XDP™ XDP710-001 config file translation and programming guide

About this document

Scope and purpose

XDP™ XDP710 is a wide input voltage hot-swap and system-monitoring controller IC that drives single or multiple parallel N-channel MOSFETs. XDP710 has two types of internal nonvolatile memory (NVM) to store specific command settings; at power-up, during the READ_CFG state, all the settings saved in one-time programmable (OTP) and multiple time programmable (MTP) memory are copied into volatile memory.

This document describes how to read the production configuration (.txt) file and store the commands to the volatile memory over the I^2C serial interface and then store the settings in nonvolatile memory (NVM).

Intended audience

This document is intended for design and application engineers who use XDP™ XDP710.

Table of contents

About this document **1**
Table of contents **2**
1 Introduction **3**
2 Hardware setup **5**
3 PMBus commands **6**
3.1 PMBus protocol diagram symbols and elements 6
3.2 PMBus commands communication protocol 7
4 Production file format details and programming procedure **9**
4.1 Identifying the connected device for programming 9
4.1.1 Reading device identification 9
4.2 Production file format 9
4.3 PMBus register configuration and programming to RAM 11
4.3.1 Interpreting PMBus register values from production (.txt) file 11
4.3.2 Write PMBus commands into RAM 13
4.3.3 Reading PMBus register CRC and verifying with config file CRC 14
4.4 SOA register configuration and programming to RAM 16
4.4.1 SOA register interpretation from production (.txt) file 16
4.4.2 SOA data programming onto RAM 19
4.5 Storing commands to nonvolatile memory (NVM) 21
4.5.1 Checking necessary programming conditions before programming to OTP, MTP, and SOA 21
4.5.2 Storing PMBus commands settings to OTP 21
4.5.3 Storing I_SNS_CFG settings to MTP 22
4.5.4 Storing SOA settings to SOA memory 23
4.6 Handling PMBus address change because of configuration file 24
4.7 Memory check after reboot 26
References **29**
Revision history **30**
Disclaimer **31**

1 Introduction

XDP™ XDP710 is a wide input voltage hot-swap and system-monitoring controller IC that drives single or multiple parallel N-channel MOSFETs.

XDP710 has the following types of memory for programmability:

- Volatile memory
- One-time programmable (OTP)
- Multiple-time programmable (MTP)
- Safe operating area (SOA) memory

The OTP memory can be used to fix and save specific command settings; at power-up, during the READ_CFG state, all the settings saved in the OTP memory are copied into volatile memory.

XDP710 contains 10 pages of MTP for multiple-time programmability. When the number of reprogrammings reaches 10 (indicated by the MTP_FULL bit in the `STATUS_MEM` command), the circuit keeps the latest programmed values. This memory section contains the `I_SNS_CFG` command which contains the CS_RNG, CS_RNG_TRIM, SOC_FAULT_LIMIT, and START_ILIM configuration bits.

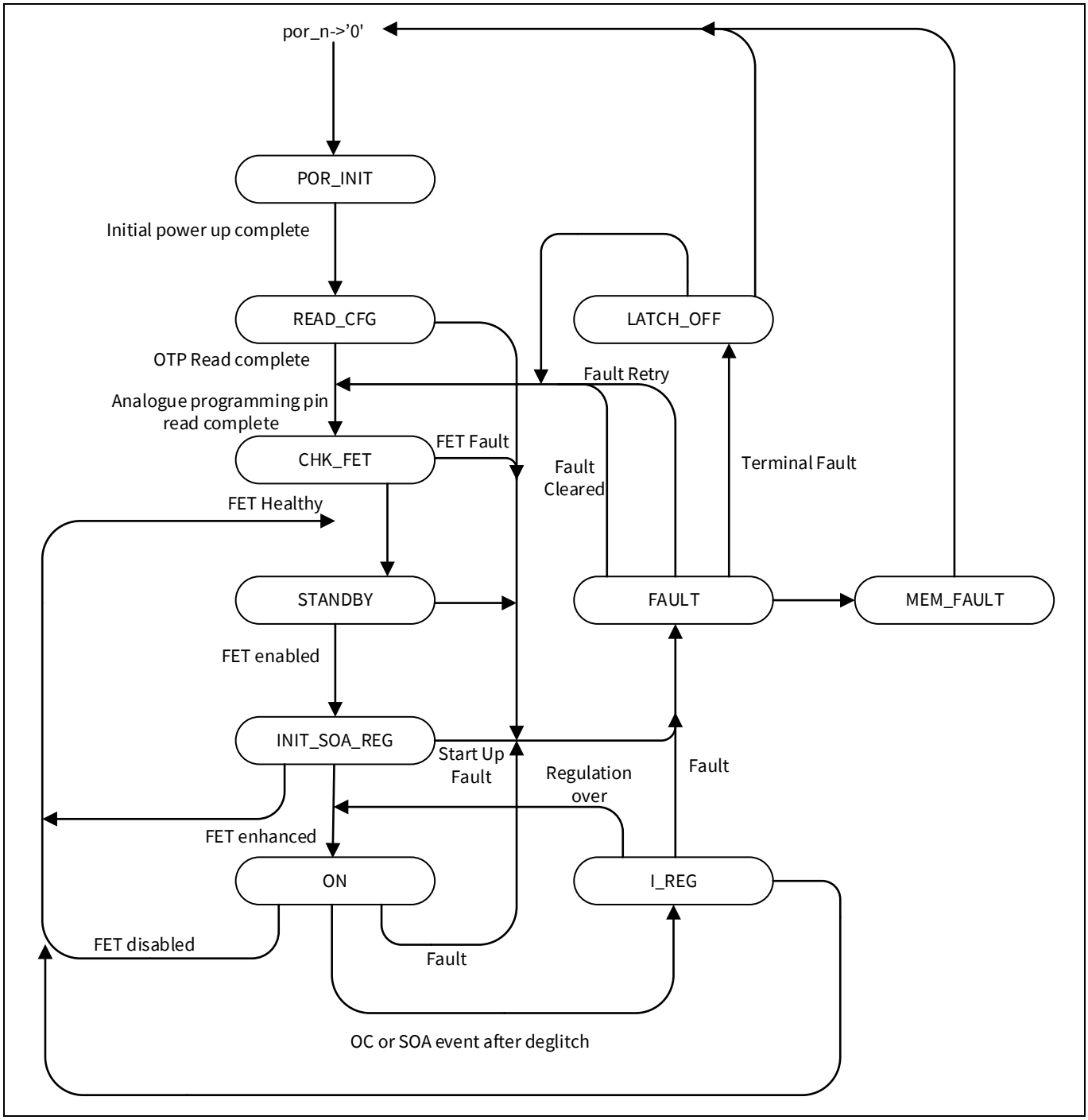


Figure 1 XDP710 state machine (XDP710-001)

2 Hardware setup

Setup the hardware as follows:

1. Apply a voltage at the VDD_VIN (XDP710) and ISNS_P(XDP710) pins:

a) At least 5.5 V (XDP710) to program commands

b) At least 20 V to program OTP or MTP memory

2. Keep the UV/EN pin at chip GND potential.
3. Communication via PMBus is possible as soon as the standby state is entered. At this point, commands, OTP, or MTP memory can be programmed.
4. For successful programming, the internal temperature of the device must stay below 125°C.

Figure 2 shows the board setup and the connection of the I²C to the PMBus communication module.

