Chipcon Products
from Texas Instruments

User Manual

Rev. 1.4

CC1010IDE Integrated Development Environment

Texas Instruments

SWRU057

Table of contents

Introduction

The Integrated Development Environment (IDE) supports development, debugging and simulation of CC1010 software applications and includes a project manager GUI, text editor, simulator and debugger GUIs, and a compiler/assembler/linker. The CC1010IDE is based on “uVision2”, a software development tool from Keil ™ Elektronik GmbH. This tool provides a framework for most of the CC1010IDE features and it also supports most 8051 microcontroller platforms.

The editor is primarily a tool for editing source and assembler files. However, it also provides syntax highlighting and other helpful functionality, such as GUI, needed for simulation/debugging (disassembly, register dumps, memory dumps, watch windows, instruction stepping, etc.). In addition, the IDE provides the interfaces towards the DLL used for simulation and in-circuit debugging.

Since the compiler/assembler/linker is integrated in the development platform, the IDE in effect ‘hides’ the invocation of these tools. More specifically the compiler converts one or more C source files into assembly code, which, together with any handwritten assembler files are fed to the assembler. The assembler then produces object files (machine code and binary data), which in turn are fed into the linker together with any precompiled libraries. Finally, the linker isolates functions and variables that are actually used and produces an executable file in Intel HEX format that can be downloaded into the FLASH memory of a CC1010.

Documentation

In addition to the files related to the use and functionality of the CC1010, the CC1010IDE includes a set of documentation files (i.e.: CC1010DK User Manual), that provide details of the CC1010 platform. The CC1010IDE documentation and software files are specified in later chapters and distributed as follows (shaded boxes indicate location of the Chipcon files):

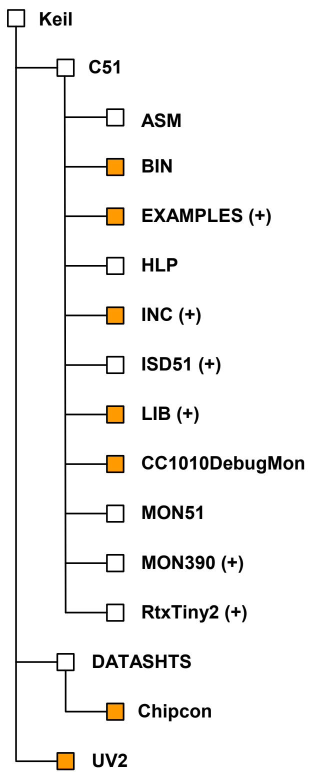


Figure 1: Software.

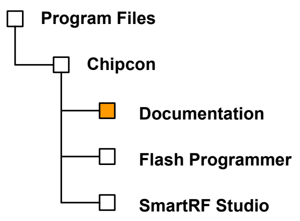


Figure 2: Documentation

ASM
Hardware definitions for 8051 and other microcontrollers.

BIN
Keil ™ program files, i.e.: compiler, linker, etc.
CC1010 debug extensions (DLL's).

EXAMPLES(+)
CC1010 application examples + generic examples.

HLP
Keil ™ help documents (compiler help, syntax help, etc).

INC(+)
Header files for CC1010 and other supported platforms.

ISD51(+)
In System Debugger provided by Keil ™.

LIB (+)
Keil ™ library files, i.e.: RS232 adapted dialog functions.
Chipcon libraries (HDF, HAL and CUL).

MON390(+)
Debug monitor for Dallas CPU.

MON51
Keil ™ library files for the debug monitor.

RtxTiny2(+)
Tiny real time operating system provided by Keil ™, including task scheduler, etc.

CC1010DebugMon
CC1010 debug monitor (target/embedded debug driver).

DATASHTS
CC1010 documentation, i.e.: user manuals.

UV2
Keil ™ uVision2 IDE program files (including device database).

Documentation
Chipcon documentation, datasheets, etc.

Flash Programmer
CC1010 flash programmer.

SmartRF® Studio
SmartRF® Studio (tool for RF performance evaluation).

Abbreviations / Definitions

CC1010IDE	CC1010 Integrated Development Environment

CC1010EB	CC1010 Evaluation Board
CC1010DK	CC1010 Development Kit
CC1010DS	CC1010 Data Sheet
CUL	Chipcon Utility Library
DLL	Dynamic-Link Library
HAL	Hardware Abstraction Library
HDF	Hardware Definition Files
ICD	In-Circuit Debugger
IDE	Integrated Development Environment
RF	Radio Frequency
UV2	Keil ™ uVision2

Basic CC1010IDE associations

In order to provide a complete development environment the CC1010IDE integrates with a number of other components. In addition to the application source code, it associates with source libraries, documentation and DLL's, and uses the serial port and parallel port to download/communicate with the CC1010 embedded software:

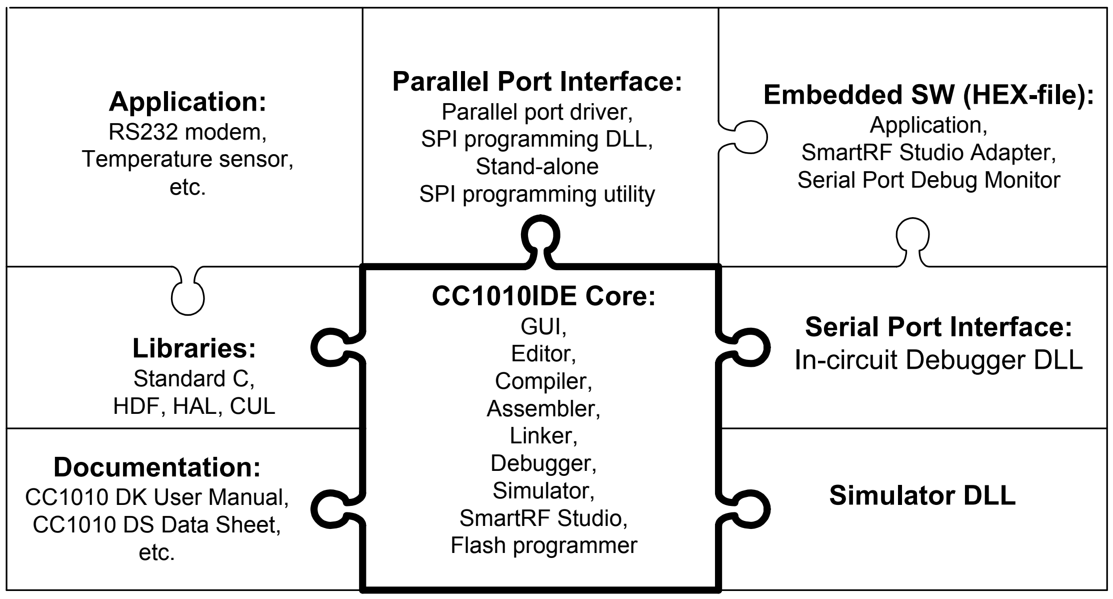
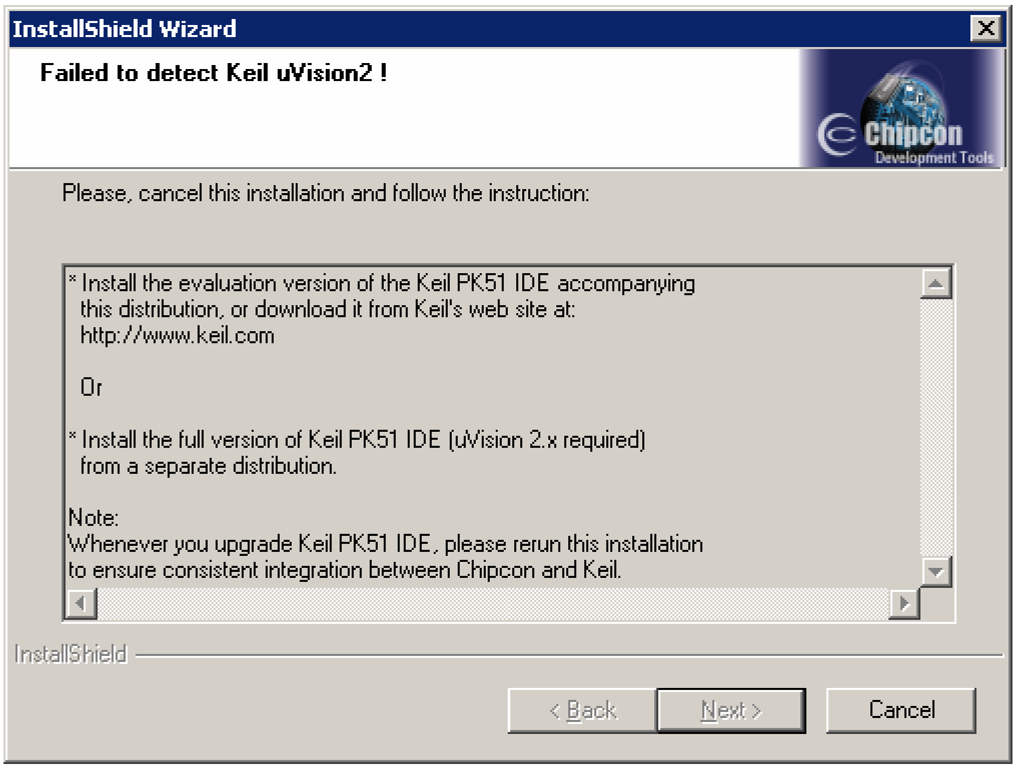


Figure 3: Basic CC1010IDE associations.

Installing the CC1010IDE

The CC1010IDE integrates closely with Keil ™ uVision2 IDE. Hence in order for the CC1010IDE modules to work Keil ™ uVision2 must be installed on the computer first, otherwise the CC1010IDE installation will throw the following error message:



Failed to detect Keil uVision2 !

Please, cancel this installation and follow the instruction:

* Install the evaluation version of the Keil PK51 IDE accompanying
this distribution, or download it from Keil's web site at:
http://www.keil.com

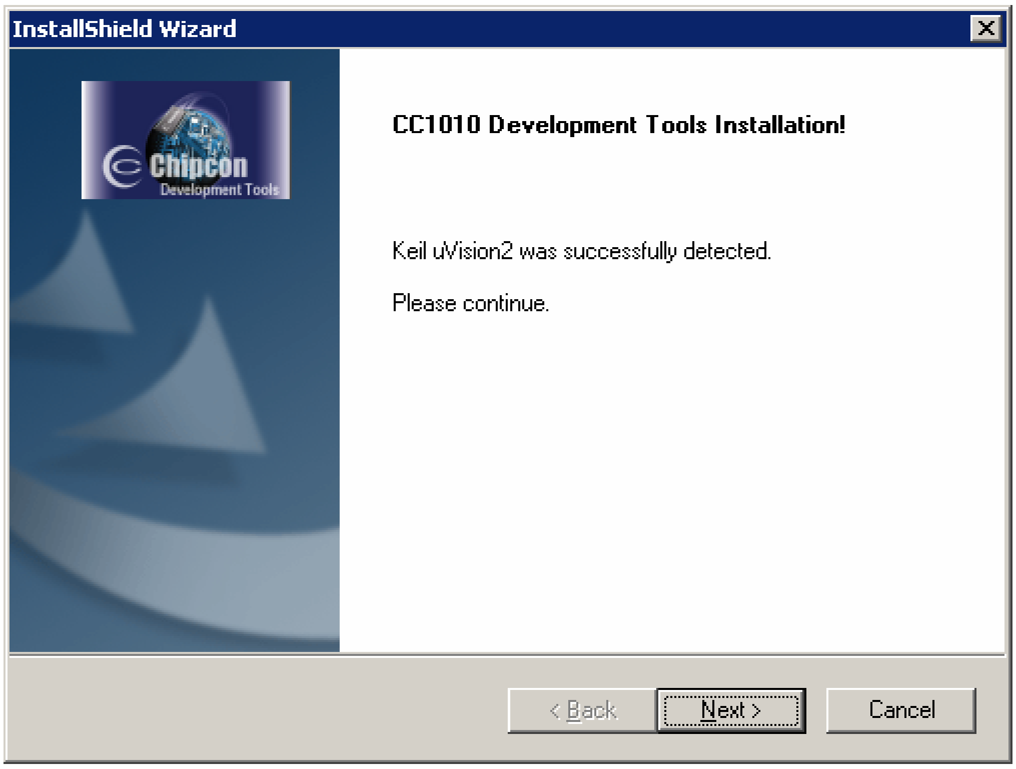
Or

* Install the full version of Keil PK51 IDE (uVision 2.x required)
from a separate distribution.

