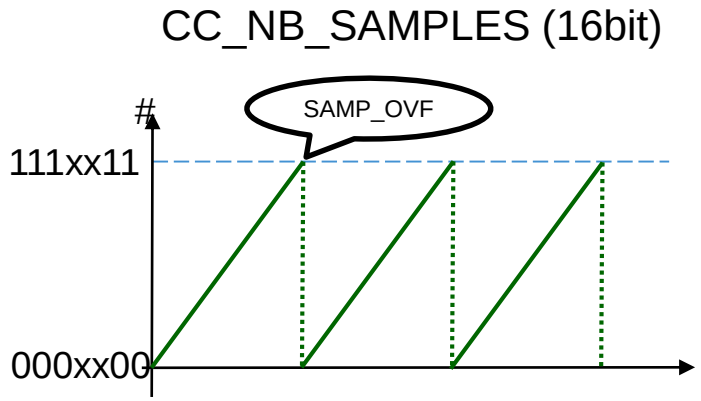
AGC & Gain Settings of 4, 16, 64 & 256

Coulomb Counter

Each successive continuous ADC acquisition is added to the CC accumulator



Each successive ADC acquisition Increments the CC number

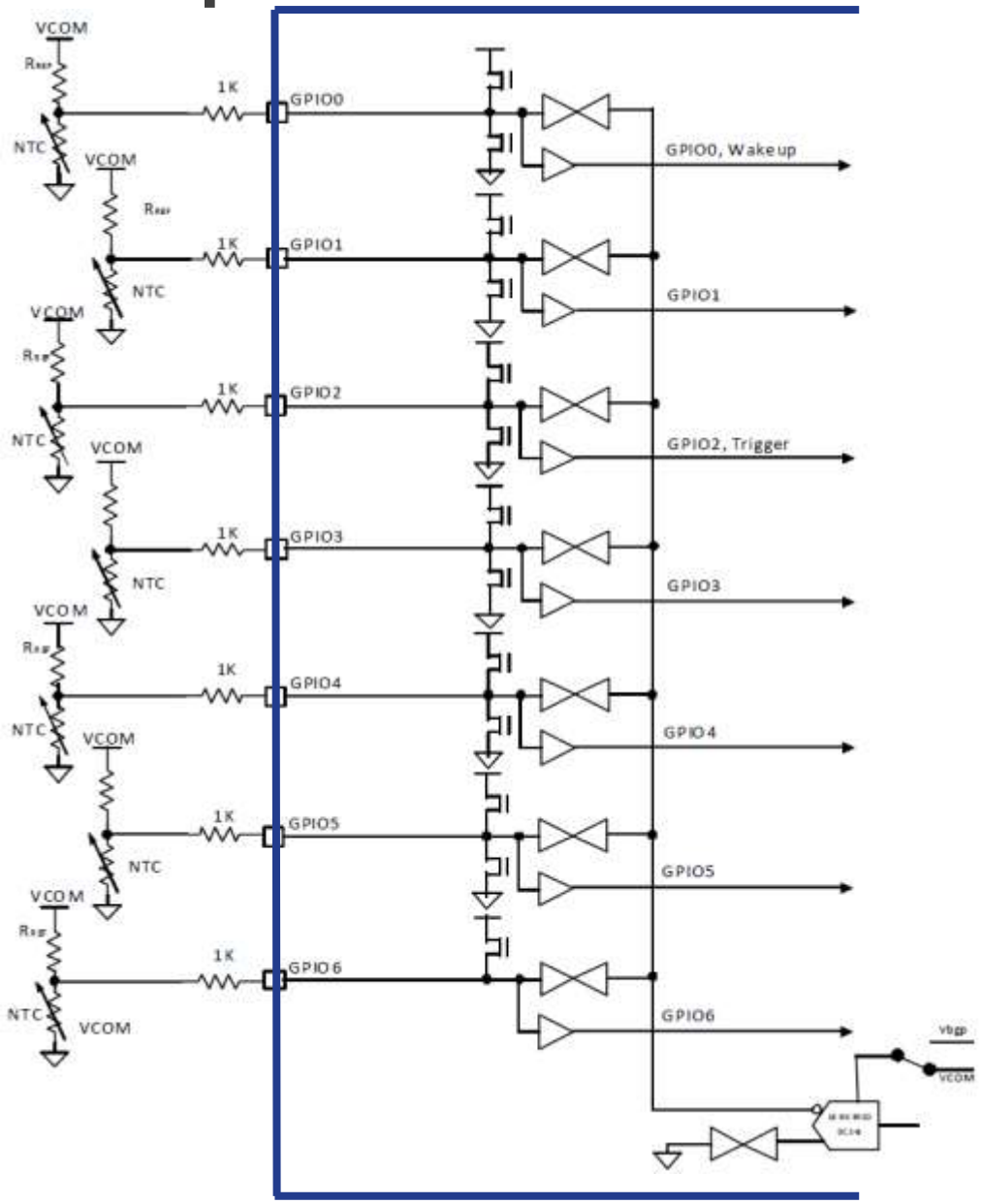


- Operates in normal & sleep modes
  - Normal mode: Continuous conversions
  - Sleep mode: Conversions based on cyclic timer setting
- Selectable coulomb counter threshold for sleep mode wakeup
- Selectable counting modes;
  - Overflow counter or
  - Clamp counter

Iave = Coulomb_CNT ÷ CC_NB_Samples

$\Delta Q = (I_{ave}) \times (t_{old} - t_{new})$

Temperature / GPIO Measurement



	GPIO			Anx		ISENSE
GPIO Port	Std gpio	Wup& Daisy Chain	Convert Trigger	Absolute	Ratiometric	
0	X	X		X	X	
1	X			X	X	
2	X		X	X	X	
3	X			X	X	
4	X			X	X	
5	X			X	X	X
6	X			X	X	X

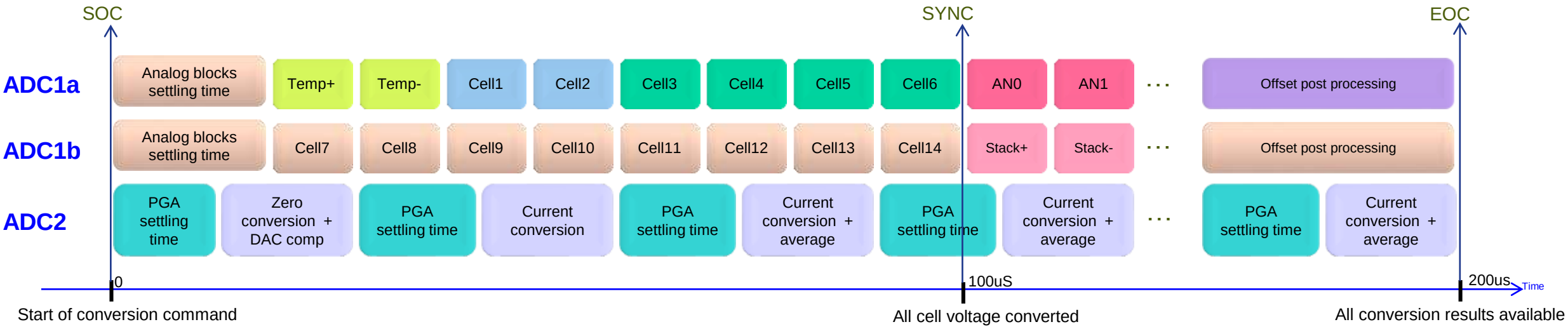
Open & short circuit detection

Selectable UT / OT thresholds with Fault output assertion

UT / OT functional verification

Measurement Sequence

- Voltage conversions of ADC1-A and ADC1-B are synchronized with the current measurement of ADC2 (SOH)
- At time t_{SYNC} the V/I samples are frozen and then post processed (offset cancellation, temperature compensation).
- At time t_{EOC}: all results are stored into user registers and their associated data ready bits are set to Logic 1



