Intel® Quark™ SoC X1000
Board Support Package (BSP)
Build and Software User Guide

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Revision History

Date	Revision	Description
January 2015	008	Updated Sections 4 and 9 Added Appendix B
16 June 2014	007	General updates to coincide with the EDKII Update 1.0.2 release including: Updated Section 4, Building the EDKII Firmware (added Windows* build environment).
22 May 2014	006	General updates for software release 1.0.1 including: Updated Section 4, Building the EDKII Firmware (added TPM). Added Section 6.1 Build a Full-featured Linux for SD card or USB Stick Updated Section 9 Platform Data Tool (corrected `platform-data.ini` filename). Updated Section 14, Capsule Recovery (added DediProg information). Updated with trademarked term: Intel® Quark™ SoC.
04 March 2014	005	General updates for software release 1.0.0 including: Added Section 13 Capsule Update. Added Section 14, Capsule Recovery.
20 January 2014	004	General updates for software release 0.9.0 including: Added Section 4, Building the EDKII Firmware. Added Section 10.2, Programming Flash Using Linux* Run-time System. Updated Section 15, Signing Files (Secure SKU only). Removed OpenOCD details because patch is now open source. Added Appendix A Related Documents.
15 November 2013	003	Added `CapsuleApp.efi` to Section 3, Downloading Software.
07 November 2013	002	General updates for software release 0.8.0 including: Added supported boards to list of hardware. Section 8: Changed SPI Flash tools path from `clanton_peak_EDK2` to `Quark_EDKII` Moved Signing Files (Secure SKU only) section to later in the document.
15 October 2013	001	First release with software version 0.7.5.

1 About This Document

This document, the Intel® Quark™ SoC X1000 Board Support Package (BSP) Build and Software User Guide, is divided into two major sections:

- **Part 1 of 2 - Building the BSP Software** contains instructions for installing and configuring the Intel® Quark™ SoC X1000 Board Support Package sources.
- **Part 2 of 2 - Using the BSP Software** provides information on BSP software features and functionality.

Use this document to create an image to boot on your Quark-based board, and to learn more about BSP software features.

The intended audience for this document are hardware/software engineers with experience in developing embedded applications.

This software release supports the following software and hardware:

- Board Support Package Sources for Intel® Quark™ SoC X1000 v1.0.0
- Intel® Galileo Customer Reference Board (CRB) (Fab D with blue PCB)
- Galileo GEN2 Customer Reference Board (CRB)
- Intel® Quark™ SoC X1000 Industrial/Energy Reference Design (Cross Hill)
- Intel® Quark™ SoC X1000 Transportation Reference Design (Clanton Hill)

Part 1 of 2 - Building the BSP Software

This section contains the following topics:

2 Before You Begin

Before you begin:

- You need a host PC running either:
  - Linux*; Intel recommends a 64-bit Linux system
  - Microsoft* Windows* 7, x64
- You need an internet connection to download third party sources.
- The build process may require as much as 30 GB of free disk space.
- To program the board you can use:
  - A serial interface using the UEFI shell or Linux* run-time (see Section 10)
  - A DediProg* SF100 SPI Flash Programmer (or equivalent) and the associated flashing software (see Section 11)
  - An Intel® Galileo IDE (Galileo GEN@ board only; refer to *Appendix A Related Documents* for User Guide details)

Note: Remove all previous versions of the software before installing the current version.

Individual components require very different environments (compiler options and others). **To avoid cross-pollution, the commands in each section that follows must be run in a new command line window every time**.

Note: If the commands fail or timeout, it may be due to your proxy settings. Contact your network administrator. You may find answers here: https://wiki.yoctoproject.org/wiki/Working_Behind_a_Network_Proxy

This release has been tested with Windows* 7, 64-bit and Debian* Linux* 7.0 (Wheezy), but will work with most other Linux distributions.

Linux builds have been validated on 64-bit Linux systems and may need additional steps for operation on 32-bit systems.

3 Downloading Software

Download the BSP sources zip file from the following location:

https://downloadcenter.intel.com/Detail_Desc.aspx?DwnldID=23197

Note: If you are using an Intel® Quark™ Reference Design board, see your Intel representative for the appropriate software download URL.

This release is comprised of:

- Board Support Package (BSP) sources:
  - `Board_Support_Package_Sources_for_Intel_Quark_v1.1.7z` (2.6 MB)

For customers using the Clanton Hill FFRD, additional CAN software must be downloaded from Intel Business Link (IBL). See your Intel representative for the URL. The CAN package comprises:

- Fujitsu CAN Firmware:

`CAN_Firmware_for_Intel_Quark_v1.0.1.zip` (36 kB)

If building on a Debian host PC, use the Debian-provided meta package called `build-essential` that installs a number of compiler tools and libraries. Install the meta package and the other packages listed in the command below before continuing:

```
# sudo apt-get install build-essential gcc-multilib vim-common
```

4 Building the EDKII Firmware

You need to build the open source EDKII firmware for the Intel® Quark™ SoC. Additional details may be found here:

- www.tianocore.sourceforge.net
- https://github.com/tianocore/tianocore.github.io/wiki/Getting-Started-with-EDK-II

4.1 Dependencies

Linux* build environment dependencies:

- Python 2.6 or 2.7 (Python 3.x not supported)
- GCC and G++ (tested with GCC 4.3 and GCC 4.6)
- subversion client
- uuid-dev
- iasl (https://www.acpica.org/downloads/linux)
  Note: An ACPI5.0 compatible version is required.

Windows* build environment dependencies:

- Python 2.6 or 2.7 (Python 3.x not supported)
- Microsoft* Visual Studio* 2008 Professional.
- The Intel® Quark™ SoC EDKII build is validated with the **Win7 x64 / VS2008x86** option shown in:
  https://github.com/tianocore/tianocore.github.io/wiki/Windows-systems-ToolChain-Matrix

  In addition, the `quarkbuild.bat` below enforces the x86 postfix onto the Visual Studio* option for building under x64 Windows.
- TortoiseSVN (1.4.2.8580 or later) installed with optional SVN command line tools.
- iASL Windows binaries (https://www.acpica.org/downloads/binary-tools)
  Note: An ACPI5.0 compatible version is required and they should be extracted to a C:\ASL directory.

4.2 Pre-build Setup

The following steps are performed one time to prepare the EDKII workspace directory with the required source code before commencing the actual firmware build.

1. Create the EDKII workspace directory and extract the contents of the Intel® Quark™ SoC EDKII BSP into this directory.

The file will have the name `Quark_EDKII_<version>.tar.gz`. After the contents have been extracted the files `quarkbuild.sh` and `quarkbuild.bat` should be in the root of the created workspace directory.

2. Fetch the upstream core EDKII packages using `svn_setup.py` and the SVN command line tool.
3. Optionally, if OpenSSL is required by the build configuration in Section 4.3 or Section 4.4 following, then perform the steps in the `CryptoPkg/Library/OpensslLib/Patch-HOWTO.txt` file.

4.2.1 Performing pre-build Steps in a Linux/gcc Build Environment

Open a new terminal session and enter the following commands:

```
# sudo apt-get install build-essential uuid-dev iasl subversion

# tar -xvf Quark_EDKII_*.tar.gz

# cd Quark_EDKII*

# ./svn_setup.py

# svn update
```

4.2.2 Performing pre-build Steps in a Windows Build Environment

Use a preferred tool to extract the `Quark_EDKII_*.tar.gz` to a user created EDKII Workspace directory and run the `cmd.exe` Windows command. Then, issue the following commands:

```
>cd %USER_SELECTED_EDKII_WORKSPACE_DIR%

>.\svn_setup.py

>svn update
```

Note: The `svn update` command can take a few minutes to complete depending on the speed of your internet connection.

