Application Report

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Feature Set Comparison Between bq2084 and bq20z80

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ABSTRACT

The bq20z80 differs from the bq2084 in several areas, although all bq2084 features are available in the bq20z80. Both devices support SBS1.1 with SMBus communications, but the bq20z80 has many extended SBS commands to enable additional features. The array of bq2084 safety features is expanded in the bq20z80, with a wider range of configuration options. The bq20z80 offers greater flexibility in use and configuration of the features. Each feature setup is very similar, making the device easier to understand and use. An overview of the operation of each device can be seen in the diagrams at the end of this document. Although the gas-gauge hardware is different, the pinout is the same except for an additional thermistor input (TS2).

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1 Hardware Platform

The bq20z80 architecture is based on the bq8024, and uses the bq29312 Analog Front End (AFE) to complete the gas-gauge first-level protection chip set. The differences in the bq8020/bq29312 platform used by the bq2084 are shown in Table 1.

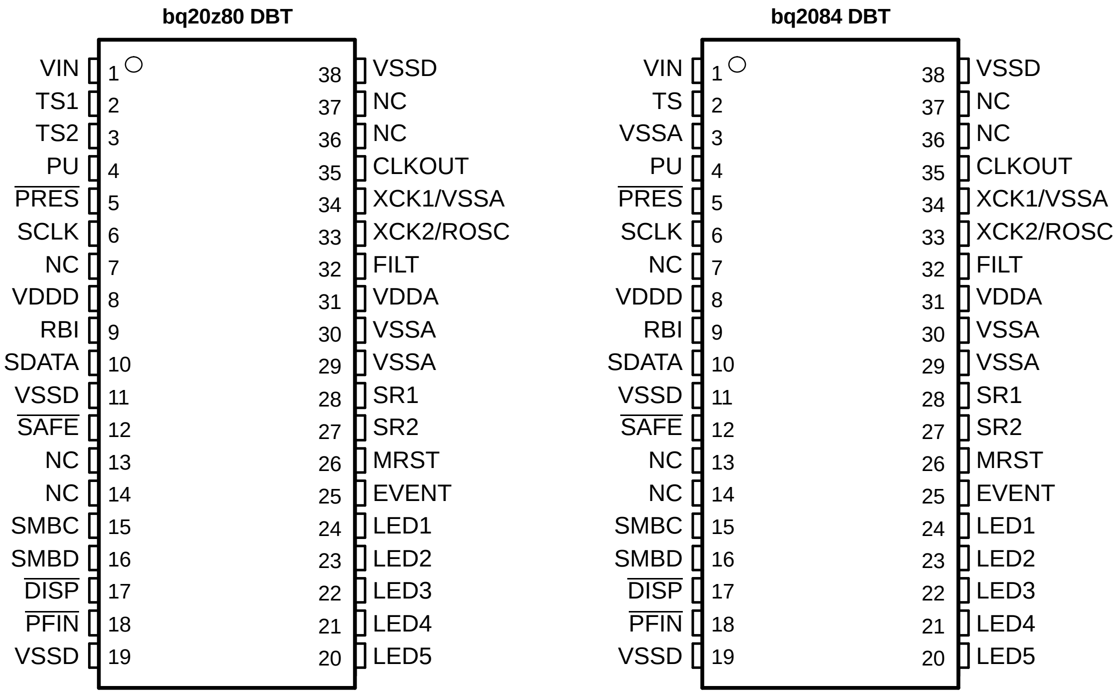
ImpedanceTrack is a trademark of Texas Instruments.

Table 1. BMU Hardware Differences

DEVICE	POR CIRCUIT				XTRA INTERNAL CAP	FLASH MEMORY		RAM
	SLOW	FAST	LOW VDD	DEGLITCH		PROGRAM	DATA	
bq8020	ü	ü	ü			16kx22	1kx8	768x8
bq8024 [(1)]	ü			ü	ü	24kx22	2kx8	1kx8

(1) The bq8024 platform require a 100 kΩ resistor from MRST to VSSA, and a 0.1 µF capacitor from VDDA to MRST to align the rise of VDDA and the release of MRST.

