M9.2 Manufacturing Manual (DRAFT Version)

for the development of an STM ATB

DRAFT

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1 Introduction

1.1 What is an STM ATB

Text, STMA-68992 - An STM is a train protection system which prevents trains from over speeding and/or unauthorized movements. It allows ETCS equipped trains to operate on conventional (non ETCS) lines. An STM ATB is a “Specific Transmission Module” designed and built according to the ERA ERTMS specifications and national requirements for ATB-EG. When integrated with an onboard ETCS system, the combination of STM ATB and the ETCS onboard system ensures all ATB-EG and ATB-Vv functionalities on ATB equipped lines.

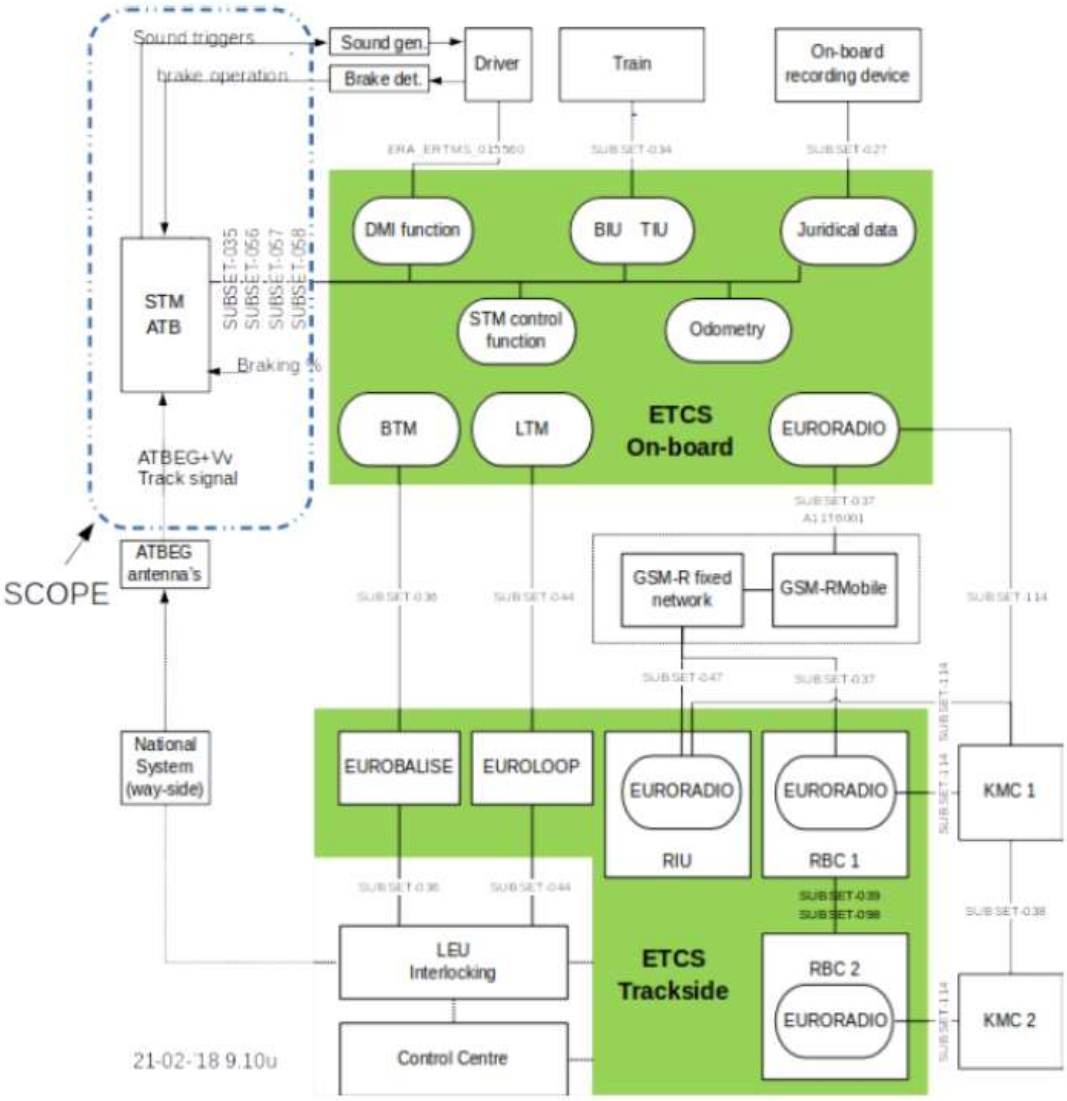
1.2 Purpose

Text, STMA-68987 - This document is the installation manual for STM ATB. It provides instructions and guidance for the installation design and for safe construction and installation work.

1.3 Scope

Text, STMA-68989 - Figure 1 (STMA-69011) is taken from the ETCS specifications (subset-035). It shows the ETCS reference architecture and the integration of STM ATB with the ETCS onboard system. The scope for this installation manual is marked.

Definition, STMA-69011 - Figure 1: ETCS reference architecture and scope of this manual



2 HQSE guidance note

Definition, STMA-69012 - In this document the following graphical elements are used to emphasize HQSE relevance:

	DANGER Denotes a danger with a high HQSE content which must always be avoided.

	WARNING Denotes a risk with medium HQSE content which always requires attention as indicated.

	REMARK Denotes a situation with no or only minor HQSE content which is best served by attention as indicated.

Text, STMA-69322 - All parts of this STM ATB manufacturing procedure may only be executed if all prevailing health and safety requirements are met. These health and safety requirements include, but are not limited to:

- proper staff training and qualification for the tasks to performed;
- appropriate HQSE measures, based on project specific risk inventory;
- proper use of personal protective equipment.

The manufacturer shall provide its staff with appropriate instructions and oversees the adherence thereof.

3 References

3.1 Reference documents

Text, STMA-69003 -

Ref.nr.	Document ID	Title	Revision
1	2012/19/EU	WEEE Directive	04.07.2012
2	2016/797/EU	Interoperability Directive	11.05.2016
3	2016/798/EU	Railway Safety Directive	11.05.2016
4	2016/919/EU	Technical Specification of Interoperability for Control Command and Signaling	17.05.2016
5	EN 45545	Fire Protection on Railway Vehicles	2018
6	EN 50121	Railway Applications. Electromagnetic Compatability	2017
7	EN 50125-1	Railway Applications – Environmental Conditions for Equipment – Part 1: Rolling Stock and On-board Equipment	2014
8	EN 50155	Railway Applications. Rolling Stock. Electronic Equipment	2010
9	EN 50264	Railway Applications – Railway Rolling Stock Power and Control Cables having Special Fire Performance	2008
10	IEC 61158-2	Industrial Communication Networks – Fieldbus Specifications – Part 2: Physical Layer Specification and Service Definition	2014
11	IEC 61373	Railway Applications – Rolling Stock Equipment – Shock and Vibration Tests	2010

3.2 Abbreviations, definitions and terminology

Text, STMA-69004 - Table 1: abbreviations [P6.2]

abbreviation	legend
AC	Alternating Current
ADC	Analog to Digital Converter
AIN Board	Analog Input Board
ATB	Automatische Trein Beïnvloeding – Dutch national ATP system
ATB-EG	First generation ATB in the Netherlands, based on 75 Hz encoded track signal
ATB-Vv	Improved version of ATB-EG system, with add on balises and signal loops for protection of trains at 0-40 km/h
ATP	Automatic Train Protection
BIU	Brake Interface Unit
CCS	Control, Command and Signaling
CPU	Central Processing Unit
DC	Direct Current
DI	Digital Input
DIO+PS Board	Digital IO plus Power Supply Board
DMI	Driver Machine Interface
DO	Digital Output
ECM	Entity in Charge of Maintenance
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EN	European Norm
ERA	European Railway Agency
ERTMS	European Rail Traffic Management System
ESD	Electrostatic Discharge
ETCS	European Train Control System
EVC	European Vital Computer (part of the ETCS onboard system)
GND	Ground
GSM-R	Global System for Mobile Communications - Railways
IEC	International Electrotechnical Commission
IO	Input Output
JRU	Juridical Recorder Unit
LED	Light Emitting Diode

LRU	Line Replaceable Unit
N/A	Not Applicable
NC	Normally Closed
NO	Normally Open
NOBO	Notified Body
PCB	Printed Circuit Board
PE	Protective Earth
PROFIBUS	Process Field Bus
PSU	Power Supply Unit
SAP Board	Safe APplication Board
STM	Specific Transmission Module
STS	Signal at danger (stoptonend sein)
TBD	To Be Defined
TIU	Train Interface Unit
TSI	Technical Specifications for Interoperability
UIC	International Union of Railways
USB	Universal Serial Bus

3.3 Requirement identification

Test Case Result, STMA-68994 - The STM ATB product development project makes use of an automated requirement management system and references to the requirements have been made in this document. Each requirement has been assigned with a unique ID, with the format "STMA-<number>".

4 Audience

Test Case Result, STMA-68995 - This ATB STM manufacturing manual is intended to be used by manufacturing production and supervising staff qualified and responsible for the production of ATB/ETCS.

Test Case Result, STMA-69127 - The qualification demands are to be determined by the management of the manufacturer concerned in accordance with the safety demands, statutory and customer requirements.

5 Manufacturing requirements

5.1 Organizational requirements

Test Case Result, STMA-68986 - The STM ATB product development and production are subject to the European Commission Decision on modules 2010/713/EU. The conformity of the product development of the STM ATB has been assessed and certified by the Notified Body(NOBO) TÜV Süd according to 2010/713/EU module CB.

As such, the production of the STM ATB is subject to one of the following three 2010/713/EU modules:

- *Module CD. Conformity to type based on quality management system of the production process:*
  - requires the manufacturer to operate a quality management system approved by a NOBO for the production, final product inspection and testing of the interoperability constituents and be subject to surveillance under the responsibility of that NOBO as well as to draw up a written EC declaration of conformity for the interoperability constituent and keep it at the disposal of the national authorities for the period defined in the relevant TSI or for 10 years after the last interoperability constituent has been manufactured;

- *Module CF. Conformity to type based on product verification:*
  - Requires the manufacturer to operate an assessment procedure under examinations and tests by a NOBO based on individual (as opposed to statistical (according to TSI CCS ch. 6.2.2)) product verification which ensures conformity of the interoperability constituents with the approved type described in the EC-type examination certificate and with the requirements of the TSI that apply to them;

- *Module CH1. Conformity based on full quality management system plus design examination:*
  - Requires the manufacturer to operate a full quality management system plus design examination under assessment of a NOBO which covers all design and production activities in an approved CMS and in which the manufacturer ensures and declares on his sole responsibility that the interoperability constituents concerned satisfy the requirements of the technical specification for interoperability (TSI) that apply to them.

The manufacturer shall select one of these three 2010/713/EU modules (CD, CF or CH1) to comply with in the production of the STM ATB and all of its components as well as a NOBO to assess and certify the production according to the selected module.All parts of this manufacturing procedure shall be subject to that.

Proper waste management shall be implemented in accordance with the prevailing statutory requirements including, but not limited to WEEE Directive 2012/19/EU.

The manufacturer provides its staff with appropriate instructions and oversees the adherence thereof.

5.2 PCB requirements

Test Case Result, STMA-71336 - Environmental requirements shall be taken into consideration.
The PCBs shall be compliant with the environmental requirements defined in D4.5 Environmental Requirement Specification (ERS).

Test Case Result, STMA-68984 - The manufacturing of the STM ATB is subject to the European Commission Decision on modules 2010/713/EU, module CB and one of the three modules CD, CF or CH1. As such, the manufacturing of all parts is also subject to 2010/713/EU. As such, the STM ATB manufacturer shall check that all parts have been produced and tested in accordance the applicable modules of 2010/713/EU (summarized in 5.1 Organizational requirements).

Of all parts used in the STM ATB, the PCBs are by far the most sophisticated and, consequently, most prone to production failures.

Therefore, the manufacturer of the PCBs shall perform at least the following tests after production (and provide proof thereof):

- Test 1;
- Test 2;
- Test 3;
- Test enz

5.3 Health and Safety requirements

Test Case Result, STMA-69529 -

All parts of this STM ATB manufacturing procedure may only be executed if all prevailing health and safety requirements are met. These health and safety requirements include, but are not limited to:

- proper staff training and qualification for the tasks to performed;
- appropriate HQSE measures, based on project specific risk inventory;
- proper use of personal protective equipment.

The manufacturer provides its staff with appropriate instructions and oversees the adherence thereof.

6 Software installation and testing

Test Case Result, STMA-69035 - The software of the STM ATB shall be loaded on the processors on the SAP Board.

The manufacturer shall always ascertain that the latest software version is installed. Table 2 (STMA-69038) lists the latest software versions for all four STM ATB processors as released at 8th November 2019.

Definition, STMA-69038 - Table 2: STM ATB software version at 8-11-2019 (subject to updates)

processor	software		
	file	latest version at 8-11-2019	date
Hercules	?	vD0.005	?
TIVA	?	?	?
netX	?	?	?
FPGA	?	v0.6	?

Test Case Result, STMA-69128 - The installation procedure consists of 7 parts:

1. Preparation;
2. Loading the software on the Hercules processor;
3. Debugging;
4. Loading the software on the TIVA (co)processor;
5. Loading the software on the netX processor;
6. Loading the software on the FPGA processor;
7. Testing the software.

Definition, STMA-69122 -

	WARNING The software loading procedure always starts with loading the software on the Hercules processor, followed by debugging. Only thereafter loading the software on the TIVA (co)processor, the netX processor and the FPGA processor may be started.

6.1 Preparation

Definition, STMA-69123 -

	DANGER Check that all HQSE procedures for working safely have been fulfilled.

Test Case Result, STMA-69041 - Check that all tools and materials required for the software loading procedures are available <<lijst wellicht naar appendix>>:

- laptop with software:

  - J-Flash V6.30b;
  - netX Bootwizard 1.4.0.1;
  - netHOST v1.0.0.0;
  - Vivado 2017.3;

- power supply connector with ON/OFF switch (230 V AC standard power supply – 12 V DC Backplane connector (pins A18 and C18 (+) and A15 and C15 (-)));
- JLink cable connector (USB – xxx connector);
- debugging double clamp connector;
- bootloader cable connector (USB – jumper).

6.2 Loading the software on the Hercules processor

Test Case Result, STMA-69039 -

1. Establish power supply to the SAP Board.

- Apply 12 V DC to the pins A18 and C18 (+) and A15 and C15 (-) of the Backplane connector;

Definition, STMA-69040 -

Figure 2: Hardware connections for loading the software on the Hercules processor [2219A <<vervangen>>]

Test Case Result, STMA-69057 -

2. Connect a USB port of the laptop with the X901 connector on the SAP Board.

- Using the JLink cable connector (Figure 2, STMA-69040);

3. Open the software loading program "J-Flash V6.30b" on the laptop;
4. The pop-up "Welcome to J-Flash" appears. Select "Create a new project" and click "Start J-Flash" (Figure 3, STMA-69052);

Definition, STMA-69052 -

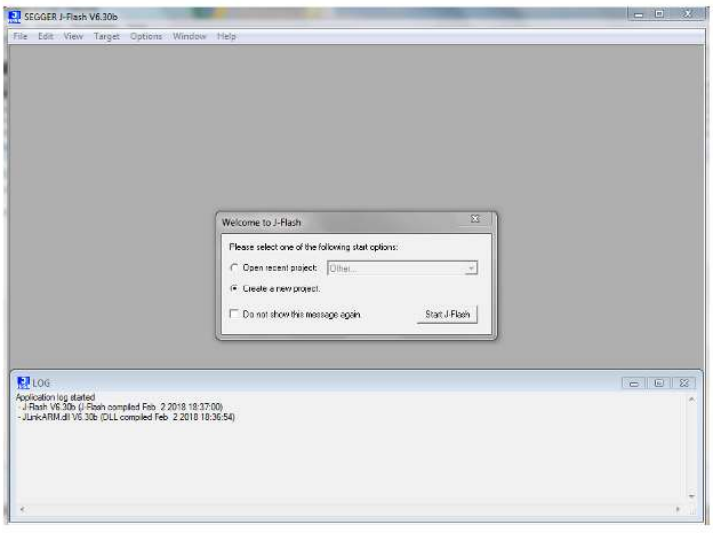


Figure 3: Welcome to J-Flash [Project]

Test Case Result, STMA-69053 -

5. The pop-up “Create New Project” appears. Click the “Target Device” browse button “…” (Figure 4, STMA-69050);

Definition, STMA-69050 -

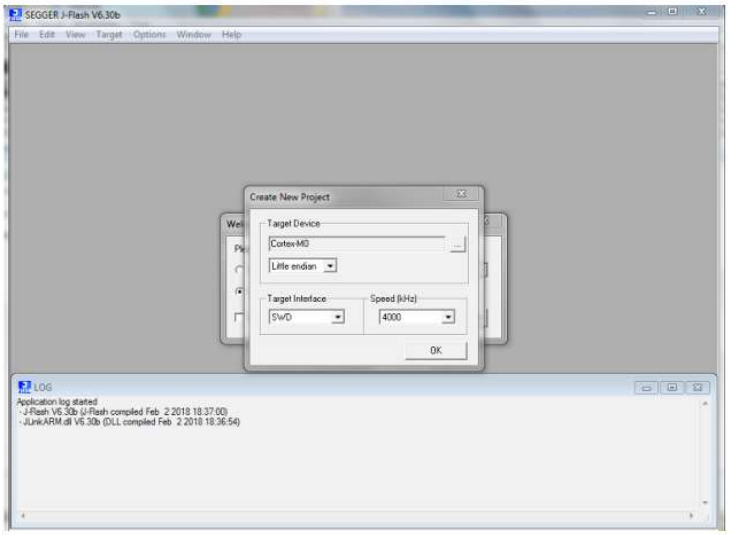


Figure 4: Create new project 1 [Project_2]

Test Case Result, STMA-69051 -

6. The “Select Device” browse window appears. First select Manufacturer “TI”, then select Device “RM48L9x” and click “OK” (Figure 5, STMA-69055);

Definition, STMA-69055 -

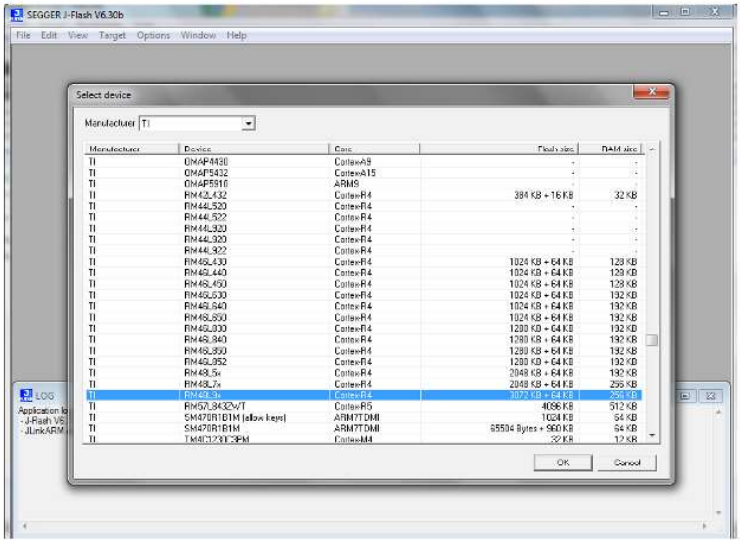


Figure 5: Select device [Project_3]

Test Case Result, STMA-69056 -

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7. The pop-up “Create New Project” re-appears. Select “Target Interface” “JTAG”, then “Speed [kHz]” “9600” and click “OK” (Figure 6, STMA-69054);

Definition, STMA-69054 -

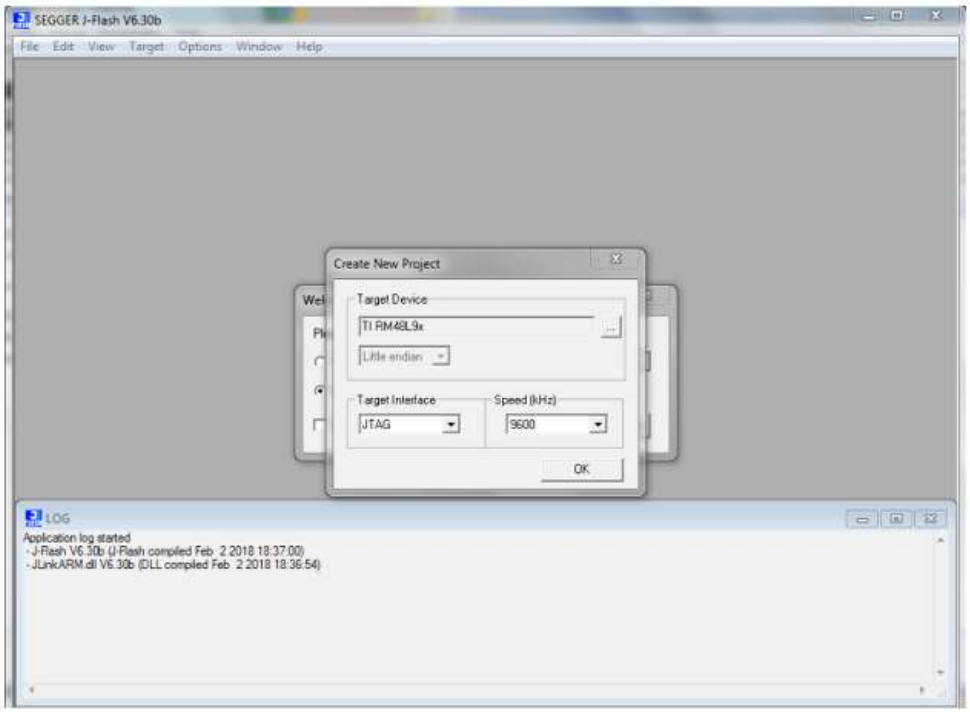

Figure 6: Create new project 2 [Project_4]

Test Case Result, STMA-69120 -

8. **Click ?File? (on the top ribbon) and select ?Open data file? on the pop-up (Figure 7, STMA-69048);**

Definition, STMA-69048 -

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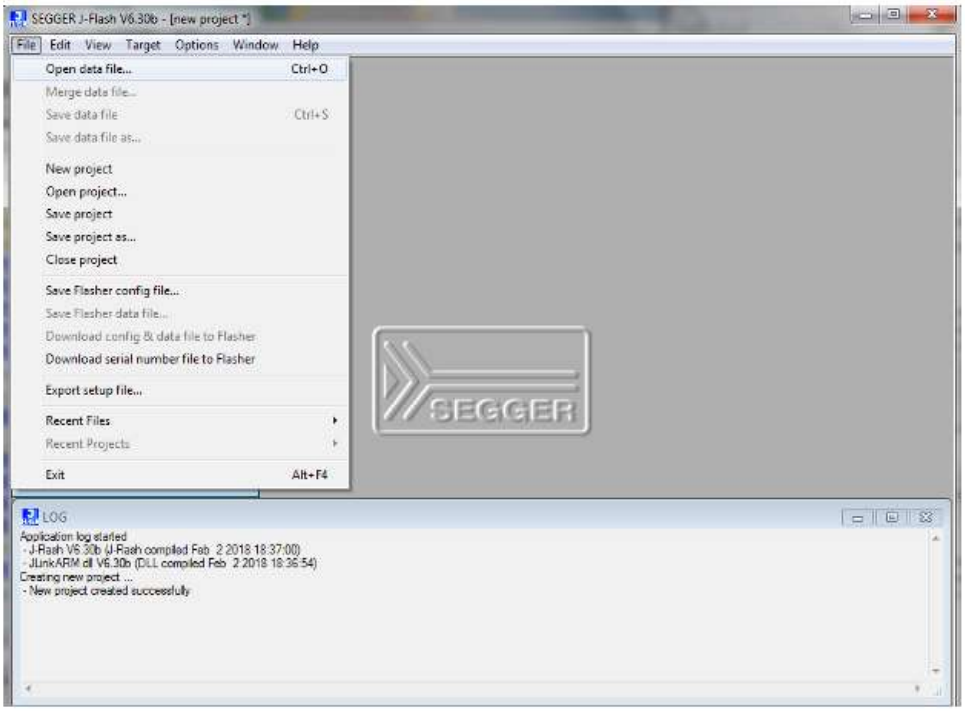

