

Production- and In-System- Programming of MTCA Boards



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Introduction

- > Hardware Installation for European XFEL is a huge logistical challenge.
- > Hundreds of boards have to be tested, programmed, maintained and serviced.
- > Boards are living → more than one revision is around, patches are applied (software / hardware) → constant changes
- > Solutions needed for:
 - **Automated Programming of all memories on MTCA boards (post-production)**
 - done with programming scripts
 - **In-field-update of all memories of MTCA boards**
 - done with hpm files and ipmitool

- Before we talk about automation, we have to talk about version control and version numbering
 - We need a solution to track changes and identify versions
 - Ensure correct version on all in-filed boards
 - Change history & List of missing fixes

 - We use SVN for version control
 - developers synchronize regularly to the database
 - they leave comments which each change
 - we “tag” everything that is final (to go back to it)

MMC V1.00: Version Number query with IPMItool

D:\MMC_V100_Software - Log Messages - TortoiseSVN

Filter by Messages, Paths, Authors, Revisions, Bug-IDs, Date, Date Range

From: 20.03.2015 To: 28.10.2015

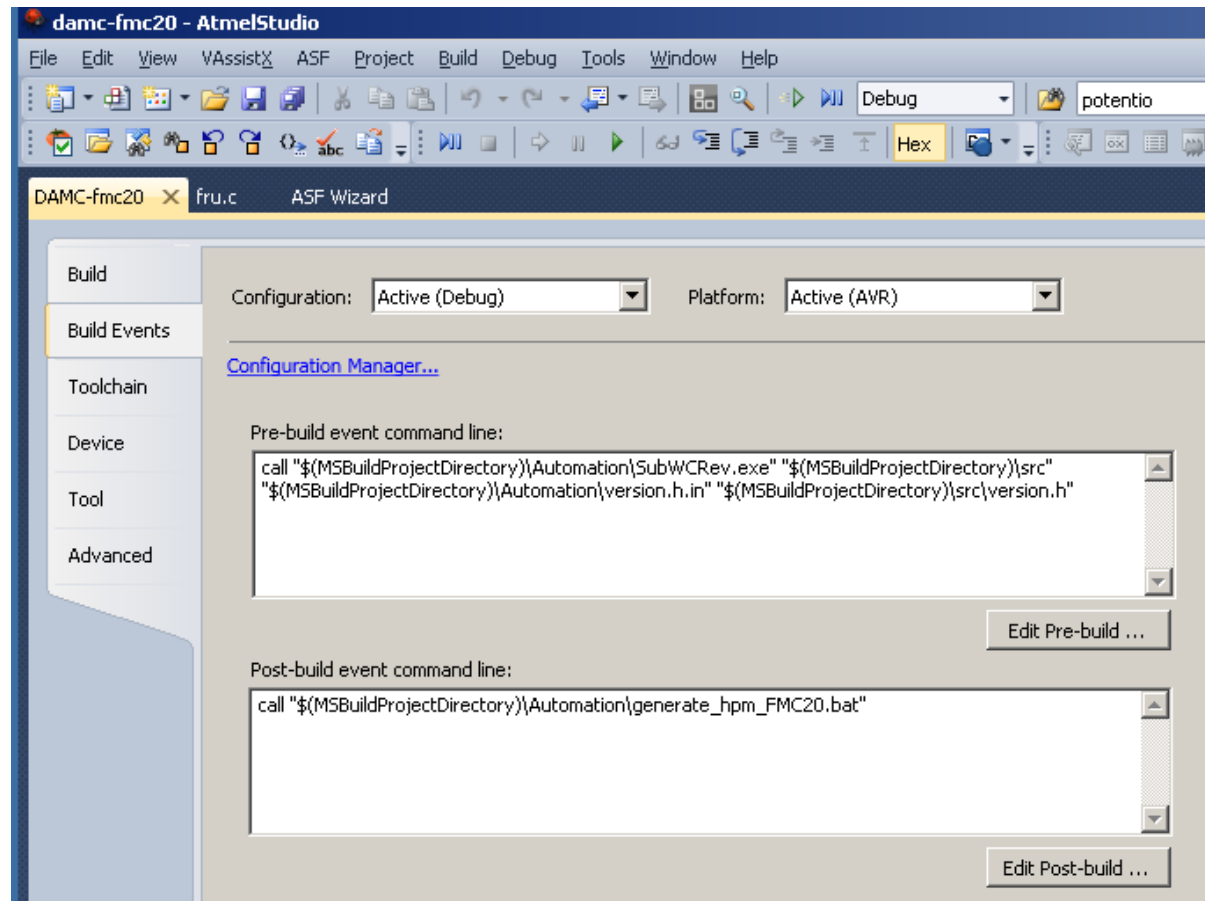
Revision	Actions	Author	Date	Message
1656		mielczar	Mittwoch, 30. September 2015 13:07:06	Allowed the EvalKit to turn on the GREEN AMC LED when there is no FPGA module inserted.
1643		dmakow	Donnerstag, 24. September 2015 21:44:39	Cleaned messages.
1642		mielczar	Donnerstag, 24. September 2015 10:55:45	TCK7 boost code rewritten. Fixed issue with boost being constantly engaged.
1632		mfenner	Mittwoch, 16. September 2015 18:11:12	Re-compile after mistake.