The pinout is identical except for the optional additional thermistor (Pin 3).



NC − No internal connection

Figure 1. Pinouts for the bq20z80DBT and bq2084DBT

Because the bq20z80 and bq2084 use the same bq29312 AFE, the only difference in the schematic and layout for these two devices is the optional use of the second thermistor. If the TS2 pin (pin 3) is not used, but is grounded, as in a bq2084 schematic, this is no concern. Therefore, testing can be performed on current bq2084-based PCBs and packs simply by replacing the bq2084 with a bq20z80.

2 CEDV vs ImpedanceTrack™

2.1 What is the Compensated End of Discharge Voltage (CEDV) Algorithm?

The CEDV algorithm mathematically models cell voltage (open-circuit voltage, OCV) as a function of battery state-of-charge (SOC), temperature, and current. It also mathematically models impedance (Z) as a function of SOC and temperature, with a total of seven parameters in the equation.

$$CEDV = OCV - I \times Z$$

This battery-voltage model is used to calibrate full-charge capacity (FCC), and a compensated battery voltage is used for end-of-discharge alarms (Battery Low%, Fully Discharged), and cutoff.

2.2 What is ImpedanceTrack?

The ImpedanceTrack (IT) algorithm performs real-time measurements and calculations before recording key battery-chemistry parameters into the on-chip data flash memory.

$$OCV = f(SOC),\ Z = f(SOC, Q_{MAX}) \text{ where } Q_{MAX} = \text{battery chemical capacity}$$

The IT algorithm dynamically updates the data flash as it fully characterizes the parameters of each cell, and generates a unique set of data for each battery pack. This data is used to predict how each battery behaves electronically under given current and temperature stimuli by continually updating and reporting *FullChargeCapacity( )*, *RelativeStateofCharge( )*, and *TimeToEmpty( )*.

2.3 Algorithm Summary

- CEDV uses a mathematical model to correlate RSOC and voltage near the end-of-discharge state
  - Relies on battery characterization to establish the model
  - Model requires an additional feature to avoid severe inaccuracy as battery ages
  - Requires a full discharge for a single-point FCC update
- ImpedanceTrack measures and records battery-chemistry data, from full to empty states
  - Uses battery data to predict battery response to electronic and thermal stimuli
  - Battery aging of Q_{MAX} and impedance is captured
  - Usable full and available capacity is continually updated

2.3.1 Learning Battery Chemical Capacity (Q_{max})

There is a correlation between OCV and SOC (or Depth of Discharge, DOD) that can be understood, and used to model the cell or battery.

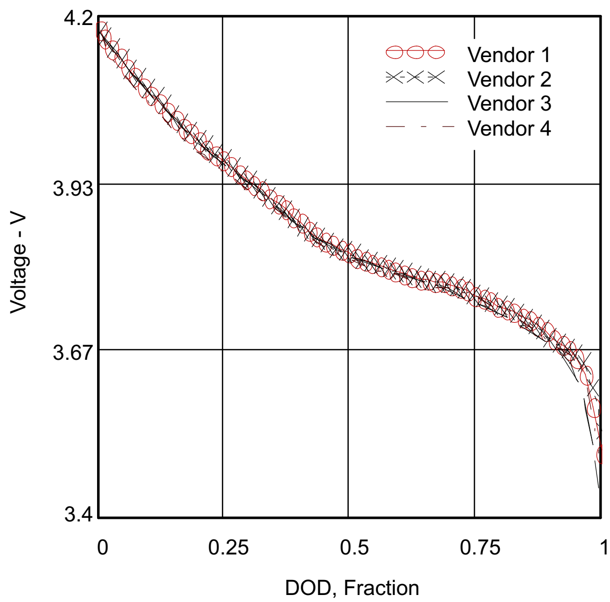


Figure 2. Relationship Between Cell Voltage and DOD for 4 Different Cell Suppliers

Notice the lack of variation between the different cell vendors. This demonstrates that there is no need to uniquely configure the ImpedanceTrack algorithm for different cell suppliers.