Note: If these commands fail, it may be due to your proxy settings. Contact your network administrator. You may find answers about proxy settings here: https://wiki.yoctoproject.org/wiki/Working_Behind_a_Network_Proxy

Note: The examples above do not show the optional OpenSSL pre build step described in the `CryptoPkg/Library/OpensslLib/Patch-HOWTO.txt` file.

4.3 Building all the EDKII Firmware Validated Build Configurations [Linux build environment only]

This section is only supported in Linux Build environments. The `buildallconfigs.sh` file is used to build all the validated EDKII build configurations. Open a terminal window and cd to the Quark_EDKII* directory created in Section 4.2.1 *Performing pre-build Steps in a Linux/gcc Build Environment.*

The script has the following options:

buildallconfigs.sh [GCC43 | GCC44 | GCC45 | GCC46 | GCC47] [PlatformName]

GCC4x	GCC flags used for this build. Set to the version of GCC you have installed. Note: Validated with GCC43; tested on GCC46.
[PlatformName]	Name of the platform package you want to build.

Example usage:

Create a build for an Intel® Quark™ SoC platform based on GCC version 4.6:

```
./buildallconfigs.sh GCC46 QuarkPlatform
```

Note: Ensure the selected version of GCC matches the one installed on the system by running the gcc --version command.

The build output can be found in the following directories:

- `Build/QuarkPlatform/<Config>/<Target>_<Tools>/FV/FlashModules/`

  Contains EDKII binary modules

- `Build/QuarkPlatform/<Config>/<Target>_<Tools>/FV/Applications/`

  Contains UEFI shell applications, including CapsuleApp.efi

Where:

- <Config> = PLAIN | SECURE
- <Target> = DEBUG | RELEASE
- <Tools> = GCC43 | GCC44 | GCC45 | GCC46 | GCC47

In Section 8, you will run a script that creates a symbolic link to the directory where the EDK binaries are placed.

4.4 Building a Single EDKII Firmware Build Configuration

This section is supported in Linux and Windows build environments. Use `quarkbuild.sh` in a Linux terminal window or `quarkbuild.bat` in a Windows command prompt (created by running `cmd.exe`) and the `cd` command to change directory to the root of the EDKII workspace directory created in Section 4.2.

Build usage:

```
quarkbuild [-r32 | -d32 | -clean]
[GCC43 | GCC44 | GCC45 | GCC46 | GCC47 | subst drive letter]
[PlatformName] [-DSECURE_LD (optional)] [-DTPM_SUPPORT (optional)]
[-DSECURE_BOOT_ENABLE=TRUE (optional)]
```

The following is the list of options for the `quarkbuild.sh` and `quarkbuild.bat` build commands:

-clean	Delete the build files/folders
-d32	Create a DEBUG build
-r32	Create a RELEASE build
GCC4x	**LINUX ONLY:** GCC flags used for this build. Set to the version of GCC you have installed.

Note: Validated with GCC43; tested on GCC46.

subst drive letter	**WINDOWS ONLY:** `quarkbuild.bat` uses the letter specified here with the Windows `subst` command to associate a drive letter with the EDKII workspace directory path. Associating a drive letter with the EDKII workspace directory reduces flash space requirements for debug executables.
[PlatformName]	Name of the Platform package you want to build
[-DSECURE_LD]	Create a Secure Lockdown build (optional).

Note: The policy decisions taken during EDKII boot for this boot option are automatically taken on secure SKU Quark SoC hardware even if SECURE_LD build option is not specified.

[-DTPM_SUPPORT]	Create an EDKII build with TPM support (optional)
[-DSECURE_BOOT_ENABLE=TRUE]	Create an EDKII build with UEFI Secure Boot support (optional)

Note: The TPM and UEFI Secure Boot build options require the one-time prerequisite described in the CryptoPkg\Library\OpensslLib\Patch-HOWTO.txt file. For more details on TPM (Trusted Platform Module) and UEFI Secure Boot, refer to the *Intel® Quark™ SoC X1000 UEFI Firmware Writer's Guide*.

Linux example usage:
Create a RELEASE build with UEFI Secure Boot and TPM support for an Intel® Quark™ SoC platform based on GCC version 4.3:

```
./quarkbuild.sh -r32 GCC43 QuarkPlatform -DSECURE_BOOT_ENABLE=TRUE -
DTPM_SUPPORT
```

Windows example usage:
Create a DEBUG build for a Quark platform. After executing quarkbuild.bat, a virtual drive S: is created which is rooted to EDKII workspace directory:

```
>.\quarkbuild.bat –d32 S QuarkPlatform
```

The built binaries are used in conjunction with chapter 8 to create Spi Flash binaries for development / manufacture, capsules for firmware update and recovery files for firmware recovery.

Note: A CAPSULE_FLAGS option can be used with the make utility in Chapter 8, this option is UEFI specific and will override the default UEFI capsule flags used by the make utility, example > ../../spi-flash-tools*/Makefile CAPSULE_FLAGS=0x00050000. See Create an Update Capsule in Intel® Quark™ SoC X1000 UEFI Firmware Writer's Guide for information on UEFI capsule flags.

4.5 EDKII Firmware Build Standalone Output Files

Chapter 8 *Creating a Flash Image for the Board [Linux build environment only]* is not required if the user only requires EDKII firmware in the SPI Flash on Intel® Quark™ SoC Open SKU silicon. Sections 4.3 and 4.4 create the following EDKII standalone output files:

- .\Build\....\FV\FlashModules\Flash-EDKII-missingPDAT.bin

  Full 8 MB image for manufacture with just the EDKII SPI flash images. The user is still expected to use Section 9 following to create the final image for the board. The platform data python script referenced in the Section 9 can be used in Linux* or Windows* build environments.

- .\Build\....\FV\RemediationModules\Flash-EDKII.cap

  Capsule with just EDKII flash images that can be used instead of the capsule file referenced in Section 10. Applying this file only updates the EDKII components of the SPI flash (as provided in the capsule). All other SPI flash assets remain intact.

Note: If programming `Flash-EDKII.cap` on a board, it is required that the SPI Flash version of the target board is at production level V1.0.0 or later. (Provided by the `Flash.cap` or `Flash+PlatformData.bin` files referenced in the sections that follow.)

- .\Build\....\FV\RemediationModules\CapsuleApp.efi

  UEFI application referenced in Section 10.1.

- .\Build\....\FV\RemediationModules\FVMAIN.fv

  Recovery file that can be used is included in Section 14. This version of the file only has the EDKII SPI flash images.

Note: To change the default UEFI Capsule flags for the EDKII standalone builds the **quarkbuild.bat** or **quarkbuild.sh** files must be changed.

5 Building the GRUB OS Loader [Linux Build Environment Only]

If you will run Yocto, skip this section and use the file output by Yocto in this directory: `yocto_build/tmp/deploy/images/grub.efi`

If you are only interested in building a Flash image without Linux and not in using Yocto, then proceed through this section.