Note:
Whenever you upgrade Keil PK51 IDE, please rerun this installation
to ensure consistent integration between Chipcon and Keil.

Figure 4: CC1010IDE installation check.

Once Keil ™ uVision2 IDE has been installed successfully the CC1010IDE installation program will automatically detect/recognize it on the computer and allow the user to proceed with the CC1010IDE installation.



InstallShield Wizard

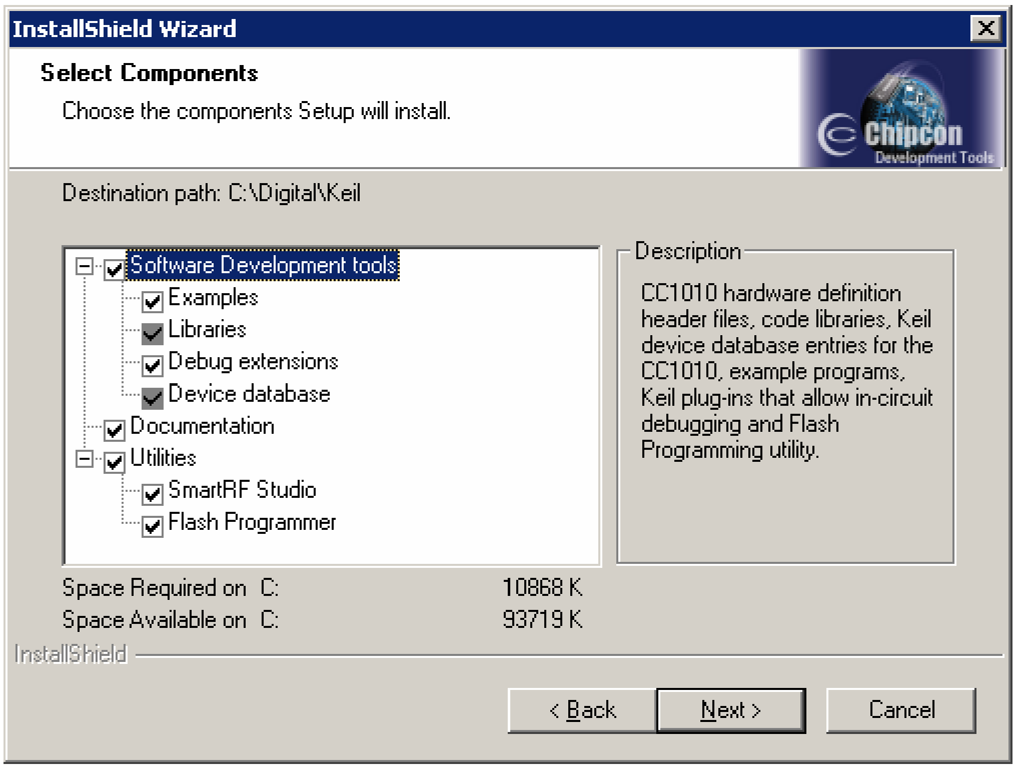
CC1010 Development Tools Installation!

Keil uVision2 was successfully detected.

Please continue.

Figure 5: CC1010IDE installation start.

The CC1010IDE installation covers multiple components that can be selected based on individual needs. However, a default installation profile is used unless specified otherwise. To change the suggested profile, just browse the 'Select Components' dialog and select/deselect components as you prefer:



InstallShield Wizard

Select Components

Choose the components Setup will install.

Destination path: C:\Digital\Keil

- ✓ Software Development tools
  - ✓ Examples
  - ✓ Libraries
  - ✓ Debug extensions
  - ✓ Device database
- ✓ Documentation
- ✓ Utilities
  - ✓ SmartRF Studio
  - ✓ Flash Programmer

Description

CC1010 hardware definition header files, code libraries, Keil device database entries for the CC1010, example programs, Keil plug-ins that allow in-circuit debugging and Flash Programming utility.

Space Required on C:	10868 K
Space Available on C:	93719 K

Figure 6: CC1010IDE installation components.

Please note that the evaluation version of Keil ™ uVision2 accompanying the CC1010IDE distribution imposes certain restrictions/limitation on the compiler:

- **PK51/C51 Compiler:**
    - The 8051 compiler, assembler, linker, and debugger are limited to 2 Kbytes of object code but source code can be any size. Programs generating more than 2 Kbytes of object code will not compile, assemble, or link.
    - The debugger supports 2 Kbyte files or smaller.
    - Programs begin at offset 0x0800.
    - No hardware support is available for multiple DPTR registers.
    - No support is available for user libraries or floating point arithmetic.
    - The following Code Banking Linker, Library Manager and RTX-51 Tiny Real-Time Operating System, which are present in the PK51 Full Version, are not included in the PK51/C51 Eval Version.
    - It is not possible to generate assembler source files or use in-line assembler features.

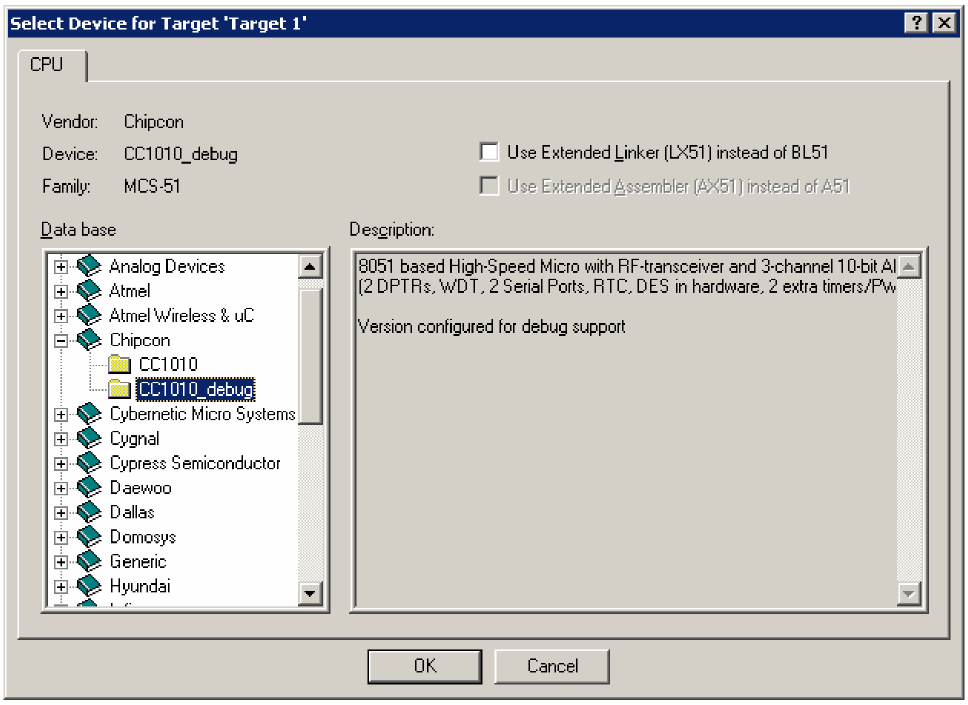
For general limitations on the Keil ™ uVision2 compiler, please refer to C51 User's Guide.

Setting up a software project for the CC1010

Before the CC1010IDE can generate any target software it needs a software project with consistent references to the actual target platform. These references can be specified in the target configuration dialog.

Configure target profile

The initial step of target configuration is device association; right-click on 'Target' (CC1010) and choose 'Select device for target'. Then browse the Chipcon folder and associate a device profile with the desired operation mode. For normal CC1010 run-time operation, just choose 'CC1010'. To configure the CC1010 device for debug operation, however, choose 'CC1010_debug'. This will dedicate specific memory ranges in the CC1010 RAM/ROM to the so-called debug monitor, an embedded software module that drives the debug process (i.e.: instruction stepping) on the CC1010 based on commands from the CC1010IDE (via RS232). Note that the evaluation version of Keil ™ IDE does NOT support 'Extended Linker…':


Select Device for Target 'Target 1'

CPU

Vendor: Chipcon
Device: CC1010_debug
Family: MCS-51

☐ Use Extended Linker (LX51) instead of BL51
☐ Use Extended Assembler (AX51) instead of A51

Data base
- Analog Devices
- Atmel
- Atmel Wireless & uC
- Chipcon
  - CC1010
  - CC1010_debug
- Cybernetic Micro Systems
- Cygnal
- Cypress Semiconductor
- Daewoo
- Dallas
- Domosys
- Generic
- Hyundai

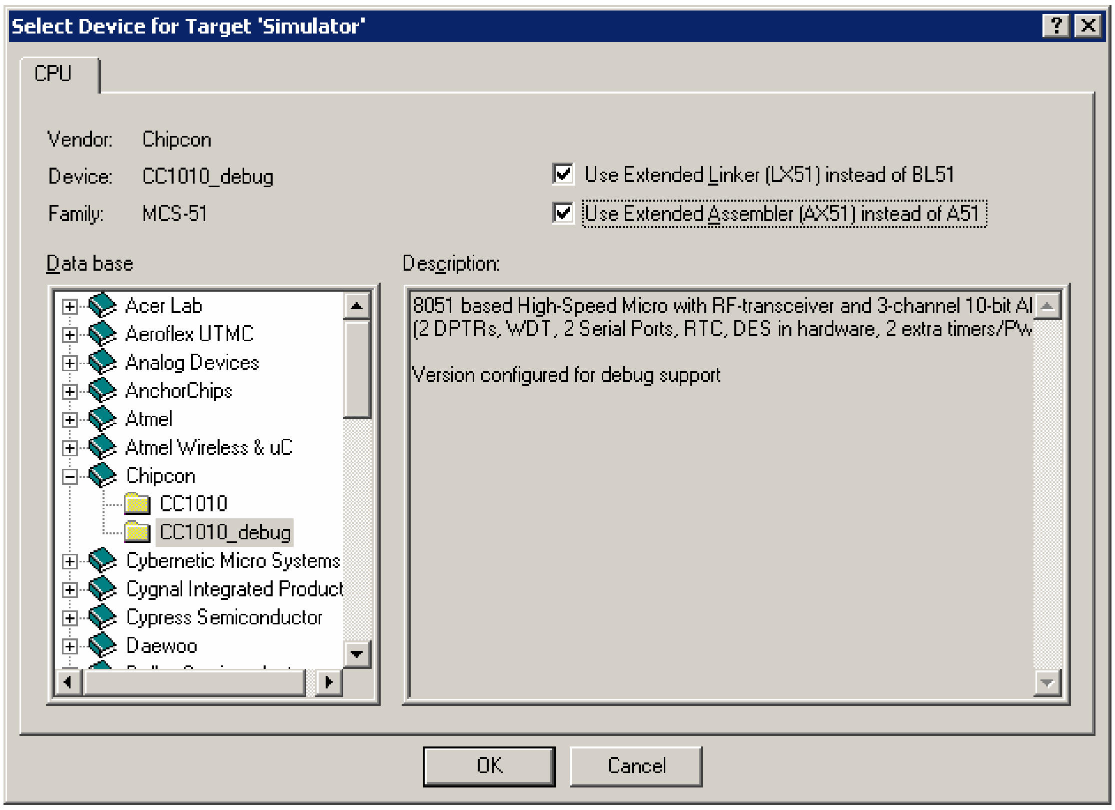
Description:
8051 based High-Speed Micro with RF-transceiver and 3-channel 10-bit Al
(2 DPTRs, WDT, 2 Serial Ports, RTC, DES in hardware, 2 extra timers/Pw

Version configured for debug support

OK Cancel

Figure 7: CC1010 device profile for Keil ™ - evaluation version.

