

TMS320C5515 Fingerprint Development Kit (FDK) Software Guide

User's Guide



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1 Overview

The C5515 Fingerprint Development Kit (FDK) is a complete signal chain solution that enables manufacturers and developers, who are interested in integrating fingerprint biometrics features into their product, to go to market faster.

The kit contains two widely used fingerprint sensor types (one swipe sensor and one optical sensor), one core board with TI's latest C5515 low-power digital signal processor, and one extension board for user interaction. The kit also includes complete hardware design collateral, simplified application source code and technical documentation including user guide, and application notes, to help users understand how to develop a fingerprint application.

A production quality demo and its .out file are also included in the kit to enable users to experience the final product performance. Some target applications include fingerprint-enabled physical access control products (electronic door locks and safe boxes), USB smart keys and storage device, PC user identification, and time and attendance monitoring systems.

The part number for the FDK is TMDXBDFP5515.

2 FDK Content

The FDK includes:

- 1 core board (30 mm x 30 mm) based on C5515 low-power DSP
- 1 extension board (78 mm x 30 mm) for power supply, communication and user interaction
- 1 swipe fingerprint sensor (AuthenTec ATW310)
- 1 optical fingerprint sensor (Tooan OP-100N)
- 1 Type-B USB cable for updating program and user interaction
- 1 mini DVD containing:
 - Code Composer Studio™ IDE
 - Simplified fingerprint application source code
 - Demo code .out file
 - C5515 datasheet and chip support library (CSL)
 - Technical documentation including user guide, application notes, quick start guide, schematics, BOM, and gerbers

3 FDK Software Overview

Figure 1 provides an overview of the FDK algorithm software.