Figure 7: Open data file [LoadFile_1]

Test Case Result, STMA-69049 -

9. The Explorer window “Open data file” opens. Select File type “.bin”, then select file “fpmain.bin” and click “open” (Figure 8, ! STMA-69047);

Definition, STMA-69047 -

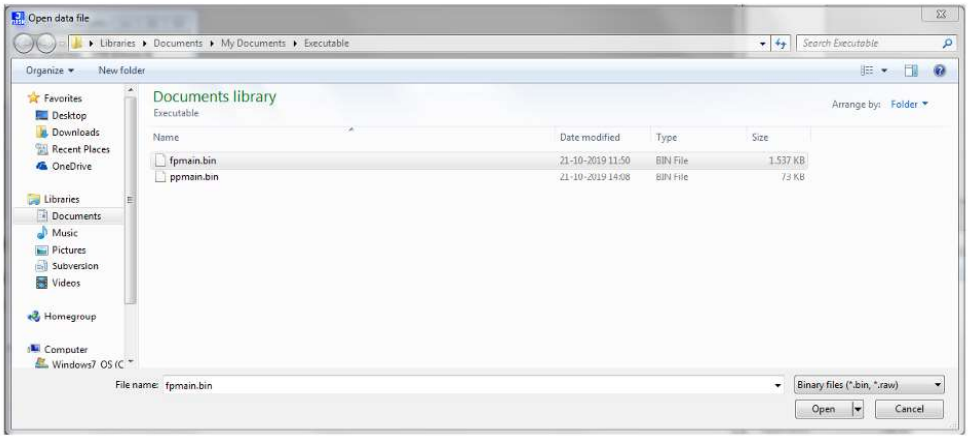

Figure 8: Select data file [LoadFile_select]

Test Case Result, STMA-69045 -

10. The pop-up “Enter start address” appears. Enter “0” (zero) and click “OK” (Figure 9, ! STMA-69046);

Definition, STMA-69046 -

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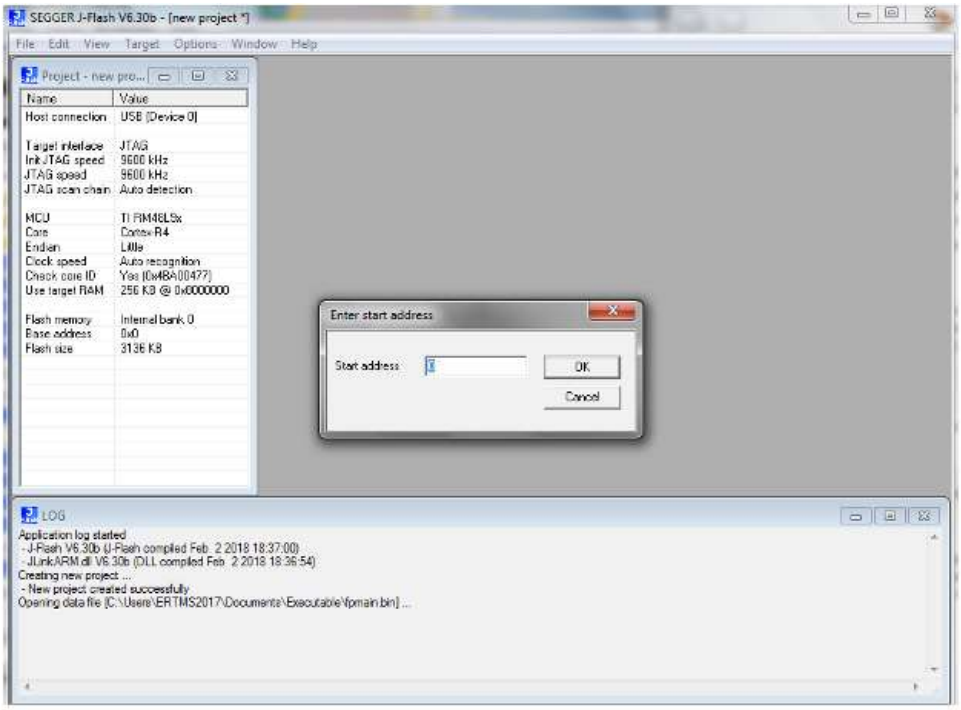

Figure 9: Enter start address [LoadFile_2]

Test Case Result, STMA-69121 -

11. The file “fpmain.bin” now loads and the screen “….\Executable\fpmain.bin” appears (Figure 10, STMA-69073);

Definition, STMA-69073 -

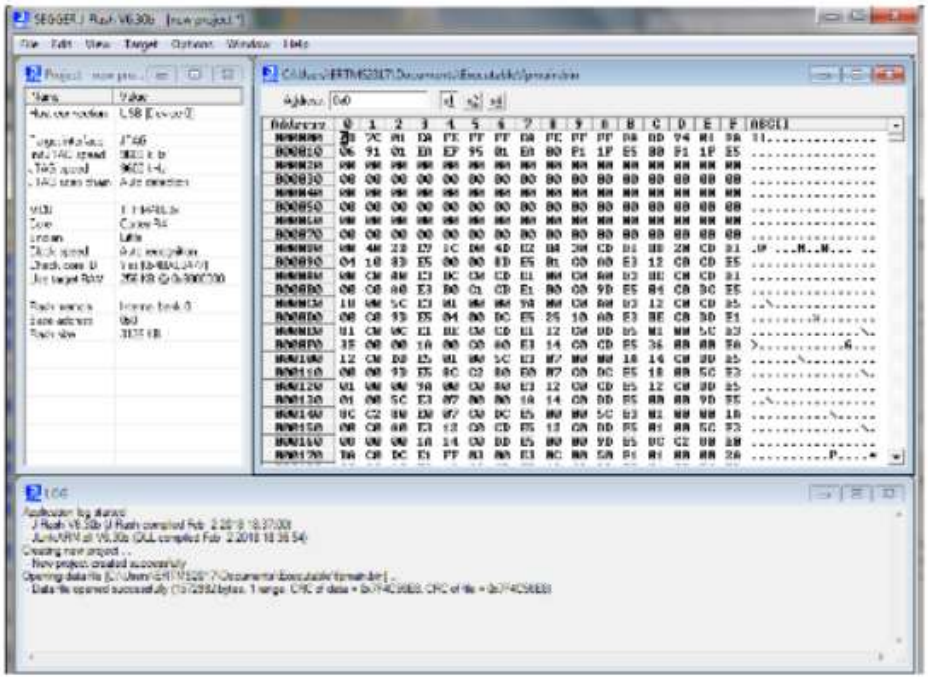

Figure 10: Screen fpmain.bin [LoadFile_3]

Test Case Result, STMA-69074 -

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12. Click “Target” (on the top ribbon) and select “Connect” on the pop-up (Figure 11, STMA-69066);

Definition, STMA-69066 -

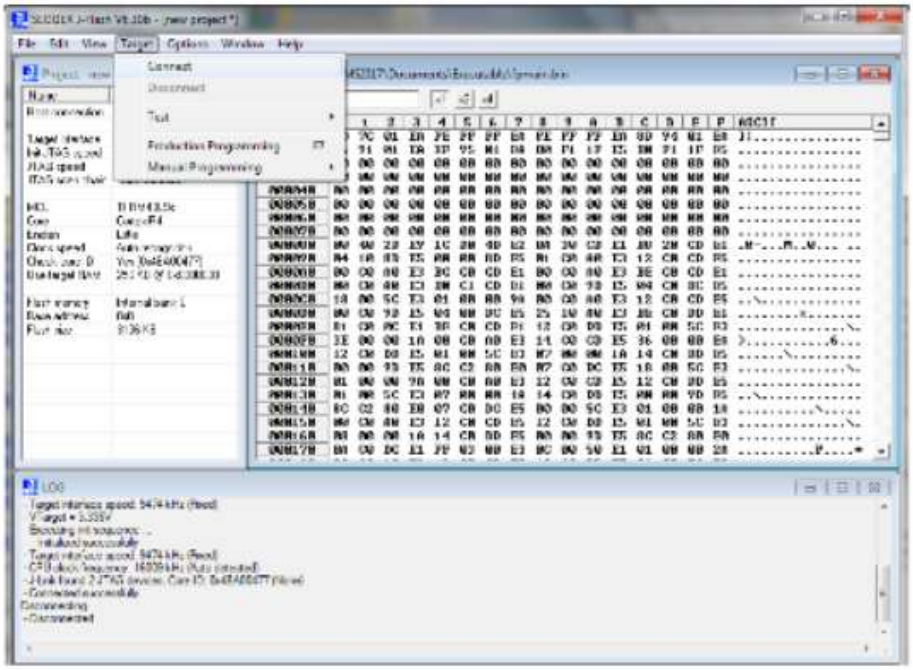

Figure 11: Connect Target [Connect]

Test Case Result, STMA-69067 -

13. If the pop-up “J-Link V6.30b Internal Error” appears, ignore the error, click “OK” (Figure 12, STMA-69064), and continue with step 14, immediately if this error message doesn’t appear;

Definition, STMA-69064 -

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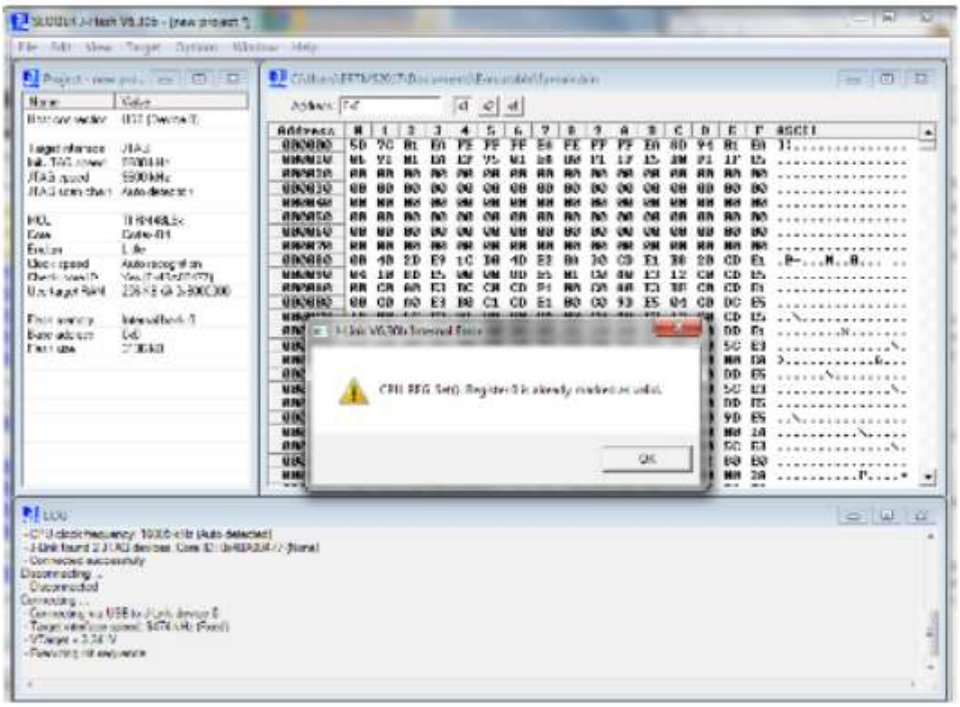

Figure 12: Internal error [Connect_error]

Test Case Result, STMA-69065 -

14. Again click “Target” (on the top ribbon) and select “Production Programming” on the pop-up (Figure 13, STMA-69069);

Definition, STMA-69069 -

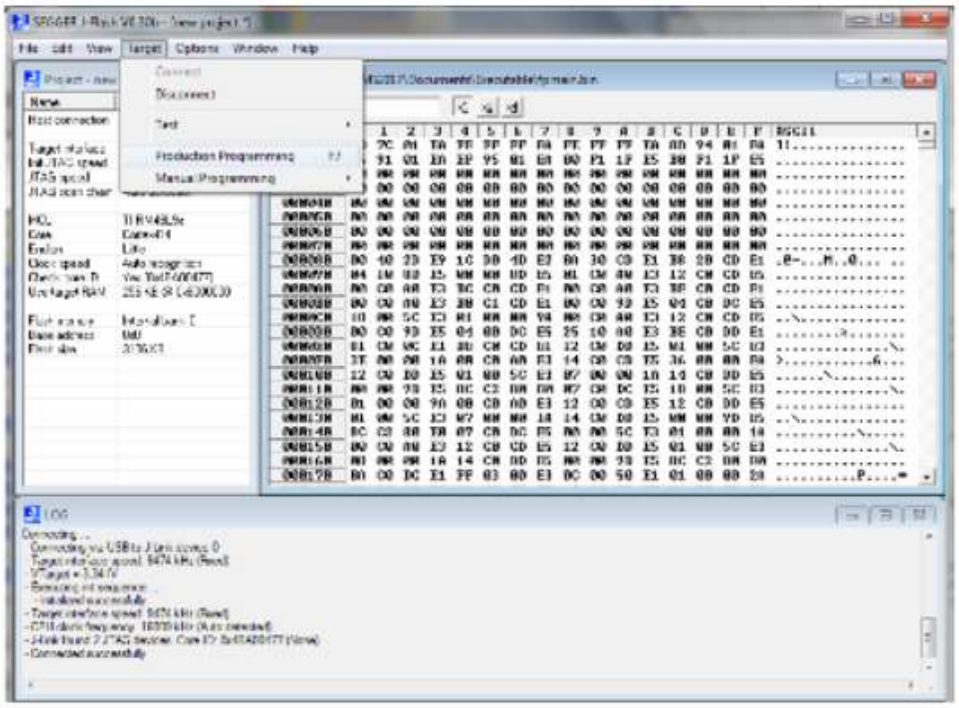

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Figure 13: Production programming [Program]

Test Case Result, STMA-69071 -

15. The pop-up “J-Flash” appears with a progress bar. The software is loaded on the Hercules processor (Figure 14, STMA-69068);

Definition, STMA-69068 -

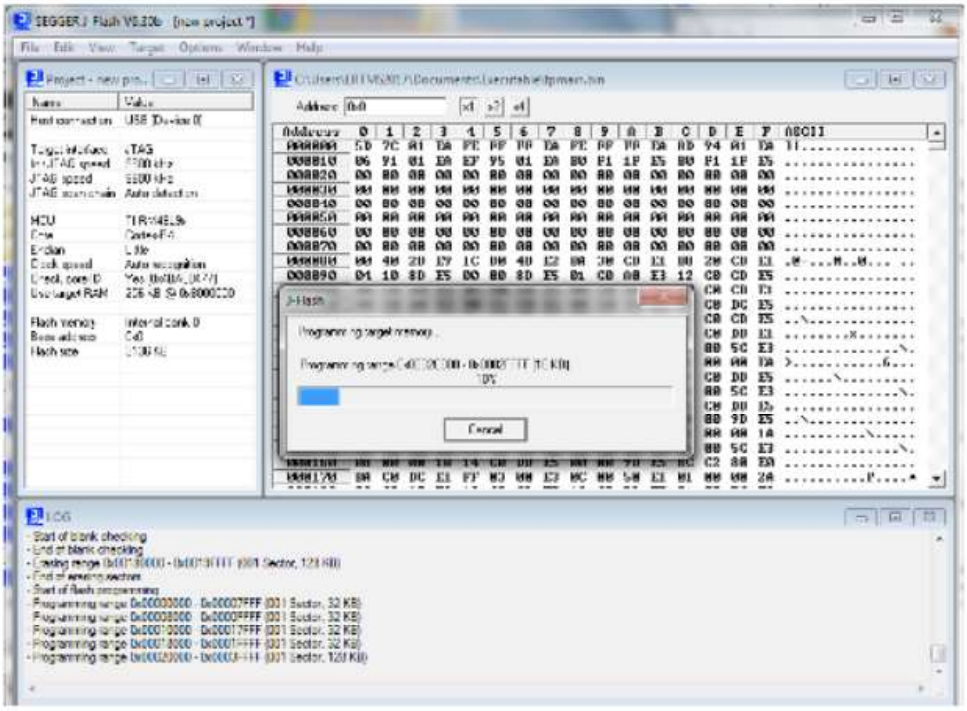

Figure 14: Progress bar [Program_load]

Test Case Result, STMA-69062 -

16. When the software is loaded on the Hercules processor, the timeline on the pop-up is replaced by the message “Target erased, programmed and verified successfully – Completed after … sec”. Click “OK” (Figure 15, STMA-69063);

Definition, STMA-69063 -

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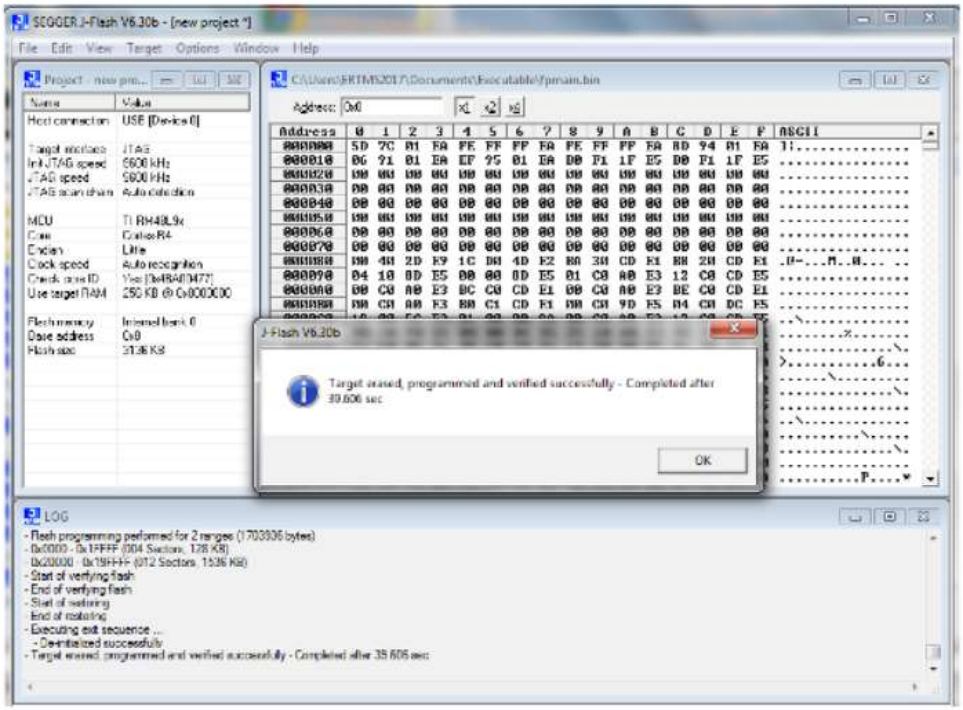

Figure 15: Hercules programmed and verified successfully [Program_done]

Test Case Result, STMA-69060 -

17. The software is successfully loaded on the Hercules processor. Close the program “J-Flash V6.30b” on the laptop by clicking “X” in the top right corner of the screen:

- If the message “Target erased, programmed and verified successfully – Completed after … sec” does not appear, the loading of the software on the Hercules processor is not confirmed or failed. In that case only, go back to step 3 and follow the procedure from there for a second time;

Test Case Result, STMA-69061 -

18. Disconnect the JLink cable connector from connector X901 on the SAP Board and continue with 6.3 Debugging;

6.3 Debugging

Test Case Result, STMA-69059 -

1. Establish power supply to the SAP Board
   - Apply 12 V DC to the pins A18 and C18 (+) and A15 and C15 (-) of the Backplane connector;

Test Case Result, STMA-69070 -

2. Connect pin 1 of the X103 connector with any GND pin, for instance pin C32 of the Backplane connector (Figure 16, STMA-69072);

Definition, STMA-69072 -

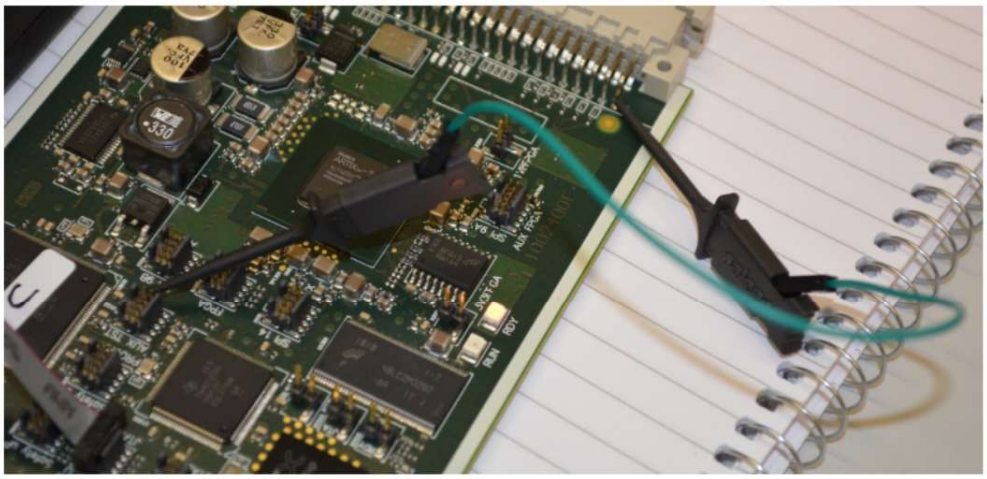

Figure 16: Hardware connections for debugging [Figure 2232A <<vervangen>>]

Test Case Result, STMA-69078 -

3. Switch the power supply OFF and, after waiting at least 2 seconds, ON again;

Test Case Result, STMA-69079 -

4. The LEDs A and C on the front of the SAP Board flash orange. Continue with 6.4 Loading the software on the TIVA (co)processor;.

6.4 Loading the software on the TIVA (co)processor

Test Case Result, STMA-69077 -

1. Establish power supply to the SAP Board

- Apply 12 V DC to the pins A18 and C18 (+) and A15 and C15 (-) of the Backplane connector;

Definition, STMA-69075 -

Figure 17: Hardware connections for loading the software on the TIVA co(processor) [Figure 2223A – 2226A <<vervangen>>]

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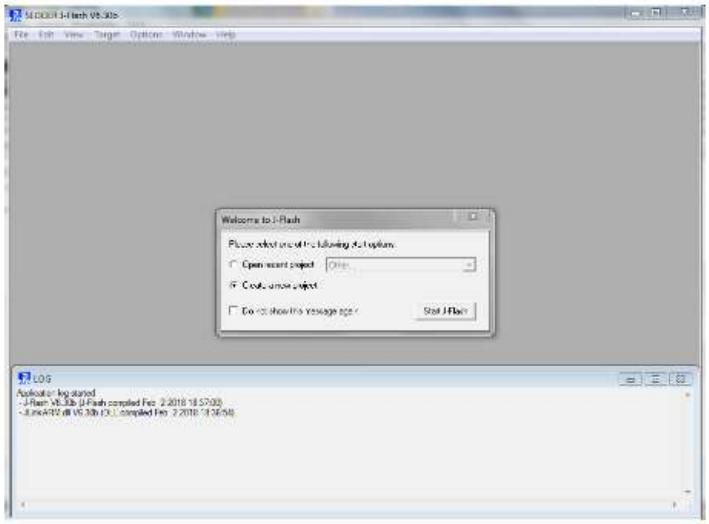
Test Case Result, STMA-69124 -

2. Connect a USB port of the laptop with the X1200 connector on the SAP Board.

- Using the JLink cable connector (Figure 17, STMA-69075);

3. Open the software loading program “J-Flash V6.30b” on the laptop;
4. The pop-up “Welcome to J-Flash” appears. Select “Create a new project” (Figure 18, STMA-69313).