Remember to always choose 'Extended Linker…' when using the full version of Keil ™ IDE:



Select Device for Target 'Simulator'

Vendor: Chipcon
Device: CC1010_debug
Family: MCS-51

☑ Use Extended Linker (LX51) instead of BL51
☑ Use Extended Assembler (AX51) instead of A51

Description:
8051 based High-Speed Micro with RF-transceiver and 3-channel 10-bit AI
(2 DPTRs, WDT, 2 Serial Ports, RTC, DES in hardware, 2 extra timers/PW

Version configured for debug support

Figure 8: CC1010 device profile for Keil ™ - full version.

After choosing the desired device profile, right-click on ‘Target’ (CC1010) and choose ‘Options for Target CC1010’:

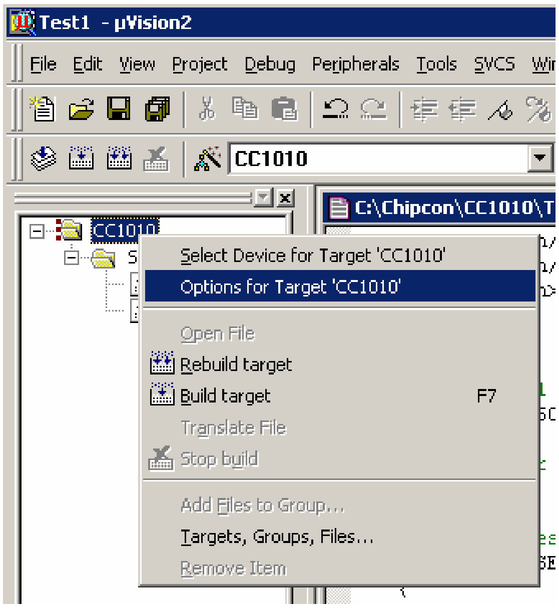
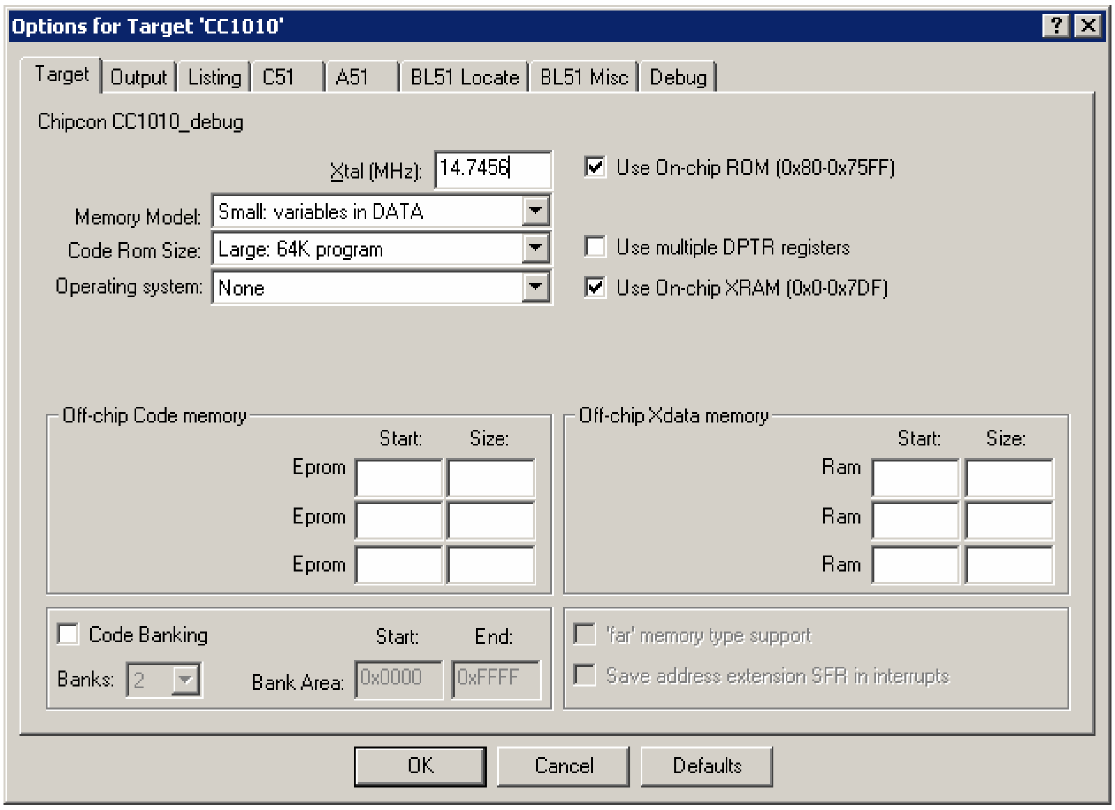

Test1 - µVision2
File Edit View Project Debug Peripherals Tools SVCS Wi
CC1010
C:\Chipcon\CC1010\T
Select Device for Target 'CC1010'
Options for Target 'CC1010'
Open File
Rebuild target
Build target F7
Translate File
Stop build
Add Files to Group...
Targets, Groups, Files...
Remove Item

Figure 9: Target options.

Configure memory and clock profile

Choose the 'Target' tab to configure the memory and clock profile for the CC1010 target. Basically, the CC1010 is driven by an oscillator and it supports on-chip ROM/XRAM. For debug operation it is necessary to allocate some memory for the debug monitor (as a result the target will offer slightly less ROM/RAM space for the CC1010 application). Thus to enable CC1010 debugging, ensure that the options 'Use On-Chip ROM/XRAM' are selected. For consistency, please refer to following recommendation:



Chipcon CC1010_debug

Xtal (MHz): 14.7456

Memory Model: Small: variables in DATA

Code Rom Size: Large: 64K program

Operating system: None

[✓] Use On-chip ROM (0x80-0x75FF)

[ ] Use multiple DPTR registers

[✓] Use On-chip XRAM (0x0-0x7DF)

[ ] Code Banking

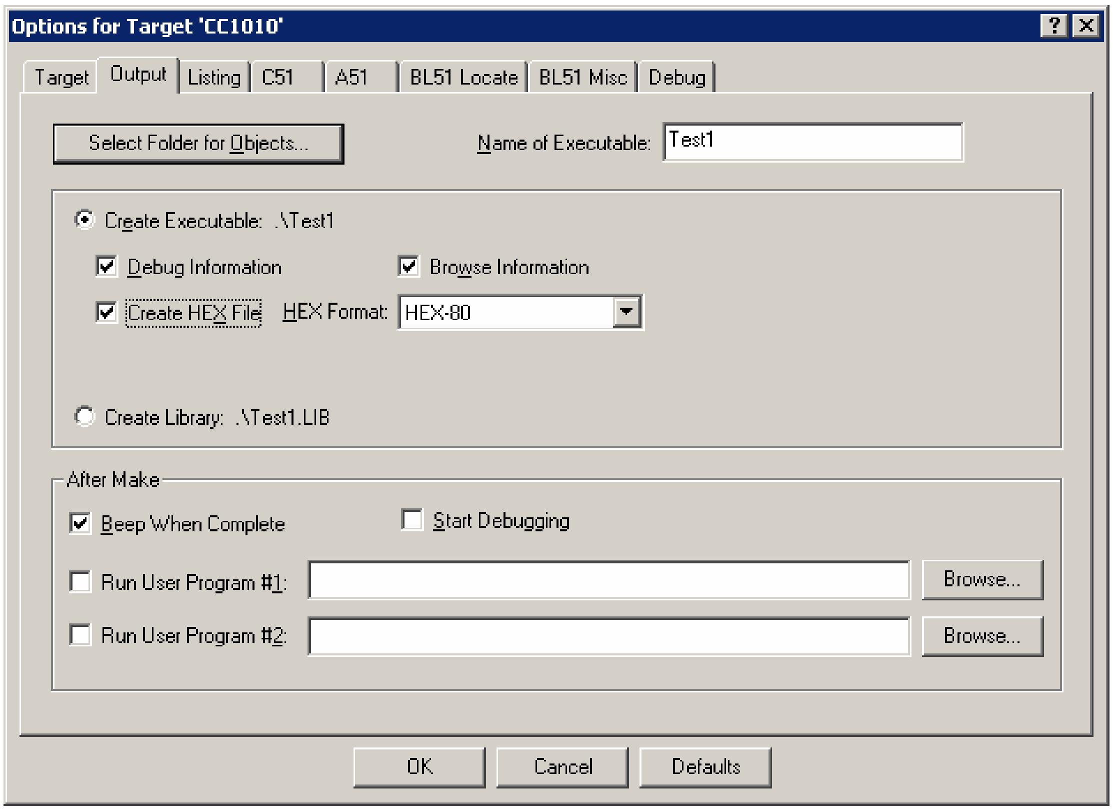
Banks: 2

Bank Area: 0x0000 0xFFFF

Figure 10: Memory and clock profile.