The correlation is only valid for the current battery chemistry materials used today. Advances in chemical technology by the use of new or modified materials are yet to be evaluated.

To actually learn a new Q_{MAX}, two OCV measurements are needed, separated by a change in capacity where a valid OCV measurement requires the battery to be at rest. "Rest" in this case is defined at a dv/dt of 0.1 µV/s, which typically takes a maximum time of 1000s.

Figure 3. Q_{MAX} Learning Opportunity

Because the voltage profile of the battery correlates to Z and SOC, the aging and self-discharge of a battery are factored into the model. Therefore, no additional factors are needed to compensate for these effects.

2.3.2 Impedance Measurement and FCC Calculation

The ImpedanceTrack algorithm calculates real-time DC impedance by measuring the voltage drop from the OCV measurement and dividing it by the current. This is sampled at 15 points between full and empty. As this occurs through the life of the battery, the impedance increase due to age is physically measured.

The ImpedanceTrack algorithm uses impedance and OCV data to predict the usable capacity under a given load and temperature using a root-finding approach to converge on usable available capacity.

Both constant current and constant power are applicable and as equally accurate as FCC tracks real time with current and temperature.

2.3.3 Pack Development With ImpedanceTrack™

No data collection for each pack design is required as all battery parameters are learned real time by the gas gauge through out the normal operational lifetime of the battery. If a full initialization is desired then it is automatically performed during one discharge cycle and that data can be copied to all packs.

No full discharge is required for capacity learning. Only a charge or discharge for 1000s is necessary for impedance scaling for cell to cell variations.

RemainingStateOfCharge( ) (RSOC) is initialized whenever a rest state is detected which does occur on exit from Ship mode (on power up).

2.3.4 Algorithm Comparison Summary

- New battery pack
  - *Cell-to-cell variation effect:* CEDVs are adapted for specific cell impedances, but cell-to-cell variation in impedance of about 15% can cause up to 2% error in EDV2 voltage estimation for Battery Low% (typically set at 7%). This can result in a 2% error in FCC. ImpedanceTrack does not exhibit this error because impedance is measured at each cell in real time.
  - *Transient effects:* In a variable-load environment, after a current change, the cell voltage does not immediately change. However, the CEDV method assumes that voltage strictly correlates with given current and SOC. In a case where current increased immediately before reaching estimated the EDV2 voltage, learned FCC will be overestimated by up to 1%. If the current decreases under similar conditions, learned FCC will be underestimated.
  - *More flexibility in compensating for temperature effects:* IT uses exponential functions for describing impedance-temperature dependence—these are more flexible than CEDV functions. In the IT algorithm, the *false learn* scenario is not possible, but is possible with CEDVs, where unusually low FCC would be learned at low temperature (therefore low temperature learn was disabled) or at a high rate. This low FCC would then be used for all subsequent cycles even at a lower rate, therefore not allowing use of the full capacity of the battery. IT does not have this problem, because FCC is always calculated using model parameters that adapt to present rate and temperature.
  - *Cell-based CEDVs:* If the cell-based CEDV method is used, the lowest cell defines the capacity of the pack. However, this is not exact, because a higher voltage cell keeps the pack operational longer. IT uses the sum of all cell voltages to estimate the whole pack voltage, so this problem is avoided.
  - *Self-discharge estimation:* During periods of inactivity, self-discharge is estimated using a simple, and hence inexact, formula in the CEDV method. IT measures self discharge directly based on OCV. Therefore, SOC information remains correct regardless of the period of inactivity.
- Aged battery pack
  - *Capacity Learning:* The CEDV method requires a full charge-discharge cycle to update the FCC value. IT only requires a 5-minute discharge to update the impedance information, and a 25% discharge (not necessary from fully charged state) to update the chemical-capacity information. Because chemical capacity changes very slowly (typically 3% in 100 cycles), resistance updates are sufficient to keep errors below 1% even without regular chemical-capacity updates. This allows accurate capacity estimation for devices that are never fully discharged, such as uninterruptable power sources (UPS) and other backup systems.