Note: GRUB is provided in two places: inside the meta-clanton Yocto BSP or independently.

Tip: If you want to build a Flash image without a Yocto Linux system (for example, because you plan to boot a larger Yocto Linux system from an SD card or USB stick), you should modify the appropriate `layout.conf` file and delete the sections for `bzImage` and `core-image-minimal-initramfs-clanton.cpio.gz`.

Dependencies:

- GCC (tested with version 4.3.4 and 4.6.3, and libc6-dev-i386)
- `gnu-efi`-3.0u library (tested with version >= 3.0)
- GNU Make
- Autotools (autoconf, automake, and libtool)
- Python 2.6 or higher
- `git`
- `gcc-multilib`
- `texinfo`

This GRUB build requires the 32 bit `gnu-efi` library which is included with many Linux distributions. Alternatively, you can download the latest version from: http://sourceforge.net/projects/gnu-efi/files

Unpack and compile the `gnu-efi` library using the commands:

```
# tar -xvf gnu-efi*
# cd gnu-efi*/gnuefi
# make ARCH="ia32"
# cd -
```

To build GRUB, **first open a new terminal session**, extract the grub package, and run the `gitsetup.py` script. The script downloads all the upstream code required for grub and applies the patch.

Note: If you are not using Debian and had to manually install `gnu-efi` in a non-system location, then you must point `GNUEFI_LIBDIR` at the location where `gnu-efi` was compiled or installed.

Run the following commands:

```
# sudo apt-get install git autoconf
# tar -xvf grub-legacy_*.tar.gz
# cd grub-legacy_*
# ./gitsetup.py
# cd work
# autoreconf --install
# export CC4GRUB='gcc -m32 -march=i586 -fno-stack-protector'
# export GNUEFI_LIBDIR=/full/path/to/gnu-efi-3.0/gnuefi/
# CC="${CC4GRUB}" ./configure-quark.sh
# make
# cd -
```

Note: If these commands fail, it may be due to your proxy settings. Contact your network administrator. You may find answers about proxy settings here: https://wiki.yoctoproject.org/wiki/Working_Behind_a_Network_Proxy

The required output from this build process is the `work/efi/grub.efi` file.

6 Creating a File System and Building the Kernel Using Yocto Project

Dependencies:

- git
- diffstat
- texinfo
- gawk
- chrpath
- file

Note: `git` requires proxy configuration. If these commands fail, it may be due to your proxy settings. Contact your network administrator. You may also find answers and tips about proxy settings here: https://wiki.yoctoproject.org/wiki/Working_Behind_a_Network_Proxy

Yocto Project can be used to create a root file system and kernel which boots from an SD card, USB key or SPI flash. Do not run any of the commands in this section as root.

Note: See Section 7 to build development tools (`gcc`) for the Linux* operating system.

To avoid a known issue unzipping packages with long file paths, extract the

`meta-clanton` tarball into a directory with a short path, for example `/tmp`.

First, **open a new terminal session**, extract the Yocto Project layer, and run the `setup.sh` script to download the external sources required for the Yocto Project build:

```
# tar -xvf meta-clanton*.tar.gz

# cd meta-clanton*

# ./setup.sh
```

Note: The `setup.sh` script takes no parameters.

When this scripts runs successfully, it will add additional folders such as bitbake, meta-yocto, repo-ext, etc.

Next, source the `iot-devkit-init-build-env` command to initialize the Yocto Project build environment. This command takes the build directory name as its parameter:

```
# source ./iot-devkit-init-build-env yocto_build
```

After this command runs, the current directory will now be the directory specified in the parameter (`yocto_build` in this case). From this directory, run `bitbake <target>` to build the root file system and kernel.

The SoC-specific `<target>` commands described below will determine whether the resulting components are built for SPI flash or for SD/USB. The output is slightly different for each target.

Note: It is not possible to perform both (SD/USB and SPI) build methods from the same directory. If you want both builds, you must perform them on two completely different and isolated directories.

6.1 Build a Full-featured Linux for SD card or USB Stick

Note: A complete Yocto Project build can take several hours to complete, depending on your internet connection speed and your machine's specifications.

To build out an image suitable for running on SD card or USB stick, the bitbake target is image-full:

```
# bitbake image-full
```

When this process complete, the required output files are found in `./tmp/deploy/images/quark/` and include the following components:

- `image-full-quark.ext3`
- `core-image-minimal-initramfs-quark.cpio.gz`
- `bzImage`
- `grub.efi`
- `boot (directory)`

The kernel and root file systems (`bzImage`, `image-full-quark.ext3` and `core-image-*.cpio.gz`, respectively) can be copied onto a USB stick or SD card and booted from grub. The `grub.conf` file must be located in the `/boot/grub/` directory of the USB stick or SD card.

6.2 Build a Small Linux for SPI Flash

An image capable of running in SPI flash must not exceed 8Mb in size and is therefore, a smaller, less featured image than the SD/USB image.

Before building out a SPI image we first need to edit a configuration file. From the build directory (yocto_build in our case), edit the `conf/local.conf` file and change the DISTRO variable. This can be done easily by commenting out (using the hash symbol #) the default value at line 115 and uncommenting the value used for SPI flash images at line 114:

```
DISTRO ?= "iot-devkit-spi"

#DISTRO ?= "iot-devkit-multilibc"
```

Before

```
102 # Default policy config

103 #

104 # The distribution setting controls which policy settings are used as
defaults.

105 # The default value is fine for general Yocto project use, at least initially.

106 # Ultimately when creating custom policy, people will likely end up
subclassing

107 # these defaults.

108 #

109 # Notes:

110 # (1) If you wish to build an image for the Galileo's on-board SPI flash you

111 #     need to set DISTRO to one of the iot-devkit-spi value listed below.

112 # (2) If you wish to build an image (Linux kernel, grub and root file-system)
that

113 #     is stored on SD card, you need to set DISTRO to iot-devkit-multilibc

114 #DISTRO ?= "iot-devkit-spi"

115 DISTRO ?= "iot-devkit-multilibc"
```

After

```
102 # Default policy config

103 #

104 # The distribution setting controls which policy settings are used as
defaults.

105 # The default value is fine for general Yocto project use, at least initially.
```

```
106 # Ultimately when creating custom policy, people will likely end up
subclassing

107 # these defaults.

108 #

109 # Notes:

110 # (1) If you wish to build an image for the Galileo's on-board SPI flash you

111 #     need to set DISTRO to one of the iot-devkit-spi value listed below.

112 # (2) If you wish to build an image (Linux kernel, grub and root file-system)
that

113 #     is stored on SD card, you need to set DISTRO to iot-devkit-multilibc

114 DISTRO ?= "iot-devkit-spi"

115 #DISTRO ?= "iot-devkit-multilibc"
```

The bitbake target for a SPI image is image-spi:

```
# bitbake image-spi
```

Note: Because the SPI image is smaller than the full SD/USB image, it completes quicker but may still take over an hour depending on network speed and machine specifications.

For the Intel® Galileo board, output files are found in `./tmp pi/deploy/images/quark` and include the following components:

- image-spi-quark.cpio.gz
- image-spi-quark.cpio.lzma
- bzImage
- grub.efi

Intel® Quark™ Linux on the SPI image uses `uclibc`, which is a C library optimized for embedded systems. This enables a very small Linux footprint that can fit into 8Mb SPI flash together with the UEFI bootloader and Grub OS loader.