1631		mfenner	Mittwoch, 16. September 2015 18:04:14	Added FMC Voltage Control for FMC25 via IPMITOOL.
1627		mfenner	Donnerstag, 10. September 2015 09:02:43	Slowed Down Automation to allow safe USB reconnect
1618		mfenner	Montag, 7. September 2015 15:35:07	Corrected FMC20 IANA ID
1601		pperek	Dienstag, 1. September 2015 13:37:48	Control of pin ENABLE_N on RTM Expander added (Bug #1672)
1592		mfenner	Dienstag, 25. August 2015 12:59:24	RTM Power Enable Added to FMC20
1540		dmakow	Freitag, 24. Juli 2015 14:25:37	Merged RTM boost for TCK v2.2 (branch => trunk) NOT TESTED.

```
SIGN INT: Close Interface IPMI v1.5 LAN Interface
ipmi@m3kvmlinuxfenner:~$ ipmitool -H m3knochlab3 -P "" -B 0 -b 7 -T 0x82 -t 0x78 hpm check
PICMG HPM.1 Upgrade Agent 1.0.8:
-----Target Information-----
Device Id       : 0x0
Device Revision : 0x80
Product Id      : 0xfc20
Manufacturer Id : 0x053f (Unknown (0x53F))

-----
| ID | Name           | Active | Versions | Backup | Deferred |
-----|-----|-----|-----|-----|-----|
| 0 | ATXMEGA MMC   | 16.18 | 00000000 | ---.-- | ---.-- |
| 1 | FPGA LX45TA  | 0.00  | 00000000 | ---.-- | ---.-- |
| 2 | FPGA LX45TB  | 0.00  | 00000000 | ---.-- | ---.-- |
| 3 | FPGA LX150   | 0.00  | 00000000 | ---.-- | ---.-- |
-----
(*) Component requires Payload Cold Reset
```

Automated Version Numbering

- Version Number from SVN is put into each build & HPM is generated
 - 1. Pre-Built-Script creates a **Version Information File** (version.h)
 - 2. Post-build script creates hpm file **for in-system update**
- Each programming file contains its SVN Build number
→ tracking
- Build outputs two files that can be programmed
- via JTAG (lab)
- or remotely via ipmitool



