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MAX1720x/MAX1721x System Side Implementation Guide

UG6259; Rev 0; 2/16

Description

This guide provides instructions for implementing the MAX17201/MAX17211/ MAX17205/MAX17215 on the system side of the application. PCB layout recommendations help to achieve the highest performance possible given limited board size and component position flexibility. Proper circuit board layout is critical for measurement accuracy. **Figure 1** shows both the single-cell circuit (MAX17201/MAX17211) and multi-cell circuit (MAX17205/MAX17215) used in this example. Note that other circuit configurations for this IC are possible, and should follow the same layout guidelines. This guide also includes a recommended board level production test procedure requiring minimum test time.

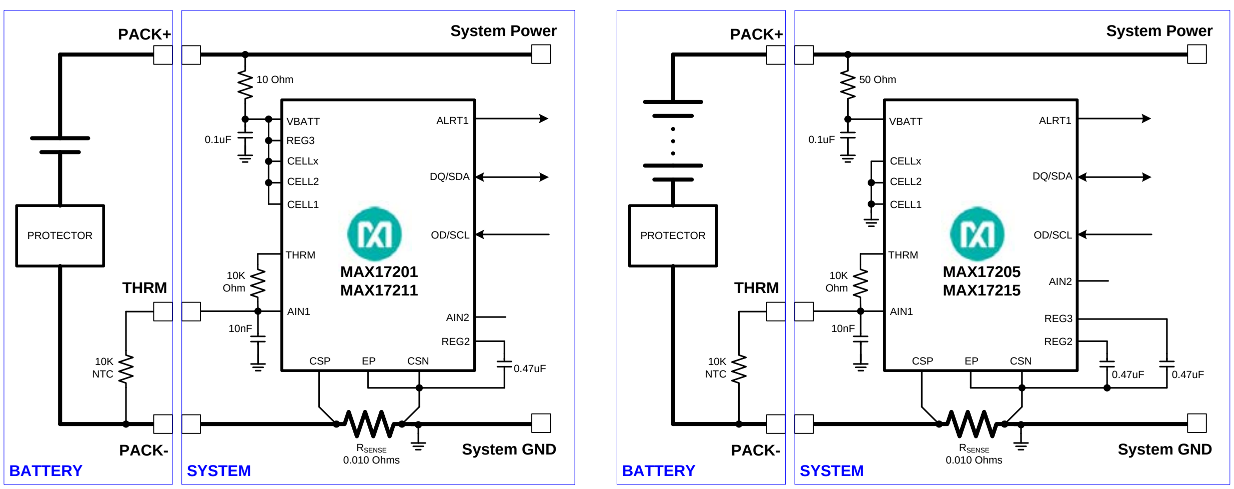

Figure 1. Example of circuit schematic.

The typical board requirements for a handheld application limit space for all components. The critical layout considerations for the fuel gauge IC are the placement of the REG2, REG3, and the BATT bypass capacitors, as well as the measurement lines for the sense resistor.

Layout considerations for current measurement accuracy

To determine current flow through the pack, the MAX1720x/1x performs a differential voltage measurement across the external sense resistor through the CSP and CSN pins. The CSP pin is a high impedance ADC input, but the CSN pin shares the ADC input with the power supply ground of the IC. Because there is current flow through the CSN pin, external resistance must be kept to a minimum. Any external resistance on CSN directly translates into negative offset error of the current measurement result. **Figure 2** shows the recommended board layout to achieve the most accurate current measurement.

1. **Minimize CSN resistance**

   The CSN trace should travel directly from the CSN pin to the battery side of the sense resistor. The trace length should be minimized, and should not travel through vias. Whenever possible, maximize the trace width.

2. **Minimize regulator bypass capacitor loop areas**

   The REG2 and REG3 bypass capacitors should be mounted as close as possible to the IC with connections running directly to the CSN, REG2 and REG3 pins. Minimize any loop area between the capacitor and the IC. Note that the MAX17201/MAX17211 does not require a REG3 capacitor. The REG2 loop area must still be minimized.

3. **Kelvin connection to sense resistor**

   The CSN and CSP traces from the IC should run directly to the sense resistor pads. There should be no shared trace area with the high current path of system ground and pack negative (P-) traces.