    Because of cell-impedance changes, the EDV2 (7% SOC) voltage calculation used to update FCC in the CEDV method becomes inaccurate with age, since CEDV parameters assume a new-cell impedance value. Cycle-number correction improves this estimate, but because aging depends not only on the number of cycles, but also on inactivity time, temperature, and usage pattern, the possibility remains for a worst-case error of approximately 10% after 300 cycles. Because impedance information is updated by continuous real-time measurements on each cell, IT does not have this problem.
  - *Termination voltage:* This is typically defined as 3 V/cell to prevent cell degradation. This voltage is typically much higher compared to minimal acceptable system-side dc/dc converter voltages (typically 2.2 V/cell). The CEDV method has no way of determining the actual chemical state-of-charge of the cells, therefore a fixed termination voltage is the only way to prevent excessive discharge. However, true end-of-chemical-capacity voltage depends on the rate of discharge and age ($V = V_0 - IR$, and R increase with age), and can move from 2.7 V for new cells down to 2 V for aged cells at the same rate. The IT method has information about the actual chemical capacity of the cell, and reports a 0 SOC at the end of chemical capacity regardless of the voltage. This allows setting the termination voltage to the converter voltage, preventing premature fixed-voltage termination when chemical capacity is still left. This increases run-time by up to 20%.

3 ManufacturerAccess( ) Features

The bq2084 has an array of features that use the *SBS ManufacturerAccess( )* command. There are differences between the two devices, as shown in Table 2.

Table 2. ManufacturerAccess( ) Commands

NAME	bq2084	bq20z80	DESCRIPTION
Part Number	0x0001	0x0001	Returns the IC part number
Firmware Version	0x0002	0x0002	Returns Firmware Version
EDV Level	0x0003	NA	Returns the pending CEDV
Hardware Version	NA	0x0003	Returns hardware version
Manufacturer Status	0x0004	0x0006(1)	Returns detailed summary of the battery status
DF_Checksum	NA	0x0004	Instructs the gas gauge to generate a static DF checksum
Qusable Update	NA	0x0005	Instructs the gas gauge to update Q_{USABLE}
Ship	0x0005	0x0010	Causes the bq29312 to enter ship mode
Sleep	NA	0x0011	Causes the bq20z80 to enter sleep mode
Seal	0x062b	0x0030	Instructs the gas gauge to restrict access to that defined by the SBS standard
Calibration Mode	0x0653	0x0040	Instructs the gas gauge to enter calibration mode
Reset	NA	0x0041	Causes the gas gauge to be fully reset
Sleep	NA	0x0011	Instructs the gas gauge to enter Sleep Mode
IT_Enable	NA	0x0021	Instructs the gas gauge to enable Impedance Track™
SAFE_Activation	NA	0x0030	Instructs the gas gauge to drive the $\overline{\text{SAFE}}$ output low
SAFE_Clear	NA	0x0031	Instructs the gas gauge to drive the $\overline{\text{SAFE}}$ output high
LEDs ON	NA	0x0032	Causes the gas gauge to turn ON all LED's
LEDs OFF	NA	0x0033	Causes the gas gauge to turn OFF all LED's
Display ON	NA	0x0034	Causes the gas gauge to turn on the Display (simulates $\overline{\text{DISP}}$ transition)
PFClear	0x2673(2) 0x1712(2)	0x2673(2) 0x1712(2)	Instructs the gas gauge to clear Permanent Failure Mode

(1) Optional configurations available in the bq20z80 (bq2084 is fixed).
(2) Default

Additional security features exist via the *SBS.ManufacturereAccess( )* commands, but are beyond the scope of this report.