Automated Version Transfer with SVN WCREV

```
/* This file (version.h) is automatically generated. Do not edit.
   The template is located here: Automation\version.h.in

   This header file contains Tortoise specific constants to automatica
   The file is parsed by SubWCRev.exe to create a valid header file to
   The call to SubWCRev.exe is done in the "pre-build macro".
*/
#ifndef TORTOISE_PROJECT_VERSION_H
#define TORTOISE_PROJECT_VERSION_H

/* The highest committed version number, an integer */
#define SVN_REVISION $WCREV$

/* In case of mixed revisions not all files have the same revision
   number. In this case there is a range which is like 137:142,
   with 137 being the oldest revision of a file, and 142 being SVN_REV
*/
#define SVN_RANGE      "$WCRANGE$"
#define SVN_COMMIT_DATE "$WCDATE$"
#define SVN_PATH       "$WCURL$"

/* Major and Minor are the two upper/lower decimals of SVN_REVISION */
#define SVN_REVISION_MAJOR ( (uint8_t) (SVN_REVISION / 100))
#define SVN_REVISION_MINOR ( (uint8_t) (SVN_REVISION % 100))

#if $WCMODS?1:0$ /* result of WCMODS */
    #define WARN_SVN_MODIFIED
#endif

#endif /* TORTOISE_PROJECT_VERSION_H */
```

```
/* THIS FILE (VERSION.H) IS AUTOMATICALLY GENER
   The template is located here: Automation\ve

   This header file contains Tortoise specific
   The file is parsed by SubWCRev.exe to creat
   The call to SubWCRev.exe is done in the "pr
*/
#ifndef TORTOISE_PROJECT_VERSION_H
#define TORTOISE_PROJECT_VERSION_H

/* The highest committed version number, an int
#define SVN_REVISION 1631

/* In case of mixed revisions not all files ha
   number. In this case there is a range which
   with 137 being the oldest revision of a fil
*/
#define SVN_RANGE      "1627:1631"
#define SVN_COMMIT_DATE "2015/09/16 18:04:14"
#define SVN_PATH       "https://svnsrv.desy.d

/* Major and Minor are the two upper/lower dec
#define SVN_REVISION_MAJOR ( (uint8_t) (SVN_RE
#define SVN_REVISION_MINOR ( (uint8_t) (SVN_RE

#if 1 /* result of WCMODS */
    #define WARN_SVN_MODIFIED
#endif

#endif /* TORTOISE_PROJECT_VERSION_H */
```

Post-Production programming

- Needed a possibility to automate MTCA board programming
- Atmel Tools do not support scripting
- Use Free tool „AVR DUDE“ to script that programming and AVR dragon programmer
 - Programming of FRU
 - Programming of FUSES
 - Programming of Bootloader
 - Programming of Standard application
- USE standard Xilinx Impact Batch mode (from free Xilinx ISE Lab Tools)
 - Programming of CPLD



Programming Script for Post-Production Programming

```
:env_vars
set dudeoptions=-p x128a1u -B 10 -c dragon_jtag
set pause=ping 127.0.0.1 -n 5 -w 1000
set impact_cmd_file=prog_fmc20_cpld_c.cmd

:fuse
echo -----
echo -- FUSE PROGRAMMING
echo -----

echo Setting FUSE: BOOTRST=BOOTLDR
avrdude %dudeoptions% -q -F -u -U fuse2:w:0xBF:m
%pause% > nul

echo -----
echo -- EEPROM PROGRAMMING (with fuses)
echo -----

:fru
echo Setting Fuse: EEPROM unprotect
avrdude %dudeoptions% -q -u -U fuse5:w:0xFF:m
%pause% > nul

echo Programming MAGIC Byte to EEPROM
rem (Needed to allow Bootlader to start App: 0x7FE=0x5A)
avrdude %dudeoptions% -q -U eeprom:w:magic_byte.hex
%pause% > nul

echo Programming FRU
avrdude %dudeoptions% -U eeprom:w:DAMC-FMC20_fru.bin:r
%pause% > nul

echo Setting Fuse: EEPROM protect
avrdude %dudeoptions% -q -u -U fuse5:w:0xF7:m
%pause% > nul

:flash
echo -----
echo -- FLASH PROGRAMMING
echo -----

echo Programming Bootloader
avrdude %dudeoptions% -e -U flash:w:mmc_bootloader_fmc20.hex
%pause% > nul

echo Programming Flash
avrdude %dudeoptions% -U flash:w:..\Debug\DAMC-FMC20.hex

:message
echo Please remove and re-insert board now...
pause

:cpld
echo -----
echo -- CPLD PROGRAMMING
echo -----

echo setMode -bscan > %impact_cmd_file%
echo setCable -p usb21 >> %impact_cmd_file%
echo addDevice -p 1 -file CPLD_XC2C256_C.jed >> %impact_cmd_file%
echo Program -p 1 -v >> %impact_cmd_file%
echo quit >> %impact_cmd_file%
%xilinx%\bin\nt64\impact.exe -batch %impact_cmd_file% | findstr '1'
del %impact_cmd_file%
%pause% > nul

:finished
echo Programming finished.
pause
```