Write 1 to the SOC bit to initiate a conversion sequence

bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
TAG_ID				SOC	PGA_GAIN			CC_RST	DIS_CH_COMP	ADC1_A_DEF		ADC1_B_DEF		ADC2_DEF	
				EOC_N	PGA_GAIN_S			0							

- 13-Bit Resolution 148 µs
- 14-Bit Resolution 201 µs
- 15-Bit Resolution 307 µs
- 16-Bit Resolution 520 µs

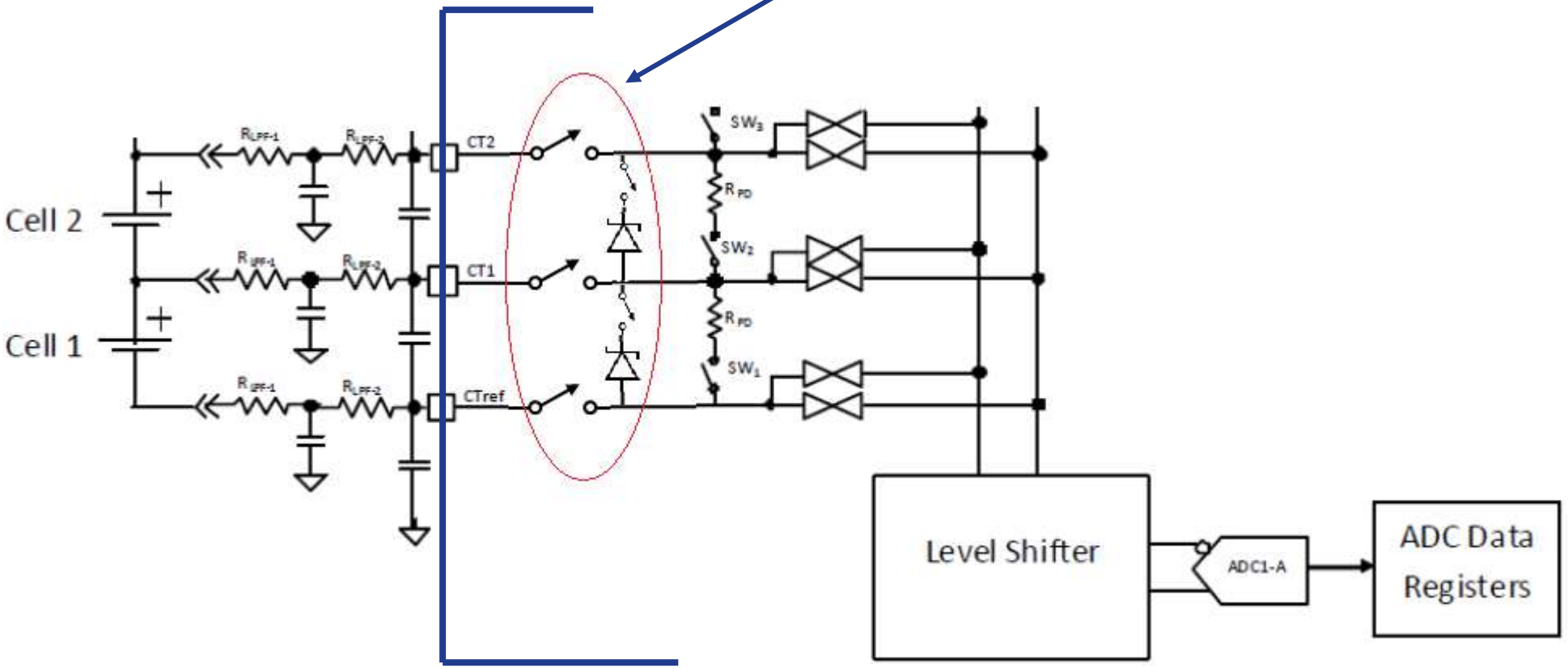
Note: SOC=Start of Conversion, not State of Charge in this case

MC33771 Diagnostic / Safety Features

- Sleep/Normal Mode OV/UV OT/UT Detection
- FAULT Pin Daisy Chain Heart Beat
- CTx OV/UV Functional Verification
- CTx Open Detection
- CTx Open Detection Functional Verification
- CTx Leakage Test
- Cell Voltage Channel Functional Verification
- ADC1 Precision Fault Check
- Current Channel Functional Verification
- Oscillator Clock Monitoring
- Cell Balance Short/Open Protection/Detection
- ISENSE+/- Measurement Integrity Check
- ISENSE+/- Open Detect
- GPIO Short Detection Protection
- GPIO Open Detection
- VPWR OV/UV Detection
- VCOM Short/UV Protection Detection
- VANA Short/UV Protection Detection
- Onboard Temperature Protection Mode
- Exit Diagnostic Mode Safety Timer
- Loss of Ground Detection
- TAG ID for Conversion Data
- Register Address Identification Frame
- Eight Bit CRC with Non-Zero Seed
- Unique Identifiable Message Start and Stop Bits
- Communication Confirmation Architecture
- Communication Error Count Register
- Write Command Echo Confirmation
- Multiple VPWR/GNDREF Pins
- Adjacent Pin Short Capable

Cell Voltage Signal Chain Functional Verification

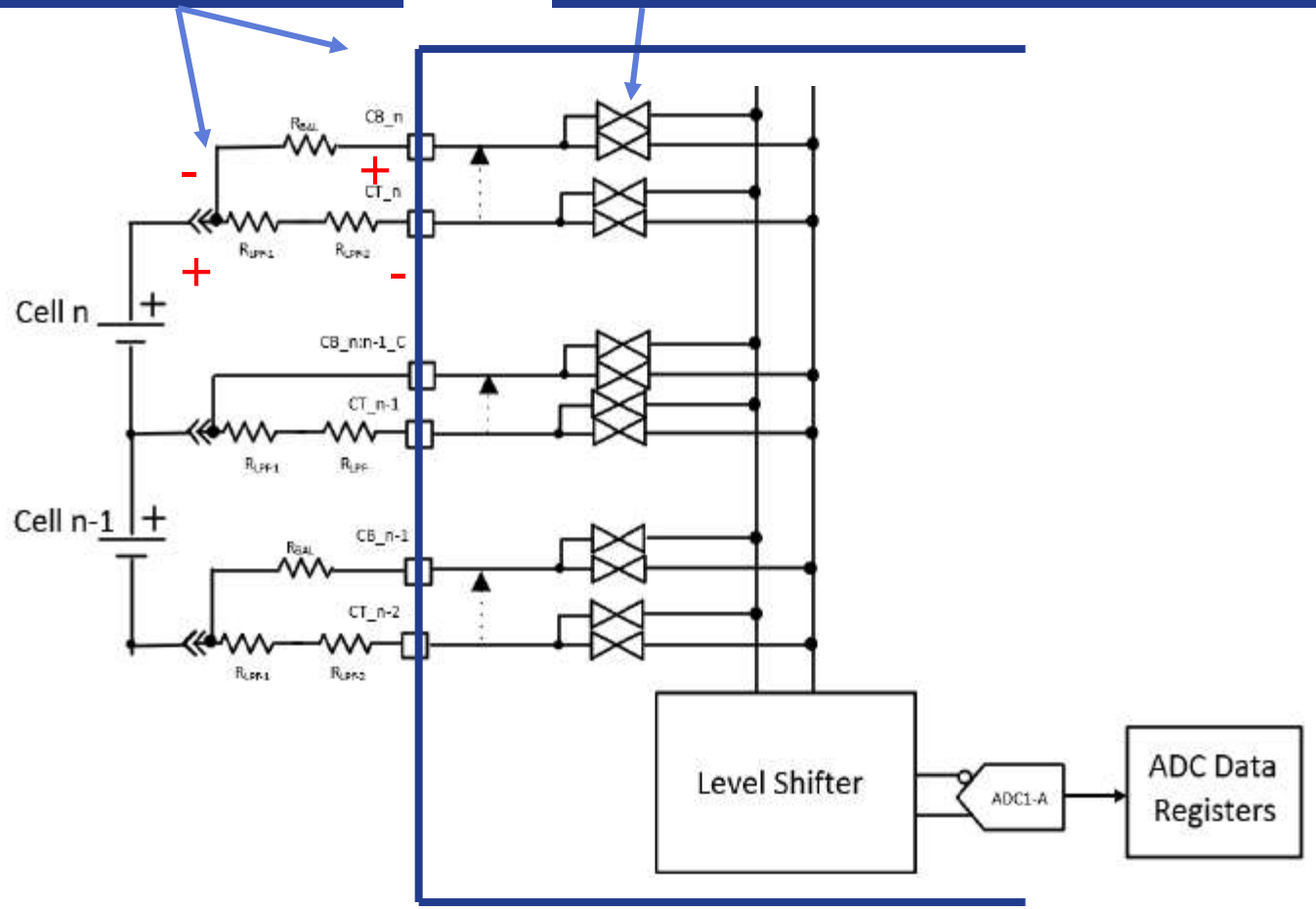
Precision references are gated into the cell terminal inputs to verify the measurement signal chain