3.1 Manufacture Status: 0x0004 (bq2084)

This 16 bit word summarizes the battery status, and is formatted differently in the bq20z80 depending on the *DF.OperationConfiguration*, *MAC1* and *MAC2* bits. The bq2084 format is the same as bq20z80 *DF.OperationConfiguration*, *MAC1* = *MAC2* = 0, and is detailed below.

Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	BIt 9	Bit 8
FET1	FET0	PF1	PF0	STATE3	STATE2	STATE1	STATE0

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	BIt 1	Bit 0
0	0	0	0	1	0	1	0

3.2 FET1, FET0

Indicates the state of the charge and discharge FETs

0, 0 Both charge and discharge FETs are on.

0, 1 Charge FET is off, discharge FET is on.

1, 0 Both charge and discharge FETs are off.

1, 1 Charge FET is on, discharge FET is off.

3.3 PF1, PF0

Indicates the cause of a permanent failure when a permanent failure is indicated by STATE3-STATE0

0, 0 Fuse is blown

0, 1 Cell imbalance failure

1, 0 Safety voltage failure

1, 1 FET failure

3.4 STATE3, STATE2, STATE1, STATE0

Indicates battery state as defined in the State and Status bit Summary.

Table 3. STATE Code for Manufacture Status

bq2084 STATE	STATE CODE (hex)	CORRESPONDING bq20z80 FLAG
wakeup	0	SBS.OperationStsatus( ) WAKE
precharge	3	SBS.ChargingStatus( ) PCHG
chargesusp	4	SBS.ChargingStatus( ) CHGSUSP
terminatecharge	7	
normalcharge	5	SBS.ChargingStatus( ) FCHG
provisionalcharge	1	SBS.ChargignStatus( ) XCHG
normaldischarge	1	SBS.OperationStatus( ) DSG
depleted	0	SBS.OperationStatus( ) XDSG or XDSGV or XDSGI or XDSGT
depleted_ac		
overheatdischarge		
overheatcharge		
battfail_overcharge		
battfail_lowtemp		
battfail_chargeterminate	8	SBS.ChargingStatus( ) OCHGI or OCHGV
battfail_afe_chg	c	SBS.SafetyStatus( ) SCC
battfail_afe_dsg	c	SBS.SafetyStatus( ) AOCD or SCD
battfail_chg	a	SBS.SafetyStatus( ) OCC or OCC2
battfail_dsg	a	SBS.SafetyStatus( ) OCD or OCD2
removed	f	SBS.OperationStatus( ) PRES
sleep	d	Communication causes exit of Sleep
permanent_failure	9	SBS.SafetyStatus( ) PF

4 Extended SBS Commands

The bq20z80 has a selection of Extended SBS Commands in addition to the SBS specified commands. The bq2084 only has one extended SBS command, *SBS.AFEData( )* [0x47].

The extended commands available in the bq20z80, which are primarily available in unsealed mode only, include

- *GetRAMDataBlock( )* [0x43] and *SetRAMBlockNumber( )* [0x44] to enable RAM dumps
- *AFEData( )* [0x45] to retrieve the complete AFE memory map
- *FETControl( )* [0x46] for improved testability at PCB and system level
- *StateOfHealth( )* [0x47] reports the state of health of the battery
- *SafetyAlert( )* [0x50] and *SafetyStatus( )* [0x51] indicate the current status of the primary (first level) safety features
- *PFAlert( )* [0x52] and *PFStatus( )* [0x53] indicate the current status of the secondary (second level) safety features
- *OperationStatus( )* [0x54] and *ChargingStatus( )* [0x55] report the current status of normal operations
- *ResetData( )* [0x57] and *WatchdogResetData( )* [0x58] report the number and type of resets in the life of the bq20z80
- *PackVoltage( )* [0x59] returns the voltage at the PACK pin of the bq29312
- *ManufacturerInfo( )* [0x70] provides scratchpad storage space for the pack manufacturer
- *DataFlashClass( )* [0x77] and *DataFlashSubclass( )* provides access to the integrated data flash space

5 LifeTime Data Logging Features

The bq20z80 offers a Lifetime data logging array of where maximum and minimum measurements are stored for warranty and analysis purposes.