Definition, STMA-69313 -
Figure 18: Welcome to J-Flash [Project]

Test Case Result, STMA-69125 -

5. The pop-up “Create New Project” appears. Click the “Target Device” browse button “…” (Figure 19, STMA-69126);

Definition, STMA-69126 -

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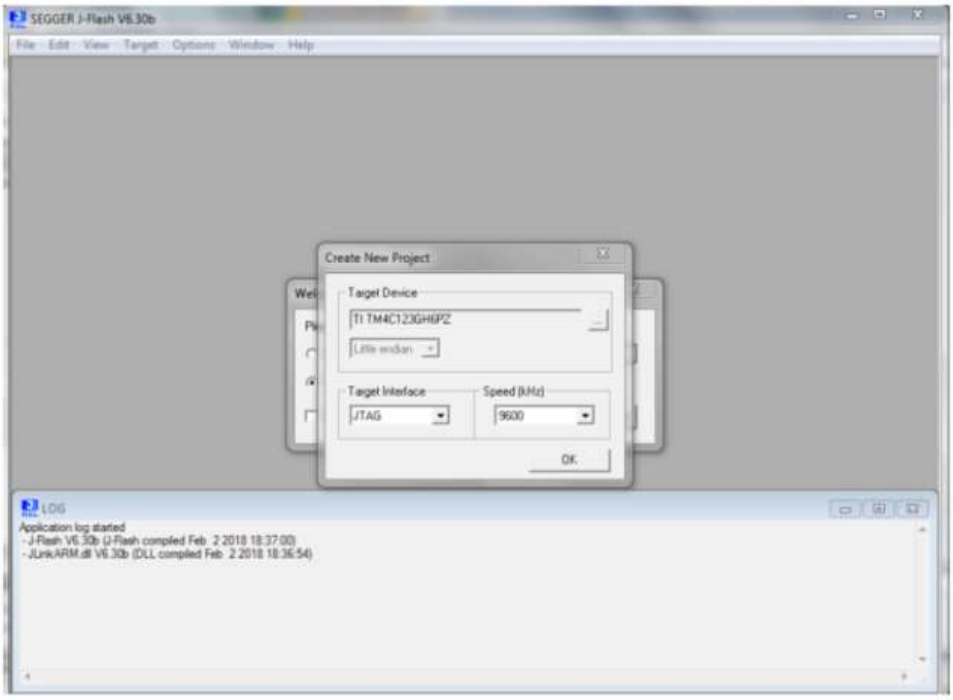

Figure 19: Create new project 1 [Project_settings]

Test Case Result, STMA-69148 -

6. The “Select Device” browse window appears. First select Manufacturer “TI”, then select Device “TM4C123GH6PZ” and click “OK” (Figure 20, STMA-69149);

Definition, STMA-69149 -

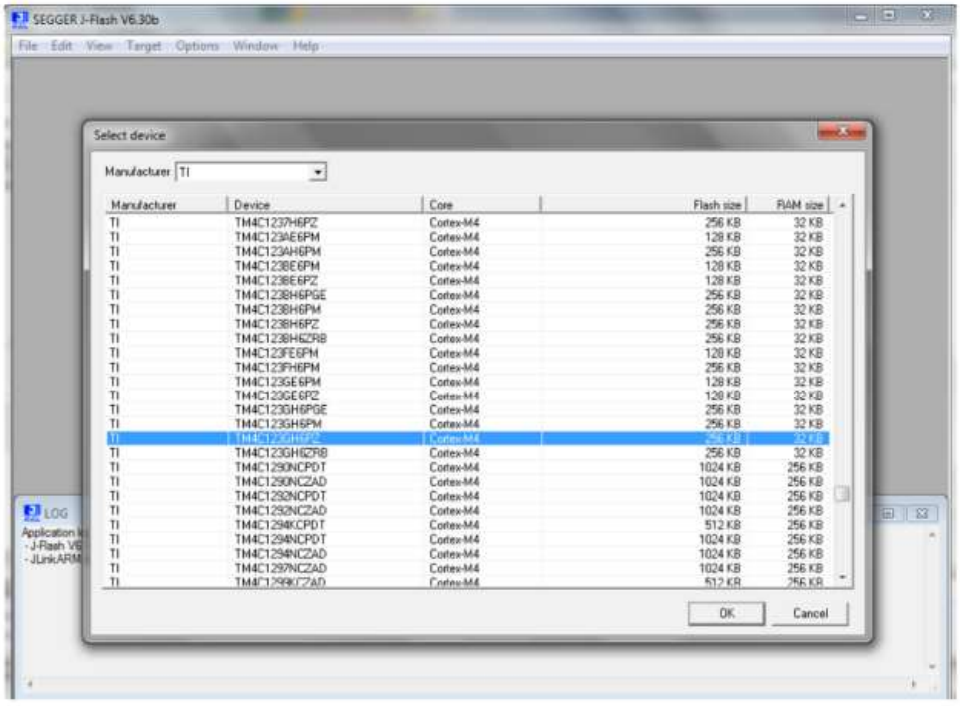

Figure 20: Select device [Project_device]

Test Case Result, STMA-69139 -

7. The pop-up “Create New Project” re-appears. Select “Target Interface” “JTAG”, then “Speed [kHz]” “9600” and click “OK” (Figure 21, STMA-69140);

Definition, STMA-69140 -

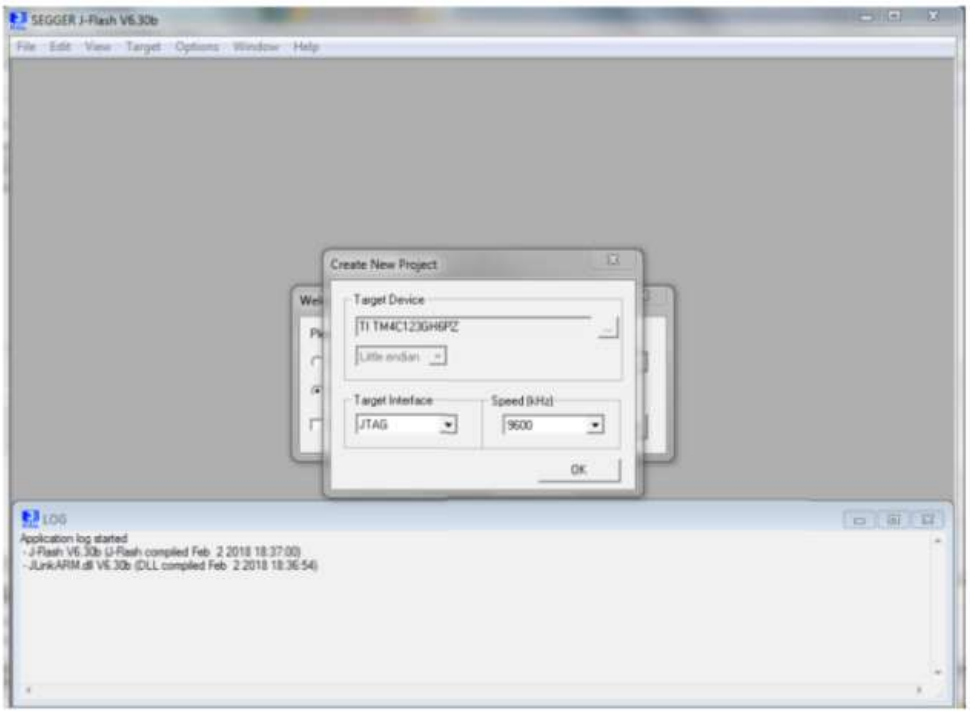

Figure 21: Create new project 2 [Project_settings]

Test Case Result, STMA-69137 -

8. Click “File” (on the top ribbon) and select “Open data file” on the pop-up (Figure 22, STMA-69138).

Definition, STMA-69138 -

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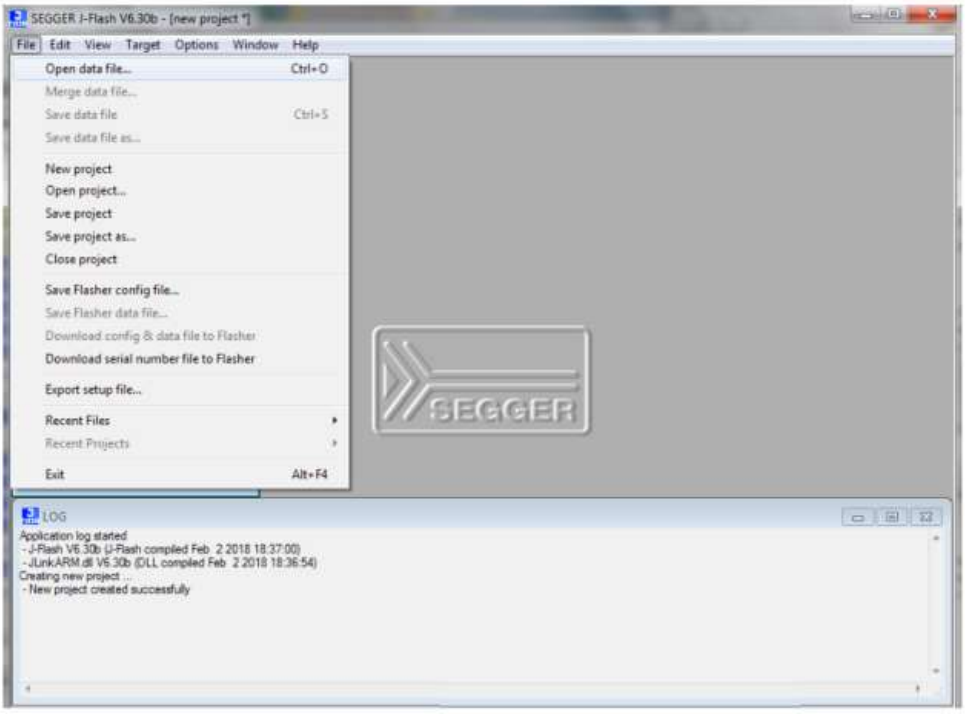

Figure 22: Open data file [LoadFile_1]

Test Case Result, STMA-69144 -

9. The Explorer window “Open data file” opens. Select File type “.bin”, then select file “ppmain.bin” and click “open” (Figure 23, STMA-69146);

Definition, STMA-69146 -

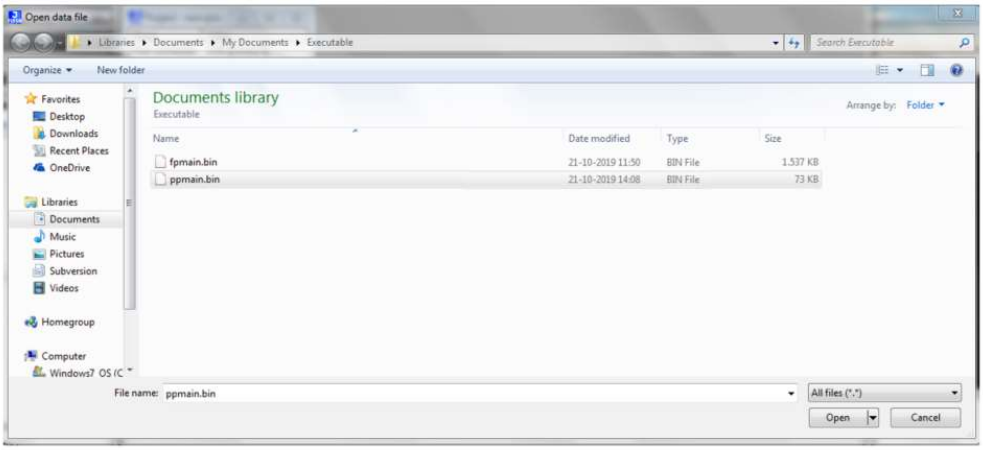

Figure 23: Select data file [LoadFile_2]

Test Case Result, STMA-69141 -

10. The pop-up “Enter start address” appears. Enter “0” and click “OK” (Figure 24, STMA-69153);

Definition, STMA-69153 -

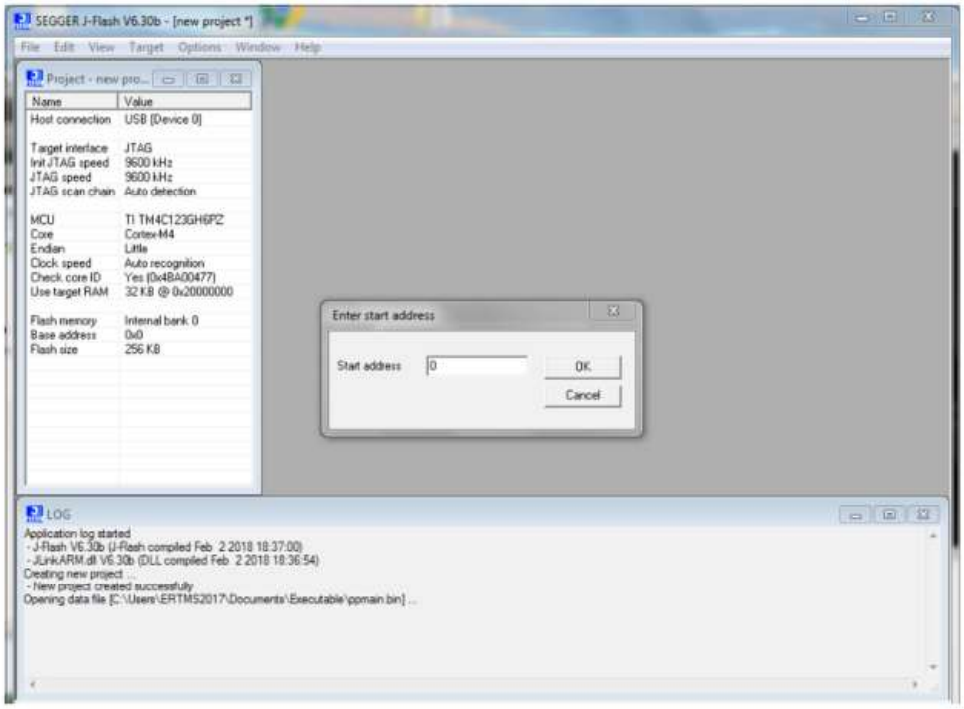

Figure 24: Enter start address [LoadFile_3]

Test Case Result, STMA-69155 -

11. The file “ppmain.bin” now loads and the screen “….\Executable\ppmain.bin” appears (Figure 25, STMA-69151);

Definition, STMA-69151 -

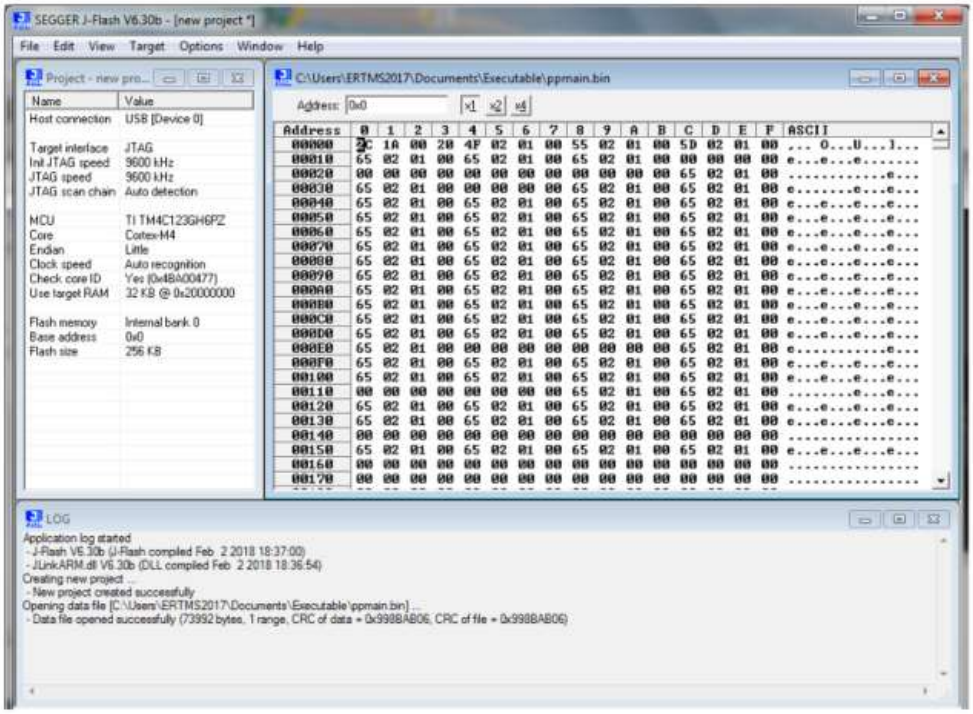

Figure 25: Screen ppmain.bin [LoadFile_done]

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Test Case Result, STMA-69152 -

12. Click “Target” (on the top ribbon) and select “Connect” on the pop-up (Figure 26, STMA-69150);

Definition, STMA-69150 -

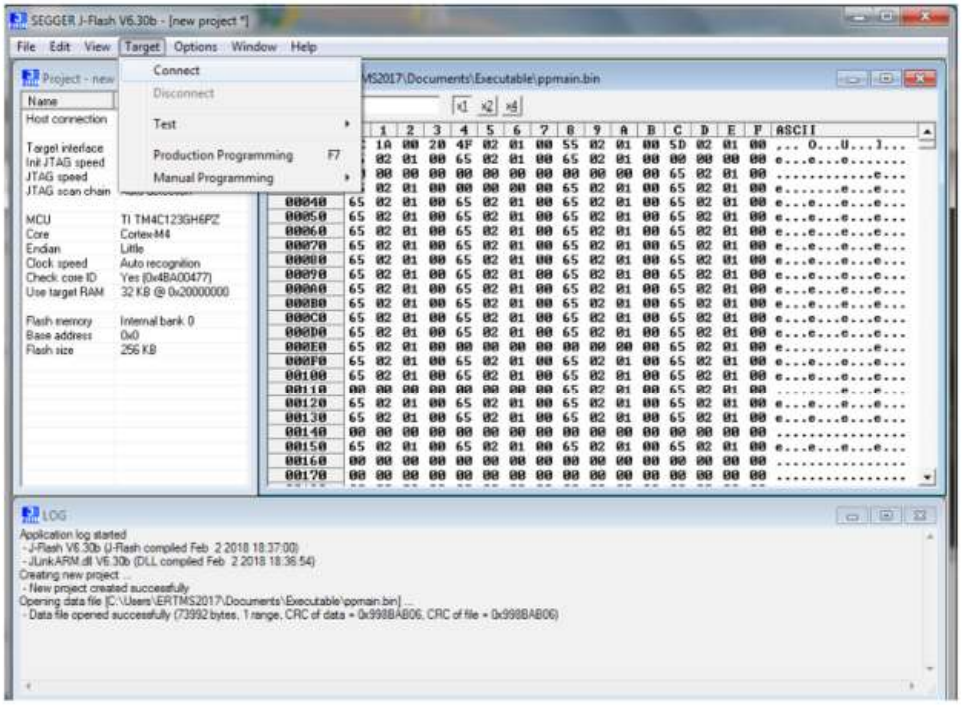


Figure 26: Connect target [Connect]

Test Case Result, STMA-69145 -

13. If the pop-up “J-Link V6.30b Internal Error” appears, ignore the error, click “OK” (Figure 27, STMA-69147), and continue with step 14, immediately if this error message doesn’t appear;

Definition, STMA-69147 -

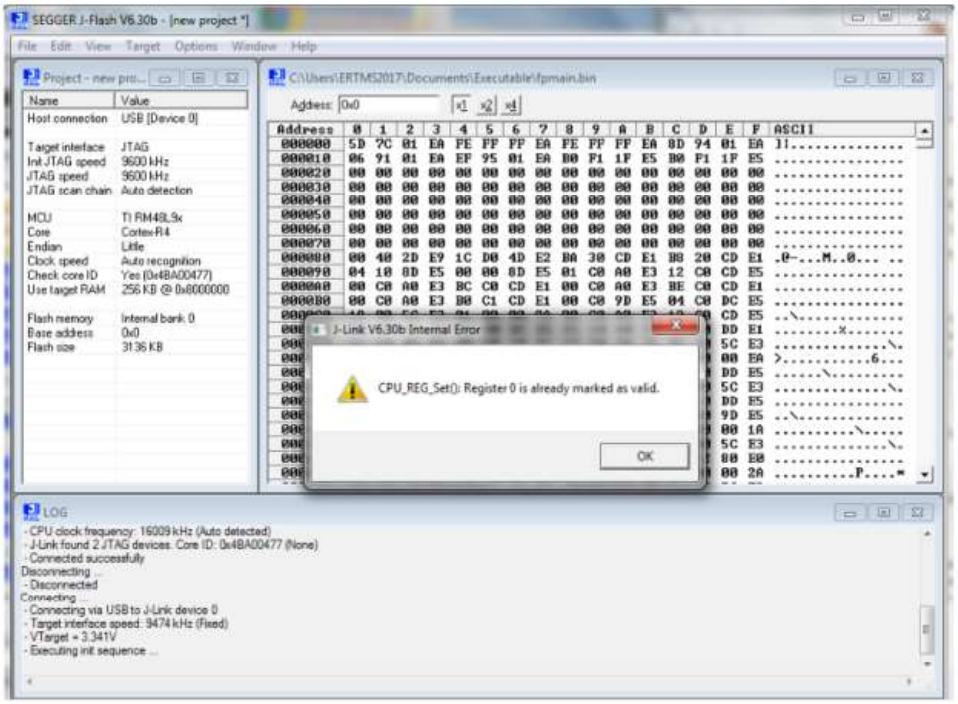


Figure 27: Internal error [Connect_error]

Test Case Result, STMA-69142 -

14. Again click “Target” (on the top ribbon) and select “Production Programming” on the pop-up (Figure 28, STMA-69143);

Definition, STMA-69143 -

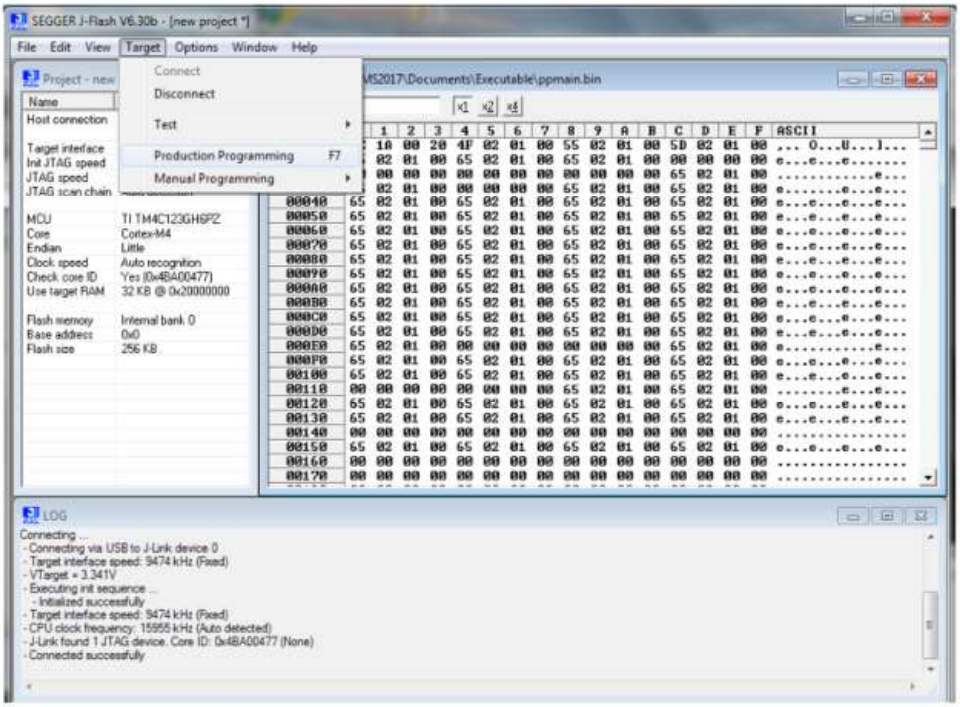


Figure 28: Production programming [Program]

Test Case Result, STMA-69136 -

15. The software is immediately loaded on the TIVA (co)processor and the message “Target erased, programmed and verified successfully – Completed after … sec” appears. Click “OK” (Figure 29, STMA-69134);

Definition, STMA-69134 -

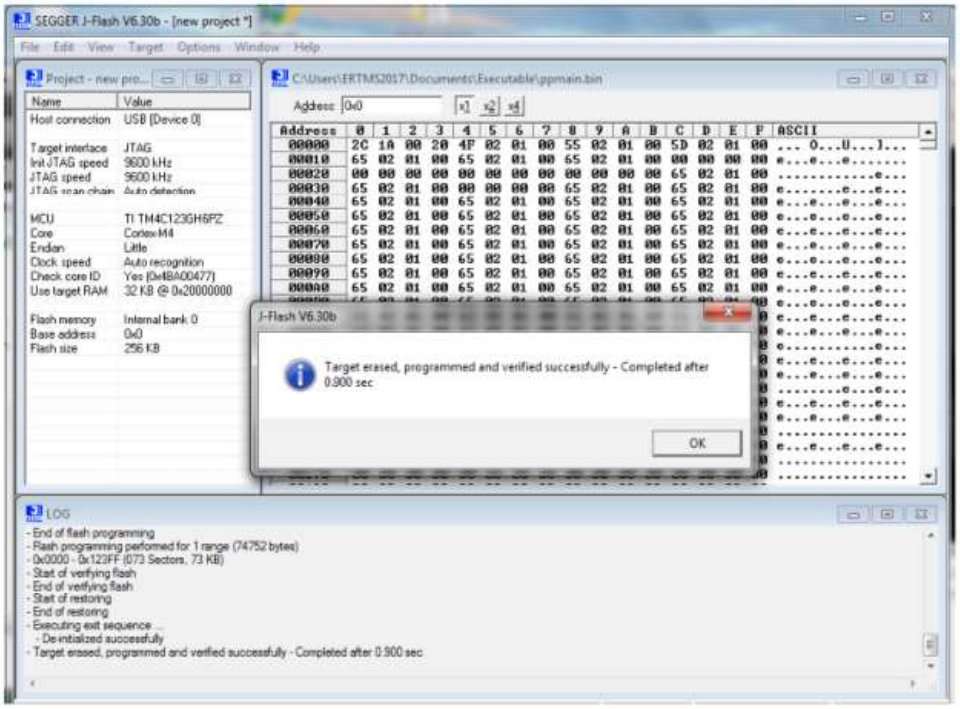


Figure 29: TIVA programmed and verified successfully [Program_done]

Test Case Result, STMA-69135 -

16. The software is successfully loaded on the TIVA (co)processor. Close the program “J-Flash V6.30b” on the laptop by clicking “X” in the top right corner of the screen;

- If the message “Target erased, programmed and verified successfully – Completed after … sec” does not appear, the loading of the software on the TIVA (co)processor is not confirmed or failed. In that case only, go back to step 3 and follow the procedure from there for a second time;

Test Case Result, STMA-69132 -

17. Disconnect the JLink cable connector from connector X1200 on the SAP Board and continue with 6.5 Loading the software on the netX processor.