Configure output profile

The CC1010IDE “build process” generates an executable file according to the settings specified in the ‘Output’ tab. To support the CC1010 target the output file must be in the correct format. The ‘Output’ tab also offers options to run user-specified programs after the output file has been made. In general Chipcon recommends the following output configuration:



Name of Executable: Test1

(●) Create Executable: .\Test1

[✓] Debug Information   [✓] Browse Information

[✓] Create HEX File   HEX Format: HEX-80

( ) Create Library: .\Test1.LIB

After Make

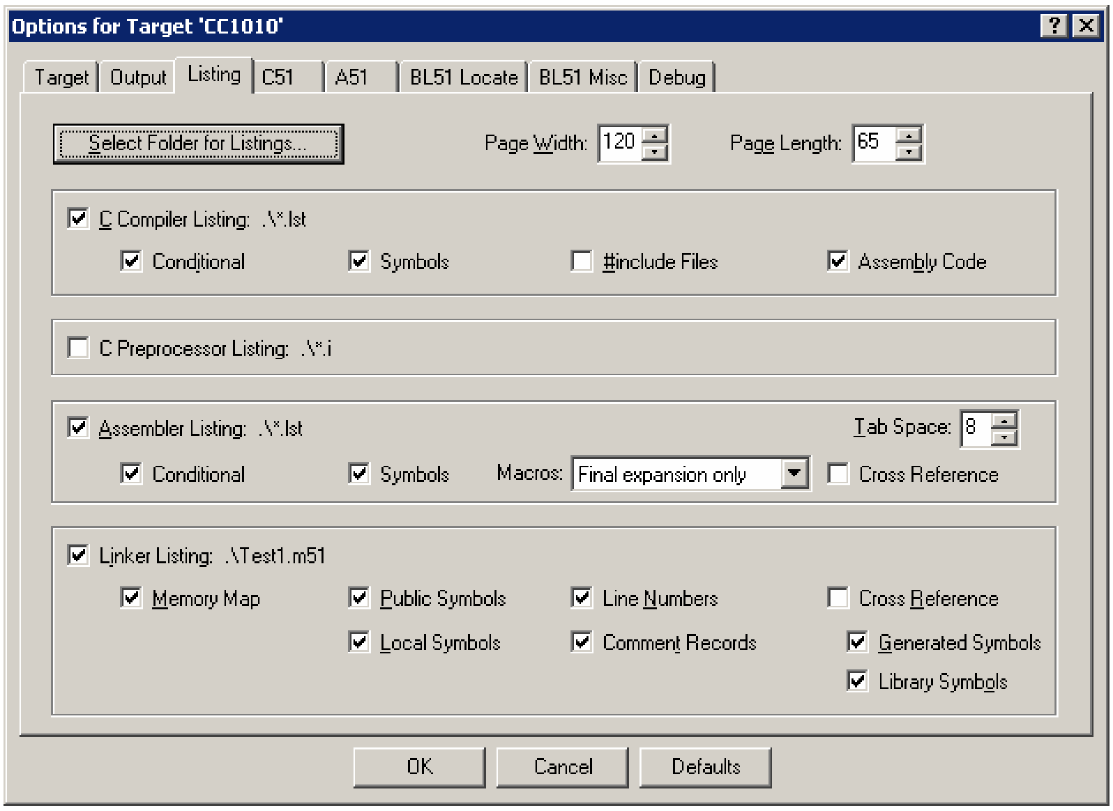
[✓] Beep When Complete   [ ] Start Debugging

[ ] Run User Program #1:

[ ] Run User Program #2:

Figure 11: Output profile.

In addition to the executable file the CC1010IDE can also produce a variety of list files, i.e.: to support inspection/debugging of the target code. In order to generate a full inspection reference to the target code the following listing configuration is recommended:


Options for Target 'CC1010'

Target | Output | Listing | C51 | A51 | BL51 Locate | BL51 Misc | Debug

Select Folder for Listings... Page Width: 120 Page Length: 65

☑ C Compiler Listing: .*.lst
☑ Conditional ☑ Symbols ☐ #include Files ☑ Assembly Code

☐ C Preprocessor Listing: .*.i

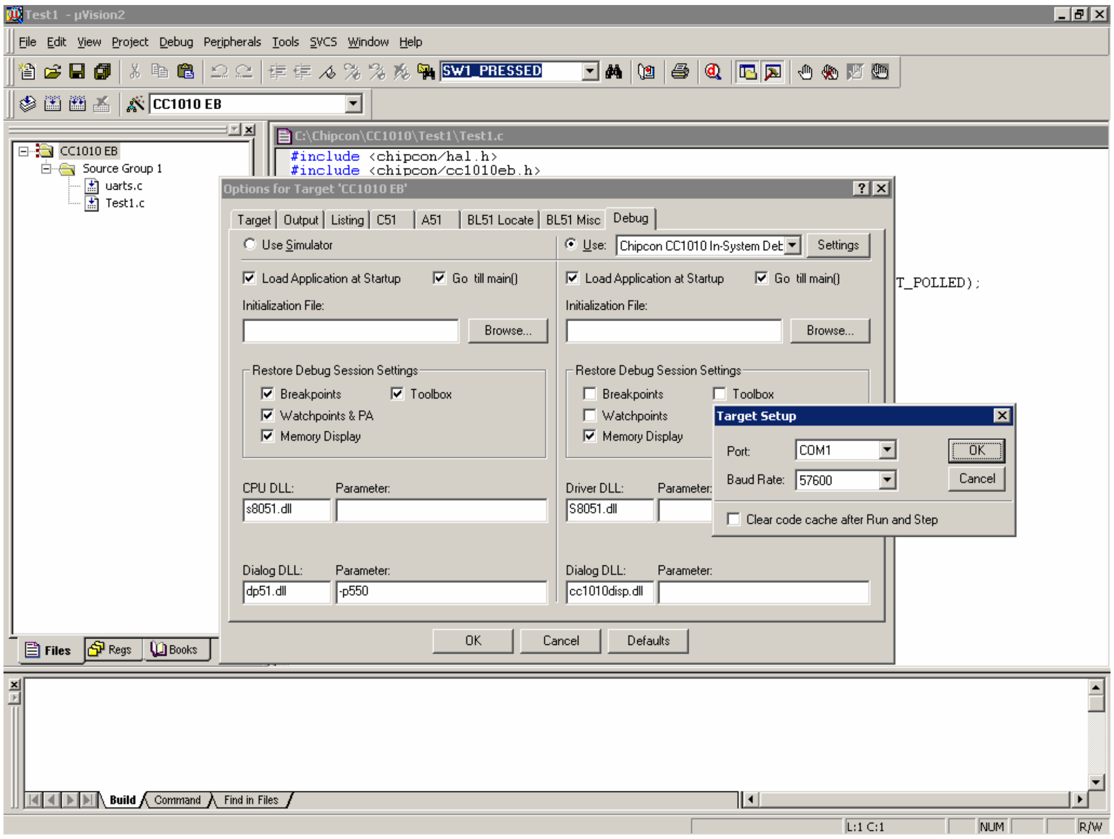
☑ Assembler Listing: .*.lst Tab Space: 8
☑ Conditional ☑ Symbols Macros: Final expansion only ☐ Cross Reference

☑ Linker Listing: .\Test1.m51
☑ Memory Map ☑ Public Symbols ☑ Line Numbers ☐ Cross Reference
☑ Local Symbols ☑ Comment Records ☑ Generated Symbols
☑ Library Symbols

Figure 12: Listing profile.

Configure debug profile (in-circuit debugger)

The ‘Debug’ tab enables you to configure the CC1010 in-circuit debugger and simulator. The in-circuit debugger supports remote run-time control of the CC1010 software and requires communication between the PC and CC1010EB. To configure the CC1010 target for in-circuit debugging Chipcon recommends the following configuration:



```
C:\Chipcon\CC1010\Test1\Test1.c
#include <chipcon/hal.h>
#include <chipcon/cc1010eb.h>
T_POLLED);
```

Options for Target 'CC1010 EB'

Target | Output | Listing | C51 | A51 | BL51 Locate | BL51 Misc | Debug

- ( ) Use Simulator
  - [✓] Load Application at Startup [✓] Go till main()
  - Initialization File: (empty) Browse...
  - Restore Debug Session Settings: [✓] Breakpoints [✓] Toolbox [✓] Watchpoints & PA [✓] Memory Display
  - CPU DLL: s8051.dll Parameter: (empty)
  - Dialog DLL: dp51.dll Parameter: -p550
- (●) Use: Chipcon CC1010 In-System Deb Settings
  - [✓] Load Application at Startup [✓] Go till main()
  - Initialization File: (empty) Browse...
  - Restore Debug Session Settings: [ ] Breakpoints [ ] Toolbox [ ] Watchpoints [✓] Memory Display
  - Driver DLL: S8051.dll Parameter: (empty)
  - Dialog DLL: cc1010disp.dll Parameter: (empty)

OK Cancel Defaults

Target Setup

- Port: COM1
- Baud Rate: 57600
- [ ] Clear code cache after Run and Step

OK Cancel

Figure 13: Debug profile.

CC1010 Code inspection and testing

To inspect and test the target software CC1010IDE includes powerful tools for in-circuit debugging and limited target simulation.

Debugger operation

The CC1010 in-circuit debugger consists of a uVision2 plug-in DLL, that communicates with a hidden 8051 program through a serial cable. With a few exceptions, it is completely transparent for the user:

- It is impossible to step into an interrupt (use breakpoints instead).
- It is impossible to stop inside a high priority interrupt (use breakpoints instead).
- The CC1010 should only be reset through the debugger.
- Idle and sleep mode should be avoided.
- The watchdog timer will be disabled.
- C-code steps are done through several assembly code steps (a progress bar is displayed in the uVision2 status bar). Expected performance: 30-40 ASM steps/second.
- The LJMP instruction at address 0 is moved to a reserved address at page 0. The move is hidden by the debugger plug-in.

For text boxes in the debugger dialogs:

- Press ‘ENTER’ to write the value to the target (CC1010).
- Exit the text box to undo an entry: If the user activates a different dialog before pressing ‘ENTER’ the current values in the text box is replaced by old values

Resources used on CC1010:

- UART 1
- Stack: 4 bytes
- Xdata: 22 bytes
- Flash: > 2k bytes

The following procedure is required for CC1010 debugging:

- Connect parallel cable between PC and CC1010EB.
- Connect serial cable between PC and CC1010EB (‘SERIAL 1’).
- On CC1010EB, make sure the SER_RST jumper is shorted and the SER_OFF jumper is open.
- Make sure the right debugger plug-in/driver is selected in Keil: ’Project->Options for Target->Debug->Use=Chipcon CC1010 In-System Debugger’
- Make sure the right PC serial port is selected for the debugger plug-in/driver in Keil: ’Project->Options for Target->Debug->Settings’.
- In the IDE choose ‘Tools->Write Debug Bootloader To CC1010 Flash’ to download the debug bootloader to CC1010. This prepares CC1010 for debugging.
- In the IDE choose ‘Debug->Start/Stop Debug Session’ to start debugging. The debugger will then automatically download the application code to CC1010.

Simulator operation

Not available in this version.

Libraries and examples

The CC1010IDE includes a variety of source files to ease and support the program development. Besides the standard C libraries, the source/support files are divided into 4 main groups: Hardware Definition Files (HDF), Hardware Abstraction Library (HAL), Chipcon Utility Library (CUL) and finally application examples. To examine these files in detail refer to the Keil ™ program directory.

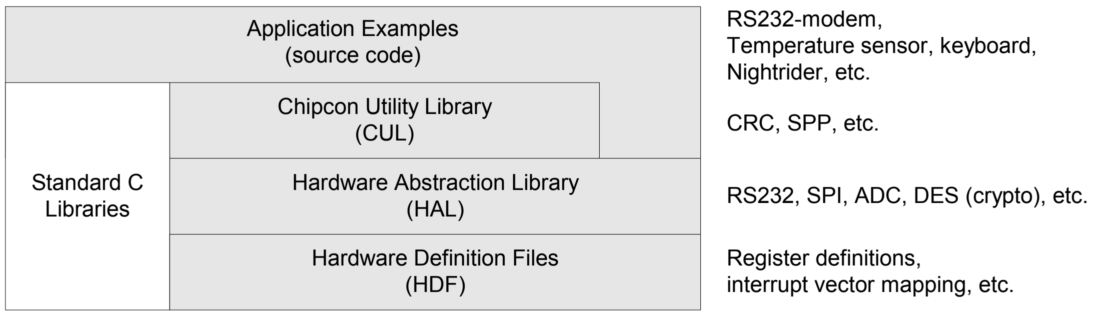


Figure 14: Library stack.

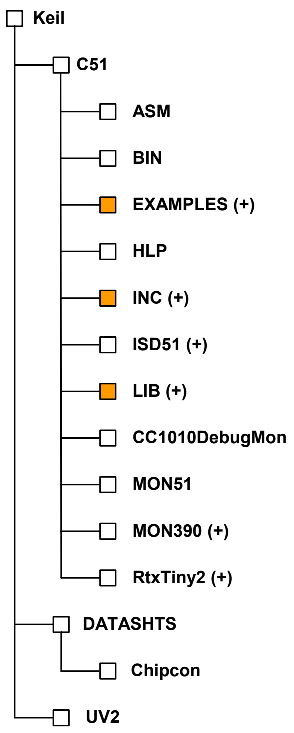


Figure 15: Library files.