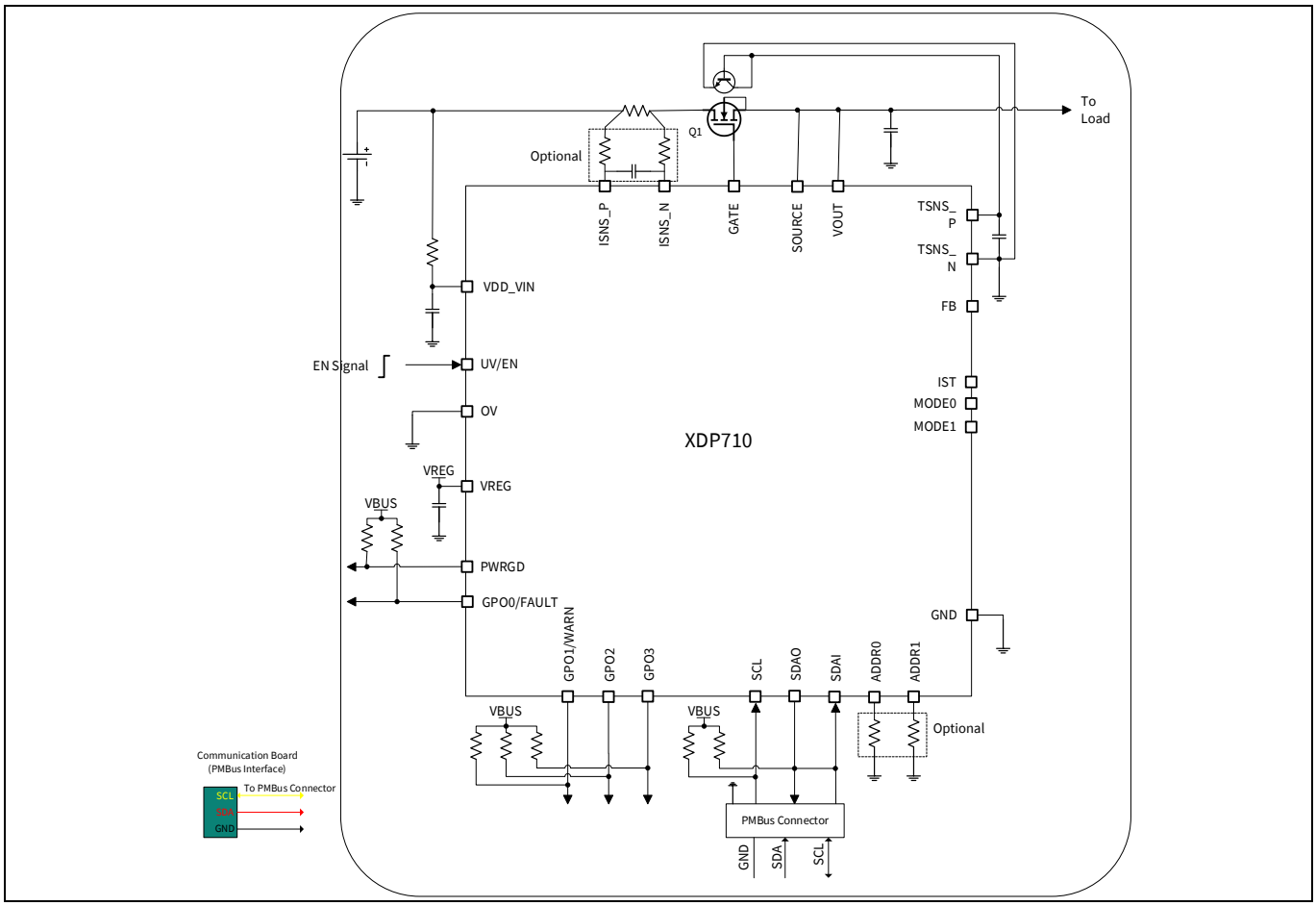


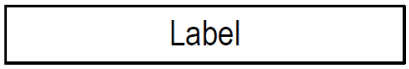
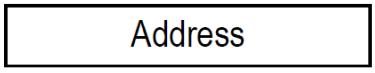
Figure 2 XDP710 I²C/PMBus connection

3 PMBus commands

3.1 PMBus protocol diagram symbols and elements

Table 1 shows the details of PMBus protocol symbols, see [1] for more details.

Table 1 PMBus protocol symbols

Symbol	Description
	An unshaded rectangle with a number over it represents one or more bits, as indicated by the number, sent from the master to the slave. A label describes the data and includes specific values.
	A shaded rectangle with a number over it represents one or more bits, as indicated by the number, sent from the slave to the master. A label describes the data and includes specific values.
	A seven-bit destination address is sent from the master to one or more devices (such as with the general call address) on the bus.
	The START condition sent from a bus master device.
	A REPEATED START condition sent from a bus master device.
	A STOP condition is sent by a bus master device.
	The bit [0] of the address byte indicates the device addressed to write data into the device. Bit [0] will have a value of ‘0’.
	The bit [0] of the address byte indicates the device addressed to read data from the device. Bit [0] will have a value of ‘1’.
	An acknowledge (ACK) bit is sent from the host.
	A not acknowledge (NACK) bit is sent from the host.
	An acknowledge (ACK) bit is sent from a slave device.
	A not acknowledge (NACK) bit is sent from a slave device.

3.2 PMBus commands communication protocol

- PMBus command write a byte:
  - [PMBus address+bit[0]] [command] [dataByte]
  - Example: Writing PMBus command OPERATION (0x01) to value of 0x80
  - [0x20] [0x01] [0x80]

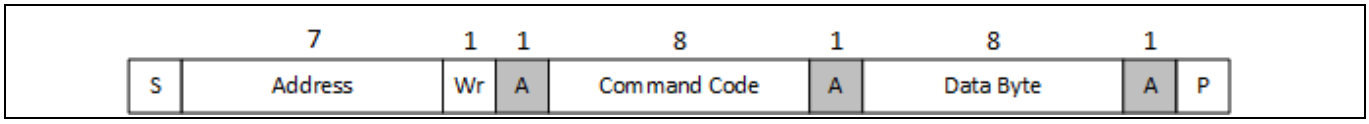


Figure 3 Write byte protocol

- PMBus command read a byte:
  - [PMBus address+bit[0]] [command] [PMBus address+bit[0]] [data0]
  - Example: Reading a PMBus command OPERATION (0x01). The read value is 0x80.
  - [0x20] [0x01] [0x21] [0x80]

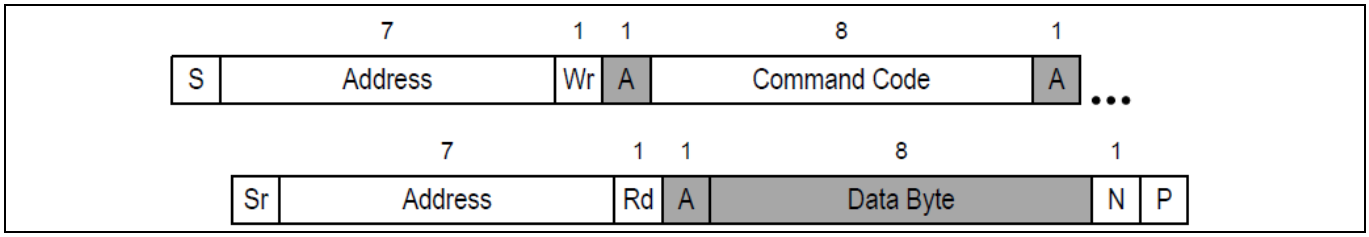


Figure 4 Read byte protocol

- PMBus command write a word:
  - [PMBus address+bit[0]] [command] [dataByte0] [dataByte1]
  - Example: Writing PMBus command VOUT_OV_WARN_LIMIT (0x42) to value of 0x0FFF
  - [0x20] [0x42] [0xFF] [0x0F]