6.5 Loading the software on the netX processor

Test Case Result, STMA-69130 -

1. Establish power supply to the SAP Board

- Apply 12 V DC to the pins A18 and C18 (+) and A15 and C15 (-) of the Backplane connector;

Definition, STMA-69131 -

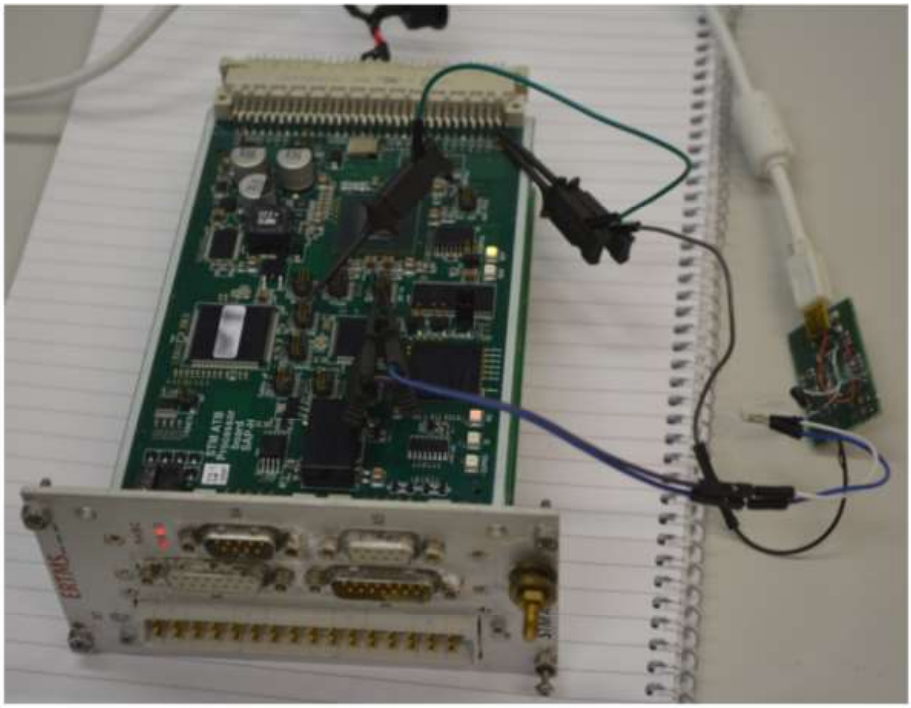


Figure 30: Hardware connections for loading the software on the netX processor [Figure 2250A <<vervangen>>]

Test Case Result, STMA-69160 -

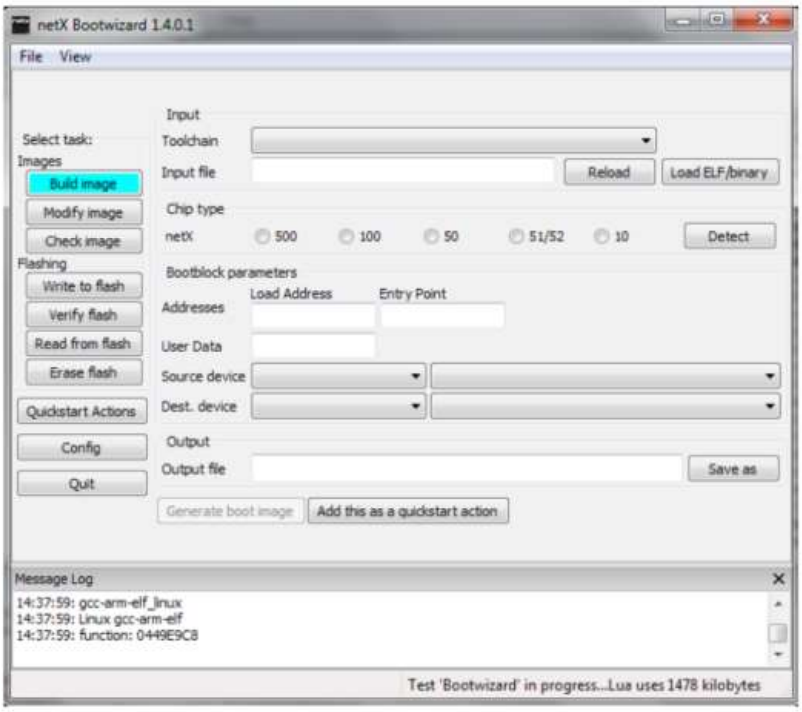
2. Connect a USB port of the laptop with the pins 9 (-) and 10 (+) of the X101 connector on the SAP Board:

- Using the bootloader X1500 jumper (Figure 30, STMA-69131);

The LED “RDY” flashes yellow;

Test Case Result, STMA-69161 -

3. Open the software loading program “netX Bootwizard 1.4.0.1” on the laptop;
4. The “netX Bootwizard 1.4.0.1” start screen appears with “Build image” selected (Figure 31, STMA-69159). Change the selection to “Write to flash”;

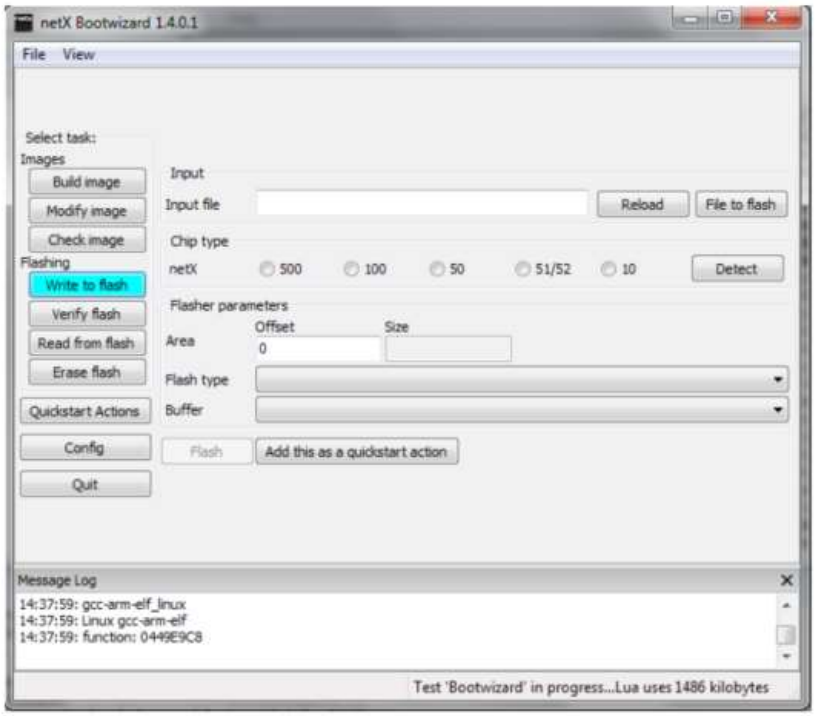


Definition, STMA-69159 -

Figure 31: netX Bootwizard start [Start]

Test Case Result, STMA-69157 -

5. The screen “Write to flash” appears. Click “Detect” (Figure 32, STMA-69158);



Definition, STMA-69158 -

Figure 32: Write to flash 1 [write_to_flash]

Test Case Result, STMA-69154 -

6. The “netX Bootwizard 1.4.0.1” detects the chiptype and the pop-up “Select the plugin” appears. Select the “romloader_uart” file (laptop dependent, in this example: “romloader_uart_COM6”) and click “OK” (Figure 33, STMA-69156);

Definition, STMA-69156 -

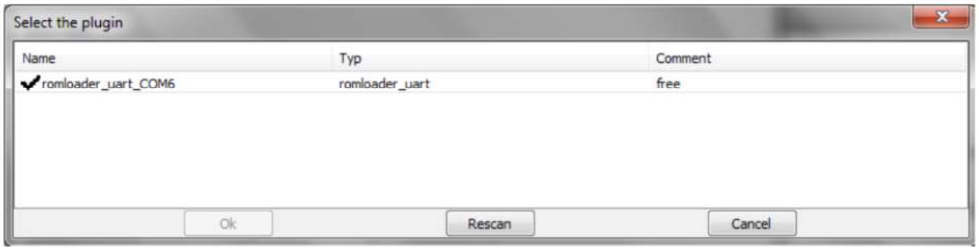


Figure 33: Select the plugin 1 [write_to_flash_detect]

Test Case Result, STMA-69179 -

7. The screen “Write to flash” (Figure 32) re-appears. Select “File to flash”. The pop-up “Select an input file” appears. Select File type “Binary, Boot Image or NXF Files” (“.bin”), then select file “NETX51-BSL.bin” and click “Open” (Figure 34, STMA-69180);

Definition, STMA-69180 -

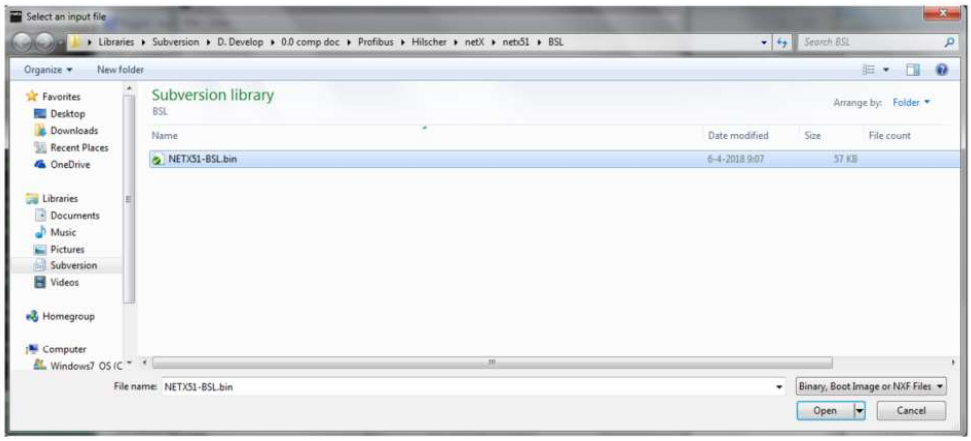


Figure 34: Select an input file [write_to_flash_file]

Test Case Result, STMA-69173 -

8. The pop-up “Information” appears with the message “the netX chip type and the source/destination devices could not be identified or there are multiple matches. Please select the correct chip type and Flash device”. Click “OK” (Figure 35, STMA-69174);

Definition, STMA-69174 -

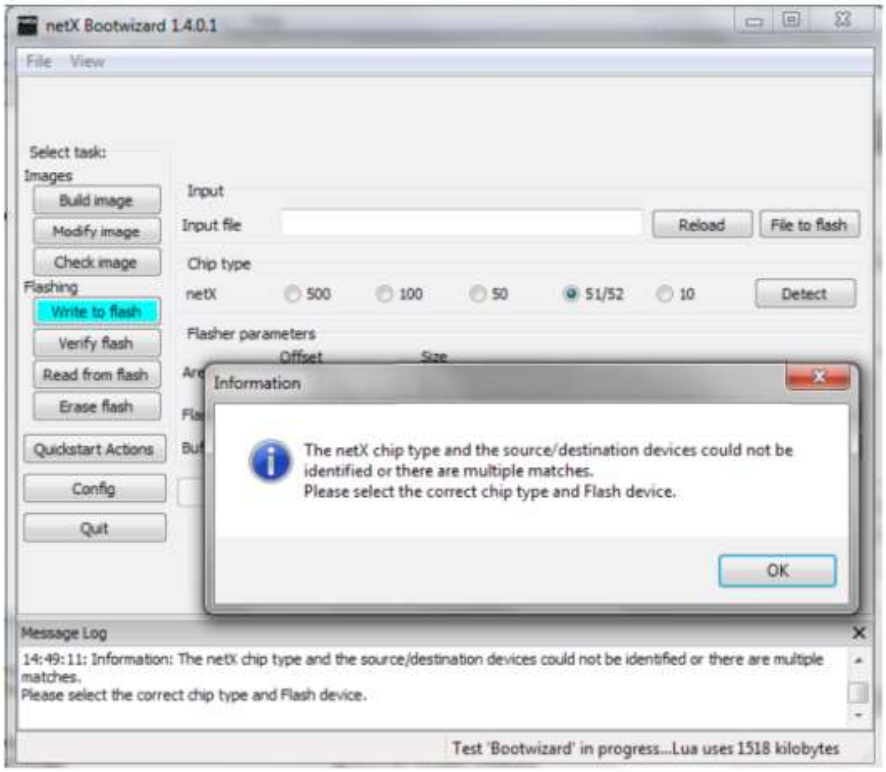
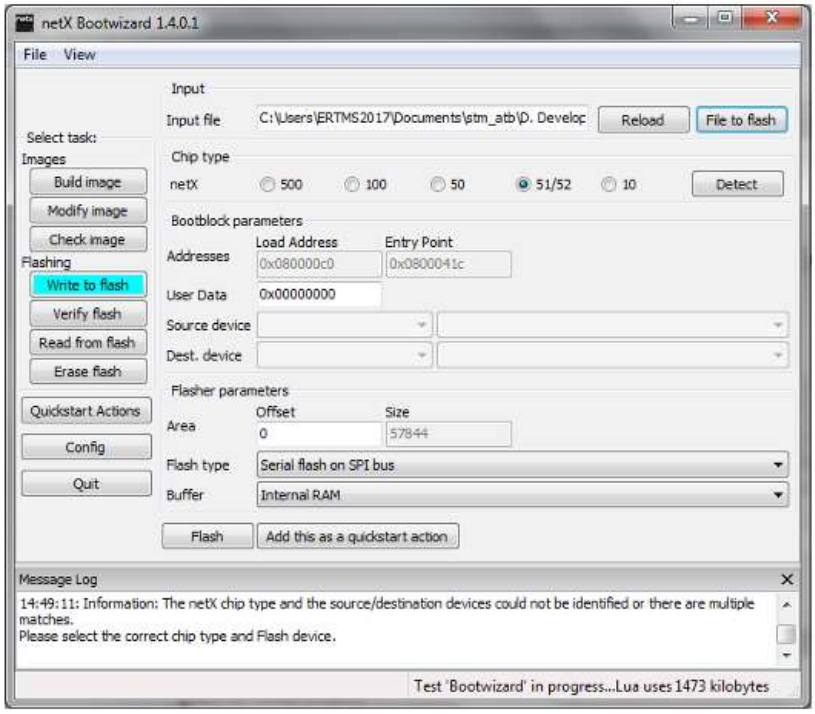


Figure 35: Information pop-up [write_to_flash_info_popup]

Test Case Result, STMA-69171 -

9. The screen “Write to flash” re-appears. Select “Flash” (Figure 36, STMA-69243);

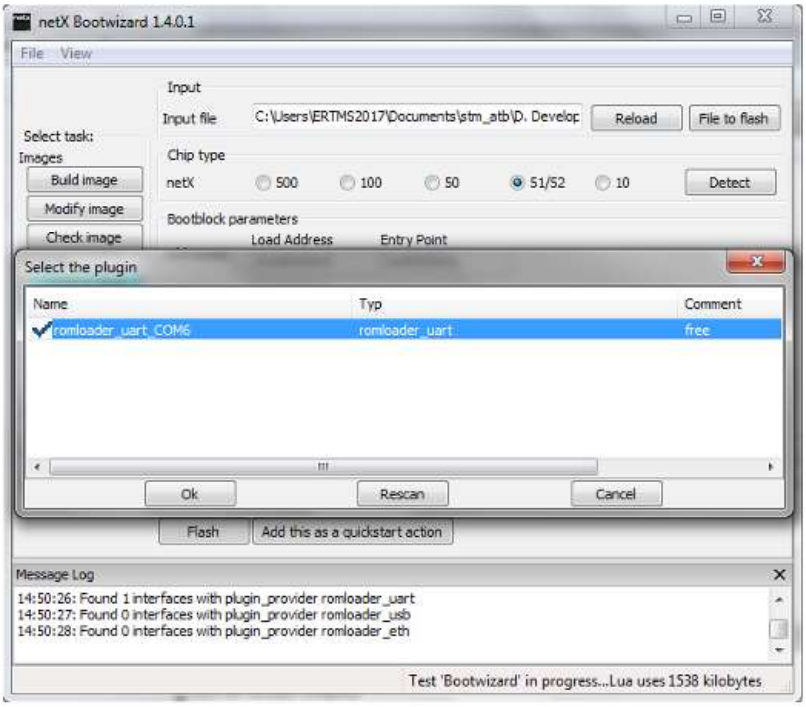


Definition, STMA-69243 -

Figure 36: Write to flash 2 [write_to_flash_new_screen]

Test Case Result, STMA-69172 -

10. The pop-up “Select the plugin” re-appears. Select “romloader_uart_COM6” once more and click “OK” (Figure 37, STMA-69244);

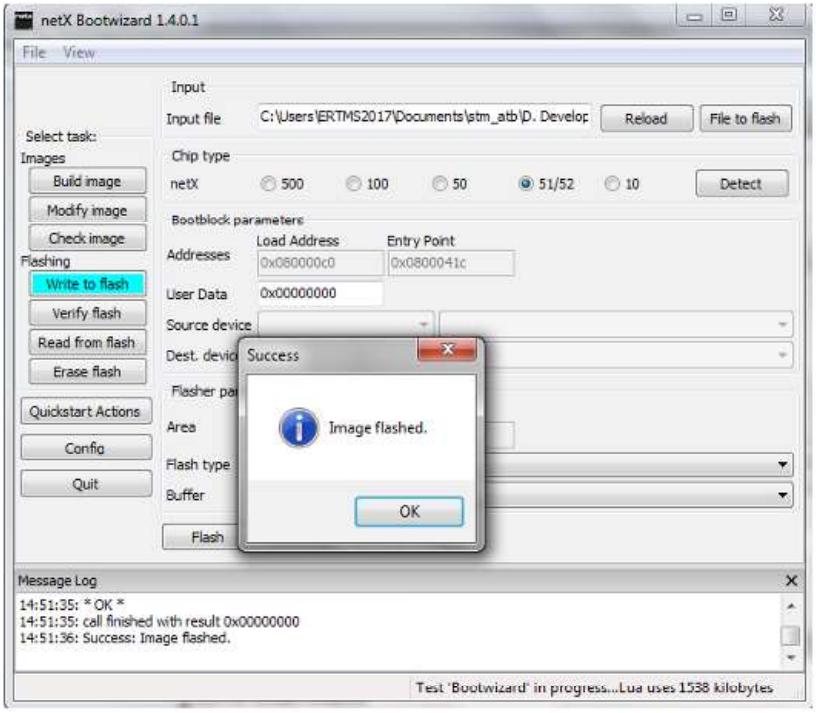


Definition, STMA-69244 -

Figure 37: Select the plugin 2 [write_to_flash_select]

Test Case Result, STMA-69176 -

11. The file “NETX51-BSL.bin” which was selected in step 7 is now loaded and the pop-up “Success” appears with the message “Image flashed” (Figure 38, STMA-69236);



Definition, STMA-69236 -

Figure 38: Success - Image flashed [write_to_flash_done]

Test Case Result, STMA-69178 -

12. Remove the jumper from the pins 9 (-) and 10 (+) of the X101 connector;
13. Switch the power supply to the SAP Board “OFF” and, after waiting at least 2 seconds, ON again;
14. Open the software loading program “netHOST v1.0.0.0” on the laptop. The “netHOST Device Test Application” start screen appears. (Figure 39, STMA-69237);

Definition, STMA-69237 -

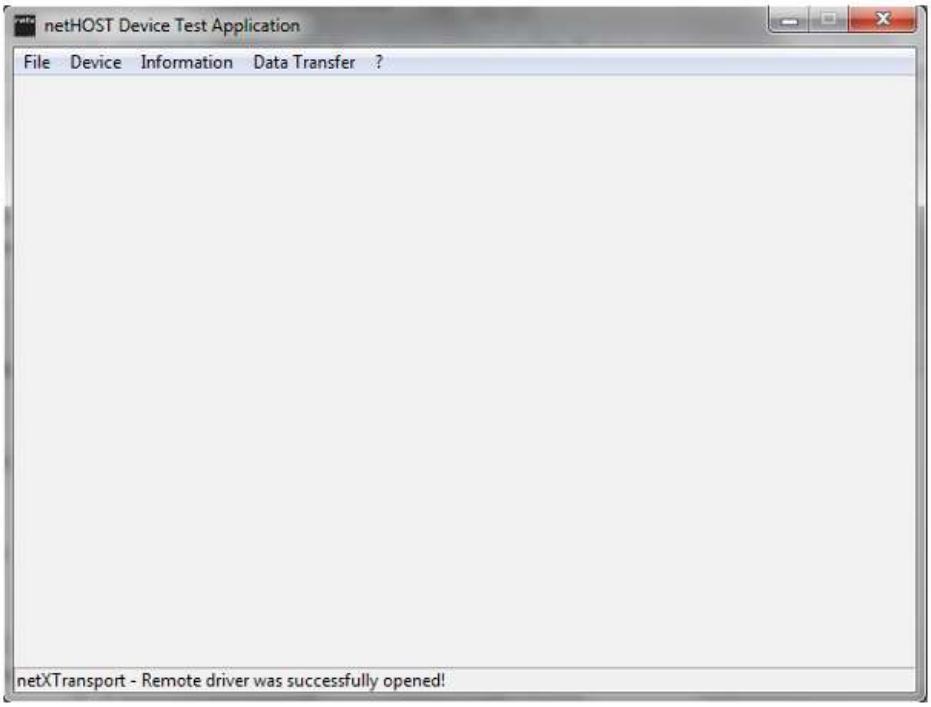


Figure 39: netHOST start [netHOST_start]