The data available includes:

Lifetime Maximum Temperature	Lifetime Minimum Battery Voltage
Lifetime Minimum Temperature	Lifetime Maximum Cell Voltage
Lifetime Average Temperature	Lifetime Minimum Cell Voltage
Lifetime Maximum Discharge Current	Lifetime Maximum Power,
Lifetime Maximum Charge Current	Lifetime Maximum Average Power
Lifetime Maximum Battery Voltage	

6 Primary (1st Level) Safety Features

The bq2084 and bq20z80 have a similar array of safety features using Voltage, Temperature, Current and system-level data to ensure that the battery remains safe during normal operation.

Table 4. Primary Safety Features

SAFETY FEATURE	bq2084		bq20z80	
	SET	RECOVERY	SET	RECOVERY
VOLTAGE BASED				
Cell Over Voltage	$VCELL_{ANY}$( ) ≥ DF.CellOverVoltage for 0 to 1s or 1 to 2s if VOD is set	$VCELL_{ALL}$( ) < DF.CellOver VoltageReset for 0 to 1s	$VCELL_{ANY}$( ) ≥ DF.CellOverVoltage[(1)] for DF.CellOverVoltageTime	$VCELL_{ALL}$( ) ≤ DF.CellOverVoltageReset for 0 to 1s
Cell Under Voltage	$VCELL_{ANY}$( ) ≤ DF.CellUnderVoltage for 0 to 1s or 1 to 2s if VOD is set	$VCELL_{ALL}$( ) < DF.CellUnder VoltageReset for 0 to 1s	$VCELL_{ANY}$( ) ≤ DF.CellUnderVoltage for DF.CellUnderVoltageTime	$VCELL_{ALL}$( ) ≥ DF.CellUnderVoltageReset for 0 to 1s
Pack Over Voltage	N/A	N/A	Voltage( ) ≥ DF.PackOverVoltage for DF.PackOverVoltageTime	Voltage( ) ≤ DF.PackOverVoltage Reset for 0 to 1s
Pack Under Voltage	N/A	N/A	Voltage( ) ≤ DF.PackUnderVoltage for DF.PackUnderVoltageTime	Voltage( ) ≥ DF.PackUnderVoltage Reset for 0 to 1s
CURRENT BASED				
DSG Over Current	Current( ) ≥ DF.OverCurrentDSG for DF.OverCurrentDSGTime	AverageCurrent( ) = 0 for 0 to 1s OR Battery Removal	Current( ) ≥ DF.OverCurrentDSG for DF.OverCurrentDSGTime	AverageCurrent( ) ≤ DF.OverCurrentDSGRecovery for DF.CurrentRecoveryTime OR Battery Removal
CHG Over Current	Current( ) ≥ DF.OverCurrentCHG for DF.OverCurrentCHGTime	AverageCurrent( ) = 0 for 0 to 1s OR Battery Removal	Current( ) ≥ DF.OverCurrentCHG for DF.OverCurrentCHGTime	AverageCurrent( ) ≤ DF.OverCurrentCHGRecovery OR DF.CurrentRecoveryTime OR Battery Removal