These components now need to be loaded into SPI flash memory. The processes for doing this are covered in Chapters 8, 9, 10 and 11.

6.3 Applying a Custom Patch to the Linux kernel Using Yocto Project (optional)

If you need any customization of your kernel (such as additional debug statements or custom driver behavior), then you may need to patch the Linux kernel. This optional step must be done **before** you run the bitbake command.

1. For customization of Yocto Project source code, extract the updates to a patch from git using the git diff or git format-patch commands.
2. Copy the patch to the location as follows:

```
$ cp mypatch.patch /PATH/TO/MY_BSP/meta-quark-bsp/recipes-
kernel/linux/files/
```

3. Locate the bitbake recipe file:

```
/PATH/TO/MY_BSP/meta-quark-bsp/recipes-kernel/linux/linux-yocto-
quark_3.8.bb
```

4. Append the following line:

```
SRC_URI += "file://mypatch.patch"
```

For example:

```
printf '%s\n' 'SRC_URI += "file://mypatch.patch"' >> linux-yocto-
quark_3.8.bb
```

5. Return to Section 6 and run the `bitbake` command to get new images.

More information can be found here:

- http://www.yoctoproject.org/docs/current/ref-manual/ref-manual.html#var-SRC_URI
- http://www.yoctoproject.org/docs/current/dev-manual/dev-manual.html#platdev-appdev-devshell

7 Building the Linux* Cross Compile Toolchain Using Yocto Project [Linux Build Environment Only]

To develop applications for the target architecture, a toolchain that allows cross compilation is required. There are a number of different methods for building out a cross toolchain. Section 3 of the Yocto Project Application Developer's Guide at the link below provides a detailed description of each method.

http://www.yoctoproject.org/docs/1.6/adt-manual/adt-manual.html#adt-prepare

There are options for creating a toolchain in the current build directory and for creating toolchain installer scripts which will allow the toolchain to be installed on other (SDK) machines different to the build machine.

When building out a cross toolchain, a matching target sysroot is also needed because it contains metadata, libs and headers used to build the appropriate cross toolchain.

Creating a cross toolchain in the current build directory

The easiest method for creating a toolchain, assuming the file system and kernel have already been built in Section 6, is to use the following bitbake command:

```
bitbake meta-ide-support
```

This command will create an environment setup file suitable for the target machine defined by the MACHINE variable in the local.conf file:

(excerpt)
```
# Machine Selection
MACHINE ??= "quark"
```

The resulting environment setup file will be located in `/tmp` and will contain `"environment-setup"` string in the name. For example, "`environment-setup-i586-poky-linux`". This method assumes that the build machine and the SDK machine are the same and that the sysroot is in the current build directory.

Creating a cross toolchain installer

In order to build a cross toolchain capable of being installed on a different machine or in a different area to the current build directory, a cross toolchain installer is required.

If building for a different SDK machine, ensure that the SDKMACHINE variable in local.conf describes this architecture:

(excerpt)

```
# This variable specifies the architecture to build SDK/ADT items for and
means
# you can build the SDK packages for architectures other than the machine
you are
# running the build on (i.e. building i686 packages on an x86_64 host).
# Supported values are i686 and x86_64
#SDKMACHINE ?= "i686"
```

You **must** source the `iot-devkit-init-build-env yocto_build` every time you use a new terminal. To build the toolchain installer to match the target root filesystem already built, **open a new terminal session** and use the `bitbake` command as follows:

```
# bitbake image-full -c populate_sdk
```

The output of the build process is a script that installs the toolchain on another system:
`iot-devkit-eglibc-x86_64-image-full-i586-toolchain-1.6.1.sh`

The script is located in `./tmp/deploy/sdk`. Run the script and extract the cross toolchain to a target directory (default: `/opt/iot-devkit/1.6.1`). This will extract the cross toolchain along with the sysroot to the target directory.

Note: The environment setup script may change your environment significantly, thus breaking other, non-Yocto Project tools you might be using (including anything which uses Python). **You must open a new terminal session** to `source` the Yocto Project environment and run `make`, and run all your other commands in other terminal sessions.

When you are ready to compile your application, first run the `source` command below to define default values for `CC`, `CONFIGURE_FLAGS`, and other environment variables, then you can compile:

```
# source /opt/iot-devkit/1.6.1/environment-setup-i586-poky-linux
# ${CC} myfile.c -o myfile
```

or

```
# source /opt/iot-devkit/1.6.1/environment-setup-i586-poky-linux
# ${CC} myfile.c -o myfile
```

For general details, see the Yocto Project Application Development Toolkit (ADT) information: https://www.yoctoproject.org/tools-resources/projects/application-development-toolkit-adt

Instructions about adding a package to the Linux build are found in Section 5.2 of the Yocto Project Development Manual:

http://www.yoctoproject.org/docs/1.6/dev-manual/dev-manual.html#creating-your-own-layer

If you do not have any size constraints, you can change the C library (using the TCLIBC variable) to a more fully featured C library. Detailed instructions are found in Section 5.9 of the Yocto Project Quick Start:

http://www.yoctoproject.org/docs/1.6/mega-manual/mega-manual.html

It is also possible to write a Yocto Project custom recipe which can be built using the bitbake command. One advantage of this is that the application can be automatically added to the target root file system.

See Section 5.3 of the Yocto Project Development Manual for more detail on writing a new recipe:

http://www.yoctoproject.org/docs/1.6/dev-manual/dev-manual.html#new-recipe-writing-a-new-recipe

8 Creating a Flash Image for the Board [Linux build environment only]

Dependencies:

- GCC
- GNU Make
- EDKII Firmware Volume Tools (base tools)
- `OpenSSL` 0.9.8w
- `libssl-dev`

8.1 Using the SPI Flash Tools

The SPI Flash Tools, along with the metadata and flash image configuration in the sysimage archive, are used to create a binary file that can be installed on the board and booted.

Open a new terminal session and extract the contents of the sysimage archive:

```
# tar -xvf sysimage_*.tar.gz
```

Extract and install SPI Flash Tools:

```
# tar -xvf spi-flash-tools*.tar.gz
```

Note: Extract all files to a directory that does not include the original tar files.

The `sysimage*` directory contains the following preconfigured `layout.conf` files:

- release build base SKU (non-secure)
- debug build base SKU (non-secure)
- release build secure SKU
- debug build secure SKU

Depending on what kind of image you want to build, you must be in either the `sysimage.CP-8M-debug` or the `sysimage.CP-8M-release` directory.

The `layout.conf` file defines how the various components will be inserted into the final binary file to be flashed onto the board. The `layout.conf` consists of a number of `[sections]` with associated address offsets, file names, and parameters. Each section must reference a valid file, so it is necessary to update the paths or create symbolic links to the valid files.

Note: For more information, refer to *Appendix B SPI Flash Tools*.

A script is provided that creates symbolic links. Run the script with the command:

```
# ./sysimage/create-symlinks.sh
```

Ensure there is no whitespace around the values defined in the `layout.conf` file.

Note: If you are using the Intel® Galileo board, you may need to modify the `layout.conf` file in the `[Ramdisk]` section from `image-spi-clanton.cpio.lzma` to `image-spi-galileo-clanton.cpio.lzma` to successfully generate your `.cap` file.