Test Case Result, STMA-69175 -

15. Click “Device” (on the top ribbon) and select “Open” on the pop-up (Figure 40, STMA-69234);

Definition, STMA-69234 -

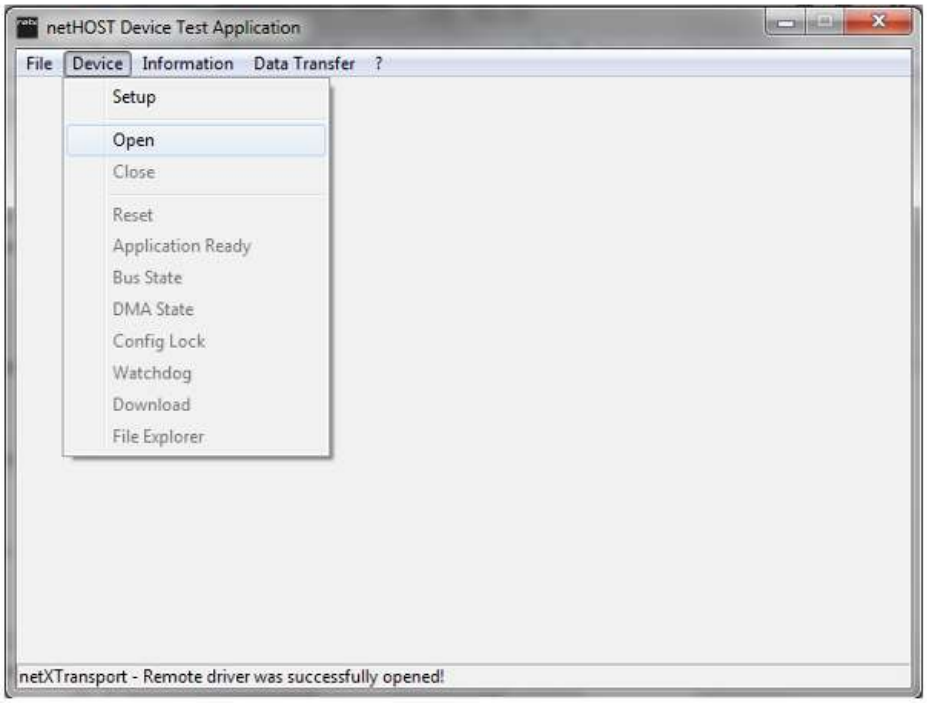


Figure 40: Open device [netHOST_open_1]

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Test Case Result, STMA-69169 -

16. The pop-up “Channel selection” appears. Select “COM8_cifX0” and click “Open” (Figure 41, STMA-69235);

Definition, STMA-69235 -

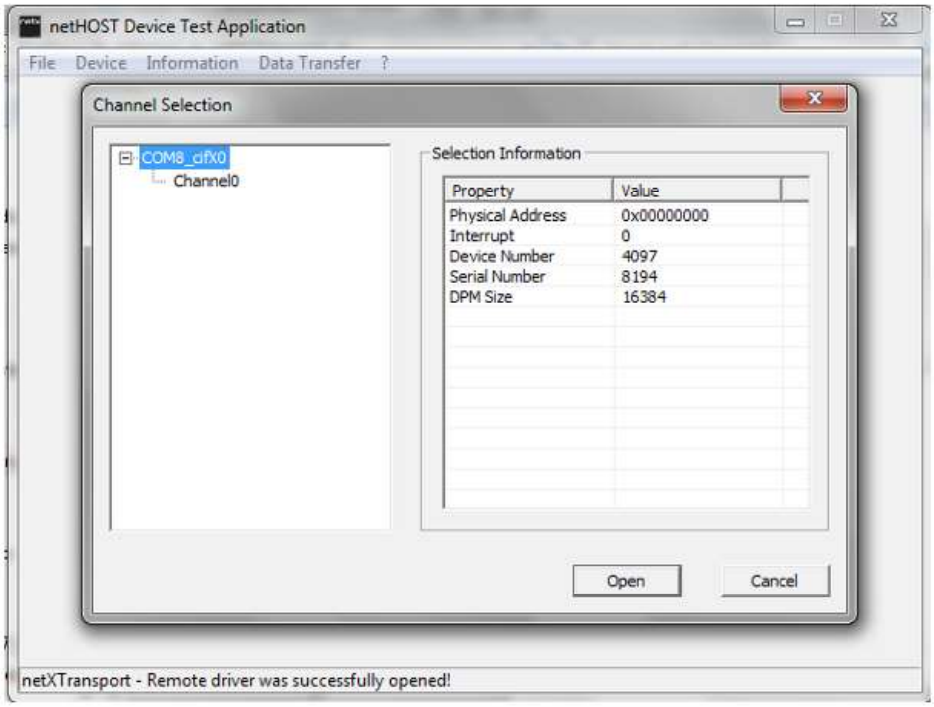

Figure 41: Channel selection [netHOST_open_2]

Test Case Result, STMA-69170 -

17. The pop-up “netHOST Device Test Application – COM8_cifX0” opens with (on the bottom line) the message “netXTransport – Remote driver was successfully opened!”. (Figure 42, STMA-69239);

Definition, STMA-69239 -

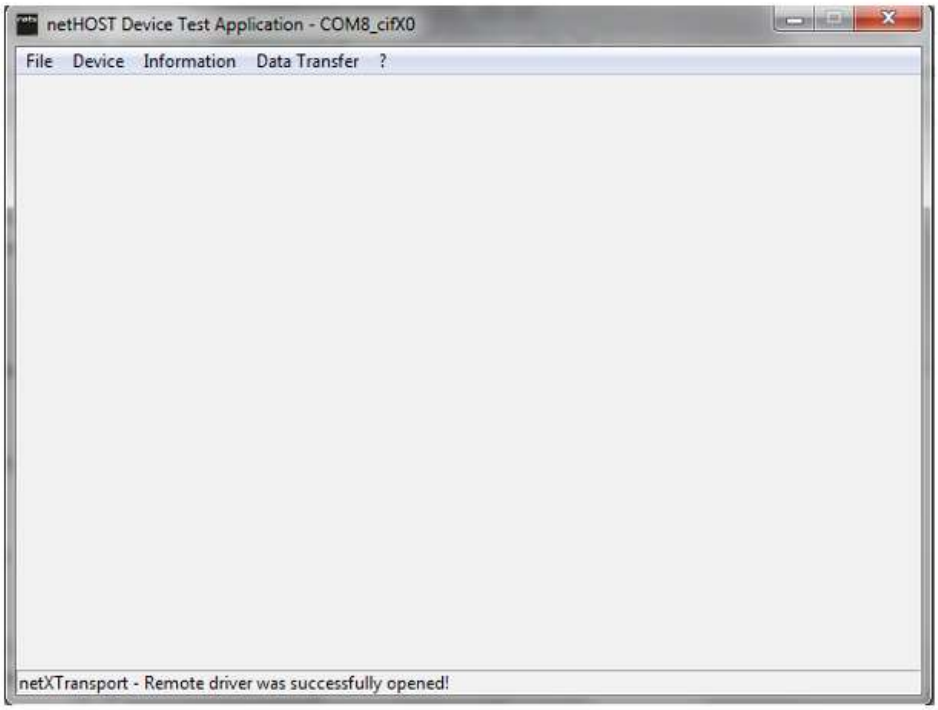

Figure 42: Remote driver was successfully opened [netHOST_open_succes]

Test Case Result, STMA-69167 -

18. Click “Device” (on the top ribbon) and select “Download” on the pop-up (Figure 43, STMA-69241);

Definition, STMA-69241 -

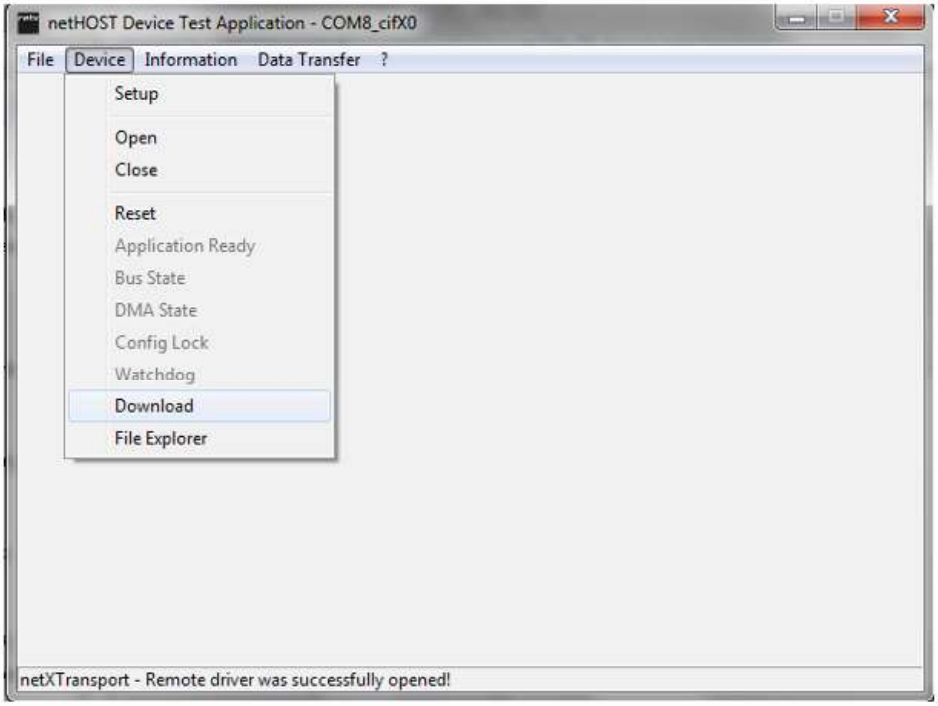

Figure 43: Download device [netHOST_download_1]

Test Case Result, STMA-69168 -

19. The Explorer window “Open”opens. Select the file type “netX Firmware Files”, the file “X0601000.nxf” and click “Open” (Figure 44, STMA-69238);

Definition, STMA-69238 -

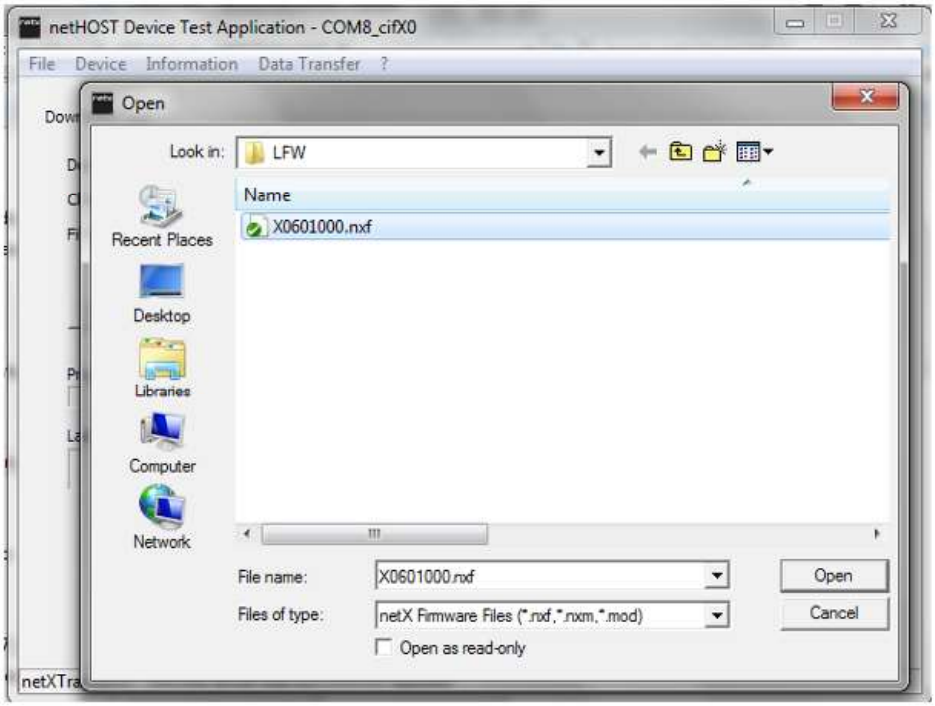

Figure 44: Open file [netHOST_download_file]

Test Case Result, STMA-69165 -

20. The pop-up “netHOST Device Test Application – COM8_cifX0” appears. Select the “Download Mode” “Firmware Download” and click “Download” (Figure 45, STMA-69282);

Definition, STMA-69282 -

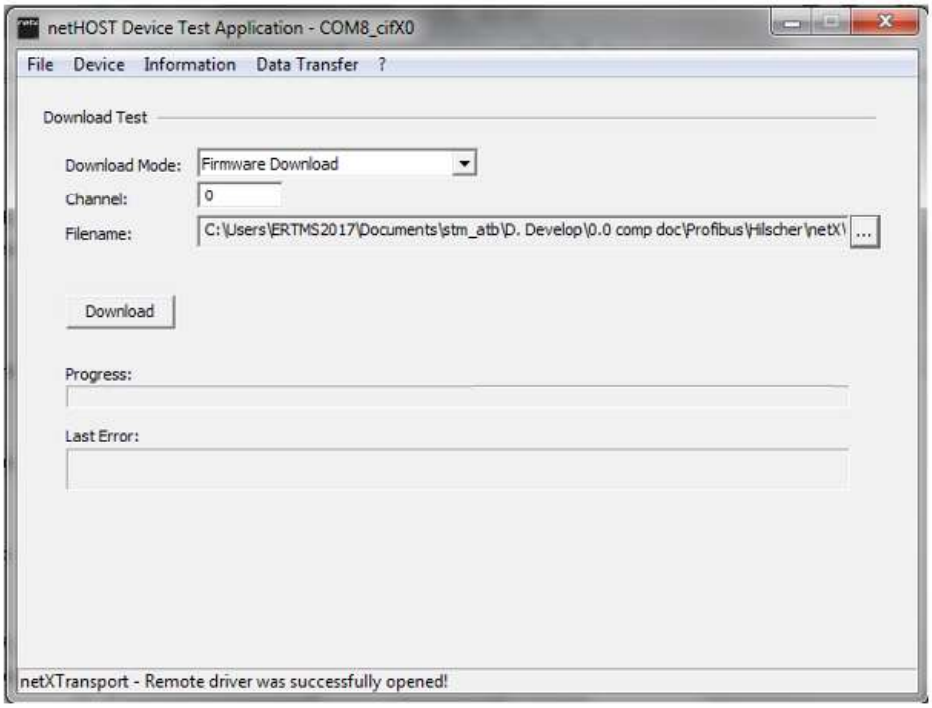

Figure 45: Download mode [netHOST_download_settings]

Test Case Result, STMA-69166 -

21. The Progress bar on the pop-up "netHOST Device Test Application – COM8_cifX fills. Once the Progress bar is filled to completion, the software is successfully loaded on the netX processor. Close the program "netHOST" on the laptop by clicking "X" in the top right corner of the screen (Figure 46, ! STMA-69284);

Definition, STMA-69284 -

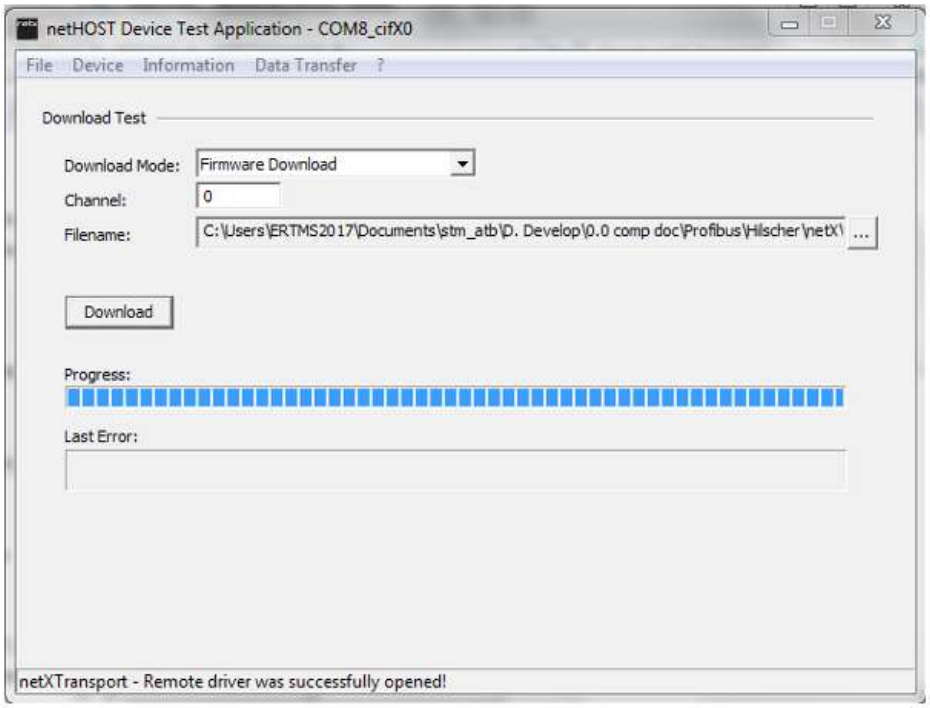

Figure 46: Progress bar [netHOST_download_done]

Test Case Result, STMA-69177 -

22. Disconnect the JLink cable connector from connector X901 on the SAP Board and continue with 6.6 Loading the software on the FPGA processor.

6.6 Loading the software on the FPGA processor

Test Case Result, STMA-69281 -

1. Establish power supply to the SAP Board

- Apply 12 V DC to the pins A18 and C18 (+) and A15 and C15 (-) of the Backplane connector;

Definition, STMA-69278 -

Figure 47: Hardware connections for loading the software on the FPGA processor [Figure 2235A <<vervangen>>]

Test Case Result, STMA-69279 -

2. Connect a USB port of the laptop with the X400 connector on the SAP Board

- Using the JLink cable connector (Figure 47, STMA-69278);

3. Open the software loading program “Vivado 2017.3” on the laptop;
4. The Vivado start screen appears appears. On the tile “Tasks”, select “Open hardware manager” (Figure 48, STMA-69271 - Figure 48: Vivado start [sc02]);

Definition, STMA-69271 -

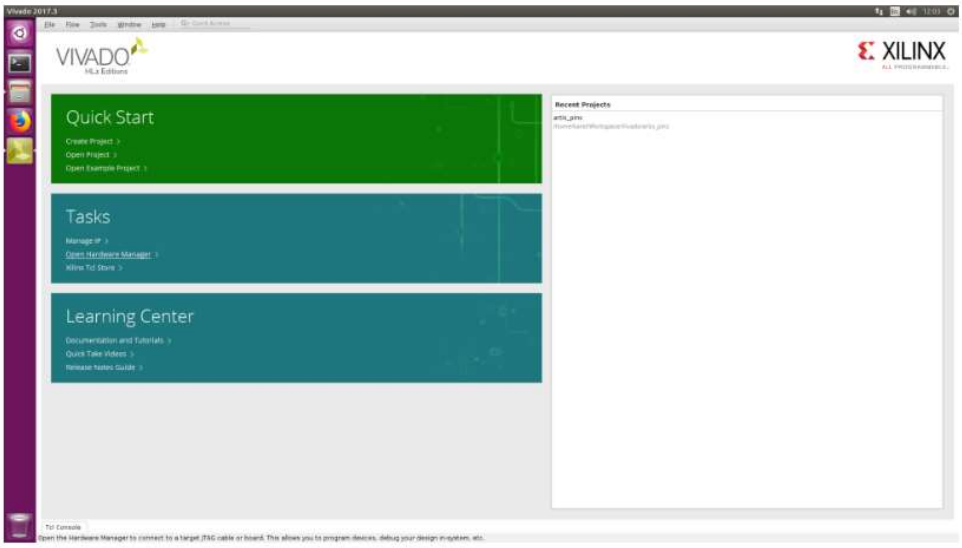

Figure 48: Vivado start [sc02]

Test Case Result, STMA-69272 -

5. The hardware manager opens and just below the top of the screen a green information bar shows the message “No hardware target is open”. Click “Open target” just behind this message (Figure 49, STMA-69252);

Definition, STMA-69252 -

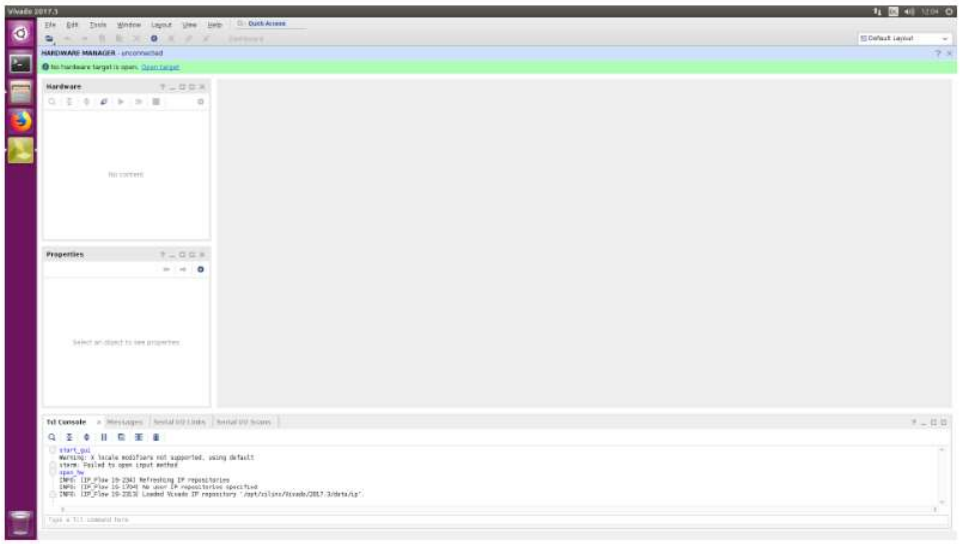

Figure 49: Open target [sc03]

Test Case Result, STMA-69269 -

6. A pop-up opens. Select “Auto Connect” to connect to the target (Figure 50, STMA-69249);

Definition, STMA-69249 -

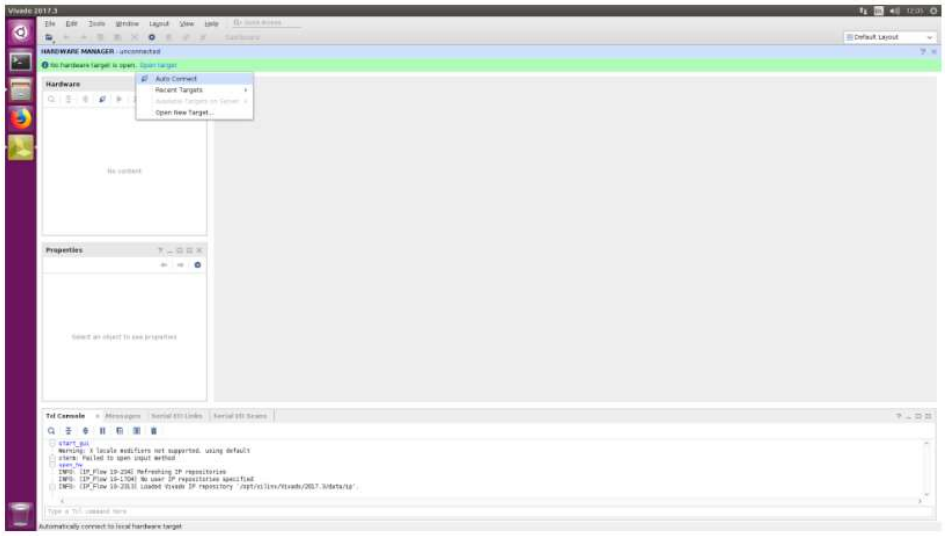

Figure 50: Auto connect [sc04]

Test Case Result, STMA-69270 -

7. The “Hardware” pane on the upper left-hand side of the screen fills. Right-click the file “xc7a200t” in the “Hardware” pane. A pop-up appears; left-click “Add Configuration Memory Device” (Figure 51, STMA-69250);