4. **Minimize CSN/CSP loop area**

   The CSP input is high impedance; therefore, the trace can have series resistance without affecting accuracy. Ideally, the CSP trace should run parallel to the CSN trace to minimize inductive loop area between the two.

5. **Exposed Pad connection.**

   Connect the exposed pad directly to the CSN pin.

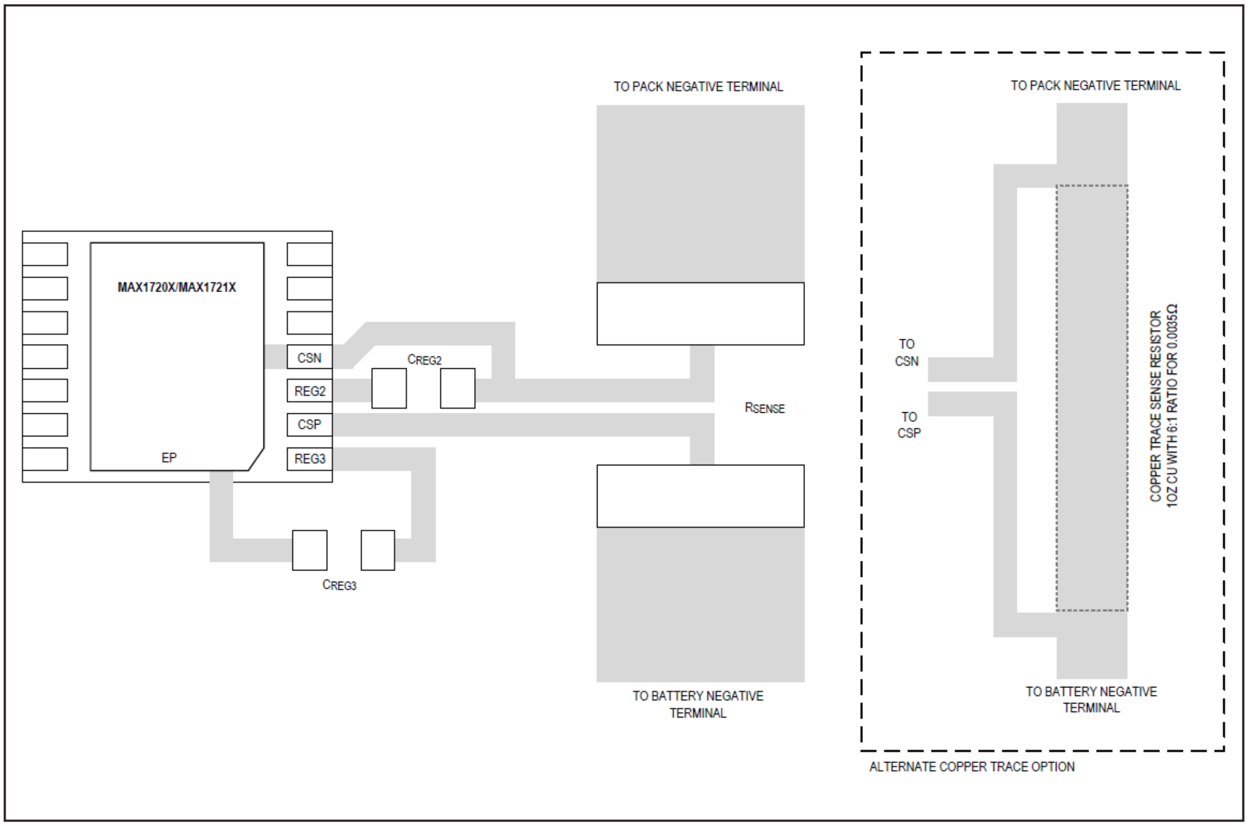

Figure 2. Recommended layout for current measurement accuracy.

Nonvolatile Memory Operations

The table below shows the nonvolatile memory of the MAX1720x/1x. The different highlighting separates the sections into what is provided by the battery characterization table, what is programmed by the factory, and the registers that are free or configurable to be free memory.