Once a valid `layout.conf` has been created, run the SPI Flash Tools makefile with the command:

```
# ../../spi-flash-tools*/Makefile
```

The output of this build is located in either the `sysimage.CP-8M-debug` or the `sysimage.CP-8M-release` directory (depending on what kind of image was selected).

The output of this build includes:

- `Flash.cap` - standard capsule file.
  Use this file to program your board using the serial interface by following the *Programming the Flash* instructions in Section 10.
- `Flash-missingPDAT.bin` - flash file with no platform data.
  Use this file to program your board with the platform data tool and a Dediprog*, as described in Section 9 and then Section 11.
- `FVMAIN.fv` – board-specific recovery file.
  See Section 14 for an overview of capsule recovery. If you are using the Intel® Galileo board, refer to the *Intel® Galileo Board User Guide* for details. For other boards, contact your Intel representative for details.

The capsule file contains a BIOS, bootloader, and compressed Linux run-time system to allow a Quark-based board to boot. Use the capsule update mechanism described in Section 10 to program the SPI flash on your board.

Note: The same build process and same image files are used for both secure and non-secure board SKUs, however, secure SKUs have certain restrictions on where a capsule update can be performed. If you have a secure SKU board (Industrial/Energy or Transportation Reference Design), you **must** update your board using the Linux* run-time system (Section 10.2).

For experienced users, you can build all sysimages configuration in just one command by running the following command at the top-level directory of the sysimage package:

```
../spi-flash-tools/Makefile [ -j ] sysimages
```

Note: Be aware of the plural `sysimages` in the command.
The `-j` option builds concurrently, which completes in a shorter time, however the output may be harder to read.

9 Platform Data Tool

The platform data file provides platform personality values such as platform type and board personality values such as Ethernet MAC addresses that must be patched into the previously mentioned Flash-missingPDAT.bin and Flash-EDKII-missingPDAT.bin files. This section is required for users who wish to update flash contents using flash programmers, for example, during a manufacturing process. This section can also be used just to generate a .pdat file that can be used as one of the capsule images placed in the firmware update .cap files or recovery FVMAIN.fv files (see Chapter 4 and Chapter 8).

Platform data is part-specific, unique data placed in SPI flash. Every binary image flashed to the board must be patched individually to use platform data. A data patching script is provided in this release.

Note: The *Intel® Quark™ SoC X1000 UEFI Firmware Writer's Guide* contains information on common platform data items.

The platform data patching script (`platform-data-patch.py`) is stored in the platform-data directory within the `spi-flash-tools` tarball in the Intel® Quark™ SoC BSP. The following text is written as if the user is executing the script on a Linux* build machine, but the script may also be run on a Windows* build machine which has Python 2.6 or Python 2.7 installed.

Before running the `platform-data-patch.py` script, open a new terminal session and copy and edit the `spi-flash-tools/platform-data/sample-platform-data.ini` file to include platform-specific data such as MAC address, platform type, and MRC parameters.

On reference platforms, the MAC address to be programmed is printed on the product label.

Note: The Intel® Quark™ SoC X1000 contains two MACs and each must be configured with one address in the `platform-data.ini` file, even on boards (such as Galileo) that have only one Ethernet port.
For Galileo, MAC 0 is the only MAC wired out. The default MAC 0 address value in the `platform-data.ini` file is invalid and must be set to the value allocated to your system, typically this is identified on a sticker.
MAC 1 must also have a valid UNICAST MAC address and the `platform-data.ini` file contains a dummy but valid address for MAC 1.
If you do **not** set a valid MAC address, system will halt during boot.

In the following UEFI Secure boot Crosshill example, recommended values are shown in **bold** text:

```
[Platform Type]
id=1
desc=PlatformID
data.type=hex.uint16
# ClantonPeak 2, CrossHill 4, ClantonHill 5, Galileo 6, GalileoGen2 8
data.value=4
```

Note: In the `[Mrc Params]` section below, the MRC `data.value` MUST correspond to the platform `data.value` used above.

```
[Mrc Params]
id=6
ver=1
desc=MrcParams
data.type=file
# data.value=MRC/clantonpeak.v1.bin

# data.value=MRC/clantonhill.v1.bin

# data.value=MRC/GalileoGen2.bin
data.value=MRC/crosshill.v1.bin
 [MAC address 0]
id=3
desc=1st MAC
data.type=hex.string
data.value=001320FDF4F2   #replace with MAC address from sticker on board

[MAC address 1]
id=4
desc=2nd MAC
data.type=hex.string
data.value=02FFFFFFFF01  #replace with MAC address from sticker on board

# X509 Public certificate file for the private key used to sign OS
bootloader.
[db cert]
id=8
ver=0
desc=db cert
data.type=list
data.list.len=3

# provisioning header field.
data[0].type=hex.string
data[0].value=02000100

# optional guid field to identify this specific cert in 'db' variable.
data[1].type=hex.string
data[1].value=79da34f148b99a49b12226a9f28ed7a4

# X509 public certificate file formated using ASN.1 DER encoding.
data[2].type=file
data[2].value=cert/db.cer

# X509 Public certificate file for the private key used to sign
# SetVariable payloads to update
```

```
# the UEFI Secure Boot 'db' or 'dbx' variables.
[kek]
id=8
ver=0
desc=kek cert
data.type=list
data.list.len=3
data[0].type=hex.string
data[0].value=01000000
data[1].type=file
data[1].value=cert/kek.cer

# Platform owner's Public certificate file for private key used to sign
# SetVariable payloads to

# update the UEFI Secure Boot 'kek' variable.
[pk]
id=7
ver=0
desc=pk
data.type=file
data.value=cert/pk.cer
```

Next, run the script as follows:

```
# cd spi-flash-tools/platform-data/
# platform-data-patch.py -p sample-platform-data.ini \
   -i ../../sysimage_*/sysimage.CP-8M-release/Flash-missingPDAT.bin
# cd -
```

This creates a `Flash+PlatformData.bin` file to be programmed on the board, as well as a `sample-platform-data.pdat` file containing the same data that was inserted in the Flash image.

To program your board using Dediprog, skip to Section 11.

Note: If creating Flash+PlatformData.bin and the sample-platform-data.ini placed UEFI Secure boot certificates in the patched binary file then the generated sample-platform-data.pdat must be used as one of the capsule images placed in the recovery FVMAIN.fv file (see Chapter 8), to allow the UEFI Secure boot system to be recovered. By default EDKII firmware will not update the MAC address in the platform data area if programming an EDKII capsule (refer to the *Intel® Quark™ SoC X1000 UEFI Firmware Writer's Guide*).

10 Programming Flash on the Board Using Serial Interface

Dependencies: `CapsuleApp.efi` (built in Section 4, located in `Build/QuarkPlatform/<Config>/<Target>_<Tools>/FV/Applications/`)

The BSP provides a mechanism to update SPI flash contents based on EDKII capsules. These capsules contain a BIOS, bootloader, and compressed Linux run-time system sufficent to boot a Quark-based board, such as the Intel® Galileo board.

The capsule update mechanism can be triggered from an EDKII shell (Section 10.1) or from a Linux* run-time system (Section 10.2). In both situations, you must have root privileges on the system.

If you have a secure SKU board (Industrial/Energy or Transportation Reference Design), you **must** update your board using the Linux* run-time system (Section 10.2).