Definition, STMA-69250 -

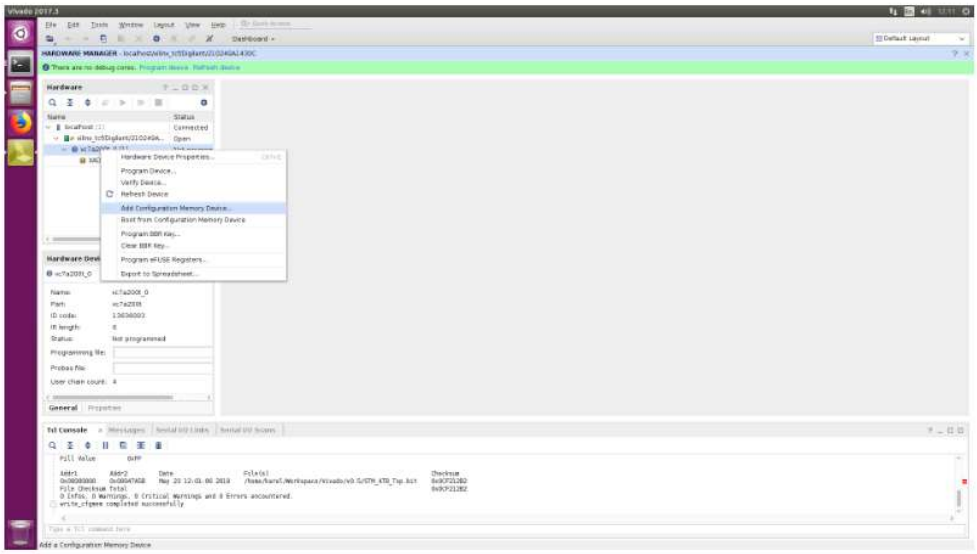

Figure 51: Add configuration memory device 1 [sc16]

Test Case Result, STMA-69268 -

8. The Explorer window “Add Configuration Memory Device” appears. Select “Manufacturer” “Micron”, then “Density (Mb)” “256”, “Type” “spi”. and “mt25ql-256-spi-x1_x2_x4” Alias “n25q256-3.3v- spi-x1_x2_x4”. Then click “OK” (Figure 52, STMA-69247);

Definition, STMA-69247 -

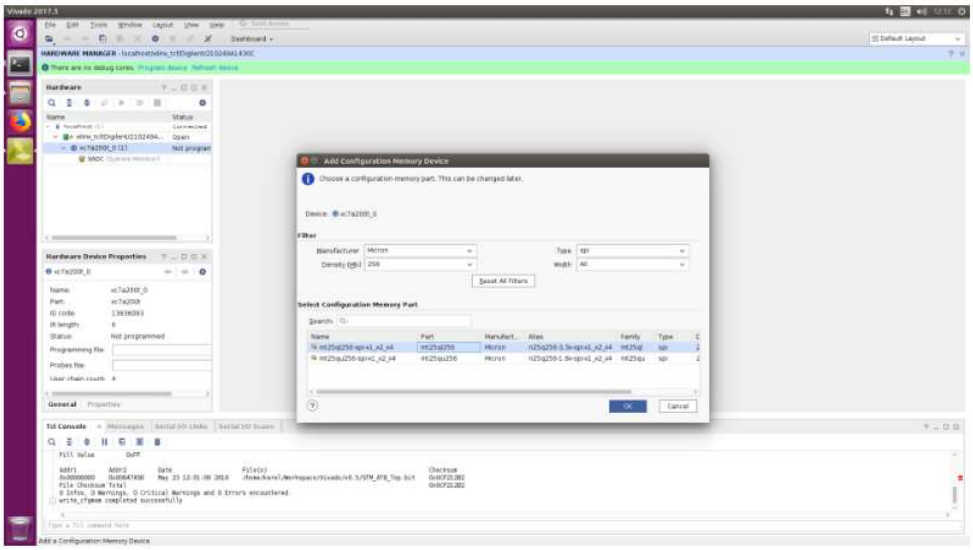

Figure 52: Add configuration memory device 2 [sc17]

Test Case Result, STMA-69266 -

9. The pop-up “Add Configuration Memory Device completed” appears. Click “OK” to program the memory configuration device (Figure 53, STMA-69248):

- Alternatively, if the pop-up “Add Configuration Memory Device completed” doesn’t appear, right-click the memory configuration device “mt25ql-256-spi-x1_x2_x4” in the “Hardware” pane on the upper left-hand side of the screen. A pop-up appears; left-click “Program Configuration Memory Device” (Figure 54, STMA-69245);

Definition, STMA-69248 -

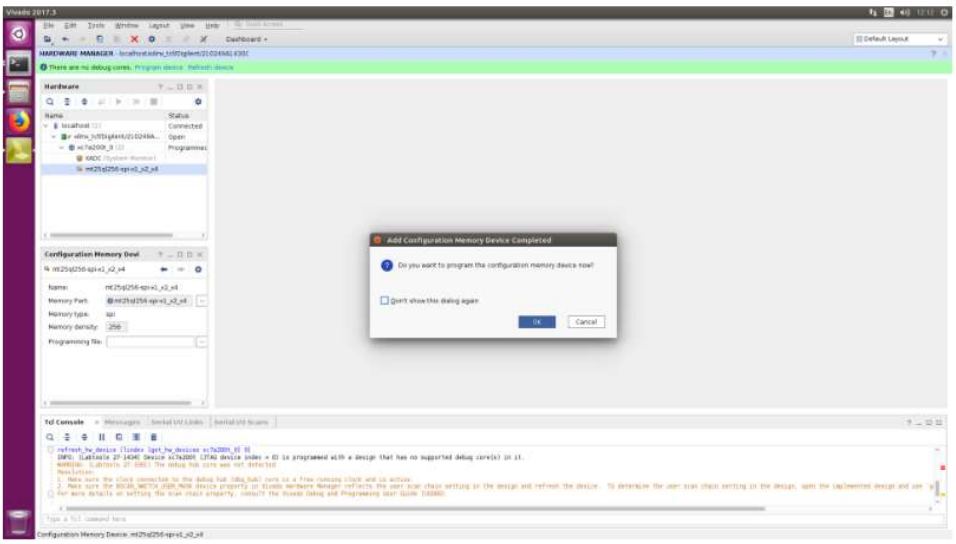

Figure 53: Add configuration memory device completed [sc18]

Definition, STMA-69245 -

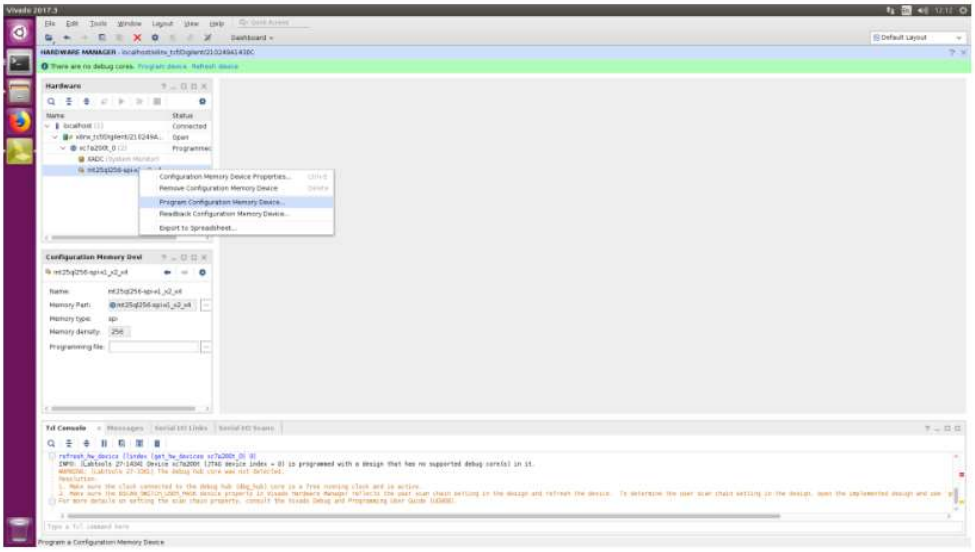

Figure 54: Program configuration memory device 1 [sc19]

Test Case Result, STMA-69267 -

10. The pop-up “Program Configuration Memory Device” opens. Click the “…” button on the right-hand side of the “Configuration file” line on the pop-up to open the explorer window (Figure 55, STMA-69246);

Definition, STMA-69246 -

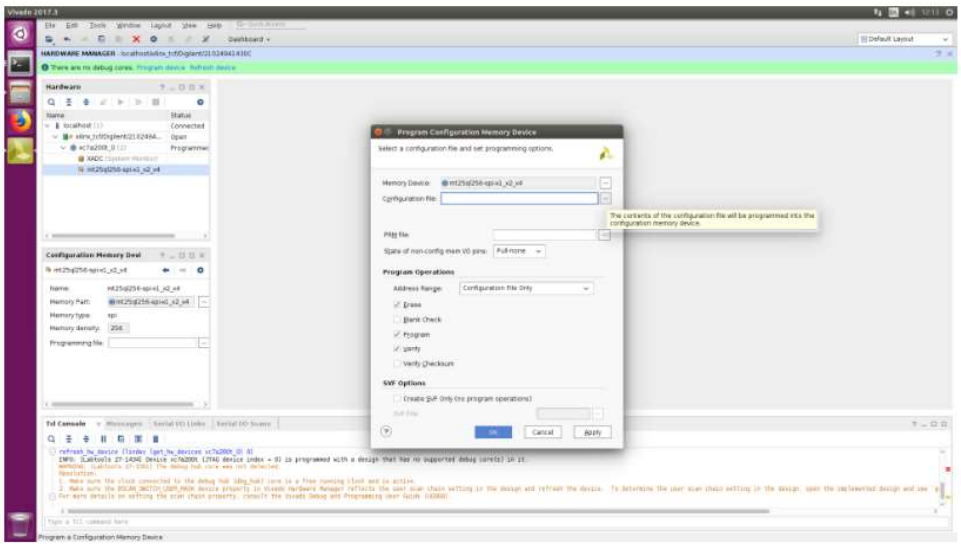

Figure 55: Program configuration memory device 2 [sc20]

Test Case Result, STMA-69264 -

11. The explorer window “Specify File” opens. Select the memory configuration file (in this example “home/karel/Workspace/Vivado/v0.5/image.mcs”) and click “OK” (Figure 56, STMA-69240);

Definition, STMA-69240 -

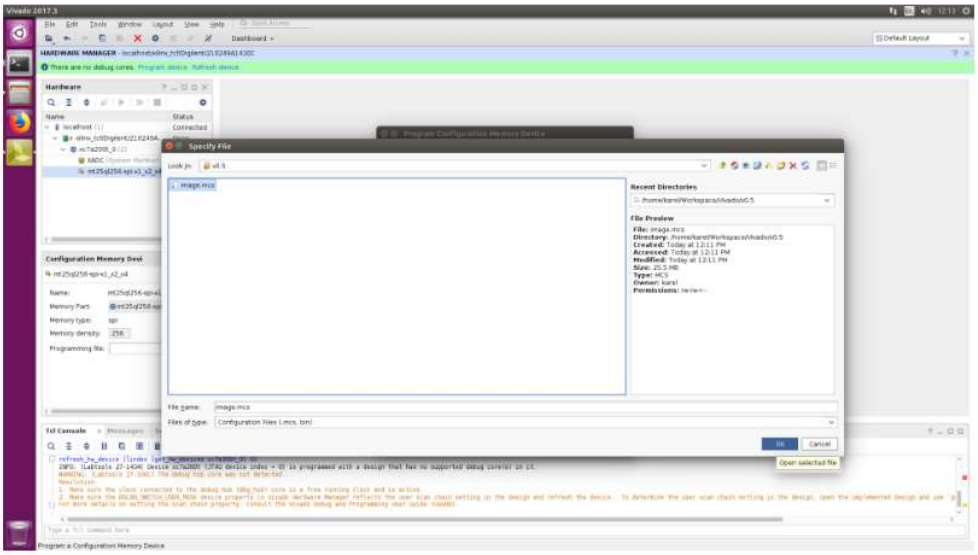

Figure 56: Specify file [sc21]

Test Case Result, STMA-69265 -

12. The pop-up “Program Configuration Memory Device” re-appears, Click the “…” button on the right-hand side of the “PRM file” line on the pop-up (Figure 55, STMA-69246) to open the explorer window (Figure 57, STMA-69242) where you can save the .prm file on the path chosen in step 11
(in this example “home/karel/Workspace/Vivado/v0.5/image.prm”);

Definition, STMA-69242 -

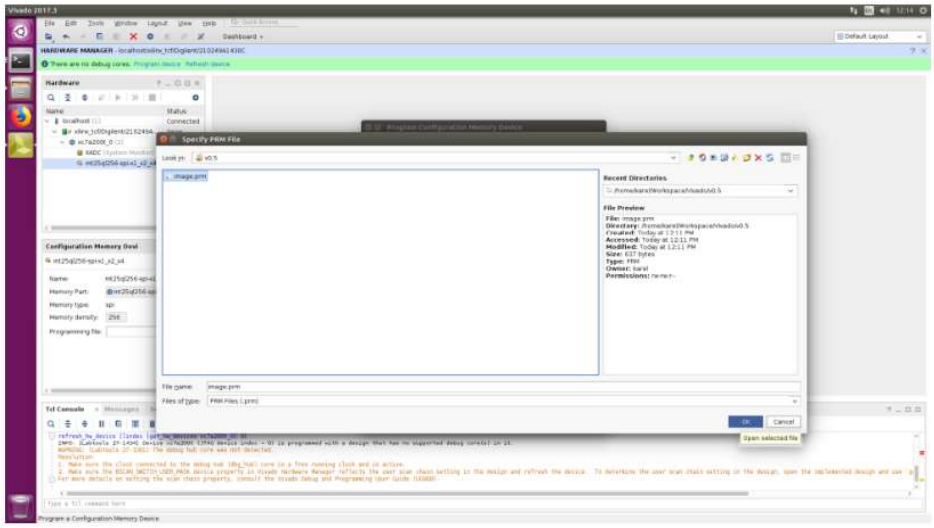

Figure 57: Specify PRM file [sc23]

Test Case Result, STMA-69262 -

13. The pop-up “Program Configuration Memory Device” re-appears again. Select “Erase”, “Program”, “Verify” and “Verify checksum” and click “OK” (Figure 58, STMA-69225);

Definition, STMA-69225 -

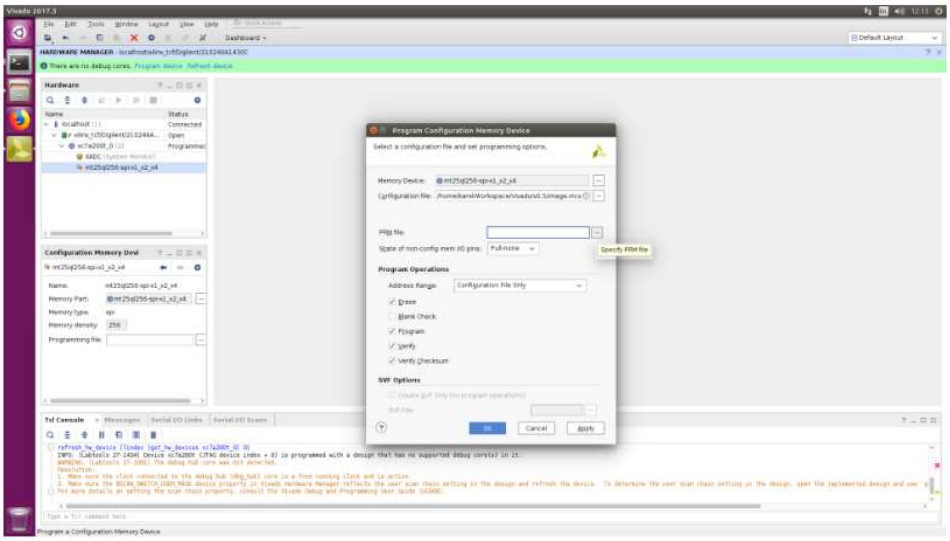

Figure 58: Program configuration memory device 2 [sc22]

Test Case Result, STMA-69263 -

14. The selected software is now loaded on the FPGA. Depending on the selection one or more consecutive progress bars in the pop-up “Program Configuration Memory Device” appear (Figure 59, STMA-69232);

Definition, STMA-69232 -

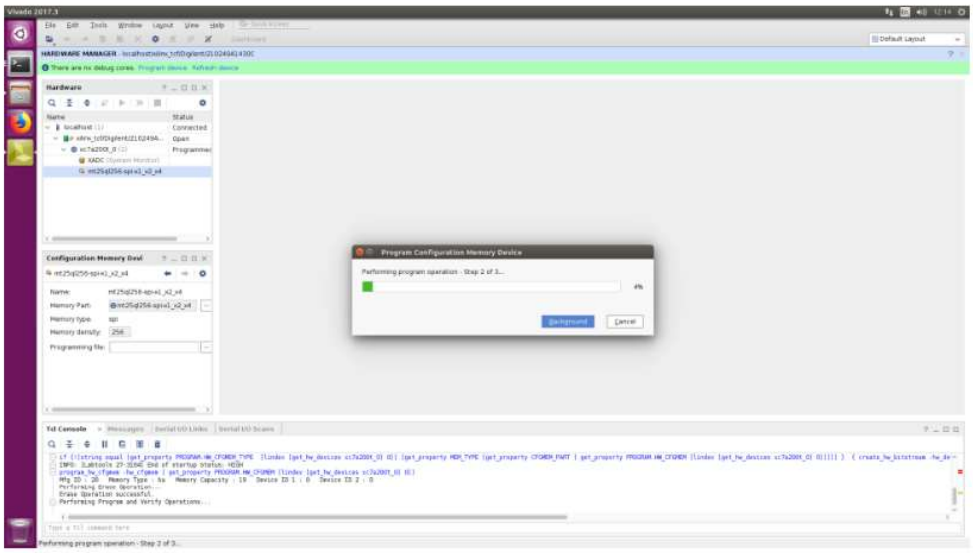

Figure 59: Progress bar [sc26]

Test Case Result, STMA-69255 -

15. The pop-up “Program Flash” now opens with the message “Flash programming completed successfully”. Click “OK” (Figure 60, STMA-69233);

Definition, STMA-69233 -

DRAFT

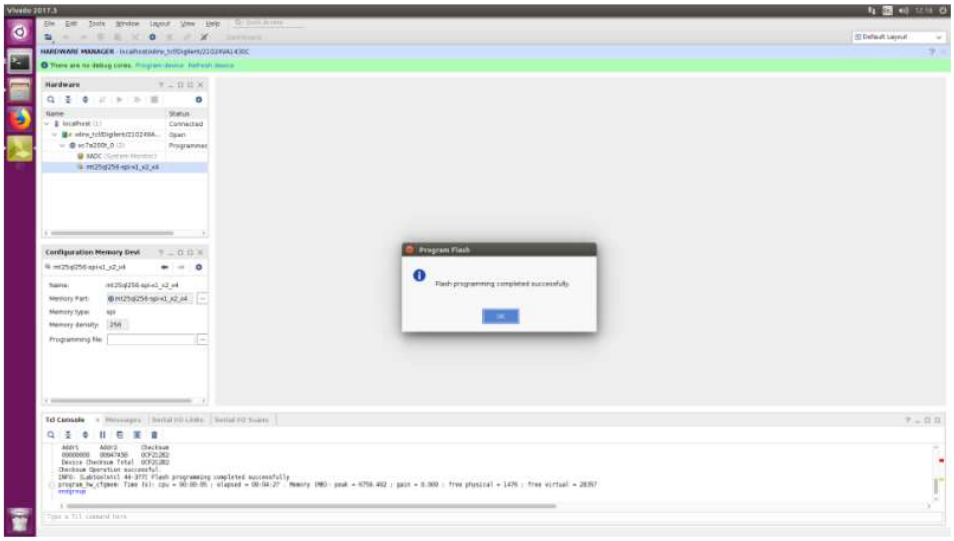

Figure 60: Program flash completed successfully [sc28]

Test Case Result, STMA-69256 -

16. With the programming completed, the FPGA is not yet loaded with the bitstream from the memory configuration device. To load the software on the FPGA processor, right-click the artix file “xc7a200t” in the “Hardware” pane on the upper left-hand side of the screen. A pop-up appears; left-click “Boot from Configuration Memory Device” (see Figure 61, STMA-69230) or switch the power supply OFF and, after waiting at least 2 seconds, ON again;

Definition, STMA-69230 -

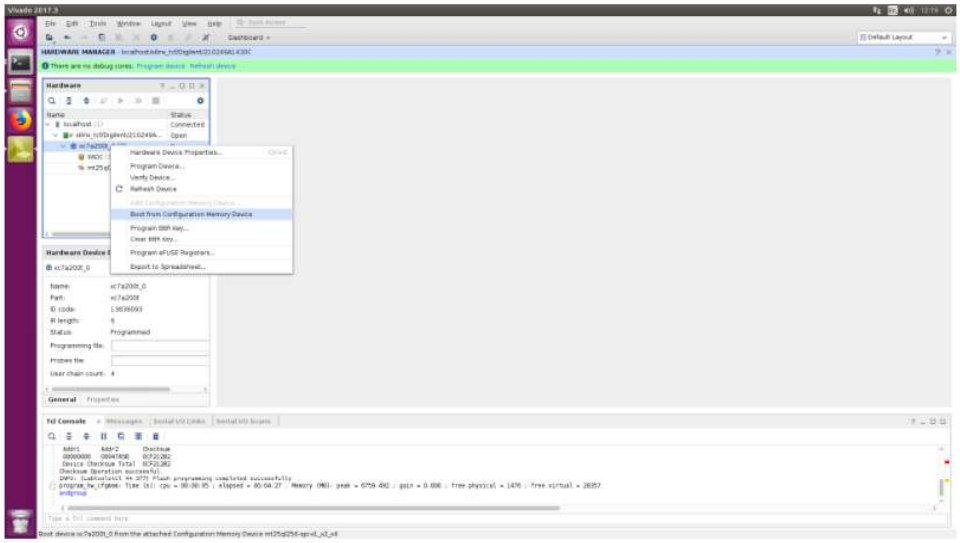

Figure 61: Boot from Configuration Memory Device [sc29]

Test Case Result, STMA-69254 -

17. The software is loaded on the FPGA processor. Close the program “Vivado 2017.3” on the laptop by clicking “X” in the top right corner of the screen.
18. Disconnect the JLink cable connector from connector X400 on the SAP Board and report the entire software loading procedure successfully finished and the software ready for testing.

6.7 Testing the software

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7 Assembling

STMA-8596: Mechanical stress on component leads/wires shall be avoided. Mechanical stress on large (mass) components shall be reduced by glueing of components to the PCB..

8 System testing

ATBEG functionality

ATBVv functionality

Visual inspection
Performance test
Insulation test

9 Cabling manufacturing and testing

9.1 Cabling requirements

Test Case Result, STMA-69229 - The STM ATB shall be installed in a variety of trains/locomotives and in a variety of locations in the train/locomotive.
The cable connector types are specified for the STM ATB interface:

- X1: DIN 41612 Type F female:
  - with 3 cables: A (DIO), B (PS) and C (DIO)
- X2: SubD-15 crimp pin:
  - with 2 cables: D (AIN) and E (AIN);
- X3: SubD-15 crimp socket;
  - with 2 cables: F (AIN) and G (AIN);
- X4: SubD-09 crimp pin;
  - with 1 cable: H (Profibus) or terminator;
- X5: SubD-09 crimp socket
  - with 1 cable: J (Profibus) or terminator

Test Case Result, STMA-69226 - The manufacturer shall choose the appropriate connectors and cables in accordance with:

- Cable specifications:
  - Profibus cables in accordance with IEC 61158-2;
  - DIO, PS and AIN cables in accordance with EN 50264:

- thickness, mechanical, thermal, fire safety, chemical etc.