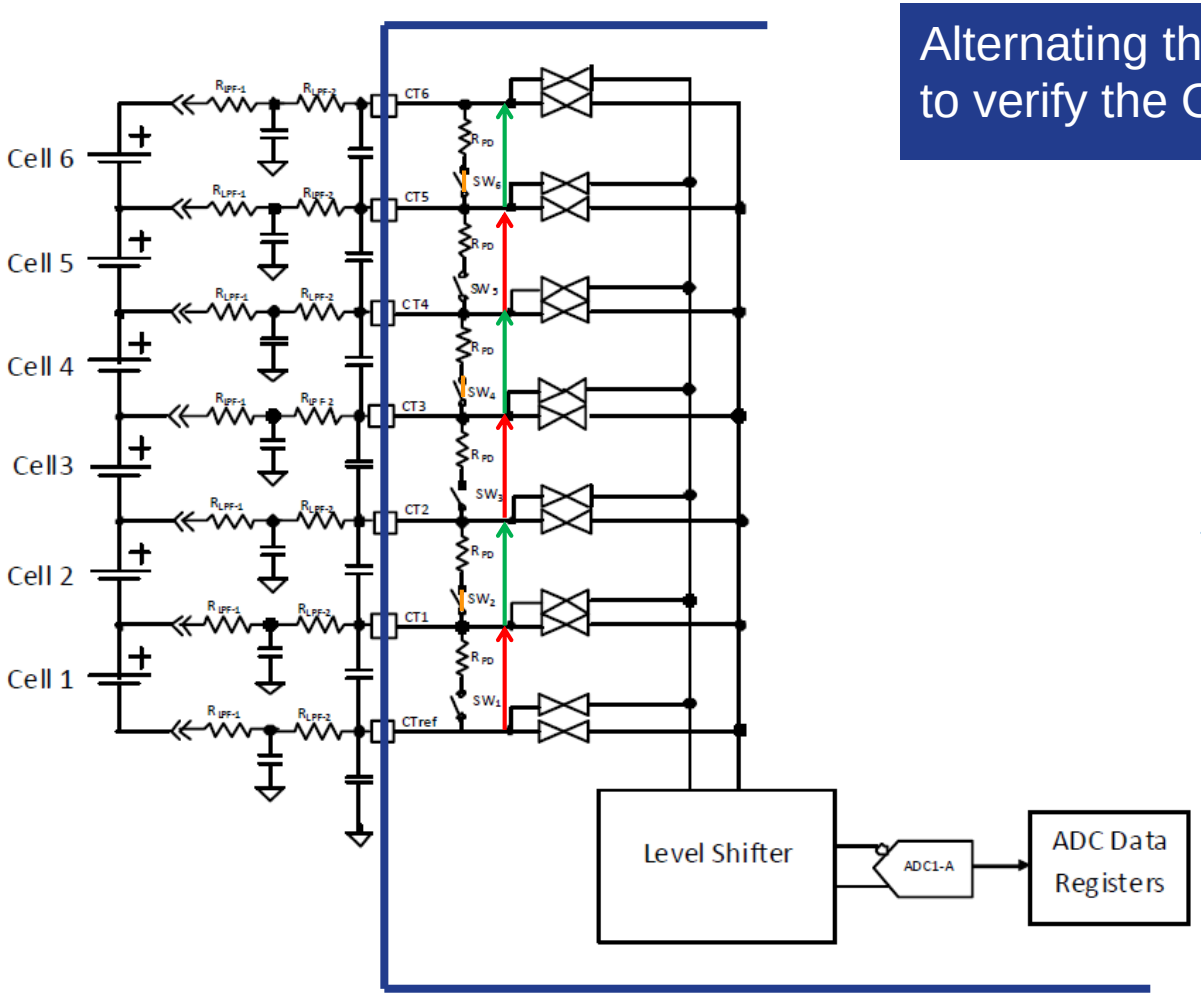
CT Leakage Current Measurement

Kelvin Connection Via CB Input

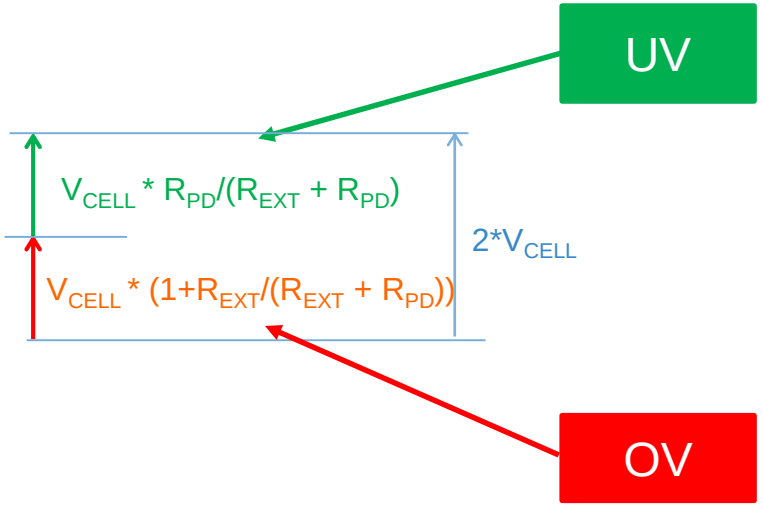
Gates to accommodate leakage into & out of the CT



Cell OV and UV Functional Verification & Open Circuit Detection

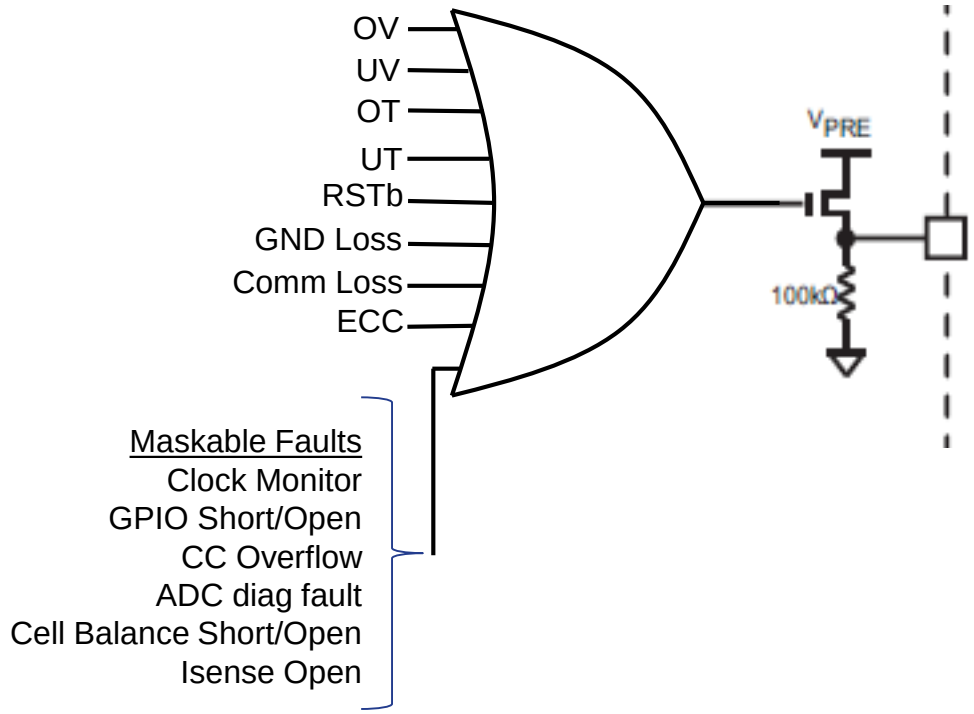


Alternating the switch closure sets up OV & UV voltages to verify the OV & UV diagnostic signal chain is functional

