AN-2187 Using the LM25066 in an Intel™ Node Manager 2.0 System

ABSTRACT

This application report discusses using the Texas Instruments LM25066 in an Intel™ Node Manager 2.0 System.

Contents

1 Introduction

Increasing the power efficiency of servers is one of the most important considerations in today's data centers. At the hardware level this means that real-time power monitoring and control need to be performed deeper in the hardware, for example, at the individual blade level instead of just at the power supply level. The LM25066 hot-swap controller with telemetry is well suited for such applications.

Configuration of the hot-swap functionality and fault limits of the LM25066 is achieved by selecting external passive components and, as such, requires no programmatic configuration. However, a rich set of configuration parameters are accessible via the PMBus™ interface of the device.

Many blade servers today are based on Intel's reference designs, which employ the Node Manager firmware on each blade to perform systems management including power. Thus, it is essential for such a server to comply with the Node Manager firmware. Intel's latest server platform, the Romley, supports blade level power telemetry at the board edge by using PMBus-enabled hot-swap controllers. For this purpose, a 'Hot-Swap Controller Profile' (HSC Profile) is being finalized by the PMBus Committee so such power management at the blade edge level may be standardized across the industry. Intel's Node Manager 2.0 firmware, which is currently being deployed on Romley and other new platforms, is expected to comply with the PMBus HSC Profile.

At the writing of this application report, the PMBus HSC Profile is close to final approval. Texas Instruments LM25066 hot-swap controller, the industry's first such PMBus-enabled device, provides much more telemetry functionality than the PMBus HSC Profile and the Node Manager 2.0 require. There are few small adaptations that the blade's firmware must perform in order to meet the exact requirements of these specifications. This document outlines the known command implementation issues needed in order to use the LM25066 in a Node Manager 2.0 environment, as well as to comply with the PMBus HSC Profile. Note that the PMBus HSC Profile will also be used on systems other than those using Node Manager 2.0. For more information regarding the Node Manager, contact Intel directly.

The solution presented in this application report assumes that the Node Manager will get access to the LM25066 through the Baseboard Management Controller (BMC) and the translation described below will be implemented in the BMC firmware, which is typically a microcontroller especially designed for BMC applications, or an ASIC with an embedded µC core.

2 Required PMBus Commands

The PMBus HSC Profile lists the following PMBus commands that it requires a compliant device to support:

- CLEAR_FAULTS (0x03)
- CAPABILITY (0x19)
- STATUS_WORD (0x79)
- READ_EIN (0x86); Not required, but desired.
- READ_VIN (0x88)
- READ_PIN (0x97); Alternative method to READ_EIN.
- PMBUS_REVISION (0x98)
- MFR_ID (0x99)MFR_MODEL (0x9A)
- MFR_REVISION (0x9B)

3 Implementation

The Node Manager 2.0 and the PMBus HSC Profile specify the 'DIRECT format' for all PMBus data. The LM25066 supports the DIRECT format. The coefficients for converting DIRECT format values to physical values (volts, amps, watts) are provided in *System Power Management and Protection IC with PMBus* (SNVS700). Note that these coefficients are not needed in the translations described here, but will be needed by the Node Manager software in order to obtain the physical values or the design requires implementing the LM25066 warning thresholds.

The PMBus HSC Profile requires that the value returned by the READ_VIN and READ_PIN commands be the average value. The LM25066 has built in averaging available on the telemetry values, but the averaging period must be configured at startup for the LM25066. Also, the averaged telemetry values are available at different command codes than the instantaneous values.

The Profile recommends, but does not require, a new form of power averaging with the READ_EIN command and a slightly different configuration on the STATUS_WORD to be used. These two commands are the ones that will likely require the most code to implement.

Each of the required commands is listed here with a description of any required translation or modification.

CLEAR_FAULTS (0x03) is supported directly by the LM25066 and requires no modification.

CAPABILITY (0x19) is supported directly by the LM25066 and requires no modification.