In-Field Update of Memories

- MMC hpm files directly come out of make process → ipmitool
- FPGA .bit files come out of build process; We offer a command-line based conversion tool „bin2hpm“
 - Directly accepts bit files (no .MCS FLASH files etc.)
 - Creates .hpm files for ipmitool
 - Option: compresses down to 10%~30% of initial file size (proprietary with MMC V1.00)

```
C:\Windows\system32\cmd.exe
D:\MMC_U100_Software\trunk\Automation>bin2hpm.exe /bit /compress lx45t.bit
BIN-to-HPM file converter. Version: 2.0.2
Written by Michael Fenner (C) DESY 2014;
with Xilinx BIT file support and
with compression based on UPackBits (C) Michael Dipperstein (GPL) and
with MD5 algorithm from Alexander Peslyak (public domain)

Reading file                : lx45t.bit
File Length is             : 1484564 bytes
Bit File mode. Header check ok.
a-Section detected. Design info : LX45T.ncd;UserID=0xFFFFFFFF
b-Section detected. Part name   : 6slx45tcsg324
c-Section detected. File date   : 2015/01/13
d-Section detected. File time   : 22:44:33
e-Section detected. Image size  : 0x0016A6B8 (1449KB)
BIT header successfully parsed.
Generating HPM header...
Device ID                  : 0x00
Manufacturer ID           : 0x000000
Product ID                 : 0x0000
Time value                 : 0x5665F5E3
Components                 : 0x02 (ComponentID = 1)
Firmware revision         : 0x0000
Firmware revision auxiliary information : 0x00000000
Generating header checksum : 0x07
Generating upgrade action checksum (prepare) : 0xFD
Generating upgrade action checksum (upload) : 0xFC
Information: Output will be compressed with RLE
Reading 1484472 Bytes from file...
Largest RLE block is      : 110 bytes
Compression Ratio is     : 1.6%
16-bit Checksum of data is : 0xF7E2
Begin of data stream is  : 434F4D50524553534544000016A6B88EFF33AA99...
End of data stream is    : 200020002000200020002000200020002000200020002000.
Verifying decompression   : Checksum OK / Length OK
Generating MD5 checksum   : DF1011CD85CDFC072FC1B2499E968C03
Output data length is    : 24541 bytes
Overhead (header+MD5) size is : 103 bytes
Writing file              : lx45t.rle.hpm
Bytes actually written    : 24541
All done.

D:\MMC_U100_Software\trunk\Automation>
```