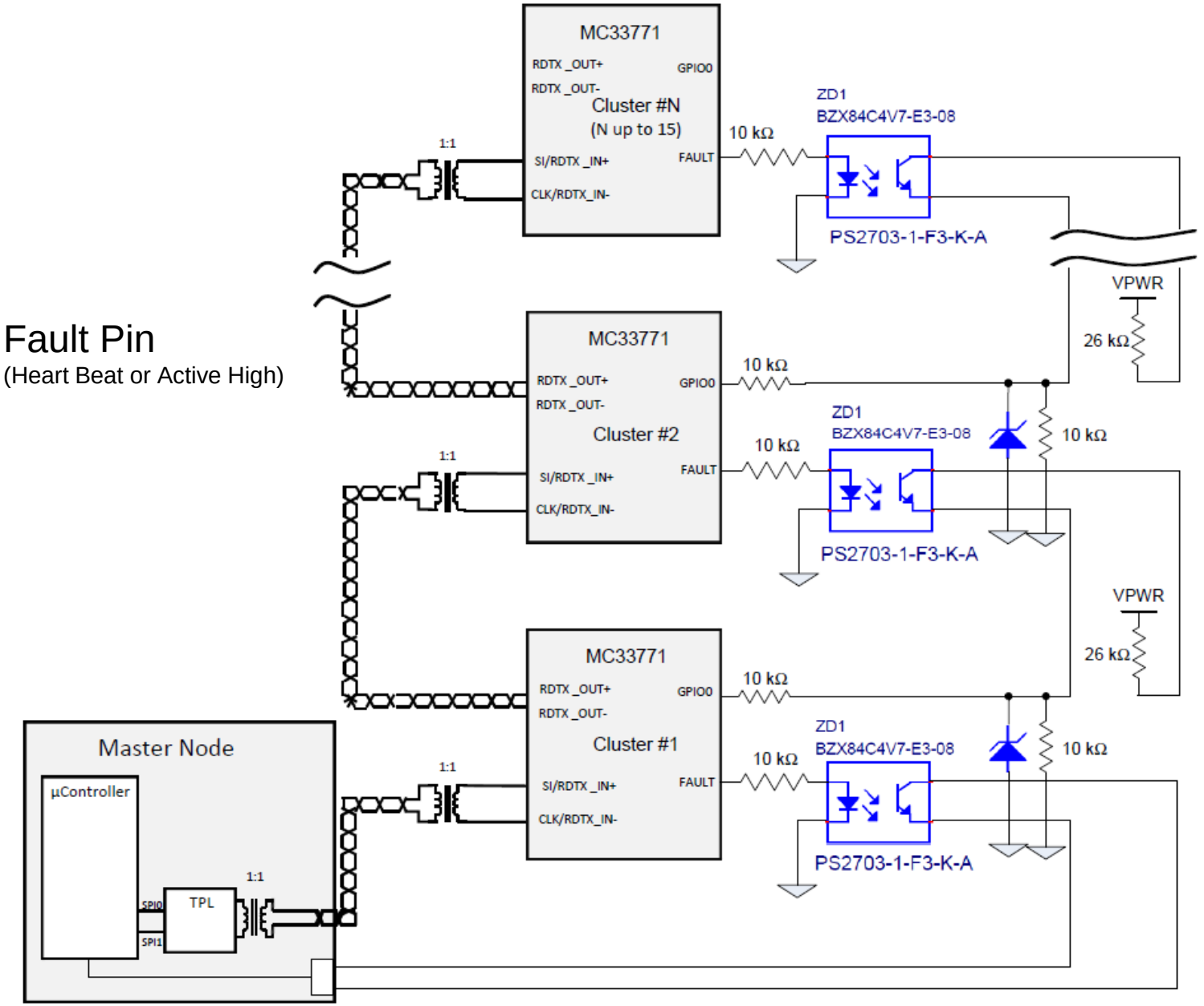


$R_{EXT} = 2(R_{LPF-1}+R_{LPF-1})$

Fault Pin



Fault Pin
(Heart Beat or Active High)