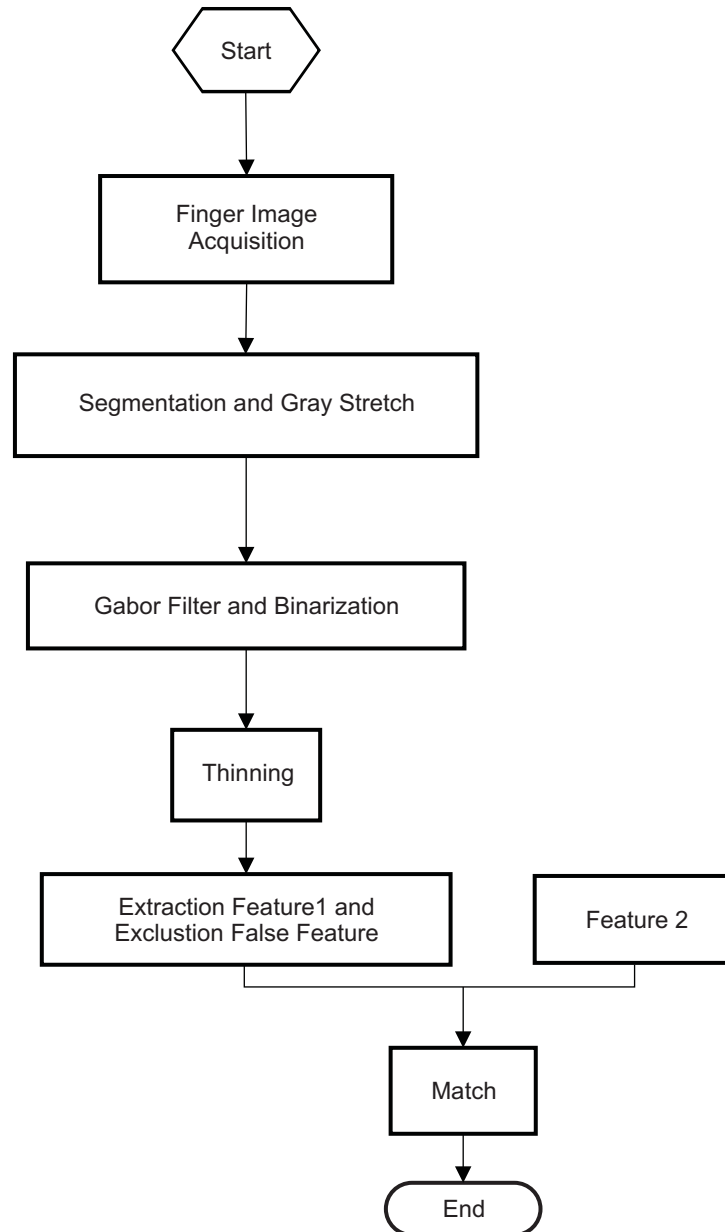


Figure 1. FDK Algorithm Overview

Segmentation: The image acquired from the fingerprint sensor is first subjected to Segmentation. Image Segmentation is the process of partitioning the image into regions based on certain metrics so that the pixels in a given segment all have the same values for the metric. The result of this operation is a labeling of image regions into “valid” and “invalid” areas corresponding to the presence and absence to fingerprint information. An example of an image acquired from the fingerprint sensor and the result after Segmentation is shown in [Figure 2](#) and [Figure 3](#).



Figure 2. Original Image



Figure 3. Segmentation Result

Gray Stretch: The image after segmentation is subjected to Gray Stretch to increase the global contrast of the image. Gray Stretch is performed by means of Histogram Equalization, resulting in an even distribution of gray scale intensities in the image. [Figure 4](#) shows the result of Gray Stretch for the example image.



Figure 4. Gray Stretch Result

Block Direction: A gradient based Block Direction algorithm is used to process the output of Gray Stretch, resulting in a gradient map for the image. [Figure 5](#) shows the result of Block Direction for the example image.

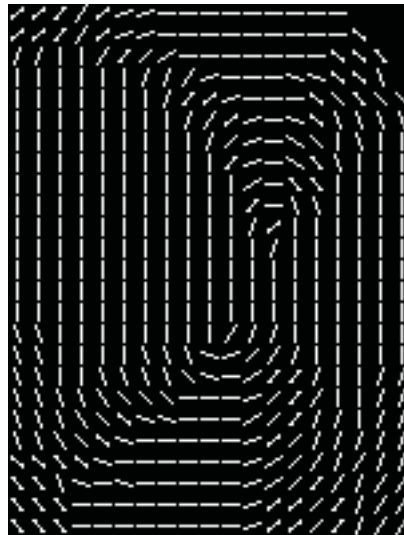


Figure 5. Block Direction

Gabor Filter: The results of Gray Stretch and Block Direction for the input to Gabor Filtering. Gabor filters are directional filters used for extracting edge oriented information. The result is enhancement of certain frequencies and directions based on parameter settings. The parameter settings are critical to the overall algorithm performance.

Binarization: The output of Gabor filtering is subjected to Binarization. Binarization converts an image with multiple gray levels into an image with binary (black and white) levels. Thresholding operations are used to binarize the input gray scale image, typically with input values at and below the threshold set to black and those above the threshold set to white.

The result of Binarization and Block Direction are subjected to a second pass of Gabor Filtering and Binarization.

[Figure 6](#) and [Figure 7](#) show the output of Gabor Filter and Binarization on the first pass.

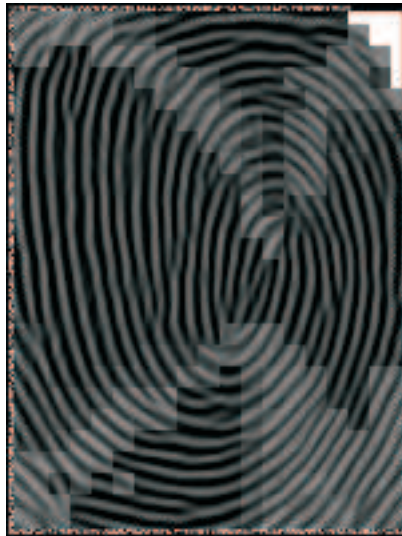


Figure 6. Output of First Pass of Gabor Filter

[Figure 8](#) and [Figure 9](#) respectively show the output of Gabor Filter and Binarization on the second pass.



Figure 7. Output of First Binarization



Figure 8. Output of Second Pass of Gabor Filter and Binarization



Figure 9. Output of Second Pass of Binarization

Thinning: The output of the second Binarization step is subjected to Thinning. This step is used for skeletonization, to reduce the output of the Binarization step to lines of single pixel thickness. Thinning is done by performing the morphological operation of Erosion on the Binarization output. [Figure 10](#) shows the result of Thinning for the example image.