Example: FPGA firmware update through IPMItool

```
ubuntu_ym_192.168.112.128
ipmi@mskvmlinuxfenner:~$ ipmitool -H mskmchlab3 -P "" -B 0 -b 7 -T 0x82 -t 0x78 hpm upgrade s6.rle.hpm
PICMG HPM.1 Upgrade Agent 1.0.8:
Validating firmware image integrity...OK
Performing preparation stage...
  Invalid image file for product 64544

Image Information
  Device Id : 0x0
  Prod Id : 0x0000
  Manuf Id : 0x000000
Board Information
  Device Id : 0x0
  Prod Id : 0xfc20
  Manuf Id : 0x00053f
Continue ignoring DeviceID/ProductID/ManufacturingID (Y/N) :y
OK
Performing upgrade stage:

-----
| ID | Name | Active | Versions | Backup | File | % |
|-----|-----|-----|-----|-----|-----|-----|
| 1 | FPGA LX45TA | | | | | 100% |
| | Upload Time: 02:31 | | Image Size: 107614 bytes | | |
|-----|-----|-----|-----|-----|-----|
(*) Component requires Payload Cold Reset

Firmware upgrade procedure successful
```

Version Control also applied to Hardware

- All Hardware and Firmware is kept in SVN Database
- All old versions are available („One tag for each board“)
- Documentation of changes

PCB_FRED/	1545	5d 02h	mfenner	Log	Download
branches/	1019	104d 06h	mfenner	Log	Download
tags/	1035	104d 04h	mfenner	Log	Download
FirstFullyWorkingVersion/	271	514d 23h	killenb	Log	Download
FRED1_A/	1010	104d 06h	mfenner	Log	Download
FRED2_A/	1011	104d 06h	mfenner	Log	Download
FRED2_C/	1020	104d 06h	mfenner	Log	Download
FRED3M_A/	1014	104d 06h	mfenner	Log	Download
FRED3_A/	1012	104d 06h	mfenner	Log	Download
FRED3_B/	1035	104d 04h	mfenner	Log	Download
trunk/	1545	5d 02h	mfenner	Log	Download

Rev	Age	Author	Path	Log message
<input type="checkbox"/> 1035	104d 04h	mfenner	/other/Fuse-Relay-Board/PCB_FRED/	Modified wrong STEP file
<input type="checkbox"/> 1017	104d 06h	mfenner	/other/Fuse-Relay-Board/	folder rename
<input type="checkbox"/> 1013	104d 06h	mfenner	/other/Fuse-Relay-Board/PCB/tags/FRED3_B/	copy to tag
<input type="checkbox"/> 1006	105d 06h	mfenner	/other/Fuse-Relay-Board/PCB/branches/FRED3_B/Mechanics/	3D Model updated to latest PCB revision (as produced)
<input type="checkbox"/> 918	145d 01h	mfenner	/other/Fuse-Relay-Board/PCB/branches/FRED3_B/	Old Step file deleted
<input type="checkbox"/> 917	145d 01h	mfenner	/other/Fuse-Relay-Board/PCB/branches/FRED3_B/	Step Model Added
<input type="checkbox"/> 899	146d 21h	mfenner	/other/Fuse-Relay-Board/PCB/branches/FRED3_B/	Production Data for FRED3B created
<input type="checkbox"/> 874	150d 22h	mfenner	/other/Fuse-Relay-Board/PCB/branches/FRED3_B/	Fred3B finished, 0 Errors
<input type="checkbox"/> 869	151d 18h	mfenner	/other/Fuse-Relay-Board/PCB/branches/FRED3_B/	Continued Routing, all resistors placed
<input type="checkbox"/> 868	151d 20h	mfenner	/other/Fuse-Relay-Board/PCB/branches/FRED3_B/	8 New transistors placed , planned corrected, polygons corrected
<input type="checkbox"/> 864	151d 23h	mfenner	/other/Fuse-Relay-Board/PCB/branches/FRED3_B/	Further Work on 3D
<input type="checkbox"/> 859	152d 05h	mfenner	/other/Fuse-Relay-Board/PCB/branches/FRED3_B/	3D Positioning
<input type="checkbox"/> 858	152d 05h	mfenner	/other/Fuse-Relay-Board/PCB/branches/FRED3_B/	3D Model Improvements
<input type="checkbox"/> 857	152d 18h	mfenner	/other/Fuse-Relay-Board/PCB/branches/FRED3_B/	Started Changes
<input type="checkbox"/> 828	159d 19h	mfenner	/other/Fuse-Relay-Board/PCB/branches/FRED3_B/	Processed some requests by ILFA
<input type="checkbox"/> 827	159d 20h	mfenner	/other/Fuse-Relay-Board/PCB/branches/FRED3_B/	DNP Setting for 470uF Caps
<input type="checkbox"/> 826	159d 20h	mfenner	/other/Fuse-Relay-Board/PCB/branches/	FRED3B created