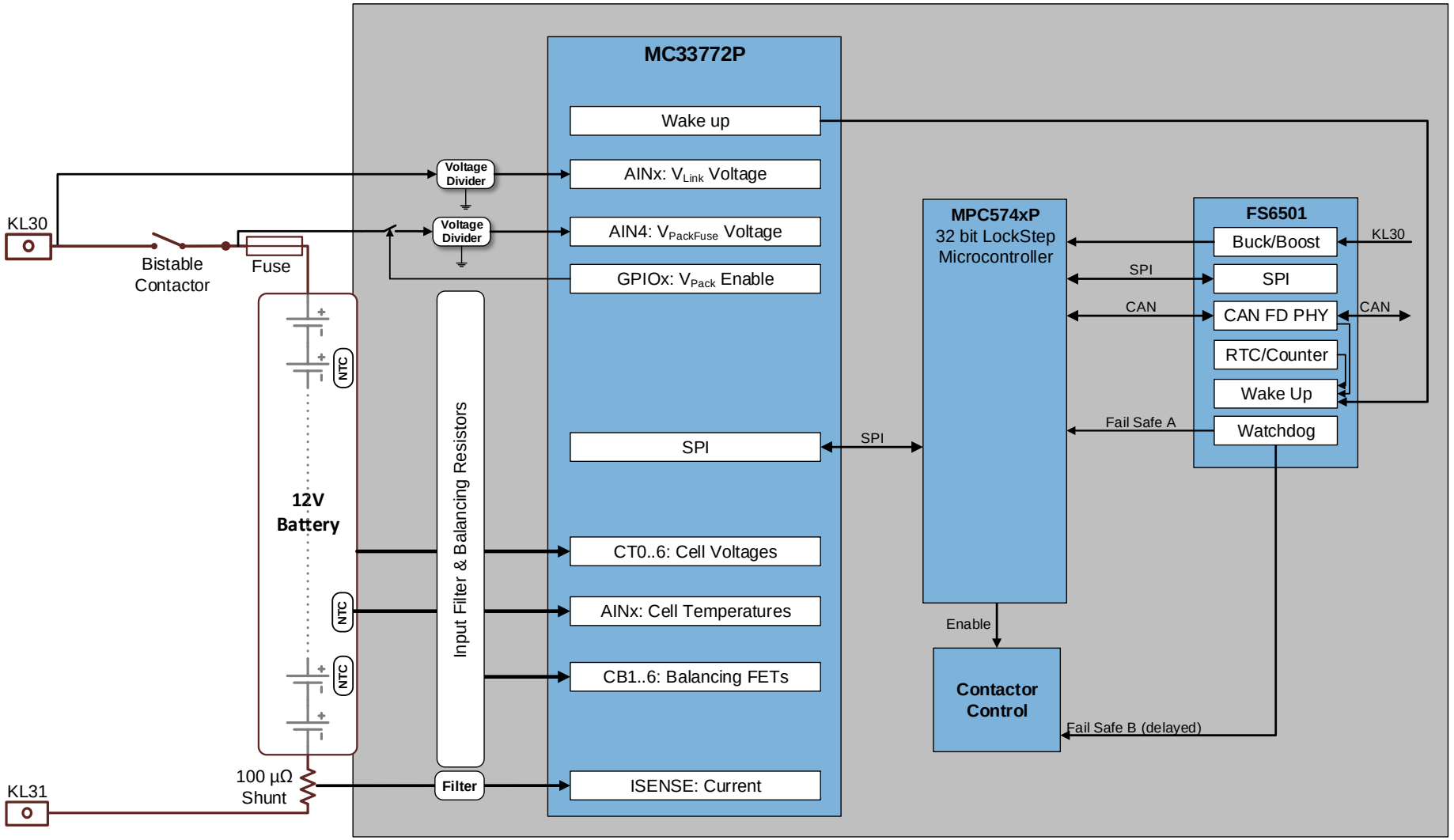


Fault pin not necessary for ASIL-C

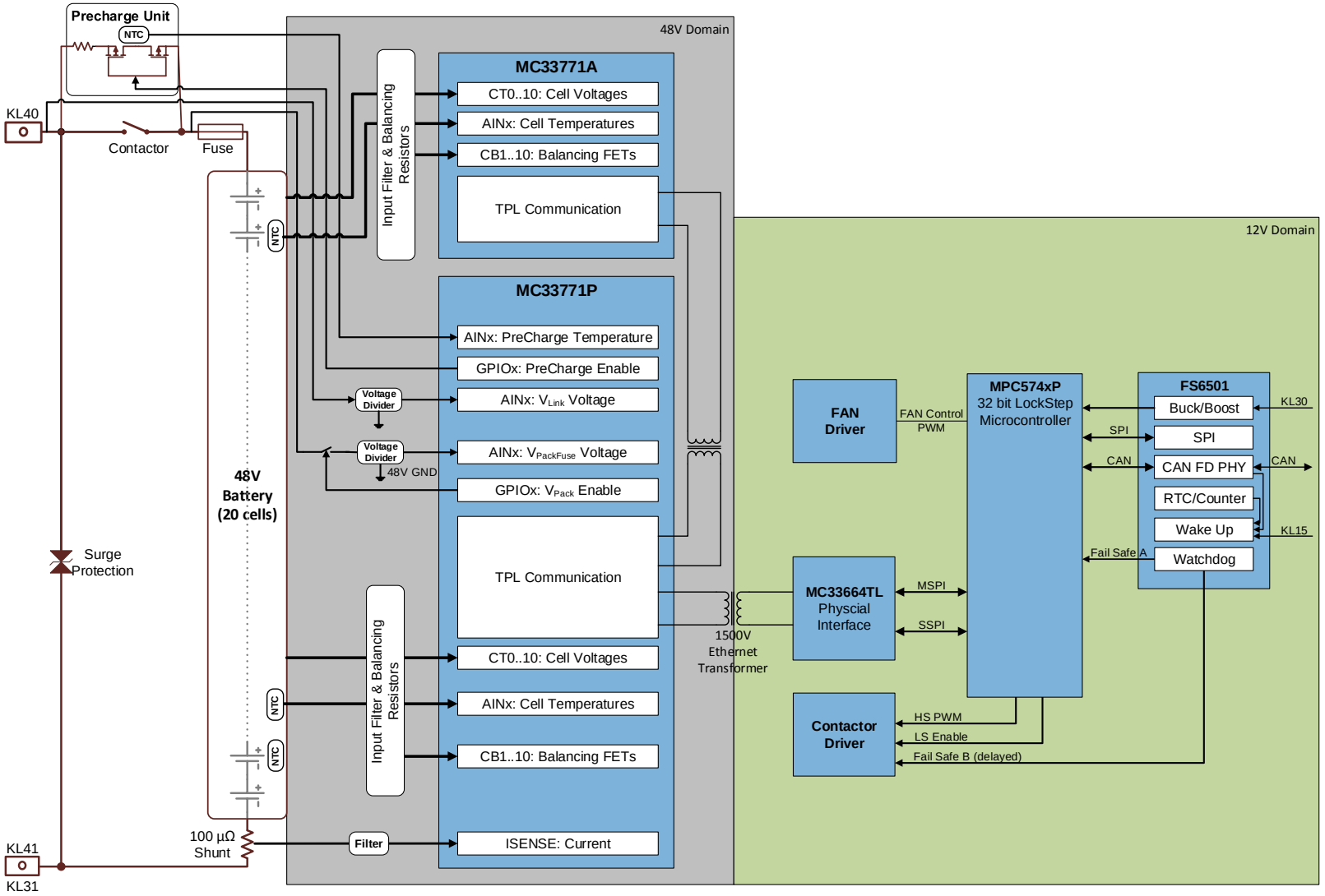
05.

BMS Applications

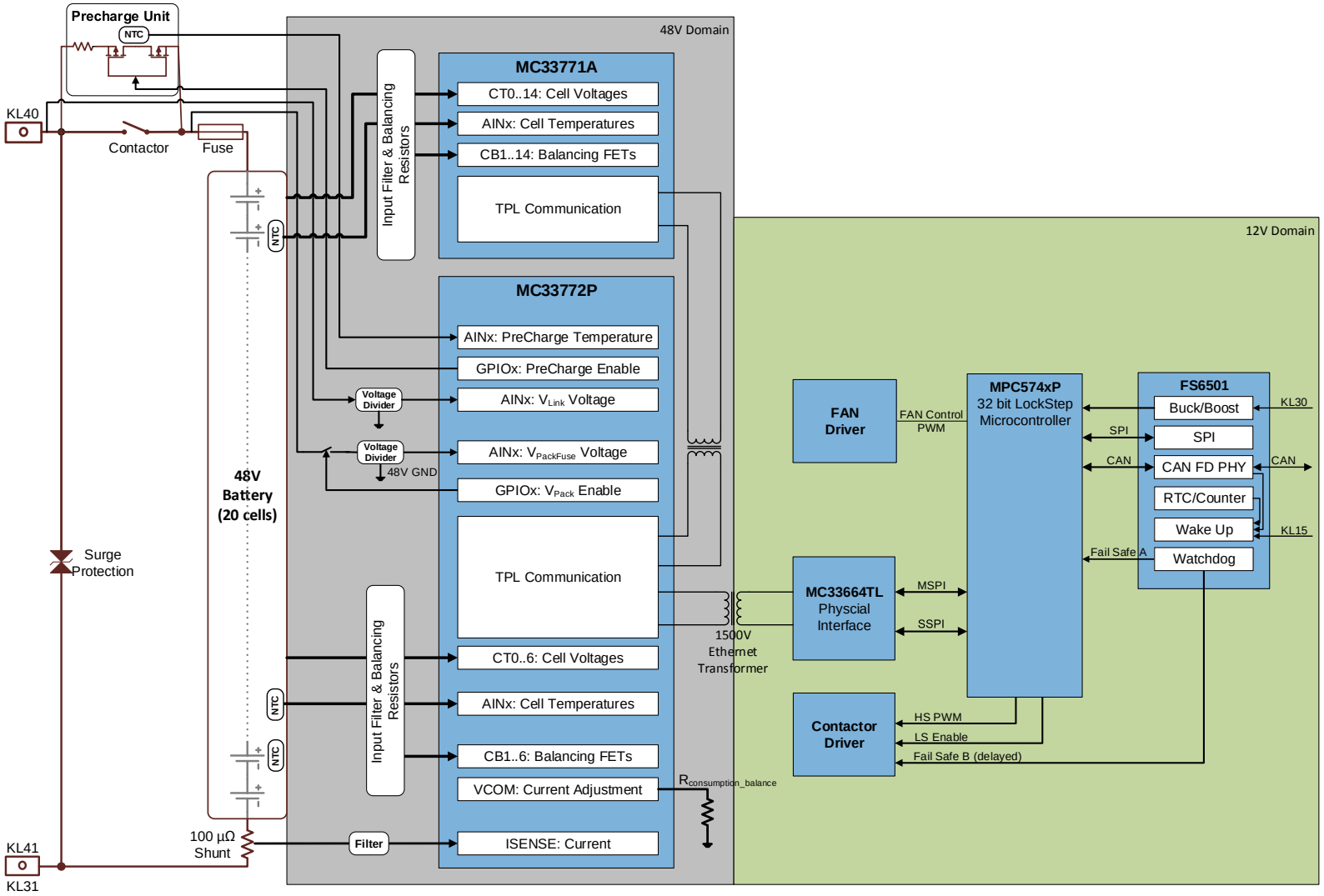
12V System (4/6 cells)