Figure 10. Thinning Output

Feature Extraction: Minutae based features are extracted from the image after thinning. Minutiae represent local discontinuities in the fingerprint ridge flow. A map of the minutiae is extracted from the data and can be matched against stored minutiae maps to identify/verify an individual. Removal of false minutae is conducted and then the features corresponding to each minutae are tagged resulting in a feature vector of up to 45 values. [Figure 11](#) shows the result of Feature Extraction for the example image.



Figure 11. Feature Extraction Result

[Figure 12](#) shows the result of processing on two instance of fingerprint acquisition that were confirmed as a match by the matching algorithm.

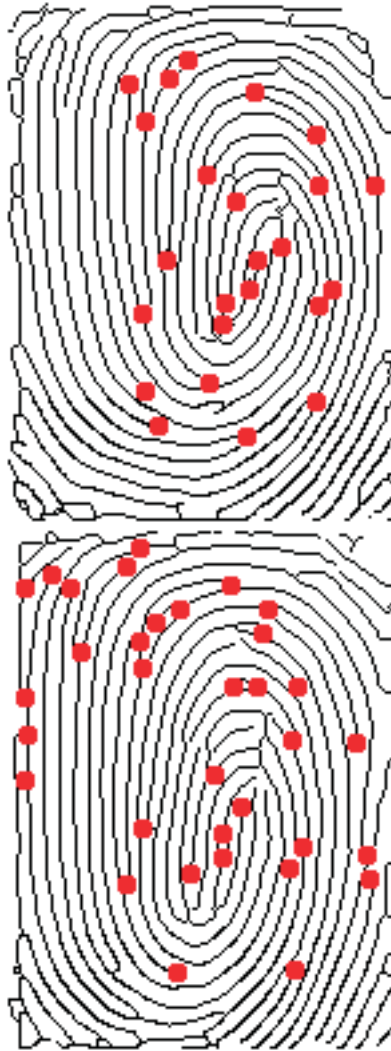


Figure 12. Confirmed Match


4 CCS4.x Setup

This section describes the procedure for configuring Code Composer Studio 4.x(CCS) to communicate with the C5515 DSP on the FDK through the XDS100 JTAG interface.

- Install CCS4 from the Mini-DVD provided with this development kit.
- Ensure that you have installed the XDS100 drivers for CCS4
 - See instructions at the hyperlink below (drivers included with CCS4.1 and newer):
http://processors.wiki.ti.com/index.php/XDS100#XDS100_Installation_Instructions
- <FDK PATH> represents the path to the disk location where the FDK CD ROM contents are located in the Windows file system.

CCS4 can be downloaded from: <http://processors.wiki.ti.com/index.php/CCSv4>

4.1 Configure CCS4.x for C5515 Target Configuration

- Open CCS4.x and select a workspace
- When the welcome screen appears, click on the  icon to close the welcome screen and go to the CCS workbench
- When the workbench opens, click on Target→New Target Configuration...
- In the New Target Configuration window, enter a name for the Target Configuration and click Finish.
- In the next window that opens, under General Setup, from the Connection drop-down menu, select Texas Instruments XDS100v1 USB Emulator.
- Type C5515 into the Device field to filter out nonrelevant devices.
- Check the box labeled EVM5515 and click Save.