2nd Tier DSG OC	N/A	N/A	Current( ) ≥ DF.2ndTierOverCurrentDSG for DF.2ndTierOverCurrentDSGTime	AverageCurrent( ) ≤ DF.OverCurrentDSGRecovery OR DF.CurrentRecoveryTime OR Battery Removal
2nd Tier CHG OC	N/A	N/A	Current( ) ≥ DF.2ndTierOverCurrentCHG for DF.2ndTierOverCurrentCHGTime	AverageCurrent( ) ≤ DF.OverCurrentCHGRecovery OR DF.CurrentRecoveryTime OR Battery Removal
3rd Tier DSG OC	V_{RSNS} ≥ AFE.Overload setting for AFE.OLDelay	AverageCurrent( ) < DF.ClearFailCurrent for DF.FaultResetTime OR Battery Removal	V_{RSNS} ≥ AFE.Overload setting for AFE.OLDelay	AverageCurrent( ) ≤ DF.OverCurrentDSGRecovery OR DF.CurrentRecoveryTime OR Battery Removal
Short Circuit in Charge	V_{RSNS} ≥ AFE.SCC setting for AFE.SCCDelay	AverageCurrent( ) < DF.ClearFailCurrent for DF.FaultResetTime OR Battery Removal	V_{RSNS} ≥ AFE.SCC setting for AFE.SCCDelay	AverageCurrent( ) ≤ DF.OverCurrentDSGRecovery OR DF.CurrentRecoveryTime OR Battery Removal
Short Circuit in Discharge	V_{RSNS} ≥ AFE.SCD setting for AFE.SCDDelay	AverageCurrent( ) < DF.ClearFailCurrent for DF.FaultResetTime OR Battery Removal	V_{RSNS} ≥ AFE.SCD setting for AFE.SCDDelay	AverageCurrent( ) ≤ DF.OverCurrentCHGRecovery OR DF.CurrentRecoveryTime OR Battery Removal
TEMPERATURE BASED				
DSG Over Temperature	Temperature( ) ≥ DF.OverTempDSG for DF.OverTempDSGTime	Temperature( ) ≤ DF.OverTempDSGReset for 0 to 1s	Temperature( ) ≥ DF.OverTempDSG for DF.OverTempDSGTime	Temperature( ) ≤ DF.OverTempDSGRecovery for 0 to 1s
CHG Over Temperature	Temperature( ) ≥ DF.OverTempCHG for DF.OverTempCHGTime	Temperature( ) ≤ DF.OverTempCHGReset for 0 to 1s	Temperature( ) ≥ DF.OverTempCHG for DF.OverTempCHGTime	Temperature( ) ≤ DF.OverTempCHGRecovery for 0 to 1s
SYSTEM BASED				
AFE Watchdog	CLKOUT to WDI out of range	CLKOUT to WDI in range	CLKOUT to WDI out of range	CLKOUT to WDI in range *and* AFE Verification passes
Host Watchdog	N/A	N/A	SMBus communications not detected for DF.HostWatchdogTime	SMBus communication detected