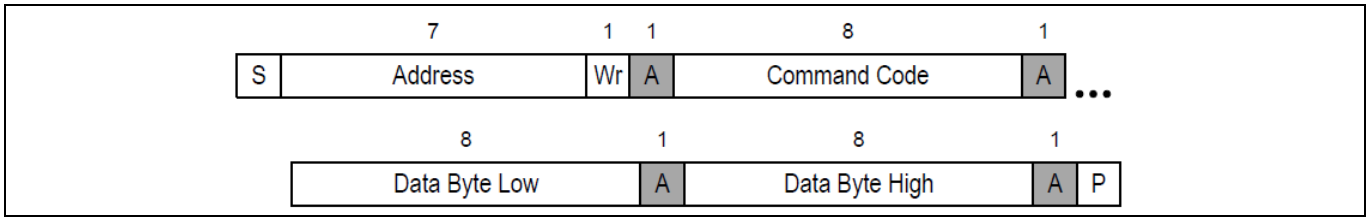


Figure 5 Write word protocol

- PMBus command read a word:
  - [PMBus address+bit[0]] [command] [PMBus address+bit [0]] [dataByte0] [dataByte1]
  - Example: Reading a PMBus command VOUT_OV_WARN_LIMIT (0x42). The read value is 0x0FFF.
  - [0x20] [0x42] [0x21] [0xFF] [0x0F]

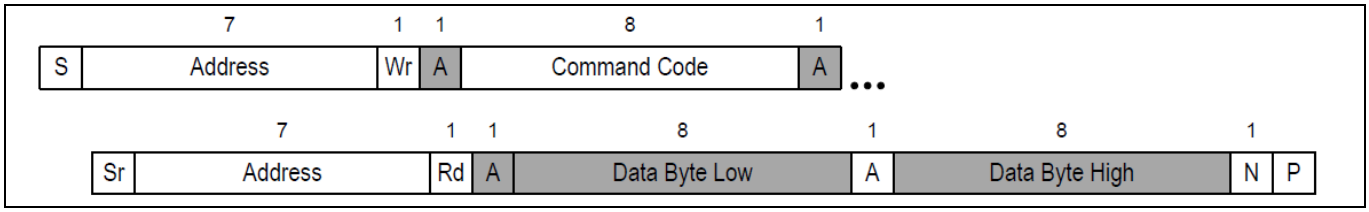


Figure 6 Read word protocol

- PMBus read a block command:
  - [PMBus address+bit[0]] [command] [PMBus address+bit[0]] [number of bytes] [dataByte0] [dataByte1] … [dataByteN]
  - Example: Reading a PMBus command MFR_ID (0x99). The read value is [0x46] [0x49] [0x00].
  - [0x20] [0x99] [0x21] [0x03] [0x46] [0x49] [0x00]

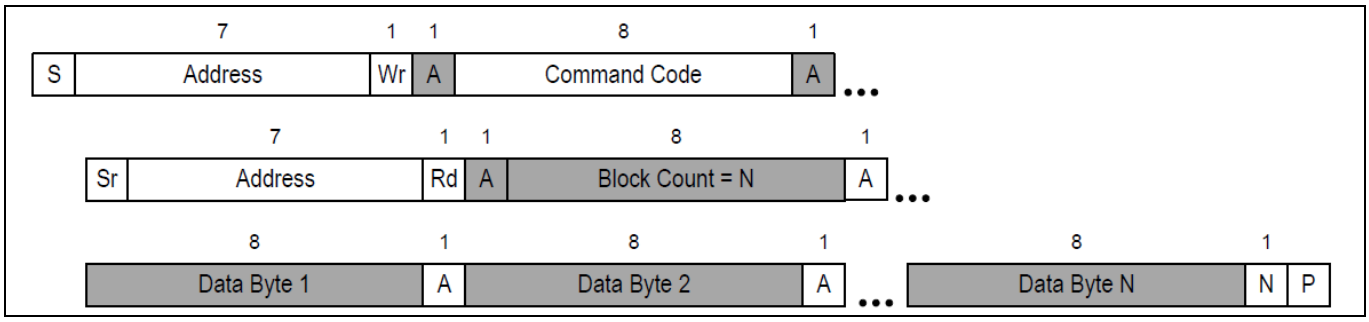


Figure 7 Block read protocol

4 Production file format details and programming procedure

4.1 Identifying the connected device for programming

Identify the connected device by reading the PMBus commands 0x99 (MFR ID) and 0x9A (MFR MODEL).

4.1.1 Reading device identification

Follow these steps to identify the connected device.

- Reading a PMBus command MFR_ID (0x99). This is a block read command. The read value is [0x46] [0x49] [0x00].
  - [0x20] [0x99] [0x21] [0x03] [0x46] [0x49] [0x00]
- Reading a PMBus command MFR_MODEL (0x9A). This is a block read command. The read value is [0x01] [0x00] [0x00] [0x00] [0x00] [0x00] [0x00] [0x00].
  - [0x20] [0x9A] [0x21] [0x08] [0x01] [0x00] [0x00] [0x00] [0x00] [0x00] [0x00] [0x00]

Code Listing 1 Reading connected Device ID

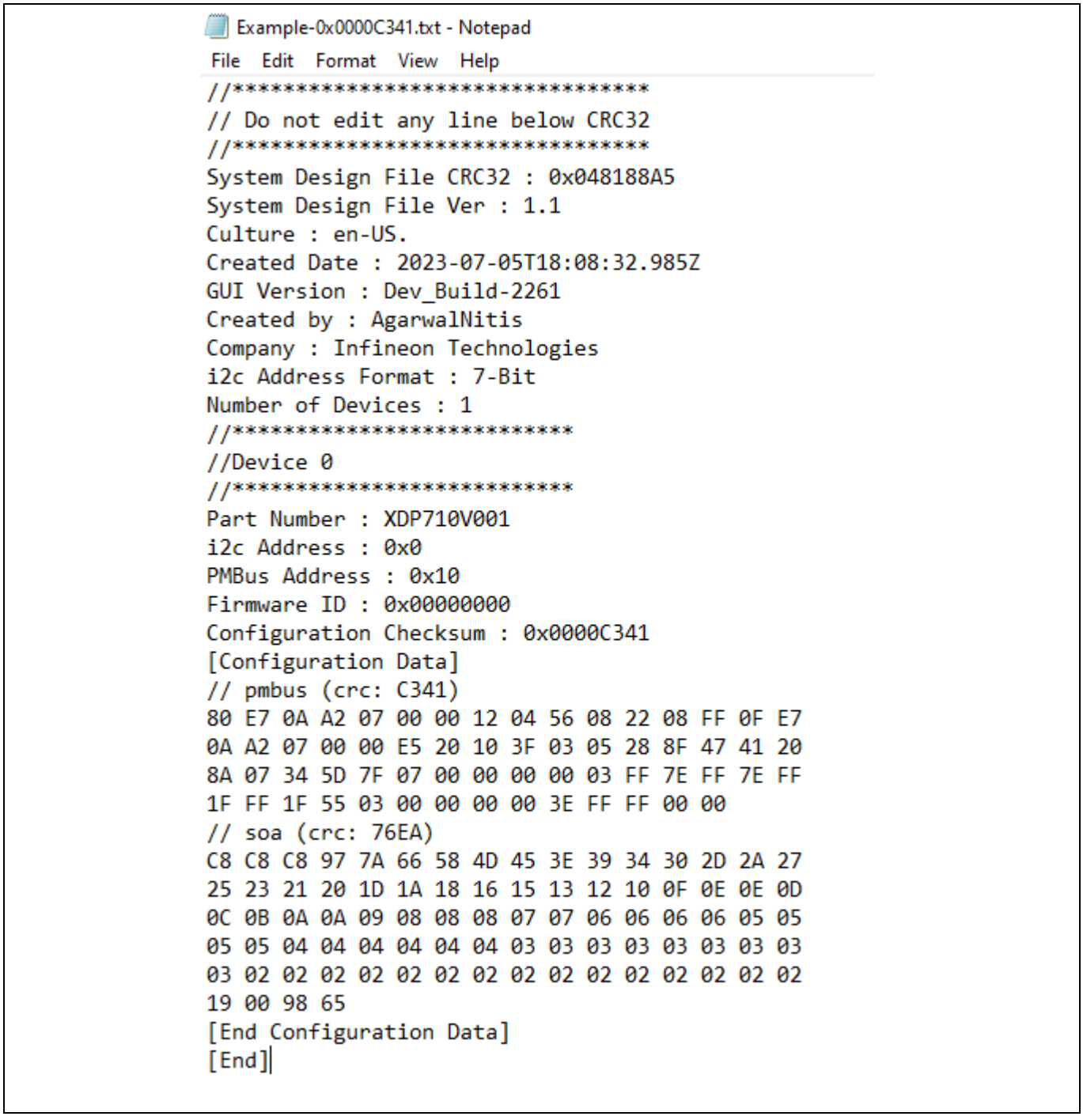
```
//1. Check MFR_ID
       data = PMBus read block (0x99, 4)
        data_check = data[4] + data[3]<<8 + data[2]<<16
       IF data_check == 0x004946
             True    //MFR identified as Infineon
       Else
             False  //Different Manufacturer

//1. Check MFR_MODEL
       data = PMBus read block (0x9A, 8)
       data_check = data[9] + data[8]<<8 + data[7]<<16 + data[6]<<24 +
data[5]<<32 + data[4]<<40          + data[3]<<48 + data[2]<<56
       IF data_check == 0x1
             True    //Device identified is XDP710-001
       Else
             False  //Incorrect device
```