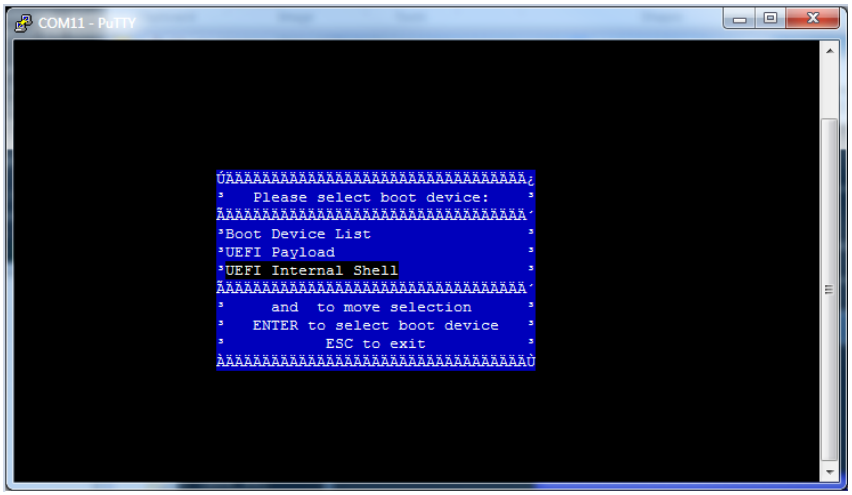
10.1 Programming flash using UEFI shell

This procedure cannot be used for a secure SKU board (Industrial/Energy or Transportation Reference Design) because the UEFI shell is not available on secure SKU boards. Follow the Section 10.2 procedure instead.

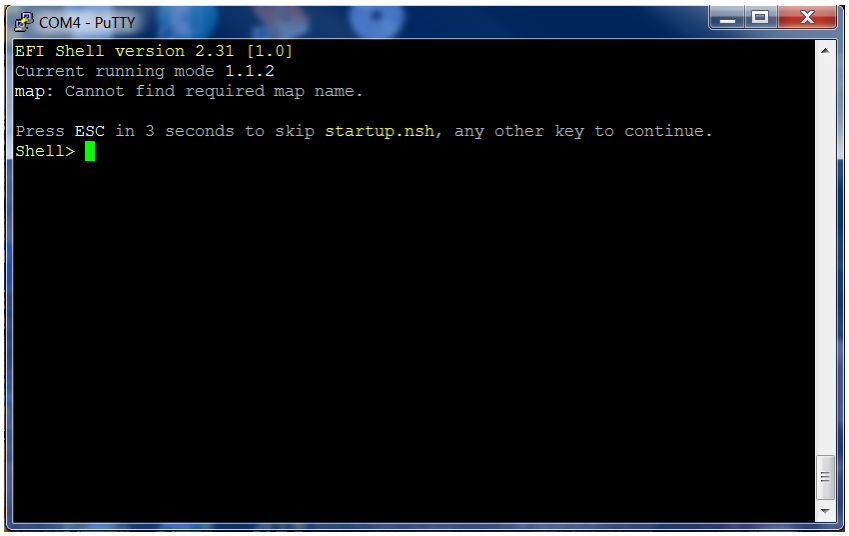
Perform the steps that follow:

1. Use the files created in Section 8.
2. Copy `CapsuleApp.efi` and `Flash.cap` to a microSD card (or USB stick) and insert it into the slot on the board.
3. Connect the serial cable between the computer and the board. Set up a serial console session (for example, PuTTY) and connect to the board's COM port at 115200 baud rate.
4. Configure the serial console session to recognize special characters. For example, if you are using PuTTY, you must explicitly enable special characters. In the PuTTY `Configuration` options, go to the `Terminal > Keyboard` category and set the `Function keys and Keypad` option to `SCO`. You may also set `Backspace` to the `Control-H` key.
5. Power on the board. Enter the EFI shell before grub starts by pressing F7.

6. The serial console displays a boot device selection box (below). Select `UEFI Internal Shell`.



You will see a display similar to this:

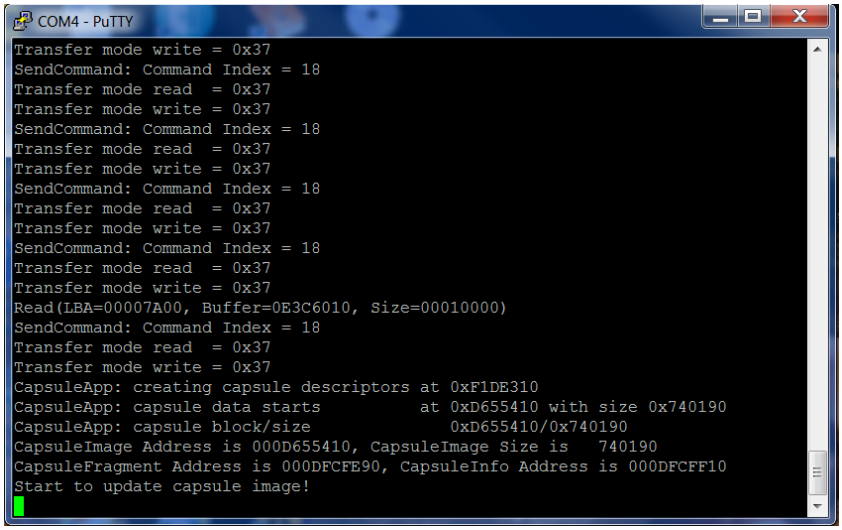


6. You will see a print out, the top line of which looks like this:
   `fs0  :HardDisk - Alias hd7b blk0`

   This is your SD card. To mount it, type: `fs0:`
7. Verify you are using the correct version of `CapsuleApp.efi` by using the `-v` option. You **must** use version 1.01 or later.
8. Enter the following command:
   `CapsuleApp.efi Flash.cap`

Note: You must enter the full filename of the `Flash.cap` file.

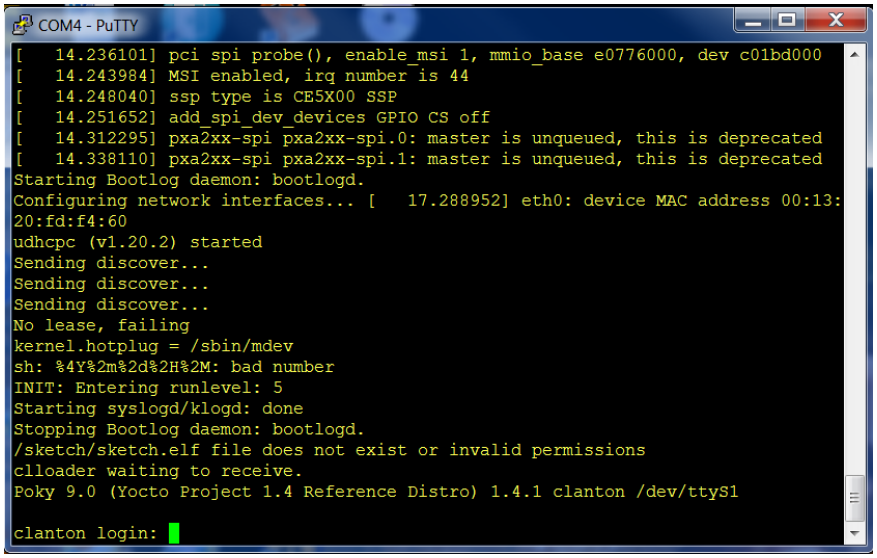
You will see a display similar to this:



The `CapsuleApp` will update your SPI flash image. This process takes about 5 minutes.