(1) The Cell Over Voltage threshold can be programmed to be compensated based on temperature.

7 Secondary (2nd Level) Safety Features

Table 5. Secondary Safety Features

SAFETY FEATURE	bq2084	bq20z80
External Input (PFIN)	PFIN input low for DF.PFINTime	PFIN input low for DF.PFINTime
Safety Over Voltage	Voltage( ) ≥ DF.SafetyOverVoltage for 0 to 1s or 1 to 2s if VOD is set	Voltage( ) ≥ DF.SafetyOverVoltage for DF.SafetyOverVoltageTime
Safety Over Current CHG	N/A	Current( ) ≥ DF.SafetyOverCurrentCHG for DF.SafetyOverCurrentCHGTime
Safety Over Current DSG	N/A	Current( ) ≥ DF.SafetyOverCurrentDSG for DF.SafetyOverCurrentDSGTime
Safety Over Temperature CHG	Temperature( ) ≥ DF.SafetyOverTemperatureCHG	Temperature( ) ≥ DF.SafetyOverTemperatureCHG for DF.SafetyOverTemperatureCHGTime
Safety Over Temperature DSG	Current( ) ≥ DF.SafetyOverTemperatureDSG	Current( ) ≥ DF.SafetyOverTemperatureDSG for DF.SafetyOverTemperatureDSGTime
Cell Imbalance	$VCELL_{MAX}$( ) – $VCELL_{MIN}$( ) ≥ DF.CellImbalanceThreshold for DF.CellImablanceTime	$VCELL_{MAX}$( ) – $VCELL_{MIN}$( ) ≥ DF.CellImbalanceThreshold for DF.CellImablanceTim
Charge FET Failure	CHG FET commanded OFF *and* Current( ) ≥ DF.FETFailCHGThreshold for DF>FETFailTime	CHG *and* ZVCHG FET commanded OFF *and* Current( ) ≥ DF.FETFailThreshold for DF>FETFailTime
Discharge FET Failure	CHG FET commanded OFF *and* Current( ) ≥ DF.FETFailDSGThreshold for DF>FETFailTime	DSG FET commanded OFF *and* Current( ) ≥ DF.FETFail Threshold for DF>FETFailTime
AFE Comms Verification	AFE communications incorrect *and* AFE_Fail_Counter ≥ AFE_Fail_Limit	AFE communications incorrect *and* AFE_Fail_Counter ≥ AFE_Fail_Limit
Periodic AFE Verification	Periodic AFE RAM verification fails *and* AFE_Fail_Counter ≥ AFE_Fail_Limit	Periodic AFE RAM verification fails *and* AFE_Periodic_Fail_Counter ≥ AFE_Fail_Limit
Data Flash Verification	N/A	Periodic checksum verification = DF.Checksum

8 Charge Control Features

The bq204 and the bq20z80 have the same feature set except for a few additions in the bq20z80.

8.1 SBS.ChargingCurrent( ) Temperature Throttling

Under normal fast charge conditions the *SBS.ChargingCurrent( )* can be reduced per the following:

If *DF.Charge Suspend Temperature High (CHGSUSPH) > SBS.Temperature( ) ≥ CHGSUSPH–DF.Delta Temperature (dT)*

Then *SBS.ChargingCurrent( )* = Pre-Charge Current

If *DF.CHGSUSPH –DF.dT > SBS.Temperature( ) ≥ DF.CHGSUSPH–* 2 x *DF.dT*

Then *SBS.ChargingCurrent( )* = (Fast Charge Current - Pre-Charge Current) / 2

If *DF.CHGSUSPH–* 2 x *DF.dT > SBS.Temperature( ) ≥ DF.Pre-Charge Temperature*

Then *SBS.ChargingCurrent( )* = Fast Charge Current

Note 1: If *DF.dT* = 0 then no change in *SBS.ChargingCurrent( )* from Fast Charge occurs.

Note 2: If *SBS.ChargingCurrent( )* is modified per this feature then *TCHG* in *SBS.ChargingStatus( )* is set

8.2 Pre-Charge Maximum Timeout

The bq2084 maximum-charge timeout does not differentiate between pre-charge and fast-charge modes. The bq20z80 differentiates between these modes, if the appropriate values are set in *SBS.ChargingCurrent( )*. Status is reported in *SBS.ChargingStatus( )*.

9 Data Flash Access

The bq2084 requires individual addressing of each byte of configuration data flash. As a result, new additions to the data-flash-constant array are added to the end of the array to minimize confusion and to enable easier updates. However, this causes problems with keeping data flash constants contiguous when new constants are added to existing features, eg: *Cell Over Voltage* at *DF 0x63,0x64* and *Cell Over Voltage Recovery* at *DF. 0xe0,0xe1* in the bq2084.

The bq20z80 uses a simpler addressing method where a Class and Subclass offset structure is used to access the data flash space. This allows easy grouping of like constants, and enables the introduction of new constants with the maximum ease to the user.

Eg: *Cell Over Voltage Recovery* is defined as:

Class = 1st Level Safety / Voltage = ID 0 with Subclass Offset = 3

10 Device Operational Diagrams

Operational diagrams for the bq2084 and bq20z80 are appended to the end of this application report.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		**Applications**	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
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