4.2 Production file format

The production file (.txt) generated from XDP Designer GUI includes all the PMBus commands for storing a complete configuration via volatile registers to OTP and MTP and SOA data to be stored into SOA.

Figure 8 shows a snapshot of the production file .txt generated by the XDP Designer GUI.



Example-0x0000C341.txt - Notepad

File Edit Format View Help

```
//**********************************
// Do not edit any line below CRC32
//**********************************
System Design File CRC32 : 0x048188A5
System Design File Ver : 1.1
Culture : en-US.
Created Date : 2023-07-05T18:08:32.985Z
GUI Version : Dev_Build-2261
Created by : AgarwalNitis
Company : Infineon Technologies
i2c Address Format : 7-Bit
Number of Devices : 1
//****************************
//Device 0
//****************************
Part Number : XDP710V001
i2c Address : 0x0
PMBus Address : 0x10
Firmware ID : 0x00000000
Configuration Checksum : 0x0000C341
[Configuration Data]
// pmbus (crc: C341)
80 E7 0A A2 07 00 00 12 04 56 08 22 08 FF 0F E7
0A A2 07 00 00 E5 20 10 3F 03 05 28 8F 47 41 20
8A 07 34 5D 7F 07 00 00 00 00 03 FF 7E FF 7E FF
1F FF 1F 55 03 00 00 00 00 3E FF FF 00 00
// soa (crc: 76EA)
C8 C8 C8 97 7A 66 58 4D 45 3E 39 34 30 2D 2A 27
25 23 21 20 1D 1A 18 16 15 13 12 10 0F 0E 0E 0D
0C 0B 0A 0A 09 08 08 08 07 07 06 06 06 06 05 05
05 05 04 04 04 04 04 04 03 03 03 03 03 03 03 03
03 02 02 02 02 02 02 02 02 02 02 02 02 02 02 02
19 00 98 65
[End Configuration Data]
[End]
```

Figure 8 Production file in .txt format

The production file (.txt) is categorized into two segments of data: PMBus configuration and safe operating area (SOA) data. All the numbers in the .txt file are hex values.

4.3 PMBus register configuration and programming to RAM

4.3.1 Interpreting PMBus register values from production (.txt) file

Figure 9 shows the PMBus configuration segment of the file. The line “CRC:” value calculates a checksum of the complete PMBus configuration segment.

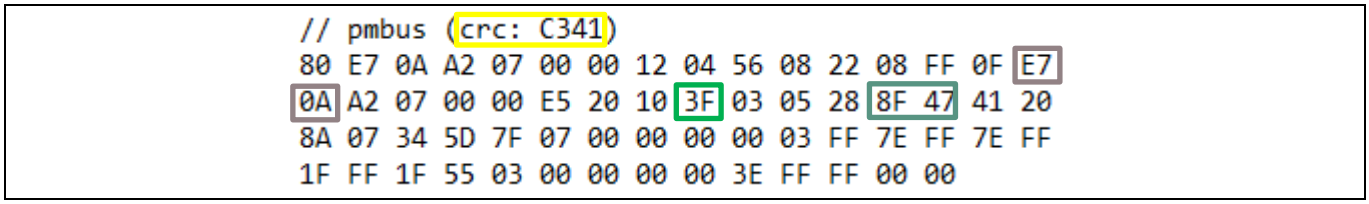


Figure 9 PMBus configuration of production file

The CRC (CRC16-CCITT) calculation is from the start of the first data byte (0x80) of the PMBus register configuration to the last data byte (0x00). The CRC value of the PMBus commands for the production file is **crc: 0xC341** as mentioned in the header of the PMBus configuration section highlighted in yellow.

The values written in the .txt file are 8-bit hex values. These are the data values of all the PMBus commands available for OTP and MTP programming. They are written in ascending order of commands i.e., the first data byte in Figure 9 corresponds to command 0x01 while the last two data bytes 0x0000 correspond to command 0xE9. For the command with the protocol write byte, only an 8-bit hex value is considered as data while for a command with write word protocol, the first 8-bit hex value is considered as a data byte LOW and the one next to it is considered as data byte HIGH.

Table 2 shows some examples of how to interpret the corresponding command data from the .txt file shown in Figure 9.

Table 2 Command data interpretation example (XDP710-001)

Address/PMBus command code (hex)	Command name	PMBus command protocol	Color of the box in Figure 9	Data from .txt file	
0x57	VIN_OV_WARN_LIMIT	Write word	Red	Data byte LOW	Data byte HIGH
				0xE7	0x0A
0xD1	MODE	Write byte	Green	Data byte	
				0x3F	
0xD5	I_SNS_CFG	Write word	Blue	Data byte LOW	Data byte HIGH
				0x8F	0x47

Table 3 shows the corresponding command values translated from the .txt file shown in Figure 9.