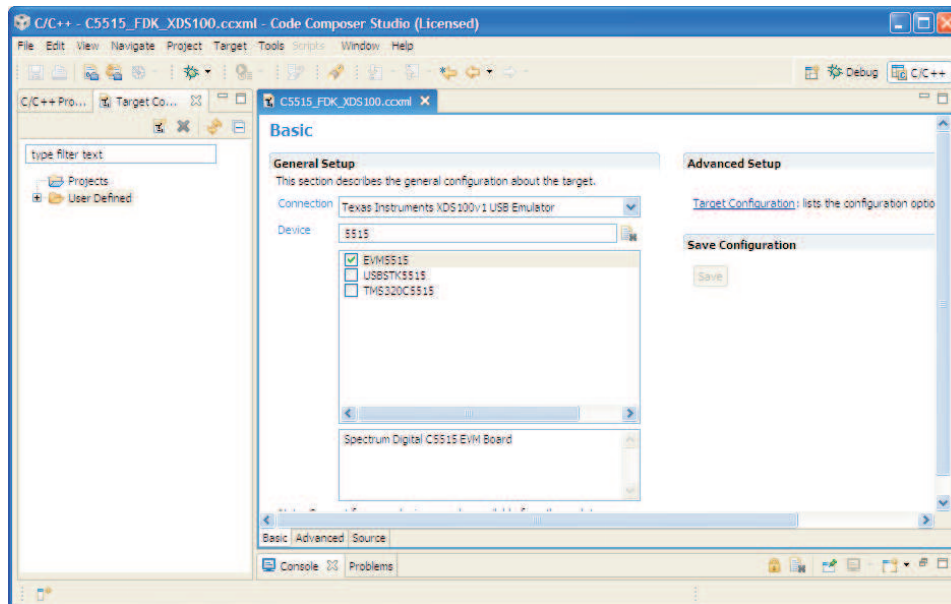


Figure 13. General Setup of Code Composer Studio

- Click the Advanced tab at the bottom of the window.
- Under All Connections click on the plus icons to fully expand the list hierarchy.

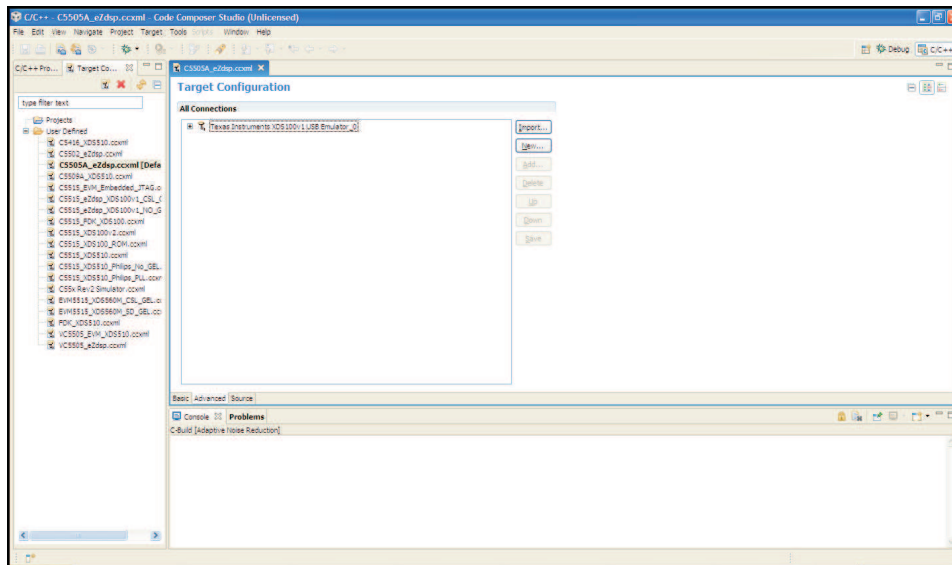



Figure 14. Plus Icon

- Click on  C55xx to access the CPU properties.
- In the Initialization Script field, browse to the C5515 GEL file located at "<FDK PATH>\Software\C5515_code_development\FDK_Demo\gel\c5515.gel"
- Click Save.