<u>Library limitations</u>
- Keil ™ Full version:
  CUL and HAL are provided as libraries (.lib).
- Keil ™ Evaluation version:
  User libraries are not supported.
  Each individual HAL, CUL, files must be added "manually" to each software project.

<u>HDF overview (INC):</u>
- Evaluation Board macros (i.e.: LED control).
- Register definitions (i.e.: special function registers).
- Control register definitions/macros.
- Interrupt macros (i.e.: vector assignments).
- Etc.

<u>HAL overview (LIB):</u>
- RF calibration, configuration, packet transfer, etc.
- Flash memory write.
- Timer configuration.
- ADC configuration.
- Port configuration.
- UART control/configuration.
- DES data encryption.
- Etc.

<u>CUL overview (LIB):</u>
- CRC checksum calculation.
- Simple Packet Protocol (SPP).
- Etc.

<u>Application examples overview (EXAMPLES):</u>
- Simple UART communication (echo function).
- RS232 modem communication.
- Etc.

Hardware Definition Files (HDF)

The hardware definition files define register addresses, interrupt vector mapping and other hardware constants. They also include useful macros for the CC1010EB, and all definitions generally support both assembly and C language:

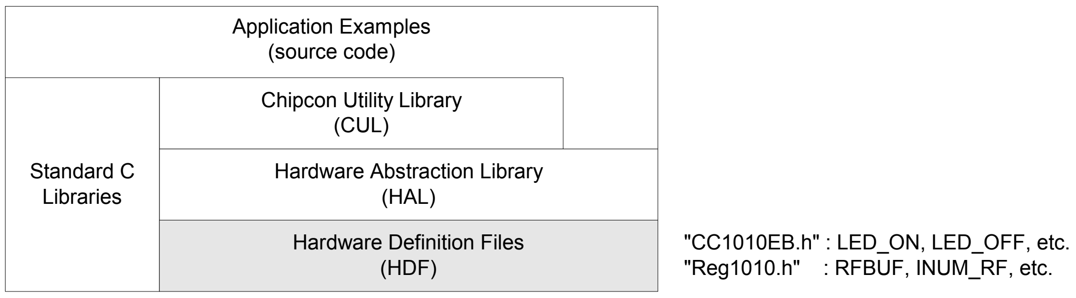

Application Examples
(source code)
Chipcon Utility Library
(CUL)
Standard C
Libraries
Hardware Abstraction Library
(HAL)
Hardware Definition Files
(HDF)
"CC1010EB.h" : LED_ON, LED_OFF, etc.
"Reg1010.h" : RFBUF, INUM_RF, etc.

Figure 16: Hardware Definition Files (HDF).

Hardware Abstraction Library (HAL)

To support quick and easy program development Chipcon provides a library of macros and functions that simplify hardware access on the CC1010. These are located in the Hardware Abstraction Library (HAL) and implement a hardware abstraction interface for the user program. As a result the user program can access the microcontroller peripherals, etc. via function/macro calls, without specific knowledge about the hardware details.

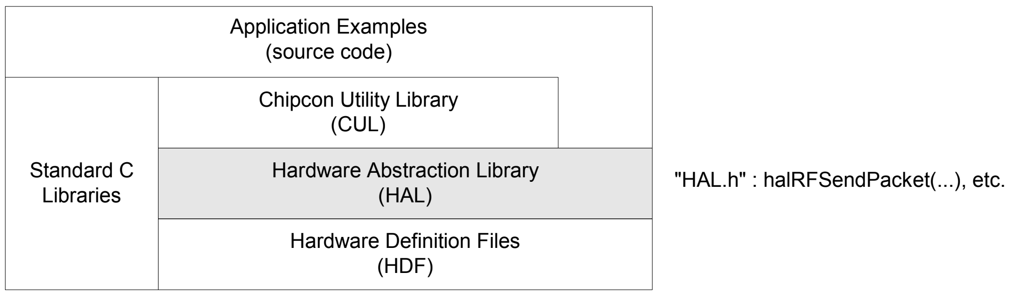


Figure 17: Hardware Abstraction Library (HAL).

Chipcon Utility Library (CUL)

Besides the HAL module the CC1010IDE also provides a library of RF communication building blocks located in the Chipcon Utility Library (CUL). This library offers useful support for typical RF applications and, eventually it will provide a full RF protocol.

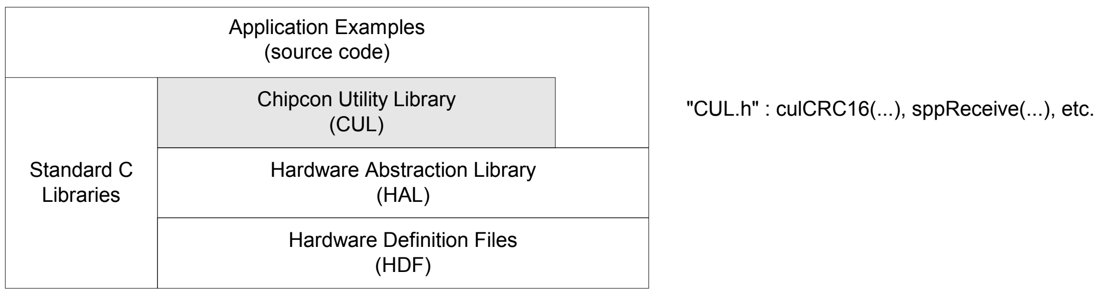

Application Examples
(source code)
Chipcon Utility Library
(CUL)
"CUL.h" : culCRC16(...), sppReceive(...), etc.
Standard C
Libraries
Hardware Abstraction Library
(HAL)
Hardware Definition Files
(HDF)

Figure 18: Chipcon Utility Library (CUL).

HAL library reference

void halConfigADC(byte options, word clkFreq, byte threshold)

Description:

This function configures the ADC.
An interrupt is generated in all modes (except for reset-generating mode in which a reset is generated instead) whenever the 8 MSB of the measured sample is greater or equal to the threshold value. Thus, if an interrupt for each sample is desired, the threshold should be set to 0 (and the ADC and GLOBAL_ADC_DES interrupts enabled.) After configuring the ADC it must be powered up using the ADC_POWER(bool) macro. It should be powered down again when not in use to conserve power. The correct ADC input must be selected using the ADC_SELECT_INPUT(input) macro and started using the ADC_RUN(bool) macro for continuous modes. The ADC_SAMPLE_SINGLE macro is used to initiate a sample acquisition in single-conversion mode, and the ADC_RUNNING macro can be used to determine whether the sample is complete The ADC_GET_SAMPLE_10BIT or ADC_GET_SAMPLE_8BIT macros return the latest sample value.

Arguments:

byte options
Selects operational mode

word clkFreq
The XOSC clock frequency in kHz.

byte threshold
The threshold value for generating interrupts (and stopping in multi-conversion, stopping mode) or reset (in multi-conversion, reset-generating mode).

Return:

void

void halConfigRealTimeClock(byte period)

Description:

This function configures the realtime clock. In order for the realtime clock to function the 32 kHz oscillator must be connected to a 32 kHz crystal or a 32 kHz clock signal must be available on pin XOSC32_Q1. The 32 kHz oscillator must be started up and stable before the RTC is activated. The realtime clock must be started by using the macro RTC_RUN(TRUE).

Arguments:

byte period
The desired period between interrupts in seconds.

Return:

void

ulong halConfigTimer01(byte options, ulong period, word clkFreq, word* modulo)

Description:

This function configures timer 0 or 1 (depending on the value given in *option* as either an interrupt timer (an interrupt is generated at certain intervals in time, as specified by *period*) or an interrupt pulse counter (an interrupt when *period* number of pulses have been detected on P3.4/P3.5 for timer0/timer1.) Some timer settings (with long timeouts) require that the user initializes timer register in the interrupt service routine (ISR.) This should be done by using the appropriate version of the ISR_TIMERx_ADJUST(m) macro with the word pointed to by *modulo* as an argument. The *modulo* argument takes a pointer to a word, if it is NULL, many timer settings will be unavailable. It is the responsibility of the programmer to make sure that the appropriate timer ISR has been declared (and that it begins with the obligatory ISR_TIMERx_ADJUST(m) macro). The timer must be started with macro TIMERx_RUN(TRUE).

Arguments:

byte options
Options indicating which timer to configure and how.

ulong period
The desired period between interrupts in microseconds in timer mode, or the number of counted pulses between interrupts in counter mode.

word clkFreq
The XOSC clock frequency in kHz.

word modulo*
A pointer to a word (in xdata) which after the function has returned contains the value to supply to the obligatory macro invocation of ISR_TIMERx_ADJUST(m) at the start of the timer ISR.

Return:

ulong
In timer mode, the actual period in microseconds between interrupts or zero if the period is impossible to achieve. In counter mode, zero if the supplied count value is impossible to achieve, otherwise one.

ulong halConfigTimer23(byte options, ulong period, word clkFreq)

Description:

This function configures timer 2 or 3 (depending on the value given in *option* as either an interrupt timer (an interrupt is generated at certain intervals in time, as specified by *period*) or a pulse width modulator (PWM). If *period* is specified as 0, then, in timer mode the timeout period will be set to the maximum possible, and in PWM mode the period will be set as long as possible. Using the PWM mode of timer 2/3 overrides the normal operation of ports P3.4/P3.5 and can thus not be used in conjunction with timer 0/1 configured as counters. The duty cycle is set to 50% (128/255) initially in PWM mode. The timer/PWM must be started with macro TIMERx_RUN(TRUE).

Arguments:

byte options
Options indicating which timer to configure and how.

ulong period
The desired period between interrupts in microseconds. In PWM mode the duty cycle will be set as close to 50% as possible. This duty cycle can be changed (in an ISR or at any other time) by using the appropriate PWMx_SET_DUTY_CYCLE(...) macro. If *period* is 0, then the maximum period possible will be set. The period can also be adjusted dynamically with the PWMx_SET_PERIOD(...) macro.

word clkFreq
The XOSC clock frequency in kHz.

Return:

ulong
The actual period in microseconds or zero if the desired period is too high.

bool halCopy2Flash(byte code* flashPtr, byte* src, word length, byte xdata* ramBuffer, word clkFreq)

Description:

Copies *length* bytes from the memory area pointed to by *src* (in any memory space) to the memory area in CODE memory space pointed to by *flashPtr*. A 128 byte temporary buffer in the XDATA memory space must be pointed to by *ramBuffer*. None of the pointers (*flashPtr*, *src* or *ramBuffer*) need to be page-aligned (address mod 128=0) as with halFlashWritePage(...), neither does *length* have to be a multiple of 128 bytes -- it can in fact be between 1 and 32768 bytes, although it goes without saying that it is unwise to overwrite the memory occupied by the code for this function. The result is undefined if the memory areas occupied by [*src*, *src*+*length*-1] and [*ramBuffer*, *ramBuffer*+127] overlap. A verification of the data written is performed after programming – if this verification fails for some reason (flash page is write locked, flash programming failure) or some of the supplied arguments are invalid the function returns FALSE. All interrupts are turned off while this function executes.

Arguments:

byte code flashPtr*
Pointer to the destination of the write in code memory space.

byte src*
Pointer to the data source.

word length
The number of bytes to copy.

byte xdata ramBuffer*
A pointer to a 128 byte big buffer in XDATA memory space used to hold temporary data.

word clkFreq
The XOSC clock frequency in kHz.