Table 3 PMBus command data translated from .txt file (XDP710-001)

Address/PMBus command code (hex)	PMBus command name	PMBus command protocol	Data[n]	Data from .txt file	Command data from .txt file
0x01	OPERATION	Write byte	pmb_data[1]	0x80	0x80
0x42	VOUT_OV_WARN_LIMIT	Write word	pmb_data[2]	0xE7	0x0AE7
			pmb_data[3]	0x0A	
0x43	VOUT_UV_WARN_LIMIT	Write word	pmb_data[4]	0xA2	0x07A2
			pmb_data[5]	0x07	
0x44	VOUT_UV_FAULT_LIMIT	Write word	pmb_data[6]	0x00	0x0000
			pmb_data[7]	0x00	
0x4A	IOUT_OC_WARN_LIMIT	Write word	pmb_data[8]	0x12	0x0412
			pmb_data[9]	0x04	
0x4F	OT_FAULT_LIMIT	Write word	pmb_data[10]	0x56	0x0856
			pmb_data[11]	0x08	
0x51	OT_WARN_LIMIT	Write word	pmb_data[12]	0x22	0x0822
			pmb_data[13]	0x08	
0x55	VIN_OV_FAULT_LIMIT	Write word	pmb_data[14]	0xFF	0x0FFF
			pmb_data[15]	0x0F	
0x57	VIN_OV_WARN_LIMIT	Write word	pmb_data[16]	0xE7	0x0AE7
			pmb_data[17]	0x0A	
0x58	VIN_UV_WARN_LIMIT	Write word	pmb_data[18]	0xA2	0x07A2
			pmb_data[19]	0x07	
0x59	VIN_UV_FAULT_LIMIT	Write word	pmb_data[20]	0x00	0x0000
			pmb_data[21]	0x00	
0x6B	PIN_OP_WARN_LIMIT	Write word	pmb_data[22]	0xE5	0x20E5
			pmb_data[23]	0x20	
0xD0	PMBUS_CFG	Write byte	pmb_data[24]	0x10	0x10
0xD1	MODE	Write byte	pmb_data[25]	0x3F	0x3F
0xD3	REG_CFG	Write word	pmb_data[26]	0x03	0x0503
			pmb_data[27]	0x05	
0xD4	V_SNS_CFG	Write byte	pmb_data[28]	0x28	0x28
0xD5	I_SNS_CFG	Write word	pmb_data[29]	0x8F	0x478F
			pmb_data[30]	0x47	
0xD6	I_SNS_OFFSET_COMP	Write word	pmb_data[31]	0x41	0x2041
			pmb_data[32]	0x20	
0xD7	TSNS_LVL_CTRL	Write word	pmb_data[33]	0x8A	0x078A
			pmb_data[34]	0x07	
0xD8	WATCHDOG_TMR	Write byte	pmb_data[35]	0x34	0x34

Address/PMBus command code (hex)	PMBus command name	PMBus command protocol	Data[n]	Data from .txt file	Command data from .txt file
0xD9	V_TMR	Write word	pmb_data[36]	0x5D	0x7F5D
			pmb_data[37]	0x7F	
0xDA	PIN_POLARITY	Write byte	pmb_data[38]	0x07	0x07
0xDB	GPO_CFG	Write word	pmb_data[39]	0x00	0x0000
			pmb_data[40]	0x00	
0xDC	IOUT_UC_WARN_LIMIT	Write word	pmb_data[41]	0x00	0x0000
			pmb_data[42]	0x00	
0xDD	ONCHIP_TSD_FAULT_LIMIT	Write byte	pmb_data[43]	0x03	0x03
0xDE	ENABLE_FAULTS	Write word	pmb_data[44]	0xFF	0x7EFF
			pmb_data[45]	0x7E	
0xDF	MASK_FAULTS	Write word	pmb_data[46]	0xFF	0x7EFF
			pmb_data[47]	0x7E	
0xE1	ENABLE_WARNS	Write word	pmb_data[48]	0xFF	0x1FFF
			pmb_data[49]	0x1F	
0xE2	MASK_WARNS	Write word	pmb_data[50]	0xFF	0x1FFF
			pmb_data[51]	0x1F	
0xE4	PWRGD_DG_TMR	Write byte	pmb_data[52]	0x55	0x55
0xE5	SOA_TMR	Write word	pmb_data[53]	0x03	0x0003
			pmb_data[54]	0x00	
0xE6	TURN_OFF_CTRL	Write word	pmb_data[55]	0x00	0x0000
			pmb_data[56]	0x00	
0xE7	RETRY	Write word	pmb_data[57]	0x00	0x3E00
			pmb_data[58]	0x3E	
0xE8	TELEMETRY_EN	Write word	pmb_data[59]	0xFF	0xFFFF
			pmb_data[60]	0xFF	
0xE9	TELEMETRY_AVG	Write word	pmb_data[61]	0x00	0x0000
			pmb_data[62]	0x00	

4.3.2 Write PMBus commands into RAM

Before storing to OTP/MTP, the PMBus commands configuration must be written to RAM.

- Write all the PMBus commands to RAM registers as shown in Code Listing 2.
- Table 3 shows PMBus commands that can be stored in OTP and MTP.
- Write these PMBus commands with user values using the commands protocol described in Section 3.
  - Example: Write PMBus command 0x55 VIN_OV_FAULT_LIMIT:
  - [0x20] [0x55] [0xFF] [0x0F]

Code Listing 2 XDP710-001 steps for writing PMBus config to RAM

```
// 1. Write the PMBus configuration (PMBus commands) to RAM
          // Write all PMBus commands to according to Table 3
       count = 1
       For command code = start to end

             If protocol == Write byte
                   PMBus write byte (command code, pmb_data[count])
                    count = count + 1
             ELSE
                    data_word = pmb_data[count + 1]<<8 | pmb_data [count]
                    PMBus write word (command code, data_word)
                    count = count + 2

      Next
```

4.3.3 Reading PMBus register CRC and verifying with config file CRC

All the PMBus registers that are OTP/MTP programmable are read and then the CRC calculates for these read values. Code Listing 3 shows how the CRC (CCITT-16 FALSE) is performed. The calculated CRC is compared with the PMBus section CRC in the configuration file. If both of them match then the device RAM is programmed correctly and can proceed with the OTP programming.

Code Listing 3 XDP710-001 steps for calculating CRC

```
// 1. Reading OTP/MTP Programmable PMBus registers and calculating CRC
       count = 0
       For command code = start to end
             If protocol == Read byte
                   byte_data =  PMBus read byte (command code)
                    pmbus_data [count] = byte_data
                    count = count + 1
             ELSE //Read Word
                    word_data = PMBus read word (command code) //High Byte +
Low Byte<<8
                   pmbus_data [count] = word_data & 0x00FF //Low Byte
                    pmbus_data [count + 1] = (word_data 0xFF00) >> 8 //High
Byte
                    count = count + 2
      Next
```

Code Listing 3 XDP710-001 steps for calculating CRC

```
// 2. Calculate CRC
      // CRC16-CCITT algorithm reference, this is crc16-ccitt (bad)
implementation as described in
      // http://srecord.sourceforge.net/crc16-ccitt.html
      crcPoly = 0x1021U;
      msb = 0x8000U;
      crc = 0xFFFFU;

      For i = 0 to pmbus_data.size - 1
            ch = pmbus_data[i]
            For j = 0 to 7
                  xor_flag = ((crc ^ (ch << 8)) & msb) != 0U;
                  crc <<= 1;
                  if xor_flag
                        crc ^= crcPoly;
                  ch <<= 1
             Next
       Next
      crc = crc & 0xffff;

// 3. Matching CRC with file CRC
       If crc == file crc
            //Ok to proceed to OTP Programming
       ELSE
            //CRC mismatch, reload config
```

4.4 SOA register configuration and programming to RAM

4.4.1 SOA register interpretation from production (.txt) file

Figure 10 shows the SOA configuration segment of the file. The line “CRC:” value calculates a checksum of the complete SOA configuration segment.

```
// soa (crc: 76EA)
C8 C8 C8 97 7A 66 58 4D 45 3E 39 34 30 2D 2A 27
25 23 21 20 1D 1A 18 16 15 13 12 10 0F 0E 0E 0D
0C 0B 0A 0A 09 08 08 08 07 07 06 06 06 06 05 05
05 05 04 04 04 04 04 04 03 03 03 03 03 03 03 03
03 02 02 02 02 02 02 02 02 02 02 02 02 02 02 02
19 00 98 65
```

Figure 10 SOA configuration of production file

The values written in the .txt file are 8-bit hex values. These are the data values of the SOA register. These represent the 42 words that need to be sent out to the PMBus register 0xD2 in a FIFO as explained in section 4.4.2. The first two bytes represent the 1st word that needs to be sent out. The 1st byte (0xC8) of the 1st word (highlighted in red color box) is the low byte in it and the 2nd byte (0xC8) is the high byte in it. Similarly, the 1st byte (0x98) of the 42nd word (SOA CRC) (highlighted in blue color box) is the low byte in it and the 2nd byte (0x65) is the high byte in it. The last two bytes i.e., the 42nd word represents the SOA CRC; therefore, the user do not have to calculate this value and can send this value directly into the controller.