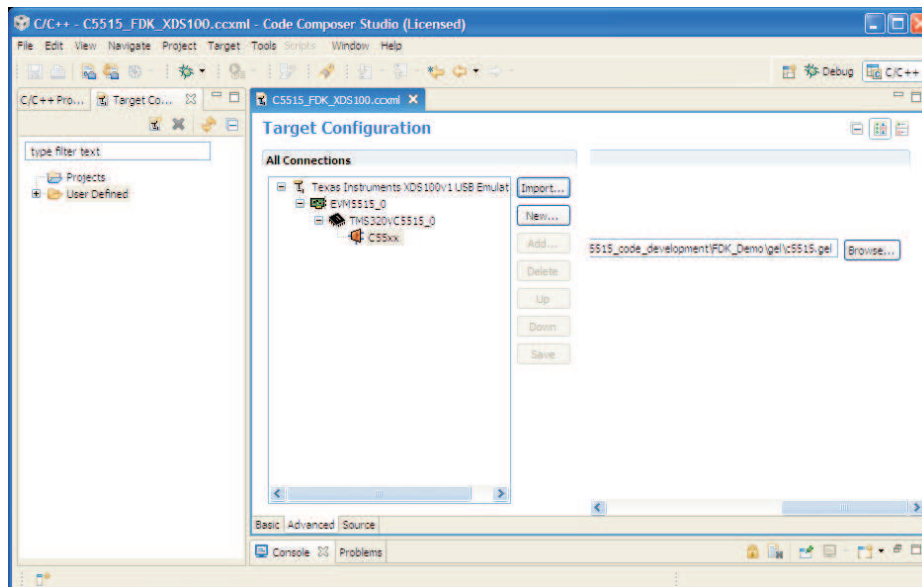


Figure 15. All Connections in Code Composer Studio

- Click on View→Target Configurations.
- Expand the User Defined folder to see the target configuration just created.
- Right click on the target configuration name and click on Launch Selected Configuration.

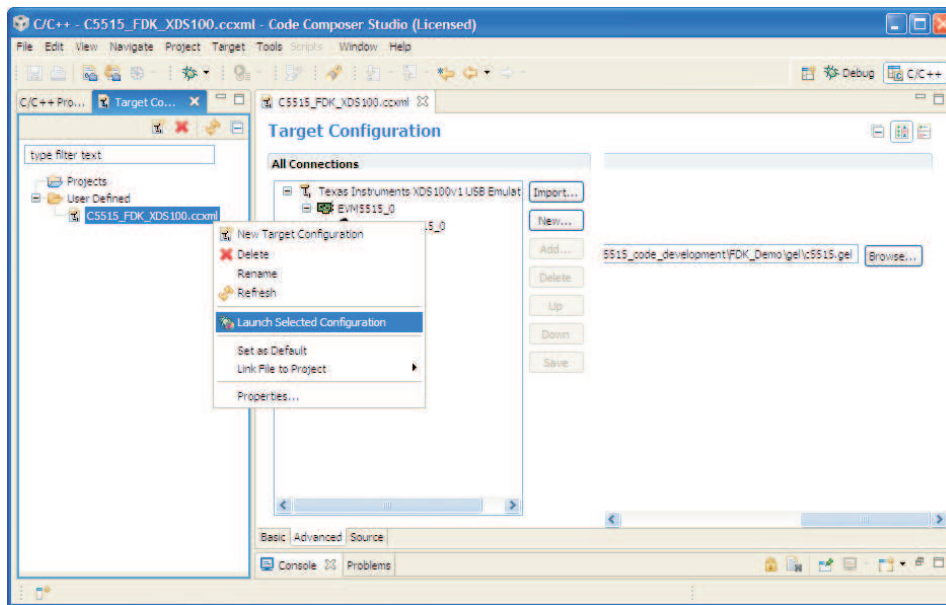




Figure 16. Launch Selected Configuration

- When the target configuration is launched, the Debug perspective opens. This is indicated by the debug selection   at the top right of the CCS window.
- Click on Target→Connect Target to connect to the C5515 device.

4.2 Load Demo Code .out File onto FDK Device

Four versions of production code in binary boot image format are provided:

- **atw310.bin** — Fingerprints obtained with AuthenTec ATW310 Swipe Sensor
- **OP-100N.bin** — Fingerprints obtained with Toan OP-100N Optical Sensor
- **OP-100R.bin** — Fingerprints obtained with Toan OP-100R Optical Sensor
- **fpc1101.bin** — Fingerprints obtained with FPC1101 sensor (Contact Toan)

Also provided is a User BIOS binary boot image, **sensor_ck.bin**, that automatically detects the attached sensor and uses the corresponding production boot image for that sensor.

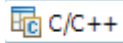
All binary files previously listed are programmed into the SPI Flash of the FDK so that the FDK can work with any of these sensors without reflashing the SPI Flash.