Warning: DO NOT remove power or try to exit during this process. Wait for the prompt to return, otherwise your board will become non-functional.

9. When the update completes, the board will automatically reboot. You will see a display similar to this:



10.2 Programming Flash Using Linux* Run-time System

If you are updating from an earlier release of the BSP software (0.7.5 and 0.8.0), you need a release-specific kernel module. Note that a 0.7.5 kernel module cannot be loaded on a 0.8.0 BSP and vice-versa.

Open a new terminal session and perform the following steps:

1. Use the files created in Section 8.
2. Copy `Flash.cap` from the `sysimage` directory onto an SD card (or USB stick) and insert it into the board.
3. **Release 0.7.5 and Release 0.8.0 only:**
   Run the command:
   ```
   # insmod /tmp/<release>/efi_capsule_update.ko
   ```
   where: `<release>` = `0.7.5` or `0.8.0`
4. **Release 0.9.0, Release 1.0.0, and later:**
   Run the command:
   ```
   # modprobe efi_capsule_update
   ```
5. **All releases:**
   Run the following commands:
   ```
   # modprobe sdhci-pci
   # modprobe mmc-block
   # mkdir /lib/firmware
   # cd /media/mmcblk0p1/
   # cp Flash.cap /lib/firmware/Flash.cap
   # echo -n Flash.cap >
        /sys/firmware/efi_capsule/capsule_path
   # echo 1 > /sys/firmware/efi_capsule/capsule_update
   # reboot
   ```

Note: Make sure you use the `reboot` command; removing/reinserting the power cable will **not** work.

Warning: It is critical to ensure that the older `sysfs` entries used by Release 0.7.5 and Release 0.8.0 are **not** used due to known issues:

```
/sys/firmware/efi/capsule_update
/sys/firmware/efi/capsule_path
```

The capsule update method for Release 0.9.0 and later uses the following corrected entries:

```
/sys/firmware/efi_capsule/capsule_update
/sys/firmware/efi_capsule/capsule_path
```

11 Programming Flash on the Board Using DediProg

You can use a DediProg* SF100 SPI Flash Programmer and the associated flashing software to program your board.

Note: These steps require the `Flash+PlatformData.bin` file that was created in Section 9.

Once the software has been installed and the programmer is connected to the board, **open a new terminal session**, and run the DediProg Engineering application.

Use the following steps to flash the board:

1. Select the memory type if prompted when the application starts.
2. Select the File icon and choose the `*.bin` file you wish to flash.
3. Optionally select the Erase button to erase the contents of the SPI flash.
4. Select `raw` file format.
5. Select the Prog icon to flash the image onto the board.
6. Optionally select the Verify icon to verify that the image flashed correctly.

Note: Intel recommends that you disconnect the programmer before booting the system.

12 Booting the Board From SD Card

To boot your board from an SD card and enable persistent `rootfs`, follow these steps. You can also use this procedure to boot your board from a USB stick.

If you are using an Intel® Galileo board, this setup allows you to save your Arduino* sketch to the board, so it will be able to repeat sketches after board power-down. This also enables a persistent `/sketch` folder and `rootfs`.

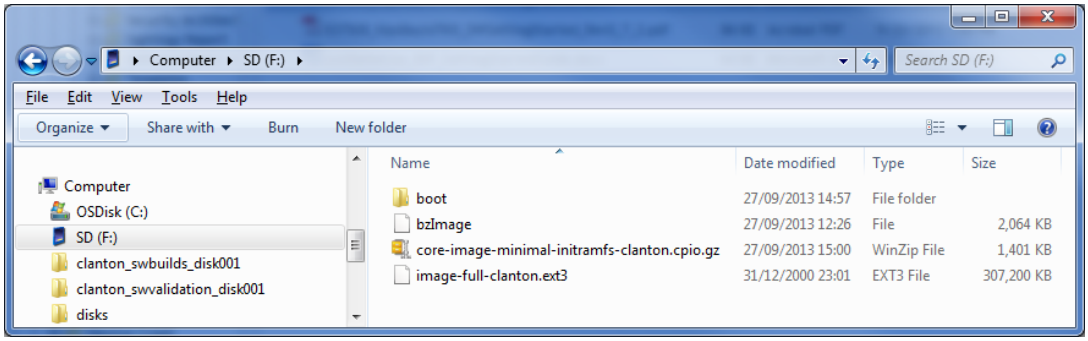
Dependencies:

- You ran the command `bitbake image-full` in Section 6 (or `bitbake image-full-galileo` if using an Intel® Galileo board)
- Your SD card must meet the following requirements:
  - SD card must be formatted as FAT or FAT32.
  - SD card size must be 32GB (or smaller) and SDHC format. SDXC format is **not** supported.

1. The output of the build process in Section 6 is found in `./tmp/deploy/images/`

   Copy the following kernel and root file system files to an SD card:
   - `boot (directory)`
   - `bzImage`
   - `core-image-minimal-initramfs-clanton.cpio.gz`
   - `image-full-clanton.ext3` or `image-full-galileo-clanton.ext3` for the Intel® Galileo board

   Be sure to set up your SD card with the files and structure shown below.



2. Insert the SD card, then power on the board.

Note: The first time you boot the board may take several minutes. This is expected behavior due to the SSH component creating cryptographic keys on the first boot.

Troubleshooting tips:
To boot from SD/USB, the grub instance embedded in the SPI flash is hardcoded to search for a `boot/grub/grub.conf` file in partition 1 on the SD/USB card. This is compatible with the factory formatting of most SD/USB devices. By default, the UEFI firmware does not try to boot from SD or USB, it is handled by grub.

If you use an SD or USB device that has been reformatted after manufacturing, you might experience problems booting from it. First, try to boot with a different memory device and see if the problem goes away. If you isolate the problem to a specific SD card, you can restore the factory formatting using this tool from the SD association:
https://www.sdcard.org/downloads/formatter_4/
It is not recommended to use normal operating system tools to format flash memory devices.

Part 2 of 2 - Using the BSP Software

This section contains the following subsections:

13 Capsule Update

The BSP software provides a mechanism to update SPI flash contents based on EDKII capsules. These capsules contain a BIOS, bootloader, and compressed Linux run-time system sufficent to boot a Quark-based board, such as the Intel® Galileo board. Capsule update is comprised of the following high-level steps:

- Building a `Flash.cap` capsule file
- Connecting a USB key or SD card that contains this file to the board
- Running the capsule update mechanism as described in Section 10.1 or Section 10.2.

Note: If you have a secure SKU board (Industrial/Energy or Transportation Reference Design), you **must** update your board using the Linux* run-time system (Section 10.2).

14 Capsule Recovery

The BSP software provides a mechanism for the SPI flash contents to be recovered if the board will not boot. For example, if power was lost during a normal SPI flash update, the board would be unbootable.

Capsule recovery is comprised of the following high-level steps:

- building a `FVMAIN.fv` recovery file
- connecting a USB key with this file to the board
- booting the board in recovery mode

Note: If you are using the Intel® Galileo board, refer to the *Intel® Galileo Board User Guide* for details. For other boards, contact your Intel representative for details on how to boot in recovery mode.

- waiting for the recovery firmware to update the SPI flash and reboot the board

Booting in recovery mode is board specific. Please refer to the board user guide for details.