STATUS_WORD (0x79) is supported by the LM25066 but has a few bits that need to be masked out and a few bits that are interpreted differently. A loose approximation of the desired STATUS_WORD value could be obtained by masking the LM25066 STATUS_WORD. A more complete implementation is to use the data from the LM25066 MFR_SPECIFIC_17 MFR_DIAGNOSTIC_WORD_READ (0xE1) and to assemble the bits for the STATUS_WORD request as follows:

```
Nm_status_word =
((Diagnostic_Word & 0x0800) <<4)  | // bit 15 Vout Fault <= PGood_Bar
                                    // bit 14 Iout Fault not supported
((Diagnostic_Word & 0x0020) <<8)  | // bit 13 Input Fault <= VIn UV Flt
((Diagnostic_Word & 0x0010) <<9)  | // bit 13 Input Fault <= Vin OV Flt
((Diagnostic_Word & 0x0008) <<10) | // bit 13 Input Fault <= in OC/OP Flt
((Diagnostic_Word & 0x0100) <<4)  | // bit 12 FET Fault <= FET Short Flt
 (Diagnostic_Word & 0x0800) |       // bit 11 PGood Bar <= PGood_Bar
                                    // bit 10 Not used
                                    // bit 9 Not used
                                    // bit 8 Not used
                                    // bit 7 Not used
 (Diagnostic_Word & 0x0040) |       // bit 6 FET Gate OFF <= Device Off
                                    // bit 5 Not Used
((Diagnostic_Word & 0x0008) <<1)  | // bit 4 OC Fault <= In OC/OP Flt
((Diagnostic_Word & 0x0001) <<4)  | // bit 4 OC Fault <= CB Flt
((Diagnostic_Word & 0x0020) >>2)  | // bit 3 Vin UV Fault <=V In UV Flt
                                    // bit 2 Not used
 (Diagnostic_Word & 0x0002) |       // bit 1 Comm Fault <= CML Flt
((Diagnostic_Word & 0x0200) >>9)  | // bit 0 Other <= TLO
((Diagnostic_Word & 0x0004) >>2);   // bit 0 Other <= OT Flt
```

READ_VIN (0x88) is supported by the LM25066, but Node Manager 2.0 requires the averaged value of the data. In order to implement this command, READ_VIN requests should issue an MFR_SPECIFIC_12 [READ_AVG_VIN] (0xDC) command to the LM25066 instead of the standard READ_VIN (0x88) command which returns an instantaneous value.

READ_PIN (0x97) is not supported by the LM25066. The LM25066 uses the MFR_SPECIFIC_02 [MFR_READ_PIN] (0xD2) command, but Node Manager 2.0 requires the averaged value of the data. In order to implement this command, READ_PIN requests should issue an MFR_SPECIFIC_15 [READ_AVG_PIN] (0xDF) command to the LM25066 instead of the standard READ_PIN (0x97) command or the MFR_SPECIFIC_02 [MFR_READ_PIN] (0xD2) commands which return instantaneous values.

PMBUS_REVISION (0x98) is not supported by the LM25066 and will have to be emulated. The answer is a constant value 0x11 corresponding to version 1.1 that should be returned in response to this command. (Refer to the PMBus specification for details on the byte format.)

MFR_ID (0x99) is supported by the LM25066 directly and needs no modification.

MFR_MODEL (0x9A) is supported by the LM25066 directly and needs no modification.

MFR_REVISION (0x9B) is supported by the LM25066 directly and needs no modification.

READ_EIN (0x86) is not supported by the LM25066. Though desired by the PMBus HSC Profile, this command is not a requirement and, alternatively, the MFR_SPECIFIC_02 [MFR_READ_PIN] (0xD2) command is allowed to accomplish the same goal. In fact, the MFR_SPECIFIC_15 [READ_AVG_PIN] (0XDF) command of the LM25066 off-loads the average calculation task from the Node Manager software. However, if the user desires, it is possible to emulate this in software.