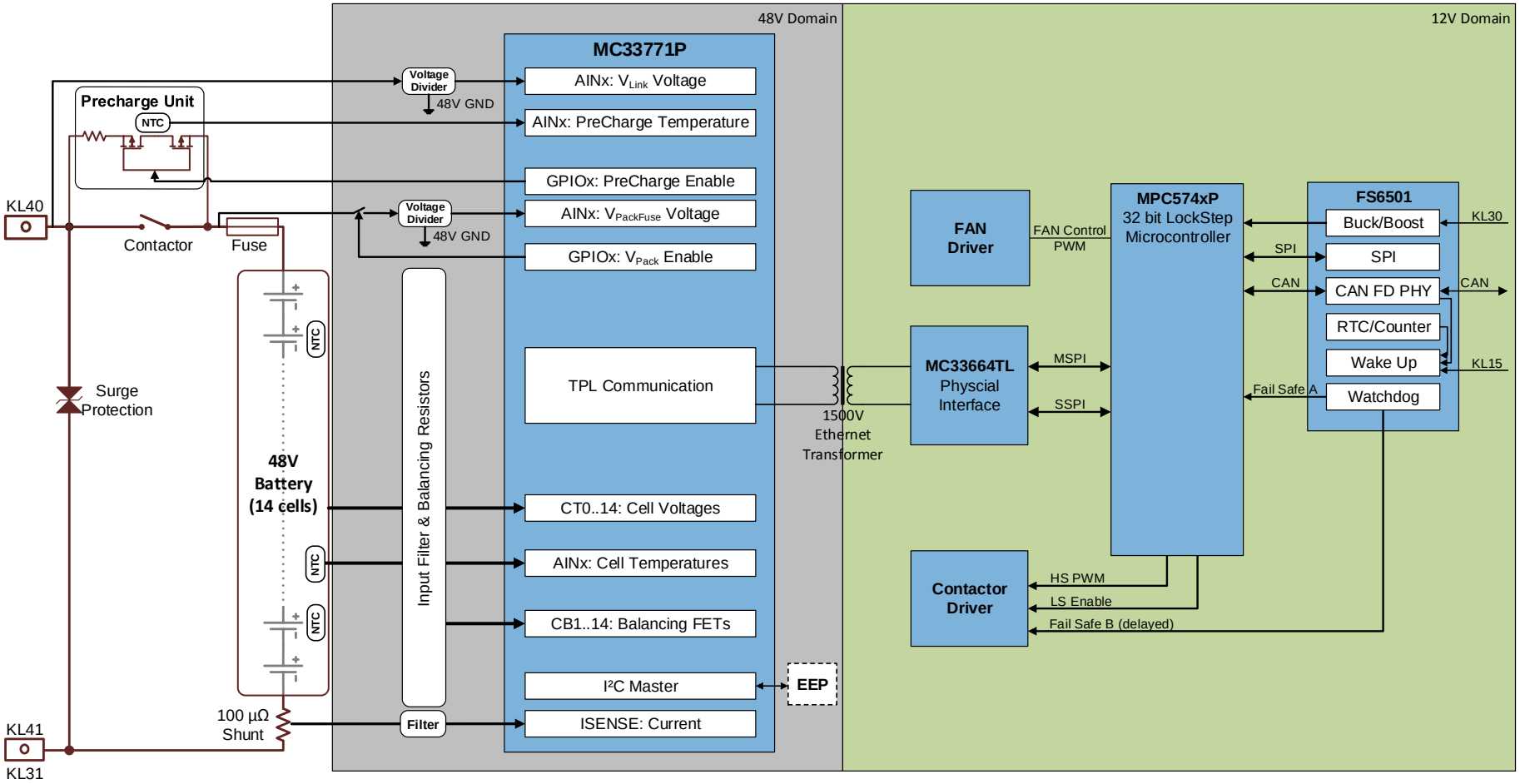
48V System (20 cells) based on 2 MC33771



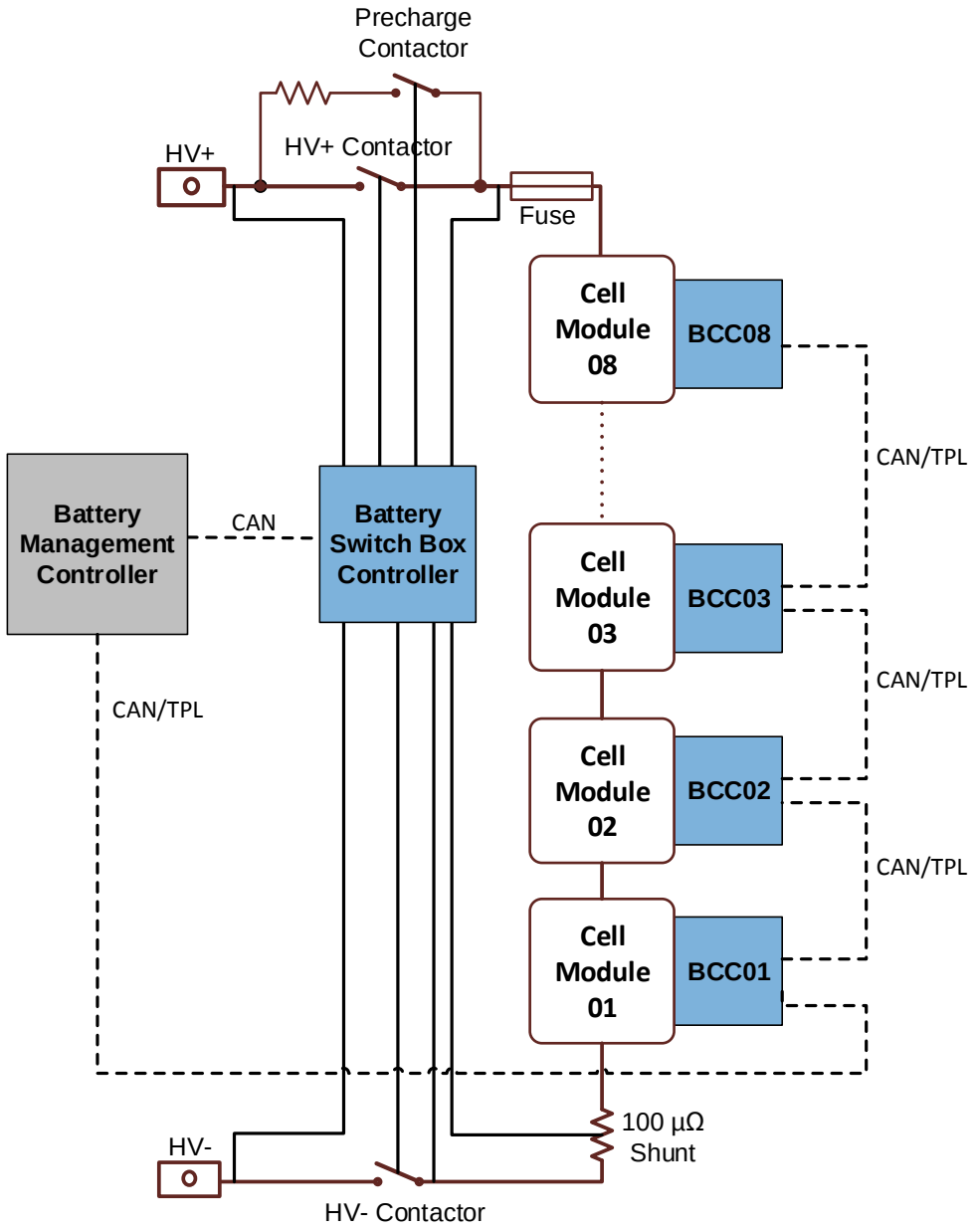
48V System (20 cells) based on MC33771 & MC33772