Table 4 shows some examples of how to interpret the corresponding command data from the .txt file shown in Figure 10.

Table 4 SOA data to be programmed in SOA register (XDP710-001)

PMBus command write word	soa_data[n]	Hex value from SOA config file in ascending order (soa_data[n])	PMBus write word bit position	Data
1st word	soa_data[1]	0xC8	LOW BYTE	0xC8C8
	soa_data[2]	0xC8	HIGH BYTE	
2nd word	soa_data[3]	0xC8	LOW BYTE	0x97C8
	soa_data[4]	0x97	HIGH BYTE	
3rd word	soa_data[5]	0x7A	LOW BYTE	0x667A
	soa_data[6]	0x66	HIGH BYTE	
4th word	soa_data[7]	0x58	LOW BYTE	0x4D58
	soa_data[8]	0x4D	HIGH BYTE	
5th word	soa_data[9]	0x45	LOW BYTE	0x3E45
	soa_data[10]	0x3E	HIGH BYTE	
6th word	soa_data[11]	0x39	LOW BYTE	0x3439
	soa_data[12]	0x34	HIGH BYTE	
7th word	soa_data[13]	0x30	LOW BYTE	0x2D30
	soa_data[14]	0x2D	HIGH BYTE	
	soa_data[15]	0x2A	LOW BYTE	0x272A

PMBus command write word	soa_data[n]	Hex value from SOA config file in ascending order (soa_data[n])	PMBus write word bit position	Data
8th word	soa_data[16]	0x27	HIGH BYTE	
9th word	soa_data[17]	0x25	LOW BYTE	0x2325
	soa_data[18]	0x23	HIGH BYTE	
10th word	soa_data[19]	0x21	LOW BYTE	0x2123
	soa_data[20]	0x20	HIGH BYTE	
11th word	soa_data[21]	0x1D	LOW BYTE	0x1A1D
	soa_data[22]	0x1A	HIGH BYTE	
12th word	soa_data[23]	0x18	LOW BYTE	0x1618
	soa_data[24]	0x16	HIGH BYTE	
13th word	soa_data[25]	0x15	LOW BYTE	0x1315
	soa_data[26]	0x13	HIGH BYTE	
14th word	soa_data[27]	0x12	LOW BYTE	0x1012
	soa_data[28]	0x10	HIGH BYTE	
15th word	soa_data[29]	0x0F	LOW BYTE	0x0E0F
	soa_data[30]	0x0E	HIGH BYTE	
16th word	soa_data[31]	0x0E	LOW BYTE	0x0D0E
	soa_data[32]	0x0D	HIGH BYTE	
17th word	soa_data[33]	0x0C	LOW BYTE	0x0B0C
	soa_data[34]	0x0B	HIGH BYTE	
18th word	soa_data[35]	0x0A	LOW BYTE	0x0A0A
	soa_data[36]	0x0A	HIGH BYTE	
19th word	soa_data[37]	0x09	LOW BYTE	0x0809
	soa_data[38]	0x08	HIGH BYTE	
20th word	soa_data[39]	0x08	LOW BYTE	0x0808
	soa_data[40]	0x08	HIGH BYTE	
21st word	soa_data[41]	0x07	LOW BYTE	0x0707
	soa_data[42]	0x07	HIGH BYTE	
22nd word	soa_data[43]	0x06	LOW BYTE	0x0606
	soa_data[44]	0x06	HIGH BYTE	
23rd word	soa_data[45]	0x06	LOW BYTE	0x0606
	soa_data[46]	0x06	HIGH BYTE	
24th word	soa_data[47]	0x05	LOW BYTE	0x0505
	soa_data[48]	0x05	HIGH BYTE	
25th word	soa_data[49]	0x05	LOW BYTE	0x0505
	soa_data[50]	0x05	HIGH BYTE	
26th word	soa_data[51]	0x04	LOW BYTE	0x0404
	soa_data[52]	0x04	HIGH BYTE	
	soa_data[53]	0x04	LOW BYTE	0x0404

PMBus command write word	soa_data[n]	Hex value from SOA config file in ascending order (soa_data[n])	PMBus write word bit position	Data
27th word	soa_data[54]	0x04	HIGH BYTE	
28th word	soa_data[55]	0x04	LOW BYTE	0x0404
	soa_data[56]	0x04	HIGH BYTE	
29th word	soa_data[57]	0x03	LOW BYTE	0x0303
	soa_data[58]	0x03	HIGH BYTE	
30th word	soa_data[59]	0x03	LOW BYTE	0x0303
	soa_data[60]	0x03	HIGH BYTE	
31st word	soa_data[61]	0x03	LOW BYTE	0x0303
	soa_data[62]	0x03	HIGH BYTE	
32nd word	soa_data[63]	0x03	LOW BYTE	0x0303
	soa_data[64]	0x03	HIGH BYTE	
33rd word	soa_data[65]	0x03	LOW BYTE	0x0203
	soa_data[66]	0x02	HIGH BYTE	
34th word	soa_data[67]	0x02	LOW BYTE	0x0202
	soa_data[68]	0x02	HIGH BYTE	
35th word	soa_data[69]	0x02	LOW BYTE	0x0202
	soa_data[70]	0x02	HIGH BYTE	
36th word	soa_data[71]	0x02	LOW BYTE	0x0202
	soa_data[72]	0x02	HIGH BYTE	
37th word	soa_data[73]	0x02	LOW BYTE	0x0202
	soa_data[74]	0x02	HIGH BYTE	
38th word	soa_data[75]	0x02	LOW BYTE	0x0202
	soa_data[76]	0x02	HIGH BYTE	
39th word	soa_data[77]	0x02	LOW BYTE	0x0202
	soa_data[78]	0x02	HIGH BYTE	
40th word	soa_data[79]	0x02	LOW BYTE	0x0202
	soa_data[80]	0x02	HIGH BYTE	
41st word	soa_data[81]	0x19	LOW BYTE	0x0019
	soa_data[82]	0x00	HIGH BYTE	
42nd word (SOA CRC)	soa_data[83]	0x98	LOW BYTE	0x6598
	soa_data[84]	0x65	HIGH BYTE	

4.4.2 SOA data programming onto RAM

Write the SOA data to RAM for SOA-related storing commands.