Software emulation would be done by having a background process issue a MFR_SPECIFIC_02 [MFR_READ_PIN] (0xD2) command to get the instantaneous power from the LM25066 on a periodic basis and add the returned value to an accumulator. The background read could be done as often as once per millisecond, but to match the rollover rate mentioned in the HSC Profile, once every 4 milliseconds would be better. A sample counter should be incremented each time the power accumulator is incremented. The READ_EIN command must return the power accumulator and sample counter from the same update period, so some form of semaphore or critical path protection should be employed to insure that both values are consistent. The code to emulate the READ_EIN command might look like this:

```
#define EIN_RESPONSE_SIZE 6
#define READ_INST_POWER_CMD ((UINT8)0xD2)

volatile UINT32 power_accumulator = 0;
volatile UINT32 sample_count = 0;

// User supplied function to perform a PMBus read word command
extern void pmbus_read_u16 (UINT8 pmbus_cmd, UINT16 *buffer);

//User supplied function to enter critical code section (interrupts off)
extern void enter_critical_section (void);

// User supplied function to exit critical code section (restore
// interrupts)
extern void exit_critical_section (void);

//========================================================================
// This function updates the power accumulator for the Ein command. It
// should be called every 4 milliseconds.
//========================================================================
void periodic_ein_update_function (void)
{
 UINT16 instantaneous_pwr;

 // get the power value from the LM25066 via PMBus
 pmbus_read_u16 (READ_INST_POWER_CMD, &instantaneous_pwr);

 // increment the accumulator and count the sample. The critical section
 // protection here is necessary if the build_ein_output_packet ()
 // function is called in an interrupt.

 enter_critical_section ();
 power_accumulator +=(UINT32)instantaneous_pwr;
 sample_count += 1;
 exit_critical_section ();
}

//========================================================================
// This function builds the output packet to respond to a Read_Ein command.
// The calling function must supply a pointer to a UINT8 buffer that is
// large enough to build the response into.
//========================================================================
void build_ein_output_packet (UINT8 *obuffer)
{
 UINT32 local_power_accum;
 UINT32 local_sample_count;

 // we need to make a local copy of the global accumulator and sample
 // count variables while preventing updates to insure that the
 // accumulator and the sample count are from the same update period.
```

```
 enter_critical_section ();
 local_power_accum = power_accumulator;
 local_sample_count = sample_count;
 exit_critical_section ();

 // now fill up the output buffer, starting with the block length
 *obuffer = EIN_RESPONSE_SIZE;

 // assemble the accumulator now. Note that the MSB of the mid (offset=2)
 // byte must be 0 because the low 2 bytes of the EIN are 2's complement
 // and our accumulator is always positive. This costs us one bit of
 // dynamic range.

 *(obuffer+1) = (UINT8)(local_power_accum & 0xFF);         // bits 7:0
 *(obuffer+2) = (UINT8)((local_power_accum >>8) & 0x7F);   // bits 14:8
 *(obuffer+3) = (UINT8)((local_power_accum >>15) & 0xFF);  // bits 22:15

 // assemble the sample counter
 *(obuffer+4) = (UINT8)(local_sample_count & 0xFF);        // bits 7:0
 *(obuffer+5) = (UINT8)((local_sample_count >>8) & 0xFF);  // bits 15:8
 *(obuffer+6) = (UINT8)((local_sample_count >>16) & 0xFF); // bits 23:16
}
```

4 Initialization and Fault Handling

The LM25066 will perform data averaging with no supervision. At power-up, it is necessary to select the desired averaging period. The HSC Profile recommends 100 to 200 milliseconds, so 2^7 or 128 milliseconds would be a good choice. This is done by writing a value of 7 to the MFR_SPECIFIC_11 [SAMPLES_FOR_AVG] (0xDB) command. This needs to be done at power-up and after a power loss by the LM25066. Power losses by the LM25066 result in the /SMBAlert signal being set and the MFR status bit (0x1000) in the STATUS_WORD register being set. Additionally, reading the MFR_SPECIFIC_17 [DIAGNOSTIC_WORD_READ] (0xE1) will return the CONFIG_PRESET (0x0080) bit set. After configuring the LM25066, a CLEAR_FAULTS command should be issued to clear the CONFIG_PRESET state and flag.

5 References

1. PMBus Power System Management Protocol Specification Part II Command Language Rev 1.2X03 System Management Interface Forum.
2. Proposed PMBus Application Profile for Hot Swap Controllers. Rev 0.91. Authored by Intel.
3. *System Power Management and Protection IC with PMBus* (SNVS700)
4. PMBus Power System Management Protocol Specification Part II Command Language Rev 1.1 System Management Interface Forum.

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