Copies of the binary boot images are located under "<FDK PATH>\Software\bin_files\".

See the system guide in the C5515 FDK Window Program User Guide, included on the mini DVD for instructions for loading the demo code onto the FDK device.

4.3 Open, Build, and Run Simplified Fingerprint Application Source Code

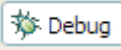
The FDK CDROM contains source code with a simplified fingerprint feature extraction/matching algorithm. This section describes how to open, build, and run that project in CCS4.x.

- Change back to the C/C++ perspective by clicking on  at the top right of the window
- Click on Project→Import Existing CCS/CCE Eclipse Project.
- In the Import window, browse to "<FDK PATH>\Software\C5515_code_development\FDK_Demo\". Ensure that FDK_Demo is checked and click Finish.
- Click on Project→Build Active Project to build the FDK Demo. Ensure no error messages were printed to the console.

- Ignore the warning about the entry-point symbol other than `_c_int00`. This project uses the entry point `reset_isr`, which is defined inside of `vectors.asm`.

WARNING:

```
<Linking>
warning: entry-point symbol other than "_c_int00" specified: "reset_isr"
'Finished building target: FDK_Demo.out'
'
Build complete for project FDK_Demo
```

- Switch back to the Debug perspective by clicking on the  icon at the top right of the window.
- Click on View→C/C++ Projects to open the project file explorer window.
- Click on the icon next to Binaries to show the `FDK_Demo.out` file.
- Right-click on `FDK_Demo.out` and click on Load Program.

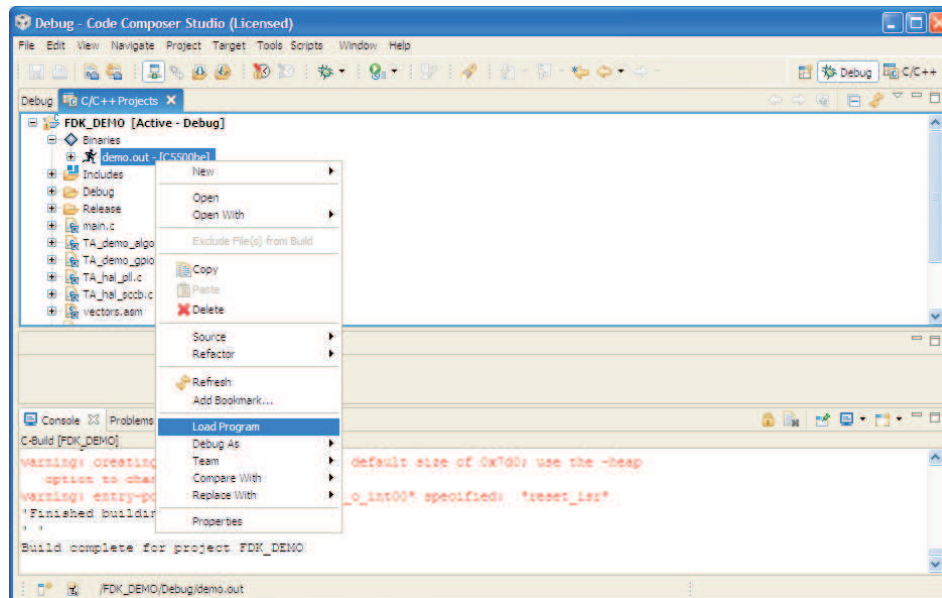



Figure 17. Load Program

- When the project finishes loading, click on View→Debug to see the Debug Window.
- Click on the  icon to run the demo.

The demo inputs two fingerprints through the optical sensor only. A single beep indicates when a fingerprint is being read.

Repeated beeps indicate either that the finger prints match or they do not match.

The results are also printed on the console.

The demo will repeat infinitely.

5 Support Resources

For additional information regarding the TMS320C5000 family of DSPs, please refer to the following page on TI website:

<http://www.ti.com/c5000>

Code Composer Studio support is available via a forum at:

<http://community.ti.com/forums/138.aspx>

Additional development support is available via the online community/tool folder:

<http://www.ti.com/c5515fdk>

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