Alternatively, the SPI flash contents can be recovered using a DediProg* SF100 SPI Flash Programmer and the associated flashing software to program your board as described in Section 11.

15 Signing Files (Secure SKU only) [Linux build environment only]

This step is optional for most users; it is only needed for booting on a secure SKU.

Dependencies: `libssl-dev`

All files located by grub require signature files for verification. This includes kernel, `grub.conf`, `bzImage`, and `core-image-minimal-initramfs-clanton.cpio.gz`.

The SPI Flash Tools package includes the Asset Signing Toolset, an application used for signing assets for secure boot. Follow the steps below to compile the signing tool, then sign assets.

For complete details on the Asset Signing Toolset, including all of the command line options, refer to the *Intel® Quark™ SoC X1000 Secure Boot Programmer's Reference Manual* (see Appendix A).

Note: For convenience during development, the software release includes a default Private Key `key.pem` file. During development, all assets are signed with the default key that is stored in the `config` directory. The default key **cannot** be used in a production system; it is not secure due to its inclusion in the release package. Contact your Intel representative for details.

Open a new terminal session and use the following commands:

```
# cd spi-flash-tools
# make asset-signing-tool/sign
```

After compiling the signing tool, you can sign assets as shown in the following example:

```
# path/to/spi-flash-tools/asset-signing-tool/sign –i <input file>
-s <svn> -x <svn index> -k <key file>
```

The output for this example is a signed binary file called `<input file>.signed` in the same directory as the `<input file>`.

To create a separate signature file, pass the `-c` command line option which creates `<input file>.csbh` as output in the same directory as the `<input file>`.

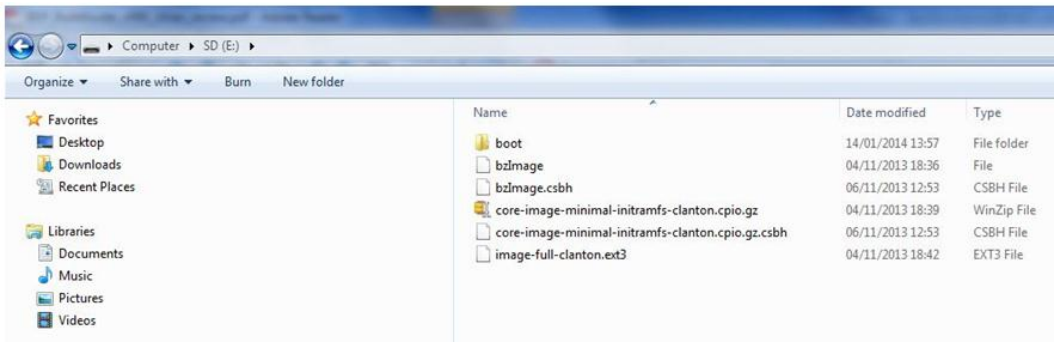
To get a full list of command line options, run the signing tool with no option.

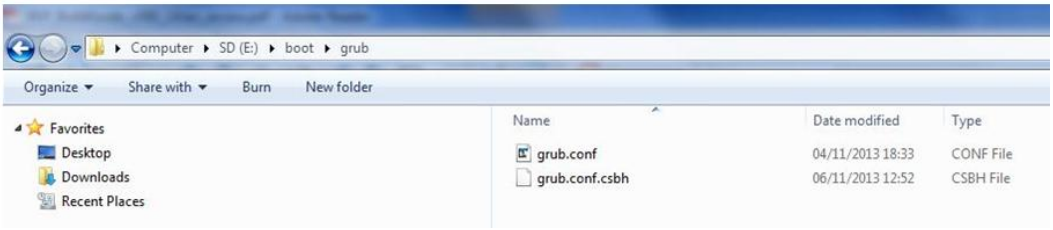
The signature files can be copied onto a USB stick or SD card and must comply with the following requirements:

- Each `.csbh` file must be in the same directory as the corresponding non-signed file.
- `grub.conf` must be located in the `/boot/grub/` directory.
- Other files can be placed anywhere as long as `grub.conf` is configured with their location.

The screenshots below show an example SD card with signature files:

- Copy signature files `core-image-minimal-initramfs-clanton.cpio.gz.csbh` and `bzImage.csbh` to the root directory.
- Copy `grub.cbsh` to the `/boot/grub/` directory.





16 Enabling the OpenOCD Debugger

Complete instructions for using the OpenOCD debugger can be found in the *Source Level Debug using OpenOCD/GDB/Eclipse on Intel® Quark™ SoC X1000 Application Note*, refer to Appendix A.

Appendix A Related Documents

The documents in the following table provide more information about the software in this release.

Document Name	Number
Intel® Quark™ SoC X1000 Board Support Package (BSP) Build and Software User Guide (this document)	329687
Intel® Quark™ SoC X1000 Software Release Notes	330232
Intel® Quark™ SoC X1000 Secure Boot Programmer's Reference Manual	330234
Intel® Quark™ SoC X1000 Linux* Programmer's Reference Manual	330235
Intel® Quark™ SoC X1000 UEFI Firmware Writer's Guide	330236
EDKII Update for Intel® Quark™ SoC X1000 Software Release Notes	330729
Source Level Debug using OpenOCD/GDB/Eclipse on Intel® Quark™ SoC X1000 Application Note https://communities.intel.com/docs/DOC-22203	330015
Intel® Quark™ SoC X1000 Datasheet https://communities.intel.com/docs/DOC-21828	329676
Intel® Quark™ SoC X1000 Core Developer's Manual https://communities.intel.com/docs/DOC-21826	329679
Intel® Quark™ SoC X1000 Core Hardware Reference Manual https://communities.intel.com/docs/DOC-21825	329678
Intel® Galileo Board User Guide https://communities.intel.com/docs/DOC-22475	330237

Appendix B SPI Flash Tools

The main functionality of the SPI flash tools is provided by a Make file. By default the Make file should be called from within a directory with a valid layout.conf and will output a flash binary and capsule.

Example of usage is in section 6.2 *Build a Small Linux for SPI Flash*.

The Make file provides a number of targets which can be used to change the behavior or output of the tool:

- all (default) - creates the flash binary, capsule and recovery image
- raw - create only the flash binary
- capsule - create only the capsule
- recovery - creates a recovery image
- clean - delete all intermediate files in the current directory
- sysimages - Search all subdirectories for a layout.conf file and if found build the images
- sysimages-clean - as above but calls clean
- sysimages-install - as above but copies all of the output files into an "installs" directory

There are also a number of variables which can be prefixed to the Makefile call on the command line to modify the behavior of the tool:

- KEYFILE - can be used to select an encryption key to use if assets are being signed
- LAYOUTFILE - specify the name of a layout file if it has a non-standard name
- PDAT_IN_CAPSULE - include the platform data in the capsule
  - true ==> include the platform data in the capsule
  - false ==> do not include the platform data in the capsule (default false)
- CAPSULE_FLAGS:
  - 0x00010000 ==> do NOT update MAC addresses
  - 0x00010001 ==> update the MAC addresses
    (default: 0x00010000)
- CAPSULE_SVN - update CAPSULE_SVN when changing KEYS for UEFI Secure Boot Systems (default = 0)

  Example: KEYFILE=/path/to/key.pem ../spi-flash-tools/Makefile
- PDAT_INI ==> name of test system pdata .ini file (defaults to platform-data.ini if not given)