- Write word 0xD2 42 times inclusive of CRC as shown in Code Listing 4.
- Table 4 shows an example of 42 write word commands.
- Use the PMBus write word protocol described in Section 3.
  - [0x20] [0xD2] [0xC8] [0xC8] … 1st word
  - [0x20] [0xD2] [0xC8] [0x97] … 2nd word
  - …similarly write PMBus word from 3rd to 41st …
  - [0x20] [0xD2] [0x98] [0x65] … 42nd word
- Read byte PMBus command 0xEB STATUS_MEM to check SOA_CRC and SOA_FULL. Verify write SOA register is successful. For details of the command see Table 5 and Table 6.
  - [0x20] [0xEB] [0x21] [0x03]

Table 5 STATUS_MEM (0xEB)

	7	6	5	4	3	2	1	0
Field	PROG_BLOCK	OTP_FAIL	MTP_FULL	MTP_USER	OTP_USER	SOA_PRG	SOA_FULL	SOA_CRC

Table 6 STATUS_MEM command bits description

Field	Bit	Description	Values
SOA_CRC	0	CRC checks the status of the data inside the FIFO.	0x0 = CRC has not been performed or did not pass. 0x1 = CRC passed.
SOA_FULL	1	Indication if the FIFO (data + CRC) is full or not.	0x0 = SOA FIFO not full. 0x1 = SOA FIFO is full and CRC has been performed.
SOA_PRG	2	SOA section of the OTP if it has been programmed or is virgin.	0x0 = Section is virgin. 0x1 = Section has been programmed.
OTP_USER	3	Indication if the configuration commands in OTP have been programmed or not.	0x0 = Configuration commands have not been programmed. 0x1 = Configuration commands have been programmed.
MTP_USER	4	Indication if MTP is in use or not.	0x0 = MTP is not in use. 0x1 = MTP is in use.
MTP_FULL	5	Indication if all the MTP memory has been used.	0x0 = Not all MTP has been used. 0x1 = All MTP has been used.

Field	Bit	Description	Values
OTP_FAIL	6:7	Indication if the programming or the readout of the OTP has been successful or not.	0x00 = Programming successful. 0x01 = OTP programming started but failed during programming because of the OTP issue. Part must be discarded. 0x10 = OTP programming has been blocked because temperature or VIN is out of range. 0x11 = OTP programming started but failed during programming because temperature or voltage is out of range during programming. Part must be discarded.

Code Listing 4 XDP710-001 steps for writing SOA data onto RAM

```
// 1. Write the SOA data onto PMBus command 0xD2
       // Write PMBus command 0xD2 42 times according to Table 4 values
       command code = 0xD2
       count = 1
       While count != 84
              data_word = soa_data[count + 1]<<8 | soa_data [count]
              PMBus write word (command code, data_word)
              count = count + 1
       Next
// 2. Check SOA written fully and CRC correct
       data = PMbus read byte (0xEB)
       data_check = data & 0x03
       IF data_check == 3
              RETURN true   //SOA CRC successful
       Else
              RETURN false //SOA CRC mismatch
```

4.5 Storing commands to nonvolatile memory (NVM)

After copying configuration to RAM, the following section details the steps for storing command configurations to OTP, MTP, and SOA.

4.5.1 Checking necessary programming conditions before programming to OTP, MTP, and SOA

Follow these steps to ensure temperature and input voltage are within limits for programming the device.

- Read byte PMBus command 0xEB STATUS_MEM to check PROG_BLOCK.
- Verify programming conditions favorable for programming by reading the bit 7 of the returned value. For details of this command see Table 5 and Table 6.
  - [0x20] [0xEB] [0x21] [0x00]
- If bit 7 is high then programming conditions are not favorable and check for input voltage and temperature to ensure they are within the limits.

Code Listing 5 Check to see if programming is blocked or not

```
//1. Check if programming not blocked
      data = PMBus read byte (0xEB)
      data_check = (data & 0x80)
      IF data_check == 0x00
            True    //Programming conditions favorable
      Else
            False  //Programming blocked; VIN or temperature out of range
```

4.5.2 Storing PMBus commands settings to OTP

Follow these steps to write the register configuration from RAM to OTP.

- Write WRITE_OTP (0xEA) PMBus command with the data option as follows:
  - PMBus write byte command (WRITE_OTP, writeData)
    - WRITE_OTP = 0xEA
    - writeData = 0x01
    - The following data bytes appear on the I^2C bus :
      - [0x20] [0xEA] [0x01]
  - Read byte PMBus command 0xEB STATUS_MEM to check OTP_USER. Verify programming is successful. For details of the command see Table 5 and Table 6.
    - [0x20] [0xEB] [0x21] [0x08]

Code Listing 6 Storing data to OTP

```
//1. Check OTP empty
      data = PMBus read byte (0xEB)
      data_check = (data & 0x08) >> 3
      IF data_check == 0
```

Code Listing 6 Storing data to OTP

```
            True    //OTP available for programming
      Else
            False  //OTP not available for programming

// 2. Write the PMBus command WRITE_OTP
      // Write all PMBus commands 0xEA
      IF True
            PMBus write byte  (0xEA, 0x01)

//3. Check OTP programmed
      data  = PMBus read byte  (0xEB)
      data_check = data & 0xC8
      IF data_check == 0x08
            RETURN true     //OTP Programming successful
      Else
            RETURN false    //OTP Programming failed
```

4.5.3 Storing I_SNS_CFG settings to MTP

Follow these steps to write the register configuration from RAM to MTP.

- Write WRITE_OTP PMBus command with the data option as follows:
  - PMBus write byte command (WRITE_OTP, writeData)
    - WRITE_OTP = 0xEA
    - writeData = 0x05
  - The following data bytes appear on the I^2C bus (see Table 6 for the description of the data byte):
    - [0x20] [0xEA] [0x05]
  - Read byte PMBus command 0xEB STATUS_MEM to check MTP_USER. Verify programming is successful.
    - [0x20] [0xEB] [0x21] [0x10]

Code Listing 7 Storing I_SNS_CFG to MTP

```
// 1. Check MTP empty
      data = PMBus read byte (0xEB)
      data_check = (data & 0x20) >> 4
      IF data_check == 0
            True    //MTP available for programming
      Else
            False   //MTP not available for programming

// 2. Write all PMBus commands 0xEA
```

Code Listing 7 Storing I_SNS_CFG to MTP

```
        IF True
                PMBus write byte   (0xEA, 0x05)

// 3. Check MTP programmed
        data   = PMBus read byte   (0xEB)
        data_check = (data & 0xD0) >> 4
        IF data_check == 1
                RETURN true      //MTP Programming successful
        Else
                RETURN false     //MTP Programming failed
```

4.5.4 Storing SOA settings to SOA memory

Follow these steps to write the register configuration from RAM to SOA OTP.

- Read byte PMBus command 0xEB STATUS_MEM to check SOA_CRC and SOA_FULL. Verify write SOA register is successful. For details of the command see Table 5 and Table 6.
  - [0x20] [0xEB] [0x21] [0x03]
- Write WRITE_OTP PMBus command with the data option as follows:
  - PMBus write byte command (WRITE_OTP, writeData)
    - WRITE_OTP = 0xEA
    - writeData = 0x03
  - The following data bytes appear on the I^2C bus (see Table 6 for the description of the data byte):
    - [0x20] [0xEA] [0x03]
  - Read byte PMBus command 0xEB STATUS_MEM to check SOA_PRG. Verify programming is successful.
    - [0x20] [0xEB] [0x21] [0x04]

Code Listing 8 Storing SOA data to SOA memory

```
// 1. Check SOA written fully and CRC correct
        data = PMBus read byte (0xEB)
        data_check = data & 0x03
        IF data_check == 3
                RETURN true   //SOA CRC successful
        Else
                RETURN false //SOA CRC mismatch

// 2. Check SOA empty
        data = PMBus read byte (0xEB)
        data_check = (data & 4) >> 2
```

Code Listing 8 Storing SOA data to SOA memory

```
        IF data_check == 0
                RETURN True      //SOA available for programming
        Else
                RETURN False     //SOA not available for programming

// 3. Write all PMBus commands 0xEA
        IF True
                PMBus write byte   (0xEA, 0x03)

// 4. Check SOA programmed
        data   = PMBus read byte   (0xEB)
        data_check = data & 0xC4
        IF data_check == 4
                RETURN true     //SOA Programming successful
        Else
                RETURN false    //SOA Programming failed
```

4.6 Handling PMBus address change because of configuration file

The device and base address of the XDP7xx device can be modified on the fly via command 0xD0. If the value of this register is modified to be different than the default value of [0x10] then the communication with the host device will be lost and the programming will be terminated.