PAGE	18xh	19xh	1Axh	1Bxh	1Cxh	1Dxh
0h	nXTable0	nOCVTable0	nQRTable00	nConfig	nVAlrtTh	nUser1D0
1h	nXTable1	nOCVTable1	nQRTable10	nRippleCfg	nTAlrtTh	nUser1D1
2h	nXTable2	nOCVTable2	nQRTable20	nMiscCfg	nSAlrtTh	nAgeFcCfg
3h	nXTable3	nOCVTable3	nQRTable30	nDesignCap	nIAlrtTh	nDesignVoltage
4h	nXTable4	nOCVTable4	nCycles	nHibCfg	nUser1C4	nUser1D4
5h	nXTable5	nOCVTable5	nFullCapNom	nPackCfg	nUser1C5	nRFastVShdn
6h	nXTable6	nOCVTable6	nRComp0	nRelaxCfg	nFullSOCThr	nManfctrDate
7h	nXTable7	nOCVTable7	nTempCo	nConvgCfg	nTTFCfg	nFirstUsed
8h	nXTable8	nOCVTable8	nIAvgEmpty	nNVCfg0	nCGain	nSerialNumber0
9h	nXTable9	nOCVTable9	nFullCapRep	nNVCfg1	nTCurve	nSerialNumber1
Ah	nXTable10	nOCVTable10	nVoltTemp	nNVCfg2	nTGain	nSerialNumber2
Bh	nXTable11	nOCVTable11	nMaxMinCurr	nSBSCfg	nTOff	nDeviceName0
Ch	nUser18C	nIChgTerm	nMaxMinVolt	nROMID0	nManfctrName0	nDeviceName1
Dh	nUser18D	nFilterCfg	nMaxMinTemp	nROMID1	nManfctrName1	nDeviceName2
Eh	nODSCTh	nVEmpty	nSOC	nROMID2	nManfctrName2	nDeviceName3
Fh	nODSCCfg	nLearnCfg	nTimerH	nROMID3	nRSense	nDeviceName4

Legend:

Required for Custom Model	If a custom model is being used, these registers need to be programmed.
Required for 1-Wire® ID	These registers are used for the 1-Wire ROM ID and device serial number. They are not writable.
Optional Customer Registers	These registers don't have fuel gauge functions. The customer can use these for their suggested operation (such as FirstUsed, ManfctName), or use them in any other mode.
Free-able Memory	These registers contain algorithm/IC operation information, but the default values can be loaded from ROM, leaving these registers free for customer data.
Mandatory Configuration Registers	These registers must be configured for the IC to work correctly.

Figure 6. Nonvolatile memory operation descriptions.

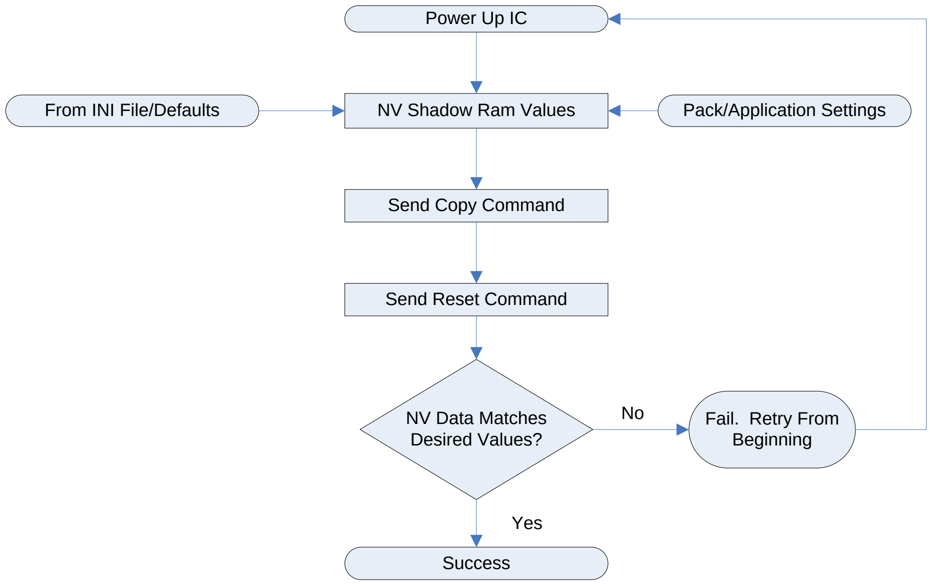

Figure 7. Nonvolatile memory loading process.