Return:

bool
TRUE if the write was successful. False if programming/verification failed or the supplied arguments were invalid.

byte* halDES(byte options, byte xdata* buffer, byte xdata* key, word length)

Description:

This function performs DES encryption/decryption on a block of data. The encryption/decryption operations are performed in place (i.e. the plaintext is overwritten by the ciphertext or vice versa) on suitably aligned data [address(*buffer*) mod 8 = 0]. *key* should point to the key used for single-DES operations or keys in the case of triple-DES. Two modes of the DES standard are supported: 8-bit Cipher Feedback (CFB) and Output Feedback (OFB.) CFB is self-synchronizing (the end of a ciphertext can be decrypted even though the beginning is unavailable) and can be used to calculate error check codes. OFB is not self- synchronizing and is not suitable for error check code calculation, but does have the favorable property that a single bit error in the received ciphertext produces only a single bit error in the decrypted plaintext. In CFB/OFB mode an initialization vector of 8 bytes is part of the algorithm. This vector must be identical for the encryption and decryption process. The choice of initialization data does not affect the security of the encryption in any way, and this function thus uses the value 0. *option* is used to chose between these modes of operation, between single-DES and triple-DES, and between decryption and decryption. This function does not return until all data has been encrypted/ decrypted, since the DES hardware is so fast. The DES hardware can run at the same time as the 8051 and generate an interrupt when finished. If this is desired the hardware must be programmed directly.

Arguments:

byte options
One or more of the below defined constants define the desired operational mode: DES_SINGLE_DES, DES_TRIPLE_DES, DES_ENCRYPT, DES_DECRYPT, DES_OFB_MODE, DES_CFB_MODE.

byte xdata buffer*
Pointer to the data to encrypt/decrypt in XDATA memory space. The address of *buffer* must be divisible by eight, i.e. address(*buffer*) mod 8 = 0.

byte xdata key*
A pointer to a key (or three keys for triple-DES) stored in XDATA memory space. This address must be divisible by eight, i.e. address(*key*) mod 8 = 0. The 56 active bits of a DES-key are expected to be in a compressed 7-byte format, in which all parity bits are removed. In the case of a single key, the 56 bits of the key must lie on *key*[0] - *key*[6], in big-endian order. In the case of three keys (triple-des), the three keys must lie on *key*[0] - *key*[6], *key*[8] - *key*[14] and *key*[16] - *key*[22], all in big-endian order. DES_NORMAL_2_COMPACT_KEY(...) can be used to convert a regular DES key to the compact form. A key can be generated by simply using 7 random bytes.

word length
The number of bytes to perform the encryption/decryption on

Return:

*byte**
A pointer to the start of *buffer* is returned.

bool halFlashWritePage(byte code* flashPage, byte xdata* ramBuffer, word clkFreq)

Description:

Writes into the flash page pointed to by *flashPage* 128 bytes of data pointed to by *ramBuffer*. The addresses of both *flashPage* and *ramBuffer* must be an integer multiple of 128, i.e. adr mod 128=0. *clkFreq* must be the XOSC frequency in kHz and is used to calculate the correct erasure and programming times. If these conditions are not met the function does not perform any programming and returns FALSE. A verification of the data written is performed after programming - if this verification fails for some reason (flash page is write locked, or flash programming failure) the function also returns FALSE. All interrupts are turned off while this function executes.

Arguments:

byte code flashPage*
Pointer to the destination of the write in code memory space. Address must be an integer multiple of 128 bytes.

byte xdata ramBuffer*
Pointer to the data source in RAM for the write in XDATA memory space. Address must be an integer multiple of 128 bytes.

word clkFreq
The XOSC clock frequency in kHz.

Return:

bool
TRUE if the write was successful. False if programming/verification failed or supplied arguments were invalid.

void halRandomNumberGen(byte* rnd_data, word length)

Description:

This function activates the true RNG in the CC1010, waits long enough for the output to be truly random and then samples individual random bits with a period that ensures that the output is sufficiently random. This function must never be used at the same time as RF is in use. A total of _length_ bytes of random data is stored at the location pointed to by *rnd_data*.

Arguments:

byte rnd_data.*
A pointer to a buffer to receive the random bytes.

word length
The number of random bytes to generate.

Return:

void

void halRFCalib(RF_RXTXPAIR_SETTINGS code* rf_settings, RF_RXTXPAIR_CALDATA xdata* rf_caldata)

Description:

Performs the necessary RF-calibration for an RX/TX channel pair with the settings specified by the RF_RXTXPAIR_SETTINGS data structure pointed to by *rf_settings*. The results of the calibration are stored in the RF_RXTXPAIR_CALDATA data structure pointed to by *rf_caldata*. Call this function once for each RX/TX channel pair that will be used by the program before they are used and whenever the supply voltage or temperature has changed significantly. The application Chipcon SmartRF® Studio should be used to generate this data structure.

Arguments:

RF_RXTXPAIR_SETTINGS code rf_settings*
Pointer to a RF_RXTXPAIR_SETTINGS data structure containing the settings for an RX/TX channel pair (exported from SmartRF® Studio.)

RF_RXTXPAIR_CALDATA xdata rf_caldata*
A pointer to a RF_RXTXPAIR_CALDATA data structure which will be filled with the results from the calibration.

Return:

void

void halRFOverrideDataFormat(byte dataFormat)

Description:

Function used to override the data format (normally specified by an RX/TX-pair). If this function is called before halRFSetRxTxOff(...) it uses the parameter passed to this function instead of whatever the RX/TX-pair defines. If it is passed during an RF-operation, i.e. after halRFSetRxTxOff(...) is called, the parameter passed is immediately updated in hardware.

Arguments:

byte dataFormat
RF data format. To disable the override the function must be called with the parameter RF_NO_OVERRIDE.

Return:

void

void halRFOverrideOutputPower(byte txPower)

Description:

Function used to override the RF TX output power (normally specified by an RX/TX-pair). If this function is called before halRFSetRxTxOff(...) it uses the parameter passed to this function instead of whatever the RX/TX-pair defines. If it is passed during an RF-operation, i.e. after halRFSetRxTxOff(...) is called, the parameter passed is immediately updated in hardware.

Arguments:

byte txPower
A value between 1 and 28 indicates desired power level -- 28 is highest and 1 lowest. Some useful constants are defined below. The override is turned off by passing 0 or RF_NO_OVERRIDE.

Return:

void

void halRFOverrideBaudRate(byte baudRate)

Description:

Function used to override the baudrate (normally specified by an RX/TX-pair). If this function is called before halRFSetRxTxOff(...) it uses the parameter passed to this function instead of whatever the RX/TX-pair defines. If it is passed during an RF-operation, i.e. after halRFSetRxTxOff(...) is called, the parameter passed is immediately updated in hardware. Note that for optimal performance, the baudrate can only be changed without a new calibration within the two sets (600, ..., 19200) and (38400, 76800).

Arguments:

byte dataFormat
To disable the override the function must be called with the parameter RF_NO_OVERRIDE.

Return:

void

char halRFReadRSSI()

Description:

This function activates RSSI output on the AD2 pin, activates the ADC for channel 2 reads, the RSSI output voltage and converts it to an approximation of the incoming signal's strength in dBm (range is appr. -110 to -50 dBm.) The value obtained is approximate and most valid for a signal @ 600 MHz. The accuracy should be no worse than +/- 10 dBm at any frequency. An RSSI filter circuit of one capacitor and one resistor is required to be connected to the AD2 pin externally (see datasheet for details). This function disrupts user ADC operation and does not restore the ADC to its former state. The function can be used as a carrier sense if the returned value is compared to some relatively low threshold.

Arguments:

void

Return:

char
The approximate signal strength of the incoming signal in dBm.

byte halRFReceivePacket(byte timeOut, byte* packetData, byte maxLength, char* rssiByte, word clkFreq)

Description:

Used to receive a packet sent using halSendPacket on another CC1010. The current modem/RF configuration is used and RX is assumed to be powered up. The function waits for a valid syncronization byte (RF_SUITABLE_SYNC_BYTE) for up to *timeOut* ms. If timed out without receiving the sync. byte the function returns 0. If a sync. byte is received in time the number of bytes indicated by the packet is received (max *maxLength* bytes) and put in the buffer pointed to by *packetData*, after which the function returns the number of bytes received. THIS FUNCTION ASSUMES THAT TIMER3 IS AVAILABLE!

Arguments:

byte timeOut
Timeout for reception of valid synchronization byte in tens of ms. A value of zero gives an infinite timeout.

byte packetData*
A pointer to a buffer for the received data.

byte maxLength
The maximum number of bytes to receive (max packet size 253 bytes).

char rssiByte*
If this pointer is different from NULL an RSSI measurement is performed after receiving the sync byte using the halReadRSSI(...) function and its return value stored in the byte pointed to by *rssiByte*.

word clkFreq
The XOSC clock frequency in kHz.

Return:

byte
The actual number of bytes received or 0 if timed out / CRC error.

void halRFSendPacket(byte numPreambles, byte* packetData, byte length)

Description:

Used to send a packet using the current RF configuration. (It is assumed that halRFSetRxTxOff(...) has been called with the appropriate RX/TX pair and mode RF_TX.) First *numPreambles* preamble bytes (RF_PREAMBLE_BYTE) are transmitted followed by a synchronization byte (RF_SUITABLE_SYNC_BYTE), the *length* byte, the data pointed to by *packetData* (*length* bytes) and then, finally, the CRC-16 (CCITT) of the data.

Arguments:

byte numPreambles
The number of preamble bytes (RF_PREAMBLE_BYTE) to transmit.

byte packetData*
A pointer to the actual data to transmit.

byte length
The number of bytes to transmit. (Max 253)

Return:

void

void halRFSetRxTxOff(byte mode, RF_RXTXPAIR_SETTINGS code* rf_settings, RF_RXTXPAIR_CALDATA xdata* rf_caldata)

Description:

Function used to set a specific RX/TX channel pair as the current RF configuration. The *mode* parameter is used to select between activating RF in RX or TX or turning off RF.

Arguments:

byte mode
Options given below. Turn off, turn on in RX, or on in TX. If RF_OFF is supplied the two pointers can be NULL.

RF_RXTXPAIR_SETTINGS code rf_settings*
Pointer to a RF_RXTXPAIR_SETTINGS data structure containing the settings for an RX/TX channel pair (exported from SmartRF® Studio.)

RF_RXTXPAIR_CALDATA xdata rf_caldata*
A pointer to a RF_RXTXPAIR_CALDATA data structure which will be filled with the results from the calibration.

Return:

void

void halSpiTransferBlock(byte* inoutBuffer, word length, bool enableRead)

Description:

Transfers *length* bytes of the data block pointed to by *inoutBuffer* over the SPI interface. It is assumed that the SPI interface has already been correctly configured. If *read* is TRUE the incoming data on the SPI interface will be stored in place in *inoutBuffer*, (overwriting the data that is transmitted), otherwise the received data is ignored.

Arguments:

byte inoutBuffer*
Pointer to a block of data that is to be transmitted. If *read* is TRUE the received data will overwrite this data.

word length
The number of bytes to receive/transmit.

bool enableRead
Overwrite the data transmitted with the received data (TRUE) or ignore received data (FALSE).

Return:

void

void halWait(byte timeOut, word clkFreq)

Description:

A wait functions which performs a number of iterations of a simple wait loop, so that at least *timeOut* ms goes by before the function returns.

Arguments:

byte timeOut
The time to wait in ms.

word clkFreq
The XOSC clock frequency in kHz.