Follow these steps to point the host to the correct/modified address of the device to maintain the communication and ensure successful programming, for explanation purpose assume the value stored in command 0xD0 is 0x32:

- First record the device current 7-bit PMBus address which for this example is “0x10” and store it in local host memory and call it say “cur_addr”
- Before sending in command 0xD0, readbyte PMBus command 0xF9 STATUS_MODE to check the bit [9:6] for selected device address. Verify write SOA register is successful. For details of the command see Table 7 and Table 8.
  - [0x20] [0xF9] [0x21] [0x03] [0xC0]
- Save the read bits [9:6] for the selected device address in the host local memory and call it say “dev_addr”.
- Now read the contents of the command 0xD0 and store it in the host memory somewhere and call it say “mod_addr”.
- Now write the value of the command 0xD0 to the device using the original PMBus address as follows:
  - [0x20] [0xD0] [0x32]
- After writing the command 0xD0, the communication between the host and the device will be lost if the value of 0xD0 is not 0x10 or 0x90. Then this case based on the “dev_addr” and “mod_addr”, the device will be relocated to the new address to establish the communication as follows:

- If “dev_addr” is equal to 0xF, then the new address will be calculated as new_addr = (mod_addr & 0x7F)
- If “dev_addr” is not equal to 0xF, then the new address will be calculated as new_addr = (mod_addr & 0x70) + dev_addr

- With this newly calculated “new_addr”, re-establish the communication with the device and complete the remaining programming procedure.

Table 7 STATUS_MODE (0xF9)

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Field	RESERVED			SELECTED_IST			SELECTED_DEVICE_ADDRESS				SELECTED_FET				STATUS_MODE	

Table 8 STATUS_MODE command bits description

Field	Bits	Description	Value
STATUS_MODE	[1:0]	Indicates the current operating mode	2’b00 = FDM with Digital Comparators (DCM) 2’b01 = FDM with Analog Comparators (ACM) 2’b10 = AADM 2’b11 = RESERVED
SELECTED_FET	[5:2]	Shows configured FET	–
SELECTED_DEVICE_ADDRESS	[9:6]	LSB part of the PMBus address [3:0]	DEVICE ADDRESS 0: 4’b0000 DEVICE ADDRESS 1: 4’b0001 DEVICE ADDRESS 2: 4’b0010 DEVICE ADDRESS 3: 4’b0011 DEVICE ADDRESS 4: 4’b0100 DEVICE ADDRESS 5: 4’b0101 DEVICE ADDRESS 6: 4’b0110 DEVICE ADDRESS 7: 4’b0111 DEVICE ADDRESS 8: 4’b1000 DEVICE ADDRESS 9: 4’b1001 DEVICE ADDRESS 10: 4’b1010 DEVICE ADDRESS 11: 4’b1011 DEVICE ADDRESS 12: 4’b1100 DEVICE ADDRESS 13: 4’b1101 DEVICE ADDRESS 14: 4’b1110 DEVICE ADDRESS programmed in PMBUS_CFG.PMBUS_DEVICE_ADDR: 4’b1111
SELECTED_IST	[12:10]	Shows selected IST	–
RESERVED	[15:13]	–	–

Code Listing 9 Updating PMBus address based on configuration file value

```
// 1. Store the device current 7-bit PMBus & store value of 0xD0 command
       cur_addr = Address
       mod_addr = pmbus_data[24]

// 2. Read status 0xF9 and store device address
       data = PMBus read word (0xF9)
       dev_addr = data & 0x03C0

// 3. Write register 0xD0 with original PMbus address
       PMBus write byte  (0xD0, pmbus_data [24])

// 4. Calculate new PMBus address
       IF dev_addr == 0xF
              new_addr =  (mod_addr & 0x7F)

       Else
              new_addr =  (mod_addr & 0x70) + (dev_addr)
```

4.7 Memory check after reboot

There could be a case where the data while loading from the volatile memory to the non-volatile memory could get corrupted. To ensure that the data is copied correctly, do the following:

- After OTP programming, reduce the voltage at the VDD_VIN pin down to 0 V and then apply 20 V onto the VDD_VIN pin to reboot the device.
- Use the read byte PMBus command (0x7E STATUS_CML) to check MEM_FAULT. Verify that there is no memory fault.
  - [0x20] [0x7E] [0x21] [0x00]
- Run a CRC check on all the data read from the non-volatile memory and compare it with the CRC of the loaded file to ensure that correct data is programmed onto the OTP memory and loaded correctly into the volatile memory.
- If the SOA register was programmed, then use the read byte PMBus command (0xEB STATUS_MEM) to check SOA_CRC and SOA_FULL. Verify that valid SOA data is copied from the SOA memory to the volatile memory.
  - [0x20] [0xEB] [0x21] [0x07]

Code Listing 10 Memory check after reboot

```
// 1. Check memory error
       data  = PMBus read byte  (0x7E)
       data_check = data & 0x10
       IF data_check == 0x10
```

Code Listing 10 Memory check after reboot

```
                RETURN true     // Memory fault occurred, discard the chip
        Else
                RETURN false    // No memory fault

// 2. Reading OTP/MTP Programmable PMBus registers and calculating CRC
         count = 0
         For command code = start to end
                 If protocol == Read byte
                       byte_data =  PMBus read byte (command code)
                        pmbus_data [count] = byte_data
                        count = count + 1
                ELSE //Read Word
                        word_data = PMBus read word (command code) //High Byte +
Low Byte<<8
                      pmbus_data [count] = word_data & 0x00FF //Low Byte
                        pmbus_data [count + 1] = (word_data 0xFF00) >> 8 //High
Byte
                        count = count + 2
        Next

// 3. Calculate CRC
        // CRC16-CCITT algorithm reference, this is crc16-ccitt (bad)
implementation as described in
        // http://srecord.sourceforge.net/crc16-ccitt.html
        crcPoly = 0x1021U;
        msb = 0x8000U;
        crc = 0xFFFFU;

        For i = 0 to pmbus_data.size - 1
                ch = pmbus_data[i]
                For j = 0 to 7
                        xor_flag = ((crc ^ (ch << 8)) & msb) != 0U;
                        crc <<= 1;
                        if xor_flag
                                crc ^= crcPoly;
                        ch <<= 1
                 Next
         Next
```

Code Listing 10 Memory check after reboot

```
       crc = crc & 0xffff;

// 4. Matching CRC with file CRC
       If crc == file crc
            //data copied correctly to OTP
       ELSE
            //CRC mismatch, memory error

// 5. Check SOA programmed
       data  = PMBus read byte  (0xEB)
       data_check = data & 0xC4
       IF data_check == 4
             RETURN true    //SOA memory programmed
       Else
             RETURN false   //SOA memory un-programmed

 // 6. Check SOA data copied correctly from SOA memory (if programmed)
       data = PMBus read byte (0xEB)
       data_check = data & 0x03
       IF data_check == 3
             RETURN true   //SOA data copied correctly
       Else
             RETURN false //SOA data copied incorrectly; memory error
```

References

[1] Robert V. White, Embedded Power Labs System Management Interface Forum, *Inc: System Management Bus (SMBus) Specification Version 3.1*, 19 Mar 2018; Available online

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[3] CRC16-CCITT; Available online

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