- EMC and EMD shielded;
- Voltage and current rated for the application;
- Number of active wires;
  - With failure rate optimized wiring

- Wires fit into the crimp size of the terminals;
- Protection against environmental influences:
  - Pollution degree PD3A or better;

- temperature -25 ºC to +70 ºC ambient and up to 85 ºC during 10 minutes maximum
  - temperature class T3 according to EN 50155:2010 and EN 50125-1:2014;

- vibration and shock dependence in accordance with IEC 61373:2010;
- cable diameter in accordance with:
  - the maximum cable diameter fitting into the connector with crimp flange fitting the cable shield;

- Installation design for the particular train/locomotive:
  - number of Profibus connections to the STM ATB
  - type of ATB antennas used in the train/locomotive;
  - brake system used in the train/locomotive;
  - two or one directional vehicle;
  - cable length and curvature.

Test Case Result, STMA-69227 - Appendix C: Parts list gives examples of cables and connector parts which could be used, but is not exhaustive.

9.2 Preparations

Test Case Result, STMA-69214 -

1. Check that the required length of each cable (A-J) has been determined, see Table 3 (STMA-69215);

Definition, STMA-69215 - Table 3: cutting length of the STM ATB cables

code	tag	number active wires	cutting length [m]	cable stripping length [cm]		core stripping length [cm]	
				STM ATB interface	train interface	STM ATB interface	train interface
A	STM-ATB DIO4-6	12	tbd	tbd	tbd	tbd	tbd
B	STM-ATB Supply	6	tbd	tbd	tbd	tbd	tbd
C	STM-ATB DIO1-3	12	tbd	tbd	tbd	tbd	tbd
D	STM-ATB AIN 1	6	tbd	tbd	tbd	tbd	tbd

E	STM-ATB AIN 2, 3	9	tbd	tbd	tbd	tbd	tbd
F	STM-ATB AIN 5	6	tbd	tbd	tbd	tbd	tbd
G	STM-ATB AIN 6, 7	9	tbd	tbd	tbd	tbd	tbd
H	STM-ATB PROFIBUS 1	2 (if connected to Profibus)	tbd	tbd	tbd	tbd	tbd
J	STM-ATB PROFIBUS 2		tbd	tbd	tbd	tbd	tbd

Test Case Result, STMA-69222 -

2. Check that the train/locomotive specific resistors to be built into the counter connectors X2, X3 and (if applicable) X4 or X5 have been determined and supplied:
    - antenna resistors (4) depending on the type of ATB coil installed in the train/locomotive for which the STM ATB cabling is ordered, see Table 4 (STMA-69223) :

Definition, STMA-69223 -

Table 4: ATB antenna specific resistors to be built into counter connectors X2 and X3

ATB antenna	antenna resistor [Ω]
Alstom Bar	x
Alstom V	x
PW-170	x
PW-225	x
Fase 3	x

Test Case Result, STMA-69220 -

- gain resistors (4):
    - 4 ATB antennas installed (general, dual-directional train/locomotive): 4 x 560 Ω;
    - only 2 ATB antennas installed (exceptional, single directional rail vehicle to be turned into the driving direction): 2 x 560 Ω for the installed ATB antennas and 2 x 1k Ω for ATB antennas which are not installed;
-
- configuration resistors (2) depending on the brake system installed in the train/locomotive for which the STM ATB cabling is ordered, see Table 5 (STMA-69221);

Definition, STMA-69221 -

Table 5: brake system specific configuration resistors to be built into counter connectors X2 and X3

brake system	configuration resistor [Ω]
1	x
2	x
3	x
4	x
5	x

Test Case Result, STMA-69218 -

- terminator resistors (3) to build into the terminator for connector X4 or X5 if only one Profibus connection to the STM ATB is to be established and the other STM ATB Profibus connector (X5 or X4) is spare: 2 x 390 Ω + 1 x 220 Ω.

Test Case Result, STMA-69219 - 3. Check that all components to be assembled and tools are present:

- see Table 20 in Appendix C: Parts list

9.3 Assemble DIN 41612 counter connector X1 with the cables A, B and C

Test Case Result, STMA-69217 -

1. Cut and strip the cables A, B and C and their wires according to Table 3 (STMA-69215):
   - If (a) cable(s) is/are provided with more cores than active (A and C: 12, B: 6):
     - Cut any unused cores and isolate each of them with a protective cover;
   - Label the cables and the cores according to Table 6 (STMA-69210) ;
2. Connect the active cable cores to the non-PE pins on the STM ATB counter connector X1 according to Table 6 (STMA-69210) :
   - Using the crimp contacts;
   - perform a visual inspection and a mild pulling test on each contact assembled;
3. Connect the cable jacket to the PE pins on the on the STM ATB counter connector X1 according to Table 6 (STMA-69210):
   - perform a visual inspection and a mild pulling test on each contact assembled;

	WARNING In order to prevent earth loops, the cable jacket should only be connected to the PE pins in the counter connector, but should not be connected to the train interface.

4. Assemble the counter connector in the housing and hand fasten all connector housing screws:
   - ensure that the counter connector is placed correctly in the housing;

	WARNING The counter connector fits into the housing in 2 ways. Only xxxx is correct.

5. Secure all cable entries into the counter connector housing with the crimp flanges and ferrules;
6. Close the unused cable entries of the connector housing with the blanking pieces and hand fasten all blanking piece housing screws;
7. Perform a visual inspection and a mild pulling test on each cable assembled;
8. Counter connector X1 with cables A, B and C is ready for testing;

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Definition, STMA-69210 - Table 6: cable cores and pinning counter connector X1

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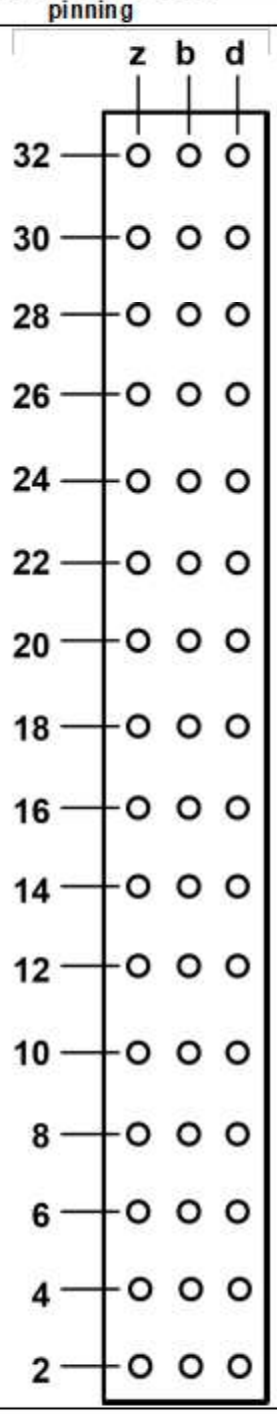
cable	core		counter connector X1	train interface
	colour	label	pinning	
C	jacket	PE	32z	tbd
	jacket	PE	32b	tbd
	jacket	PE	32d	tbd
	tbd	tbd	30z	tbd
	tbd	tbd	30b	tbd
	tbd	tbd	30d	tbd
	tbd	tbd	28z	tbd
	tbd	tbd	28b	tbd
	tbd	tbd	28d	tbd
	jacket	PE	26z	tbd
	jacket	PE	26b	tbd
	jacket	PE	26d	tbd
	tbd	tbd	24z	tbd
	tbd	tbd	24b	tbd
	tbd	tbd	24d	tbd
	tbd	tbd	22z	tbd
	tbd	tbd	22b	tbd
	tbd	tbd	22d	tbd
B	jacket	PE	20z	tbd
	jacket	PE	20b	tbd
	jacket	PE	20d	tbd
	tbd	tbd	18z	tbd
	tbd	tbd	18b	tbd
	tbd	tbd	18d	tbd
	tbd	tbd	16z	tbd
	tbd	tbd	16b	tbd
	tbd	tbd	16d	tbd
	jacket	PE	14z	tbd
	jacket	PE	14b	tbd
	jacket	PE	14d	tbd
A	tbd	tbd	12z	tbd
	tbd	tbd	12b	tbd
	tbd	tbd	12d	tbd
	tbd	tbd	10z	tbd
	tbd	tbd	10b	tbd
	tbd	tbd	10d	tbd
	jacket	PE	8z	tbd
	jacket	PE	8b	tbd
	jacket	PE	8d	tbd
	tbd	tbd	6z	tbd
	tbd	tbd	6b	tbd
	tbd	tbd	6d	tbd
	tbd	tbd	4z	tbd
	tbd	tbd	4b	tbd
	tbd	tbd	4d	tbd
	jacket	PE	2z	tbd
	jacket	PE	2b	tbd
	jacket	PE	2d	tbd

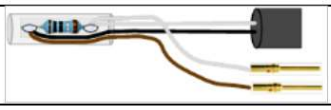


9.4 Assemble sub-D15 counter connector X2 with the cables D and E

Test Case Result, STMA-69212 -

1. Cut and strip the cables D and E and their wires according to Table 3 (STMA-69215) :
    - If (a) cable(s) is/are provided with more cores than active (D: 6, E: 9):
        - Cut any unused cores and isolate each of them with a protective cover;
    - Label the cables and the cores according to Table 8;
2. Connect the active cable cores to the pins on the STM ATB counter connector X2 according to Table 8 (STMA-69198) :
    - using the crimp contacts;
    - perform a visual inspection and a mild pulling test on each contact assembled;
3. Insert the specified resistors according to Table 7 (STMA-69213):
    - cut the resistor wires to the length required to fit into the counter connector X2 housing;
    - strip the resistor wires, turn them around the resistor pins and solder them to the pins;
    - guide the resistor wires along the resistor in the same direction;
    - shrink a shrink sleeve with inner melt around the resistor assembly for protection;
    - perform a visual inspection and a mild pulling test on each contact assembled;

Definition, STMA-69213 - Table 7: resistors to be installed in counter connector X2

resistor type	resistance	wire length	resistor wiring	between pins
antenna resistors	refer to step 2, Table 4	tbd		7-15 5-12
gain resistors	refer to step 2	tbd		6-14 4-11
configuration resistor	refer to step 2, Table 5	tbd		1-8

Test Case Result, STMA-69211 -

4. Connect the cable jacket to the PE shield on the on the STM ATB counter connector X2
    - perform a visual inspection and a mild pulling test on the contact assembled;

	WARNING In order to prevent earth loops, the cable jacket should only be connected to the PE shield in the counter connector, but should not be connected to the train interface.

Test Case Result, STMA-69200 -

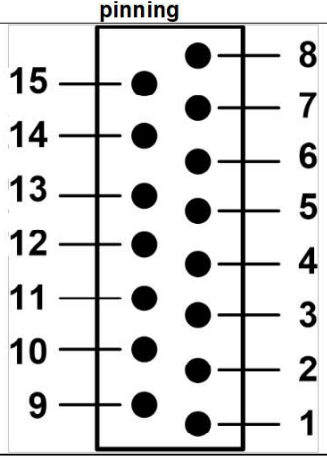
5. Assemble the counter connector in the housing and hand fasten all connector housing screws;

	REMARK There is very little room between cable D and the upper connector housing screw of cable E. Take care not to damage the cable.

Test Case Result, STMA-69201 -

6. Secure all cable entries into the counter connector housing with the cable clamps and ferrules;
7. perform a visual inspection and a mild pulling test on each cable assembled;
8. Counter connector X2 with cables D and E is ready for testing.

Definition, STMA-69198 - Table 8: cable cores and pinning counter connector X2

cable	core		counter connector X2			train interface
	colour	label	resistor	pinning		
D	tbd	tbd	config to 1	8		tbd
	tbd	tbd	antenna to 7	15		tbd
	tbd	tbd	antenna to 15	7		tbd
	tbd	tbd	gain to 6	14		tbd
	tbd	tbd	gain to 14	6		tbd
	tbd	tbd		13		tbd
E	tbd	tbd	antenna to 12	5		tbd
	tbd	tbd	antenna to 5	12		tbd
	tbd	tbd	gain to 11	4		tbd
	tbd	tbd	gain to 4	11		tbd
	tbd	tbd		3		tbd
	tbd	tbd		10		tbd
	tbd	tbd		2		tbd
	tbd	tbd		9		tbd
	tbd	tbd	config to 8	1		tbd
	jacket	PE		Sh		tbd

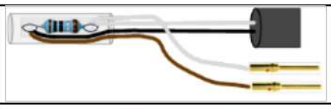
9.5 Assemble sub-D15 counter connector X3 with the cables F and G:

Test Case Result, STMA-69206 -

1. Cut and strip the cables F and G and their wires according to Table 3 (STMA-69215):
   - If (a) cable(s) is/are provided with more cores than active (F: 6, G: 9):
     - Cut any unused cores and isolate each of them with a protective cover;
   - Label the cables and the cores according to Table 10 (STMA-69205);
2. Connect the active cable cores to the pins on the STM ATB counter connector according to Table 10 (STMA-69205):
   - using the crimp contacts;
   - perform a visual inspection and a mild pulling test on each contact assembled;
3. Insert the specified resistors according to Table 9 (STMA-69207):

- cut the resistor wires to the length required to fit into the counter connector X3 housing;
- strip the resistor wires, turn them around the resistor pins and solder them to the pins;
- guide the resistor wires along the resistor in the same direction;
- shrink a shrink sleeve with inner melt around the resistor assembly for protection;
- perform a visual inspection and a mild pulling test on each contact assembled;

Definition, STMA-69207 - Table 9: resistors to be installed in counter connector X3

resistor type	resistance	wire length	resistor wiring	between pins
antenna resistors	refer to step 2, Table 4	tbd		2-9 4-12
gain resistors	refer to step 2	tbd		3-10 5-13
configuration resistor	refer to step 2, Table 5	tbd		1-8

Test Case Result, STMA-69204 -

4. Connect the cable jacket to the PE shield on the on the STM ATB counter connector:

- perform a visual inspection and a mild pulling test on the contact assembled;

	WARNING In order to prevent earth loops, the cable jacket should only be connected to the PE shield in the counter connector, but should not be connected to the train interface.

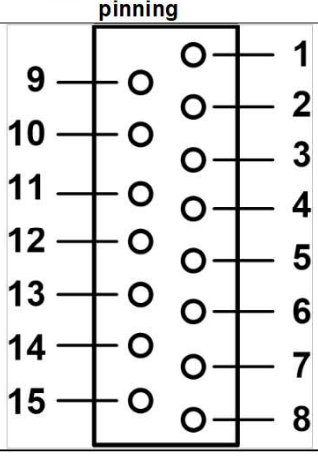
5. Assemble the counter connector in the housing and hand fasten all connector housing screws:

	REMARK There is very little room between cable F and the upper connector housing screw of cable G. Take care not to damage the cable.

6. Secure all cable entries into the counter connector housing with the cable clamps and ferrules;
7. Perform a visual inspection and a mild pulling test on each cable assembled;
8. Counter connector X3 with cables F and G is ready for testing.

Definition, STMA-69205 - Table 10: cable cores and pinning counter connector X3

cable	core		counter connector X3			train interface
	colour	label	resistor	pinning		
F	tbd	tbd	config to 8	1		tbd
	tbd	tbd	antenna to 2	9		tbd
	tbd	tbd	antenna to 9	2		tbd
	tbd	tbd	gain to 3	10		tbd
	tbd	tbd	gain to 10	3		tbd
	tbd	tbd		11		tbd
G	tbd	tbd	antenna to 12	4		tbd
	tbd	tbd	antenna to 4	12		tbd
	tbd	tbd	gain to 13	5		tbd
	tbd	tbd	gain to 5	13		tbd
	tbd	tbd		6		tbd
	tbd	tbd		14		tbd
	tbd	tbd		7		tbd
	tbd	tbd		15		tbd
	tbd	tbd	config to 1	8		tbd
	jacket	PE		Sh		tbd



9.6 Assemble SubD-09 counter connector X4:

Test Case Result, STMA-69203 -

- If the connector X4 is to be connected with the Profibus:
  - with cable H and with subD-09 connectors on both sides, but without termination resistors;

- If the connector X4 is not to be connected with the Profibus:
  - As terminator, without cable, but with termination resistors.

9.6.1 Only if the counter connector X4 is to be connected with the Profibus:

Test Case Result, STMA-69190 -

1. Cut and strip the cable H and its wires according Table 3 (STMA-69215) :

   - If the cable is provided with more cores than active (2):
     - Cut any unused cores and isolate each of them with a protective cover;

   - Label the cable and the cores according to Table 11 (STMA-69191);

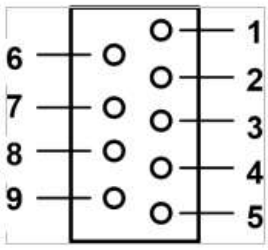
2. Connect the active cable cores to the pins on the subD-09 STM ATB counter connector X4 according to Table 11 (STMA-69191) and do the same with the subD-09 connector (m/f as specified by the customer) on the train interface side:

   - using the crimp contacts;
   - perform a visual inspection and a mild pulling test on each contact assembled;

3. Assemble the counter connector in the housing and hand fasten all connector housing screws;
4. Secure the cable entry into the counter connector housing with the cable clamp and ferrules;
5. Perform a visual inspection and a mild pulling test on both sides of the cable;

6. Counter connector X4 with cable H is ready for testing.

Definition, STMA-69191 - Table 11: cable cores and pinning counter connector X4 if connected to Profibus

cable	core		counter connector X4 pinning		Profibus interface
	colour	label			
H	-	spare	1		-
	-	spare	2		-
	red	data line minus (B)	3		tbd
	-	spare	4		-
	-	spare	5		-
	-	spare	6		-
	-	spare	7		-
	green	data line plus (A)	8		tbd
	-	spare	9		-

9.6.2 Only if the connector X4 is not to be connected with the Profibus:

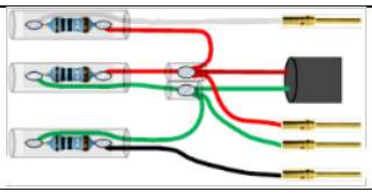
Insert the specified resistors according to Table 12 and ???

Test Case Result, STMA-69189 -

1. : ??

- cut the resistor wires to the length required to fit into the counter connector X4 housing;
- strip the resistor wires, turn them around the resistor pins and solder them to the pins;
- guide the resistor wires along the resistor in the same direction;
- shrink a shrink sleeve with inner melt around the resistor assembly for protection;
- perform a visual inspection and a mild pulling test on each contact assembled;

Table 12: termination resistors to be installed in counter connector X4 if not connected to the Profibus

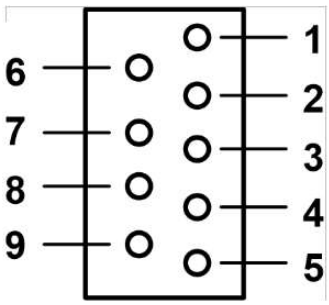
resistance	wire length	resistor wiring	between pins
220 Ω	tbd		3-8
390 Ω	tbd		3-6
			5-8

2. Assemble the counter connector in the housing and hand fasten all connector housing screws;
3. close the unused cable entry of the connector housing with the blanking pieces and hand fasten all blanking piece housing screws;

4. Perform a visual inspection;
5. Counter connector X4 is ready for testing as terminator.

Definition, STMA-69196 -

Table 13: pinning counter connector X4 if terminator

cable	core		counter connector X4		
	colour	label	resistor	pinning	
H	-	spare	-	1	
	-	spare	-	2	
	red	data line minus (B)	220 Ω to 8 390 Ω to 6	3	
	-	spare	-	4	
	black	GND	390 Ω to 8	5	
	white	5 V DC (Vp)	390 Ω to 3	6	
	-	spare	-	7	
	green	data line plus (A)	220 Ω to 3 390 Ω to 5	8	
	-	spare	-	9	

9.7 Assemble SubD-09 counter connector X5:

Test Case Result, STMA-69195 -

- If the connector X5 is to be connected with the Profibus:
  - with cable J and with subD-09 connectors on both sides, but without termination resistors;

- If the connector X5 is not to be connected with the Profibus:
  - As terminator, without cable, but with termination resistors

9.8 Only if the counter connector X5 is to be connected with the Profibus:

Test Case Result, STMA-69193 -

1. Cut and strip the cable J and its wires according Table 3 (STMA-69215) :

   - If the cable is provided with more cores than active (2):
     - Cut any unused cores and isolate each of them with a protective cover;
   - Label the cable and the cores according to Table 14 (STMA-69276);

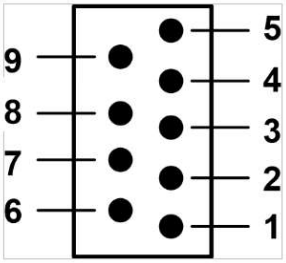
2. Connect the active cable cores to the pins on the subD-09 STM ATB counter connector according to Table 14 (STMA-69276) and do the same with the subD-09 connector (m/f as specified by the customer) on the train interface side:

   - using the crimp contacts;

- perform a visual inspection and a mild pulling test on each contact assembled;

3. Assemble the counter connector in the housing and hand fasten all connector housing screws;
4. Secure the cable entry into the counter connector housing with the cable clamp and ferrules;
5. Perform a visual inspection and a mild pulling test on both sides of the cable;
6. Counter connector X5 with cable J is ready for testing.

Definition, STMA-69276 -
Table 14: cable cores and pinning counter connector X5

cable	core		counter connector X5		STM ATB
	colour	label	pinning		side
J	-	spare	1		-
	-	spare	2		-
	red	data line minus (B)	3		tbd
	-	spare	4		-
	-	spare	5		-
	-	spare	6		-
	-	spare	7		-
	green	data line plus (A)	8		tbd
	-	spare	9		-

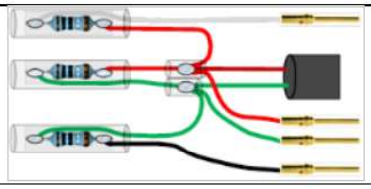
9.8.1 Only if the connector X5 is not to be connected with the Profibus:

Test Case Result, STMA-69530 -

1. Insert the specified resistors according to Table 15 (STMA-69527) and Table 16 (STMA-69526):

- cut the resistor wires to the length required to fit into the counter connector X4 housing;
- strip the resistor wires, turn them around the resistor pins and solder them to the pins;
- guide the resistor wires along the resistor in the same direction;
- shrink a shrink sleeve with inner melt around the resistor assembly for protection;
- perform a visual inspection and a mild pulling test on each contact assembled;

Definition, STMA-69527 - Table 15: termination resistors to be installed in counter connector X5 if not connected to the Profibus

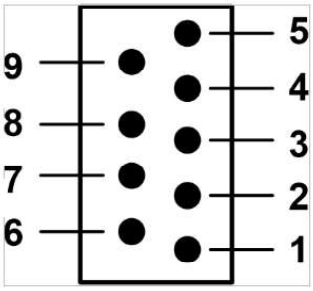
resistance	wire length	resistor wiring	between pins
220 Ω	tbd		3-8
390 Ω	tbd		3-6
			5-8

Test Case Result, STMA-69528 -

2. Assemble the counter connector in the housing and hand fasten all connector housing screws;
3. Close the unused cable entry of the connector housing with the blanking pieces and hand fasten all blanking piece housing screws;
4. Perform a visual inspection;
5. Counter connector X5 is ready for testing as terminator.

Definition, STMA-69526 - Table 16: cable cores and pinning counter connector X5 if terminator

cable	core		counter connector X5	
	colour	label	resistor	pinning
J	-	spare	-	1
	-	spare	-	2
	red	data line minus (B)	220 Ω to 8 390 Ω to 6	3
	-	spare	-	4
	black	GND	390 Ω to 8	5
	white	5 V DC (Vp)	390 Ω to 3	6
	-	spare	-	7
	green	data line plus (A)	220 Ω to 3 390 Ω to 5	8
	-	spare	-	9



9.9 Cabling testing

Test Case Result, STMA-69274 - Each cable/connector assembly shall be tested:

- Perform a ring test on each core of the connector/cable assemblies:
  - Measure the test value [unit] and check with Table 17 (STMA-69501) whether the measured test value is within the acceptable limits;

- If the recorded test values [unit] are within the acceptable limits for all cores of the tested connector/cable assembly, report the assembly fit for use;
- If the recorded test value(s) [unit] for one or more of the core(s) of the tested connector/cable assembly is/are not within the acceptable limits, discard the assembly according to WEEE Directive 2012/19/EU and report the assembly discarded.