The starting values for the memory table should be obtained from the INI file (or default values if no custom model is available). The EV kit GUI configuration wizard can be used to configure all of the nonvolatile memory, or the values can be constructed by exploring each register in the data sheet. The customer memory can be written to any values desired by the pack maker or end customer.

Once the values are known, they should be written to the shadow memory at the addresses listed in the above table. To copy the contents of shadow RAM to nonvolatile nonvolatile memory, send command 0xE904 to register 0x060 to initiate a burn. Wait until CommStat.NVBusy is cleared to indicate the copy command is complete. This takes approximately 368ms (t_{BLOCK}). Register 0x061 (CommStat) contains the NVBusy and NVError bits. NVError is set if an error occurred during the burn. NVBusy is clear when the burn operation is complete.

The IC should be reset to force the RAM to update to the desired configuration. To issue a full IC reset, the ESD detection mechanism has to be bypassed. This is accomplished by modifying the model table. The following sequence forces a complete IC reset. If the fuel gauge performance is evaluated shortly after the reset, the battery must be relaxed (no charge or load for 1 hour) before the reset command is sent.

1. Write register 0x062 = 0x0059
2. Write register 0x063 = 0x00C4
3. Write register 0x080 = 0x0000
4. Write register 0x060 = 0x000F
5. Wait 150ms (NV memory recall and RAM initialization)
6. Write register 0x0BA to clear bit 0x8000 (Disable hibernate mode. It should be re-enabled at the end of factory production.)

After the reset is complete, the contents of the nonvolatile memory should be verified against the desired write values. If everything matches, the process is complete. If there is any discrepancy, the number of write cycles should be examined to check if there is nonvolatile memory remaining. See the data sheet “Determining the Number of Remaining Updates” section for details.

Locking the Battery Model

MAX1720x/1x has a locking feature to permanently set the contents of the nonvolatile memory. The locks on the IC can be set for different portions of the memory in 5 different configuration sections. The process for setting the locks is:

1. Write register 0x061 = 0 to Clear the Comstat.NVError bit.
2. Write register 0x060 = 0x6Axx with xx representing the lock code. The lower 5 bits set Lock 5 to Lock 1 as described in the figure below.

D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
0	1	1	0	1	0	1	0	X	X	X	LOCK5	LOCK4	LOCK3	LOCK2	LOCK1

3. Wait until NVBusy clears for the copy command to complete (t_{UPDATE} = 64 ms typical).
4. Read register 0x061 to see if the operation completed successfully.

Production Test

Hibernate mode should already be disabled in the nonvolatile memory initialization section. If it is not disabled, clear HibCfg.EnHib. Ensure that Status2.HibStat is clear before proceeding.

1. Check communication
   - Validate the IC is powered on by reading the DevName register (0x021). If the IC responds with the correct version number, the communication test is successful.
2. Check voltage measurement
   - Read the VCell register (or Cell1, Cell2, Cell3 based on the pack configuration) and compare the measured voltage against the IC readings. If the error is less than 10mV, the voltage measurement check is successful.
3. Check no load current measurement
   - Check the current and AvgCurrent registers. The current should read in the range of +1mA to –1mA.
4. Set the load to the lesser of half the full-scale measurement range (25mV/R_{SENSE}), or half of the cell C-Rate (C/2).
   - Apply the selected load current.
   - Read the Current register.
   - Wait until the Timer register changes (up to 702ms).
   - The test is successful if the current reading is in an acceptable range of the set load current.

Calibration

This fuel gauge does not require any calibration. The voltage, current, and temperature accuracy are trimmed during the Maxim Integrated factory test program. The algorithm does not require any cycling for accurate state-of-charge reporting.

Conclusion

This guide describes the various steps for implementing MAX1720x/MAX17021x on the host side of the application, and how to lay out the circuit board to achieve the best possible current measurement accuracy given the requirements of the circuit board. The memory programming instructions describe how to load the fuel gauge information and lock it to prevent tampering. The other signal paths of the circuit are noncritical and should be added after the rules above have been applied.