Return:

void

void halSetPort(byte portNum, byte dataByte)

Description:

Function which sets data for an entire port.

Arguments:

byte portNum
Port identification.

byte dataByte
Data value to be placed on the requested port.

Return:

void

void halSetPortBit(byte portNum, byte bitNum, byte dataBit)

Description:

Function which sets port data bitwise.

Arguments:

byte portNum
Port identification.

byte bitNum
Bit identification (bit0 = lsb, bit7 = msb).

byte dataBit
Data value to be placed on requested port bit.

Return:

void.

void halSetPortBitDir(byte portNum, byte bitNum, byte direction)

Description:

Function which sets the direction (in/out) for one specific port bit.

Arguments:

byte portNum
Port identification

byte bitNum
Bit identification (bit0 = lsb, bit7 = msb).

byte direction
Port direction (in = 1, out = 0).

Return:

void

void halSetPortDir(byte portNum, byte direction)

Description:

Function which sets the direction for an entire port.

Arguments:

byte portNum
Port identification.

byte direction
Port direction (in = 1, out = 0).

Return:

void

byte halGetPort(byte portNum)

Description:

Function which gets current data value on requested port.

Arguments:

byte portNum
Port identification.

Return:

byte
Current data value on requested port.

byte halGetPortBit(byte portNum, byte bitNum)

Description:

Function which gets the current value on one specific port bit.

Arguments:

byte portNum
Port identification.

byte bitNum
Bit identification (bit0 = lsb, bit7 = msb).

Return:

byte
Current value on requested port bit.

CUL library reference

byte culSmallCRC8(byte crcData, byte crcReg)

Description:

A CRC-8 (DOW) implementation optimized for small code size. The function should be called once for each byte in the data the CRC is to be performed on. For the invocation on the first byte the value CRC8_INIT should be given for *crcReg*. The value returned is the CRC-8 of the data supplied so far. This CRC-value should be added at the end of the data to facilitate a later CRC check. During checking the check should be performed on all the data AND the CRC-16 value appended to it. The data is intact if the value returned is 0.

Arguments:

byte crcData
The data to perform the CRC-8 operation on.

byte crcReg
The current value of the CRC register. For the first byte the value CRC8_INIT should be supplied. For each additional byte the value returned for the last invocation should be supplied.

Return:

byte
The updated value of the CRC8 register. This corresponds to the CRC-8 of the data supplied so far. During CRC checking, after working through all the data and the appended CRC-8 value, the value will be 0 if the data is intact.

word culSmallCRC16(byte crcData, word crcReg)

Description:

A CRC-16/CCITT implementation optimized for small code size. The function should be called once for each byte in the data the CRC is to be performed on. For the invocation on the first byte the value CRC16_INIT should be given for *crcReg*. The value returned is the CRC-16 of the data supplied so far. This CRC-value should be added at the end of the data to facilitate a later CRC check. During checking the check should be performed on all the data AND the CRC-16 value appended to it. The data is intact if the value returned is 0.

Arguments:

byte crcData
The data to perform the CRC-16 operation on.

word crcReg
The current value of the CRC register. For the first byte the value CRC16_INIT should be supplied. For each additional byte the value returned for the last invocation should be supplied.

Return:

word
The updated value of the CRC16 register. This corresponds to the CRC-16 of the data supplied so far. During CRC checking, after working through all the data and the appended CRC-16 value, the value will be 0 if the data is intact.

byte culFastCRC8(byte crcData, byte crcReg)

Description:

A CRC-8 (DOW) implementation optimized for fast execution. The function should be called once for each byte in the data the CRC is to be performed on. Before the invocation on the first byte the FAST_CRC8_INIT() macro should be called. This final CRC-value should be added at the end of the data to facilitate a later CRC check. During checking the check should be performed on all the data AND the CRC-8 value appended to it. The data is intact if the value returned is 0.

Arguments:

byte crcData
The data to perform the CRC-8 operation on.

byte crcReg
The current value of the CRC register. For each additional byte the value returned for the last invocation should be supplied.

Return:

byte
The updated value of the CRC8 register. This corresponds to the CRC-8 of the data supplied so far. During CRC checking, after working through all the data and the appended CRC-8 value, the value will be 0 if the data is intact.

word culFastCRC16(byte crcData, word crcReg)

Description:

A CRC-16 (CCITT) implementation optimized for fast execution. The function should be called once for each byte in the data the CRC is to be performed on. Before the invocation on the first byte the FAST_CRC16_INIT() macro should be called. This final CRC-value should be added at the end of the data to facilitate a later CRC check. During checking the check should be performed on all the data AND the CRC-16 value appended to it. The data is intact if the value returned is 0.

Arguments:

byte crcData
The data to perform the CRC-16 operation on.

word crcReg
The current value of the CRC register. For each additional byte the value returned for the last invocation should be supplied.

Return:

word
The updated value of the CRC16 register. This corresponds to the CRC-16 of the data supplied so far. During CRC checking, after working through all the data and the appended CRC-16 value, the value will be 0 if the data is intact.

byte sppReceive (SPP_RX_INFO xdata *pRXInfo)

Description:

If the transceiver is ready (in idle mode), the receive section will be powered up and the RF interrupt enabled. The RF ISR will then receive the packet and transmit an ack if requested to. When finished, the receive section will be powered down. This function will return immediately and the application can continue while the ISR receives the packet. When finished, sppStatus() will return IDLE_MODE. During the transmission it will return RX_MODE or RXACK_MODE. After the reception: Use pRXInfo->status to find out what happened:
SPP_RX_TIMEOUT = Timeout (nothing received).
SPP_RX_TOO_LONG = dataLen > maxDataLen (the buffer is invalid).
SPP_RX_FINISHED = source, dataLen and *pDataBuffer in *pRXInfo are valid.

Arguments:

*SPP_RX_INFO xdata *pRXInfo*
An SPP_RX_INFO struct must be prepared before the reception, including the following values:
maxDataLen (Length of the data buffer, 0-255)
DataBuffer (pointer to the reception buffer).

Return:

byte
SPP_RX_STARTED if OK
SPP_BUSY if not ready.

byte sppSend (SPP_TX_INFO xdata *pTXInfo)

Description:

If the transceiver is ready (in idle mode), the transmit section will be powered up and the RF interrupt enabled. The RF ISR will then transmit the packet (pTXInfo) and receive the ack (if requested). If requested (sppSettings.txAttempts = n), the packet will be re-transmitted (n-1) times, until the ack is received. When finished the transmit section will be powered down. This function will return immediately and the application can continue while the ISR transmits the packet. When finished, sppStatus() will return IDLE_MODE. During the transmission it will return TX_MODE or TXACK_MODE. After the transmission: Use *pTXInfo->status* to find out what happened:
SPP_TX_ACK_INVALID = Something was received, but not the ack
SPP_TX_ACK_TIMEOUT = No response
SPP_TX_FINISHED
sppSettings.txAckTimeout gives the ack timeout in msecs.

Arguments:

*SPP_TX_INFO xdata *pTXInfo*
An SPP_TX_INFO struct must be prepared before the transmission, including the following values:
destination (SPP_BROADCAST or 1-255)
flags (SPP_ACK_REQ | SPP_ENCRYPTED_DATA)
dataLen (Length of *pDataBuffer, 0-255)
pDataBuffer (pointer to the transmission data buffer).

Return:

byte
SPP_TX_STARTED if OK
SPP_BUSY if not ready

void sppSetupRF (RF_RXTXPAIR_SETTINGS code *pRF_SETTINGS, RF_RXTXPAIR_CALDATA xdata *pRF_CALDATA, word clkFreq, bool calibrate)

Description:

Sets up SPP for transmission or reception.
Call this function to (re)calibrate the radio, or to switch between different RF settings.

Arguments:

RF_RXTXPAIR_SETTINGS code pRF_SETTINGS*
RF settings (frequencies, modem settings, etc.).

RF_RXTXPAIR_CALDATA xdata pRF_CALDATA*
RF_RXTXPAIR_CALDATA xdata* pRF_CALDATA

word clkFreq
The XOSC clock frequency in kHz.

bool calibrate
Calibrate now. *pRF_CALDATA is written to when calibrate = TRUE, and read from otherwise. Use FALSE if *pRF_CALDATA is valid.

Return:

void

void sppReset (void)

Description:

Stops a transmission or reception by - turning the transceiver off - entering IDLE mode (sppStatus()).

Arguments:

void.

Return:

void

byte sppStatus (void)

Description:

Returns the status of the SPP.

Arguments:

void

Return:

byte

SPP_IDLE_MODE = Ready to transmit or receive
SPP_TX_MODE = Transmitting a packet
SPP_TXACK_MODE = Waiting for the ack
SPP_RX_MODE = Waiting for or receiving a packet
SPP_RXACK_MODE = Transmitting the ack.

void sppStartTimer (word clkFreq)

Description:

Run timer3 with a period of 10 msecs.

Arguments:

word clkFreq
The XOSC clock frequency in kHz.

Return:

void

void sppSetTimerCB (byte cb, void (*pF) (), word *pTicks

Description:

Add timer callback.

Arguments:

byte cb
Callback index - use SPP_CUSTOM_0_TIMER or SPP_CUSTOM_1_TIMER
The SPP finite state machine uses SPP_FSM_TIMER.

*void *pF*
Pointer to the function to call

*word *pTicks*
The timeout in 10s of msecs

Return:

void

word sppGetTime (void)

Description:

Returns the value of the 10-msec counter, which is started by sppSetupRF(...).

Arguments:

void

Return:

word
The current time in 10s of msecs.

Application examples

The CUL, HAL and HDF enable the user to create applications based on a consistent and tested software platform. To boost the application development process the CC1010IDE also offers some useful application examples that demonstrate typical use/integration of the libraries. In general these examples can be downloaded from Chipcon's web site (http://www.chipcon.com). Detailed documentation and explanation of the application examples are available under the Chipcon documentation directory: C:\Program Files\Chipcon.