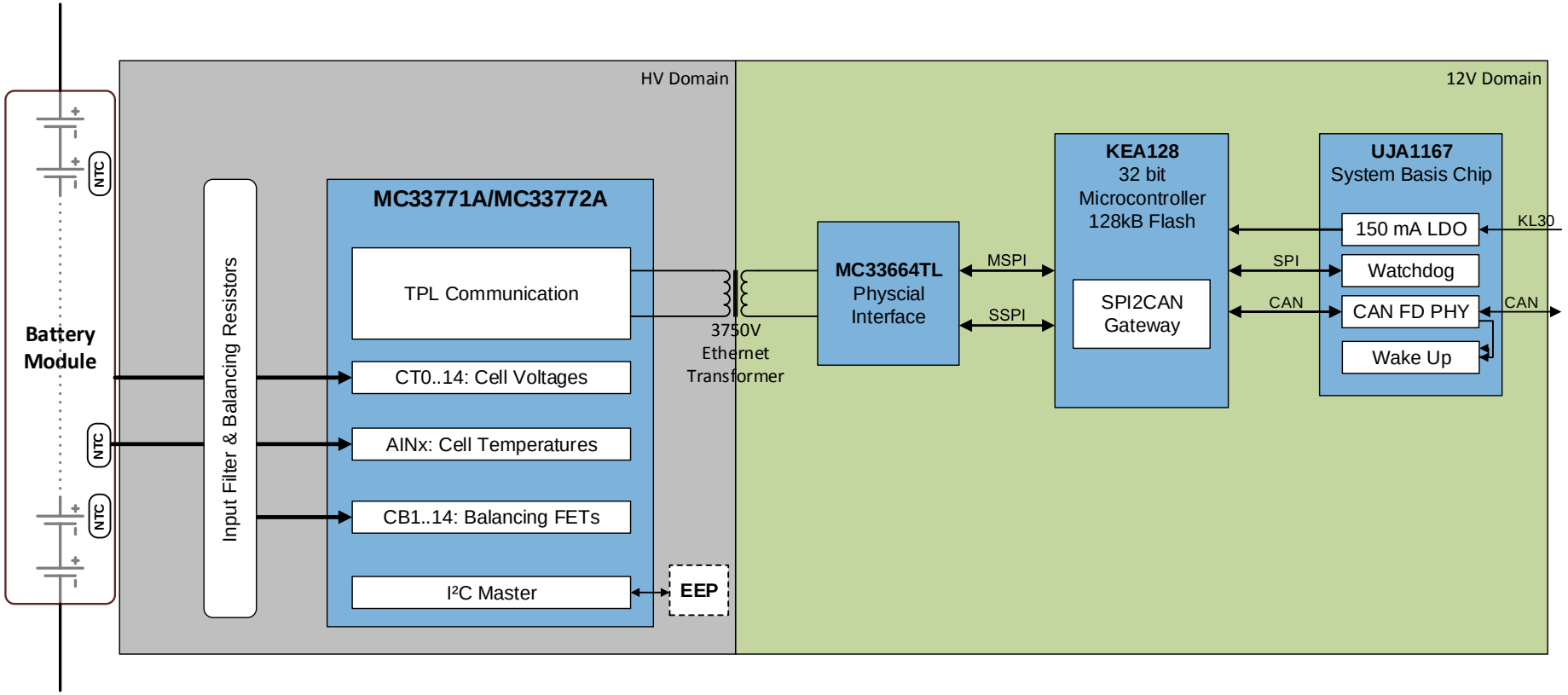
48V System (14 cells) based on MC33771



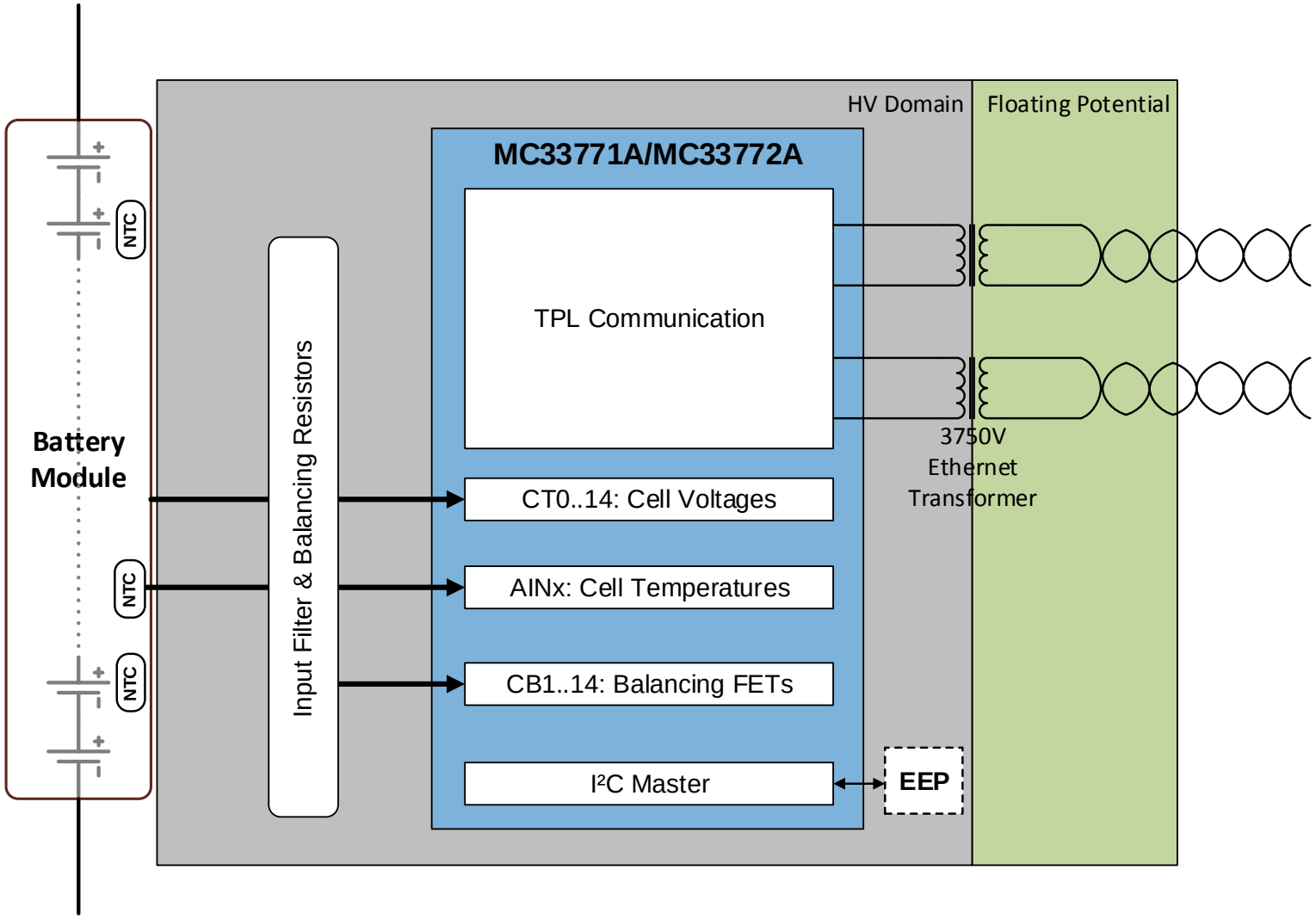
HV Battery System Overview



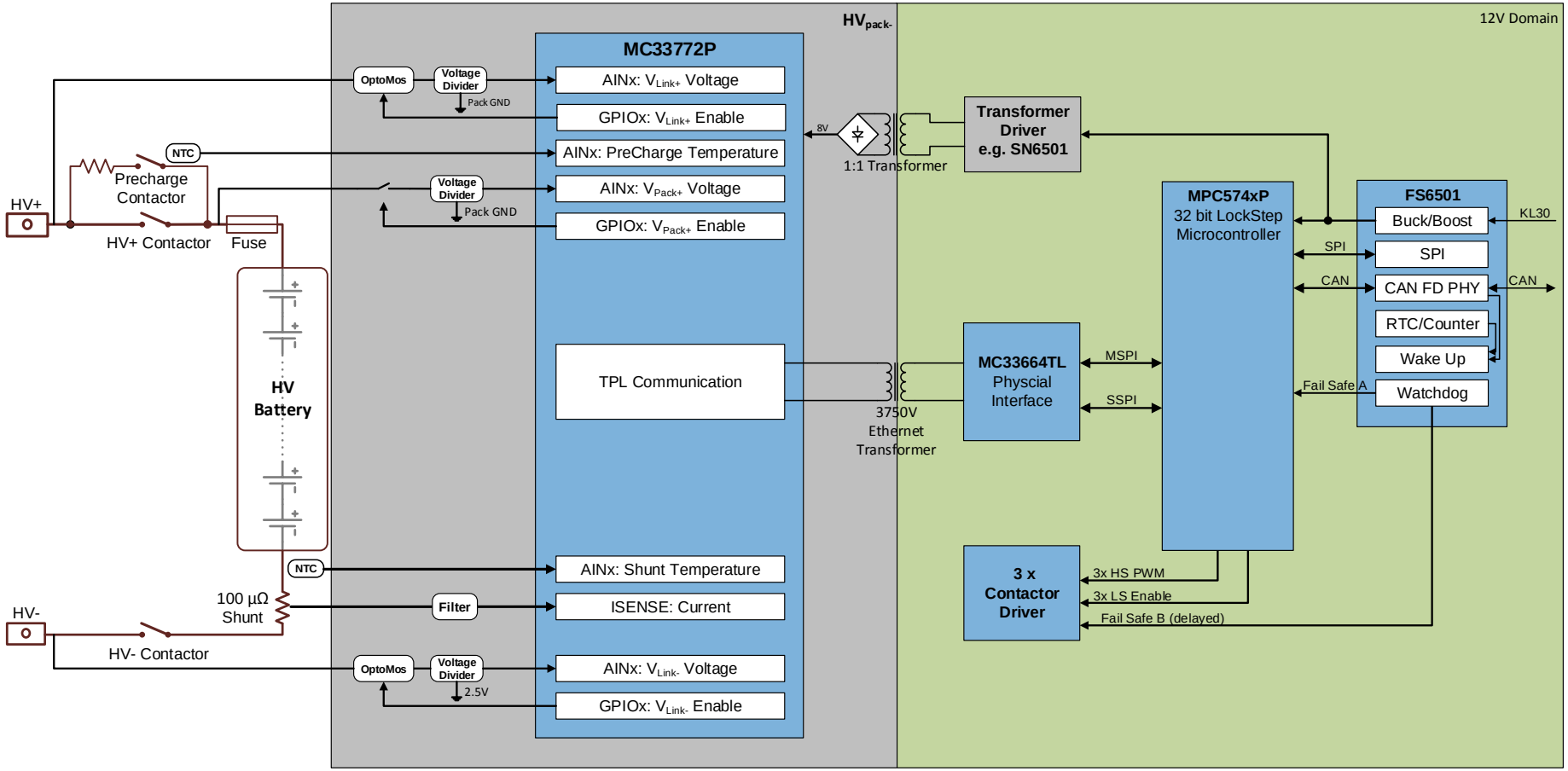
HV Battery Cell Controller with CAN



HV Battery Cell Controller with TPL



HV Battery Switch Box Controller



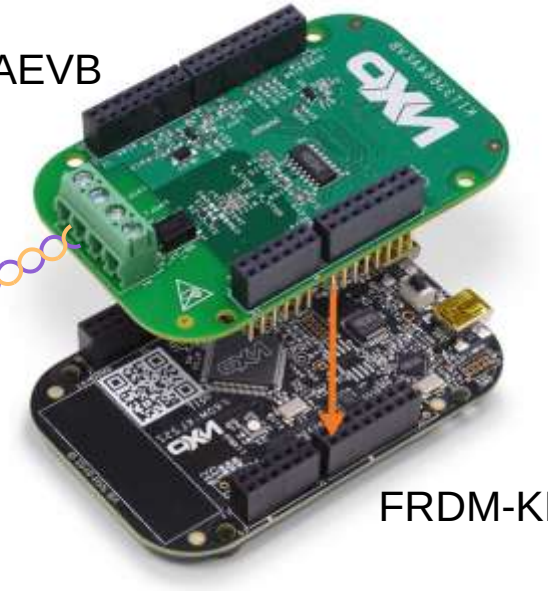
06.

Enablement Tools

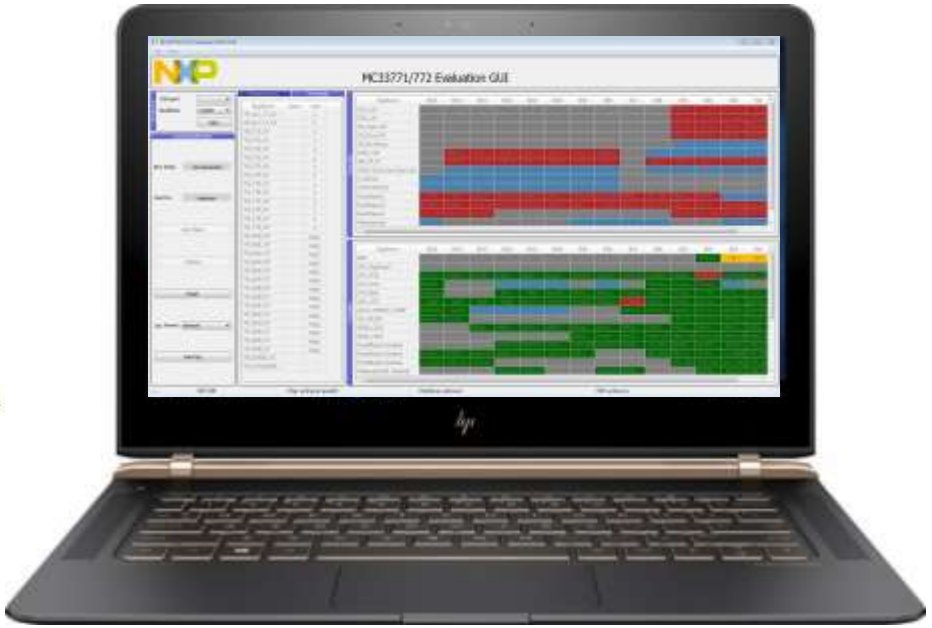
http://www.nxp.com/products/automotive-products/energy-power-management/battery-management/battery-cell-controllers/14-channel-li-ion-battery-cell-controller-ic:MC33771?tab=Design_Tools_Tab

33771 / 33664 Evaluation Kit

KIT33664AEVB



FRDM-KL25Z



KIT33771TPLEVB
KIT33771SPIEVB

BATT-14AAAPACK

07.
Conclusion

Product Differentiation

NXP's Battery Cell Controller solution enables reliable, safe and BOM optimized Li-ion cell control applications with low-cost high-speed Isolated communication

Significant Reduction in BOM & Overall System Cost	Low-cost high performance High-speed Isolated	Automotive Robustness
No need for external current sensor, external balancing, diagnostics and functional safety monitor.	Avoid expensive isolated CAN communication while maintaining isolation, high-speed and safe communication.	No damaging of devices at customer assembly. Avoids external components for robustness protection.

• **Current Measurement**
• **Coulomb Counting**
• **Current Wakeup**
• **Current Voltage Synchronization**
• **Integrated Passive Balancing**
• **Integrated Diagnostics and Functional Safety**
	• **Sine Phase Encoded Asynchronous Communication**
	• **Safe protocol:**
	  • **8bitCRC**
	  • **Bit Count**
	  • **Cluster ID**
	  • **TAG ID**
	  • **Data Address**
	• **High speed : 2Mbps TPL, 4Mbps SPI**
	• **High Immunity, Low Radiated Emissions**
	• **Robust design for BCI>200mA**
	• **Voltage Isolation Level: >3750 Vrms**
		• **Proven automotive high volume process and package technology.**
		• **Protected cell terminal inputs, power and ground pins.**
		• **Hot connect.**

SECURE CONNECTIONS
FOR A SMARTER WORLD