Test Case Result, STMA-69501 - Table 17: cable/connector assemblies testing

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Con-nector	cable		Pin	wire	test value [unit]	
	code	tag			minimum	maximum
X1	C	STM ATB DIO1-3	32z	jacket	tbd	tbd
			32b	jacket	tbd	tbd
			32d	jacket	tbd	tbd
			30z	tbd	tbd	tbd
			30b	tbd	tbd	tbd
			30d	tbd	tbd	tbd
			28z	tbd	tbd	tbd
			28b	tbd	tbd	tbd
			28d	tbd	tbd	tbd
			26z	jacket	tbd	tbd
			26b	jacket	tbd	tbd
			26d	jacket	tbd	tbd
			24z	tbd	tbd	tbd
			24b	tbd	tbd	tbd
			24d	tbd	tbd	tbd
			22z	tbd	tbd	tbd
			22b	tbd	tbd	tbd
			22d	tbd	tbd	tbd
	B	STM ATB Supply	20z	jacket	tbd	tbd
			20b	jacket	tbd	tbd
			20d	jacket	tbd	tbd
			18z	tbd	tbd	tbd
			18b	tbd	tbd	tbd
			18d	tbd	tbd	tbd
			16z	tbd	tbd	tbd
			16b	tbd	tbd	tbd
			16d	tbd	tbd	tbd
			14z	jacket	tbd	tbd
			14b	jacket	tbd	tbd
			14d	jacket	tbd	tbd
	A	STM ATB DIO4-6	12z	tbd	tbd	tbd
			12b	tbd	tbd	tbd
			12d	tbd	tbd	tbd
			10z	tbd	tbd	tbd

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			10b	tbd	tbd	tbd
			10d	tbd	tbd	tbd
			8z	jacket	tbd	tbd
			8b	jacket	tbd	tbd
			8d	jacket	tbd	tbd
			6z	tbd	tbd	tbd
			6b	tbd	tbd	tbd
			6d	tbd	tbd	tbd
			4z	tbd	tbd	tbd
			4b	tbd	tbd	tbd
			4d	tbd	tbd	tbd
			2z	jacket	tbd	tbd
			2b	jacket	tbd	tbd
			2d	jacket	tbd	tbd
X2	D	STM-ATB AIN 1	8	tbd	tbd	tbd
			15	tbd	tbd	tbd
			7	tbd	tbd	tbd
			14	tbd	tbd	tbd
			6	tbd	tbd	tbd
			13	tbd	tbd	tbd
	E	STM-ATB AIN 2, 3	5	tbd	tbd	tbd
			12	tbd	tbd	tbd
			4	tbd	tbd	tbd
			11	tbd	tbd	tbd
			3	tbd	tbd	tbd
			10	tbd	tbd	tbd
			2	tbd	tbd	tbd
			9	tbd	tbd	tbd
			1	tbd	tbd	tbd
			Sh	jacket	tbd	tbd
X3	F	STM-ATB AIN 5	1	tbd	tbd	tbd
			9	tbd	tbd	tbd
			2	tbd	tbd	tbd
			10	tbd	tbd	tbd
			3	tbd	tbd	tbd
			11	tbd	tbd	tbd
	G	STM-ATB AIN 6, 7	4	tbd	tbd	tbd
			12	tbd	tbd	tbd
			5	tbd	tbd	tbd
			13	tbd	tbd	tbd
			6	tbd	tbd	tbd
			14	tbd	tbd	tbd
			7	tbd	tbd	tbd
			15	tbd	tbd	tbd
			8	tbd	tbd	tbd
			Sh	jacket	tbd	tbd
X4	H	STM-ATB PROFIBUS 1	3	tbd	tbd	tbd
X5	J	STM-ATB PROFIBUS 2	8	tbd	tbd	tbd

10 Housing assembly

Test Case Result, STMA-69502 -

1. Check that all components to be assembled are present:

- see Table 20 (STMA-69306) in Appendix C: Parts list;

2. Open the front panel mounting set and identify all parts according to Figure 62

Figure 62: Front panel mounting set parts

Test Case Result, STMA-69287 -

3. Mount the SAP Board to the front panel:

3.1 Place the SAP Board (1) on the working space with the connectors upwards and take 2 of the 4 studs (A), 2 of the 4 M3x6 torx screws (B), 2 of the 6 countersunk M3x6 screws (C) and the 4 of the 8 M3 SubD screws (D) from the front panel mounting set (Figure 62);

3.2 Position the two studs (A) on the SAP Board (1) with the screw holes in the short side at the front (on both sides of the connectors) and the screw holes in the long side vertically positioned over the corresponding screw holes in the SAP Board (Figure 63);

Figure 63: SAP Board with studs

Test Case Result, STMA-69283 -

3.3 Carefully attach the studs (A) to the SAP Board (1) with the torx screws (B) without fastening the screws (Figure 64);

Figure 64: attaching the studs (A) with the screws (B) to the SAP board (1)

Test Case Result, STMA-69285 -

3.4 Carefully place the front panel (2) on the SAP Board (1) with the connectors on the SAP Board through the holes X4 and X5 and the LEDs on the SAP Board through the holes A, B, C, D.

3.5 Carefully attach the front panel to the SAP Board with the 2 countersunk screws (C) without fastening the screws and then screw the 4 SubD screws (D) into the SubD connectors, again without fastening the screws (Figure 65);

Figure 65: Attaching the SAP Board to the front panel

Test Case Result, STMA-69253 -

3.6 Stepwise fasten the SAP Board to the front panel ensuring a straight alignment of the studs (A) between the front panel and the SAP Board:

3.6.1 Slightly fasten the 2 countersunk screws (C) without tightening;

3.6.2 Slightly fasten the 4 SubD screws (D) without tightening;

3.6.3 Check that the studs and SubD connectors X4 and X5 are aligned straight to ensure a straight angle between the SAP Board and the front panel (Figure 66);

3.6.4 Fasten and tighten the 2 torx screws (B);

3.6.5 Fasten and tighten the 2 countersunk screws (C);

3.6.6 Fasten and tighten the 4 SubD screws (D);

3.6.7 Check that all screws are tightened and double-check the 90 ? alignment between the SAP Board and the front panel (Figure 66);

Figure 66: 90 ? alignment of the SAP Board and the front panel

Test Case Result, STMA-69259 -

4. Mount the AIN Board to the front panel:

4.1 Place the AIN Board (3) on the working space with the connectors upwards and take 2 of the 4 studs (A), 2 of the 4 M3x6 torx screws (B), 2 of the 6 countersunk M3x6 screws (C) and the 4 of the 8 M3 SubD screws (D) from the front panel mounting set (Figure 62);

4.2 Position the two studs (A) on the AIN Board (3) with the screw holes in the short side at the front (on both sides of the connectors) and the screw holes in the long side vertically positioned over the corresponding screw holes in the AIN Board (Figure 67);

Figure 67: AIN Board with studs

Test Case Result, STMA-69258 -

4.3 Carefully attach the studs (A) to the AIN Board (3) with the torx screws (B) without fastening the screws (Figure 68);

Figure 68: attaching the studs (A) with the screws (B) to the AIN Board (1)

Test Case Result, STMA-69261 -

4.4 Carefully place the front panel (2) on the AIN Board (3) with the connectors on the SAP Board through the holes X2 and X3;

4.5 Carefully attach the front panel to the AIN Board with the 2 countersunk screws (C) without fastening the screws and then screw the 4 SubD screws (D) into the SubD connectors, again without fastening the screws (Figure 69);

Figure 69: Attaching the AIN Board to the front panel

Test Case Result, STMA-69260 -

4.6 Stepwise fasten the AIN Board to the front panel ensuring a straight alignment of the studs (A) between the front panel and the AIN Board:

4.6.1 Slightly fasten the 2 countersunk screws (C) without tightening;

4.6.2 Slightly fasten the 4 SubD screws (D) without tightening;

4.6.3 Check that the studs and SubD connectors X2 and X3 are aligned straight to ensure a straight angle between the AIN Board and the front panel (Figure 70);

4.6.4 Fasten and tighten the 2 torx screws (B);

4.6.5 Fasten and tighten the 2 countersunk screws (C);

4.6.6 Fasten and tighten the 4 SubD screws (D);

4.6.7 Check that all screws are tightened and double-check the 90 ? alignment between the AIN Board and the front panel (Figure 70);

Figure 70: 90 ? alignment of the AIN Board and the front panel

Test Case Result, STMA-69257 -

5. Mount the DIO+PS Board to the front panel:

5.1 Place the DIO+PS Board (4) on the working space with the connector upwards and take the studs (E, oben) and (F, unten), the 2 M3x12 torx screws (G), and 2 of the 6 countersunk M3x6 screws (C) from the front panel mounting set (Figure 62);

5.2 Position the two studs (E) and (F) on the DIO+PS Board (4) with the screw holes in the short side at the front (on both sides of the connector) and the screw holes in the long side vertically positioned over the corresponding screw holes in the DIO+PS Board (Figure 71);

Figure 71: DIO+PS Board with studs

Test Case Result, STMA-69311 -

5.3 Carefully attach the studs (E) and (F) to the DIO+PS Board (4) with the torx screws (G) without fastening the screws (Figure 72);

Figure 72: Attaching the studs (A) with the screws (B) to the DIO+PS Board (1)

Test Case Result, STMA-69312 -

5.4 Carefully place the front panel (2) on the DIO+PS Board (4) with the connector on the DIO+PS Board through the hole X1;

5.5 Carefully attach the front panel to the DIO+PS Board with the 2 countersunk screws (C) without fastening the screws (Figure 73);

Figure 73: Attaching the DIO+PS Board to the front panel.

Test Case Result, STMA-69302 -

5.6 Stepwise fasten the DIO+PS Board to the front panel ensuring a straight alignment of the studs (E) and (F) between the front panel and the DIO+PS Board:

5.6.1 Slightly fasten the 2 countersunk screws (C) without tightening;

5.6.2 Check that the studs and connectors X1 are aligned straight to ensure a straight angle between the DIO+PS Board and the front panel (Figure 74);

5.6.3 Fasten and tighten the 2 torx screws (G);

5.6.4 Fasten and tighten the 2 countersunk screws (C);

5.6.5 Check that all screws are tightened and double-check the 90 ? alignment between the DIO+PS Board and the front panel (Figure 74);

Figure 74: 90 ? alignment of the DIO+PS board on the front panel

Test Case Result, STMA-69303 -

6. Fit the Backplane Board to the system boards.

6.1 Open the rear panel mounting set and identify all parts according to Figure 75;

Figure 75: Rear panel mounting set parts

Test Case Result, STMA-69300 -

6.2 Mount the distance blocks on the Backplane Board;

6.2.1 Place the Backplane Board (5) on the working space with the connectors upwards, take the 6 M3x10 torx screws (H) and the 6 washers (I) from the rear panel mounting set (Figure 75);

6.2.2 Position the two distance blocks (6) with the isolation tape side on the Backplane Board (5) and the screw holes in the distance blocks positioned over the corresponding screw holes in the Backplane Board (Figure 76);

Figure 76: Backplane Board and distance blocks

Test Case Result, STMA-69301 -

6.2.3 Ensure that both distance blocks are aligned with the corresponding edges of the Backplane Board, insert the 6 M3x10 torx screws (H) and the 6 washers (I) and fasten the screws (Figure 77).

Figure 77: Fastening the distance blocks to the Backplane Board

Test Case Result, STMA-69307 -

6.3 Position the Backplane Board (5) behind the system boards (1, 3 and 4) aligning the Backplane Board connectors with the connectors on the system boards. This fits in one way only! Slightly press the Backplane Board onto the system boards, position the whole assembly with the Backplane Board on the working space and press the system boards onto the Backplane Board to establish full electrical and mechanical connectivity (Figure 78).

Figure 78: Pressing the system boards onto the Backplane Board

Test Case Result, STMA-69309 -

6.4 Assemble the STM ATB:

6.4.1 Establish the front (sharp edges) and rear (rounded edges) side of the tube (7)

6.4.2 Slide the assembly of the boards and front panel into the tube with the Backplane Board first entering through the front side (sharp edges) of the tube;

6.4.3 Mount the rear panel (8) on the rear side of the tube:

6.4.3.1 Fasten the rear panel to the tube by putting the 4 countersunk M3x8 screws (J) into the outer rear panel holes and fasten the screws (Figure 79);

Figure 79: Fastening the rear panel to the tube

Test Case Result, STMA-69304 -

6.4.3.2 Fasten the rear panel to distance blocks by putting the 4 M3x10 torx screws (K) into the inner rear panel holes and fasten the screws (Figure 80);

Figure 80: Fastening the rear panel to the distance blocks

Test Case Result, STMA-69296 -

6.4.4 Fasten the front panel to the tube with the 4 M3x8 countersunk screws (L) (Figure 81);

Figure 81: Fastening the front panel to the tube

Test Case Result, STMA-69298 -

7. Coat the STM ATB housing assembly to prevent ingress of water, dust and other substances:

   - Details;

8. Report the STM ATB housing assembly ready for testing.

10.1 Testing the housing assembly

1. Testing the housing assembly:
   - details:
2.

11 Appendices

11.1 Appendix A: STM ATB pin occupation

Definition, STMA-69297 - Table 18: STM ATB pin occupation [STMA-39055, STMA-39130, STMA-39140, STMA-8172] <<omschrijving op basis ATB functionaliteit>>

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Con-nector	cable		Pin	I/O	pin name	description	Opposite connection (vehicle dependant)		
	code	tag					wire	Terminal block	clamp
X1	C	STM ATB DIO1-3	32z		PE				
			32b		PE				
			32d		PE				
			30z		DOut_A-GND	Digital Out A ground			
			30b		DOut_A-GND	Digital Out A ground			
			30d		DOut_A-GND	Digital Out A ground			
			28z	O	DOut_3A	Spare output			
			28b	O	DOut_2A	"gong" acoustic signal, cab signal change			
			28d	O	DOut_1A	"rembel" acoustic signal, overspeed			
			26z		PE				
			26b		PE				
			26d		PE				
			24z		DIn_A-GND	Digital In A ground			
			24b		DIn_A-GND	Digital In A ground			
			24d		DIn_A-PWR	Digital In A power			
			22z	I	DIn_3A	Spare Input			
			22b	I	DIn_2A	Brake Sufficiently Operated			
			22d	I	DIn_1A	Brake Handle Applied			
	B	STM ATB Supply	20z		PE				
			20b		PE				
			20d		PE				
			18z	I	Supply -	Power Supply negative input			
			18b	I	Supply -	Power Supply negative input			
			18d	I	Supply -	Power Supply negative input			
			16z	I	Supply +	Power Supply positive input			
			16b	I	Supply +	Power Supply positive input			
			16d	I	Supply +	Power Supply positive input			
			14z		PE				
			14b		PE				
			14d		PE				
	A	STM ATB DIO4-6	12z		DOut_B-GND	Digital Out B ground			
			12b		DOut_B-GND	Digital Out B ground			
			12d		DOut_B-GND	Digital Out B ground			
			10z	O	DOut_3B	Blue indicator, monitoring			

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						active			
			10b	O	DOut_2B	Red indicator, brake commanded by ATB			
			10d	O	DOut_1B	White indicator, brake operated			
			8z		PE				
			8b		PE				
			8d		PE				
			6z		DIn_B-GND	Digital In B ground			
			6b		DIn_B-GND	Digital In B ground			
			6d		DIn_B-PWR	Digital In B power			
			4z	I	DIn_3B	Spare Input			
			4b	I	DIn_2B	Brake Not Sufficiently Operated			
			4d	I	DIn_1B	Brake Handle Not Applied			
			2z		PE				
			2b		PE				
			2d		PE	shield			
X2	D	STM-ATB AIN 1	8	I	Rconfig_A	configuration resistor A input			
			15	I	AIn_1A+	ATB antenna cabin A right hand side seen from forward direction cabin A			
			7	I	AIn_1A-	ATB antenna cabin A right hand side seen from forward direction cabin A			
			14	I	Rg_1A+	ATB antenna cabin A right gain resistor			
			6	I	Rg_1A-	ATB antenna cabin A right gain resistor			
			13		AIn_A-GND				
	E	STM-ATB AIN 2, 3	5	I	AIn_2A+	ATB antenna cabin B left hand side seen from forward direction cabin B			
			12	I	AIn_2A-	ATB antenna cabin B left hand side seen from forward direction cabin B			
			4	I	Rg_2A+	ATB antenna cabin B left gain resistor			
			11	I	Rg_2A-	ATB antenna cabin B left gain resistor			
			3		AIn_A-GND				
			10	I	AIn_3A+	Brake pipe pressure transducer input			
			2	I	AIn_3A-	Brake pipe pressure transducer ground			
			9	I	AIn_A-GND				
			1	I	Rconfig_A_ret	configuration resistor A return			
			Sh		PE	shield			
X3	F	STM-ATB AIN 5	1	I	Rconfig_B	configuration resistor B input			
			9	I	AIn_1B+	ATB antenna cabin B right hand side seen from forward direction cabin B			
			2	I	AIn_1B-	ATB antenna cabin B right hand side seen from forward direction cabin B			
			10	I	Rg_1B+	ATB antenna cabin B right gain resistor			
			3	I	Rg_1B-	ATB antenna cabin B right			

						gain resistor			
			11		AIn_B-GND				
	G	STM-ATB AIN 6, 7	4	I	AIn_2B+	ATB antenna cabin A left hand side seen from forward direction cabin A			
			12	I	AIn_2B-	ATB antenna cabin A left hand side seen from forward direction cabin A			
			5	I	Rg_2B+	ATB antenna cabin A left gain resistor			
			13	I	Rg_2B-	ATB antenna cabin A left gain resistor			
			6		AIn_B_GND				
			14	I	Ain_3B+	Brake pipe pressure transducer input			
			7	I	Ain_3B-	Brake pipe pressure transducer ground			
			15	I	Ain_B_GND				
			8	I	Rconfig_B_ret	configuration resistor B return			
			Sh		PE	shield			
			1		not used				
			2		not used				
			3		RxD/TxD-P	data line plus (B)			
			4		not used				
X4	H	STM-ATB PROFIBUS 1	5		DGND	data ground			
X5	J	STM-ATB PROFIBUS 2	6		VP	+5 V DC supply for bus termination			
			7		not used				
			8		RxD/TxD-N	data line minus (A)			
			9		not used				

11.2 Appendix B: LED status indications

Definition, STMA-69299 - Table 19: LED status indications [STMA-36942, STMA-30136]

LED	indication	corresponding LED		cause
		LED	indication	
A	green	C	green	no fault
			orange	non-specific fault
			red	single power supply defect
	orange		green	coil not detected
			orange	no brake detection possible
			red	EB unavailable
	red		green	disconnected from ETCS functions
			orange	over / under temperature
			red	safe state (final)
B	green	D	green	ADC controller: ON
	orange		orange	ADC controller: BOOT
	red		red	ADC controller: OFF
	niet symmetrisch		Groen-rood - rood/groen – groen/oranje enz.??	
C	all	A	all	See LED A – corresponding LED C
D	all	B	all	See LED B – corresponding LED D
all	none	not applicable		LED defective

11.3 Appendix C: Parts list

Definition, STMA-69306 - Table 20: Housing parts

housing			
description	number	Manufacturer	Order code
DIO + PS Board	1	Schroff	
AIN Board	1	Schroff	
SAP Board	1	Schroff	
Backplane Board	1	Schroff	
Front panel	1	Schroff	31695637
Tube 188m	1	Schroff	31695640
Rear panel	1	Schroff	31695665
Front panel mounting set	1	Schroff	21191548
Rear panel mounting set	1	Schroff	21191549
Distance blocks for the Backplane Board	2	Schroff	31695902

Definition, STMA-69305 - Table 21: Cable parts

cables					
code	tag	type	description	Manufacturer (example)	order code (example)
A C	STM-ATB DIO4-6 STM-ATB DIO1-3	Railway cable	OLFLEX rTRAIN 345 C 12 x 0.75 mm2, 12.4 mm	LappKabel	1534 5054
		Alternative cable (non-railway)	OLFLEX rCHAIN 808 CP 12 x 0.75 mm2, 10.9 mm	LappKabel	102 7764
B	STM-ATB Supply	Railway cable	OLFLEX rTRAIN 345 C 4 x 1.0 mm2, 8.2 mm	LappKabel	1534 5061
		Alternative cable (non-railway)	OLFLEX rCHAIN 808 CP 4 x 1.0 mm2, 7.5 mm	LappKabel	102 7769
D E F G	STM-ATB AIN 1 STM-ATB AIN 2, 3 STM-ATB AIN 5 STM-ATB AIN 6, 7	Railway cable	OLFLEX rTRAIN 317 C TW-P 2 x (2 x 0.5 mm2), 9.6 mm	LappKabel	1531 7000
		Alternative cable (non-railway)	Unitronic CY PIDY (TP) 2 x (2 x 0.25 mm2), 9.3 mm	LappKabel	0034 250
			Unitronic FD CP (TP) plus 2 x (2 x 0.5 mm2), 9.0 mm	LappKabel	0030 937
H J	STM-ATB PROFIBUS 1 STM-ATB PROFIBUS 2	Railway cable	Unitronic rBus PB FRNC FC 1 x (2 x 0.32 mm2), 150E, 7.9 mm	LappKabel	217 0853
		Alternative cable (non-railway)	Unitronic Bus PB FD P FC 1 x (2 x 0.64 mm2), 150E, 8.0 mm	LappKabel	217 0322

Definition, STMA-69310 -
Table 22: Connector parts

Connector parts					

code	type	number	description	Manufacturer (example)	Order code (example)
X1	Connector	1	DIN 41612 Type F female	Harting	09 06 248 3201 222
	Hood	1	DIN-Power shell housing D 20 metall emv	Harting	09 06 848 0551
	Cable entries (cable type dependant)	2	Crimp flange, 9 mm	Harting	61 03 000 0072
		2	Crimp ferrule, 14 mm	Harting	61 03 000 0061
		1	Crimp flange, 5 mm	Harting	61 03 000 0066
		1	Crimp ferrule, 8 mm	Harting	61 03 000 0051
		4	Crimp flange insert	Harting	09 06 800 9952
		5	Blanking piece	Harting	61 03 000 0042
	Connector female crimp FC contacts	34	Copper alloy, conductor: 0.5…1.5 for FC 3	Harting	09 06 000 7482
	Alternative screw cable entries	?	DIN-Power cable clamp D20 zinc die cast	Harting	09 06 800 9955
		?	Blinding piece D20 zinc die cast	Harting	09 06 800 9951
X2	Pin connector	1	SubD-15 crimp pin	Inotec	DC15P-G
	hood	1	D-Sub full metal hood with screw locking, M3 screw	Inotec	DG15 MSB-91
	Cable entries	?	Cable clamp	tbd	tbd
		?	ferrule	tbd	tbd
	Crimp contacts	?	Crimp contacts, pin, AWG 24-20	Inotec	DCC2P4
X3	Socket connector	1	SubD-15 crimp socket	Inotec	DC15S-G
	hood	1	D-Sub full metal hood with screw locking, M3 screw	Inotec	DG15 MSB-91
	Cable entries	?	Cable clamp	tbd	tbd
		?	ferrule	tbd	tbd
	Crimp contacts	?	Crimp contacts, socket, AWG 24-21	Inotec	DCC2S4
X4	Pin connector	1	SubD-09 crimp pin	Inotec	DC09P-G
	hood	1	D-Sub full metal hood with screw locking, M3 screw	Inotec	DG09 MSX-91
	Cable entries	?	Cable clamp	tbd	tbd
		?	ferrule	tbd	tbd
	Crimp contacts	?	Crimp contacts, pin, AWG 24-20	Inotec	DCC2P4
X5	Socket connector	1	SubD-09 crimp socket	Inotec	DC09S-G
	hood	1	D-Sub full metal hood with screw locking, M3 screw	Inotec	DG09 MSX-91
	Cable entries	?	Cable clamp	tbd	tbd
		?	ferrule	tbd	tbd
	Crimp contacts	?	Crimp contacts, socket, AWG 24-21	Inotec	DCC2S4