➤ Benefits:

- Engineers can work on their local hard drive
- All Board revisions are accessible
- Traceability
- Backup
- Possible to easily share work

- > Bugs are tracked with Redmine (browser-based)
- > Any group member can report
- > All issues are collected and processed for next revision
- > Shared with Partners (Export)

✓ #	Tracker	Status	Priority	Subject
<input type="checkbox"/> 1792	Bug	New	Normal	FMC Inrush Current issue
<input type="checkbox"/> 1628	Bug	Closed	Normal	Route JTAG of CPLD to MMC
<input type="checkbox"/> 1627	Bug	Closed	Normal	Change Pulldown Options for MVLDS signals
<input type="checkbox"/> 1609	Bug	Closed	Normal	Front Panel Mechanics Need Plane Cutout
<input type="checkbox"/> 1608	Bug	Closed	Normal	BOM too long
<input type="checkbox"/> 1606	Bug	Closed	Normal	Front Panel LEDs emit light when FPGAs not loaded
<input type="checkbox"/> 1596	Bug	Closed	Normal	change r39, r44
<input type="checkbox"/> 1595	Bug	Closed	Normal	change top level routing of 4-2 4-0 fmc mgt option
<input type="checkbox"/> 1594	Bug	Feedback	Normal	mldvs buffer configuration resistors change
<input type="checkbox"/> 1593	Bug	Feedback	Normal	cryok interlock nand gate u38
<input type="checkbox"/> 1592	Bug	Closed	Normal	ac coupling for tclkab buffer
<input type="checkbox"/> 1591	Bug	Closed	Normal	Schematic numbering wrong

Description

Inrush current is too high, need limiting resistor (100k) in front of FMC Transistor gate to support soft-start.

- 19-inch DCM
- 19-inch EOD Detector
- 19-inch FRED (Fuse-Relay-Board) / FREDFAN
- 19-inch LOGM1300
- 19-inch PSM
- 19-inch PZ16M
- 19-inch SDiag Base-Module
- 19-inch TEC (Temperature Controller Board)
- 19-inch TMCBV2
- 19-inch UniLOGM
- DAMC-AD16
- DAMC-DS800
- DAMC-FMC20
- DAMC-FMC25
- DAMC-StarterMMC
- DAMC-TCK7
- DFMC-DSBAM
- DFMC-MD22
- DFMC-TC4
- DFMC-TESTADP
- DFMC-UNI-IO
- DRTM-2TCAL
- DRTM-AD84
- DRTM-CLKFT
- DRTM-DS8VM1
- DRTM-DWC10
- DRTM-DWC8VM1
- DRTM-KLM
- DRTM-LASY
- DRTM-LOG1300
- DRTM-PZT4
- DRTM-StarterRMC
- DRTM-VM2LF
- DRTM: MCH-RTM-BM
- RF Backplane
- RF Backplane 2U

Conclusion

- > We maintain management firmware AND hardware data in SVN
- > A complete history including all versions is available
- > We track bugs and prepare new revisions with Redmine
- > **We have introduced a fully automated firmware post-production programming process (for all on-board memories: FPGA and MMC)**
- > **We have implemented IPMI-based programming in-the-field for FPGAs and MMC**
- > **We offer a command-line based, scriptable tool to convert build outputs to hpm-files**
- > We are able to script-program large production batches

Thank you!