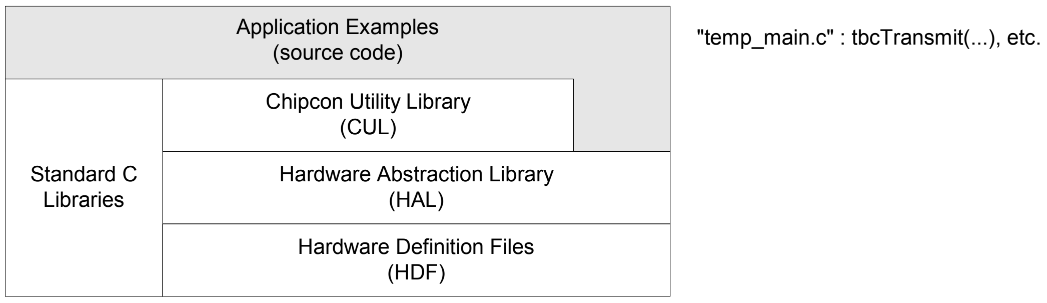
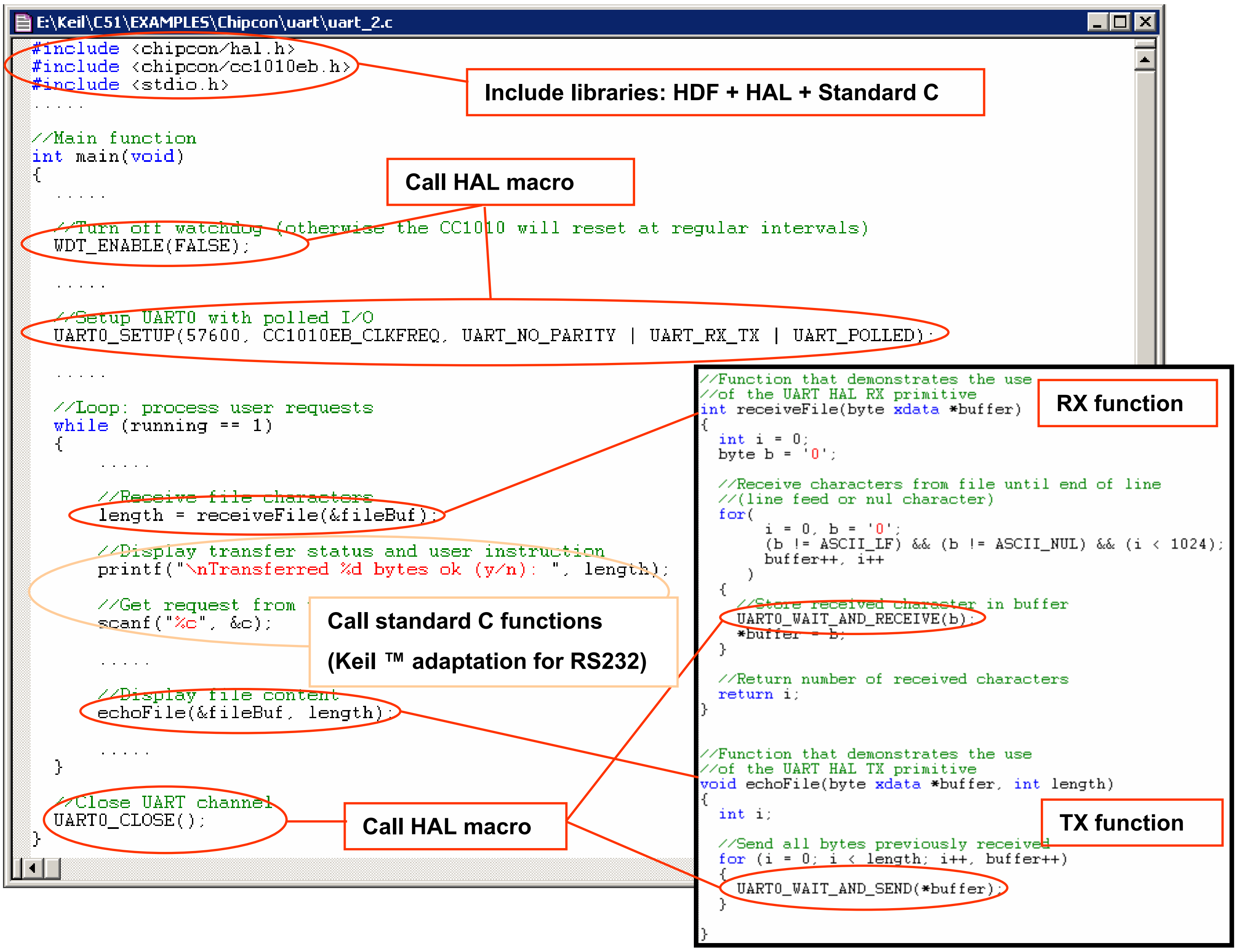

Application Examples
(source code)
"temp_main.c" : tbcTransmit(...), etc.
Standard C Libraries
Chipcon Utility Library
(CUL)
Hardware Abstraction Library
(HAL)
Hardware Definition Files
(HDF)

Figure 19: Chipcon application examples.

The example below is typical of the way the Chipcon libraries can be used in an application that enables terminal communication with the CC1010. This application example implements a simple file transfer protocol on top of HAL, and uses a UART channel to communicate with a terminal program on the PC. Note that parts of the source code, i.e.: dialog, have been removed to highlight the core functionality:

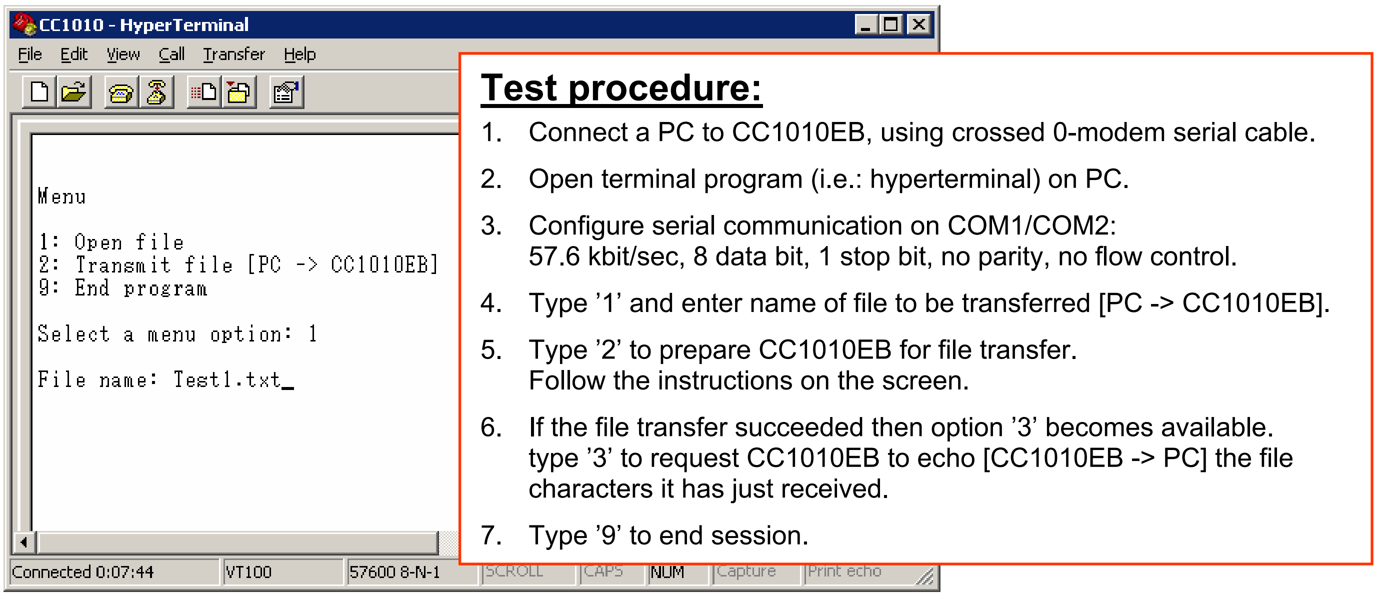

E:\Keil\C51\EXAMPLES\Chipcon\uart\uart_2.c
Include libraries: HDF + HAL + Standard C
Call HAL macro
Call standard C functions
(Keil ™ adaptation for RS232)
Call HAL macro
RX function
TX function

```
#include <chipcon/hal.h>
#include <chipcon/cc1010eb.h>
#include <stdio.h>
.....

//Main function
int main(void)
{
  .....
  //Turn off watchdog (otherwise the CC1010 will reset at regular intervals)
  WDT_ENABLE(FALSE);

  .....

  //Setup UART0 with polled I/O
  UART0_SETUP(57600, CC1010EB_CLKFREQ, UART_NO_PARITY | UART_RX_TX | UART_POLLED);

  .....

  //Loop: process user requests
  while (running == 1)
  {
      .....

      //Receive file characters
      length = receiveFile(&fileBuf);

      //Display transfer status and user instruction
      printf("\nTransferred %d bytes ok (y/n): ", length);

      //Get request from
      scanf("%c", &c);

      .....

      //Display file content
      echoFile(&fileBuf, length);

      .....
  }

  //Close UART channel
  UART0_CLOSE();
}
```

```
//Function that demonstrates the use
//of the UART HAL RX primitive
int receiveFile(byte xdata *buffer)
{
  int i = 0;
  byte b = '0';

  //Receive characters from file until end of line
  //(line feed or nul character)
  for(
      i = 0, b = '0';
      (b != ASCII_LF) && (b != ASCII_NUL) && (i < 1024);
      buffer++, i++
     )
  {
    //Store received character in buffer
    UART0_WAIT_AND_RECEIVE(b);
    *buffer = b;
  }

  //Return number of received characters
  return i;
}

//Function that demonstrates the use
//of the UART HAL TX primitive
void echoFile(byte xdata *buffer, int length)
{
  int i;

  //Send all bytes previously received
  for (i = 0; i < length; i++, buffer++)
  {
    UART0_WAIT_AND_SEND(*buffer);
  }
}
```

Figure 20: Application example promoting typical integration of Chipcon libraries.

After building and downloading the application example, follow the test procedure below:



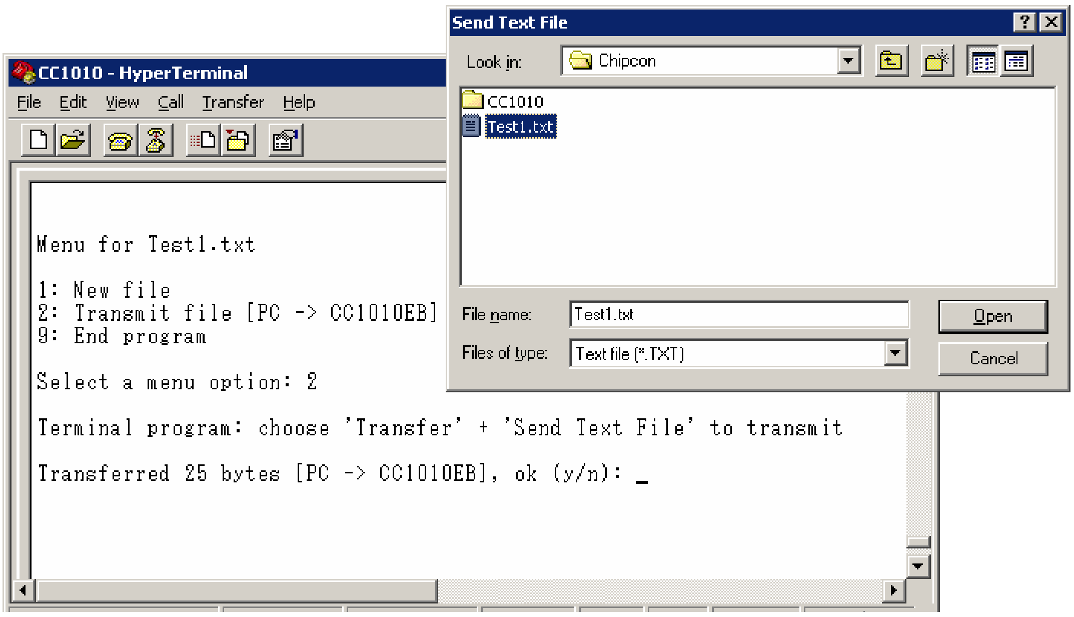
```
Menu

1: Open file
2: Transmit file [PC -> CC1010EB]
9: End program

Select a menu option: 1

File name: Test1.txt_
```

Test procedure:

1. Connect a PC to CC1010EB, using crossed 0-modem serial cable.
2. Open terminal program (i.e.: hyperterminal) on PC.
3. Configure serial communication on COM1/COM2:
   57.6 kbit/sec, 8 data bit, 1 stop bit, no parity, no flow control.
4. Type '1' and enter name of file to be transferred [PC -> CC1010EB].
5. Type '2' to prepare CC1010EB for file transfer.
   Follow the instructions on the screen.
6. If the file transfer succeeded then option '3' becomes available.
   type '3' to request CC1010EB to echo [CC1010EB -> PC] the file characters it has just received.
7. Type '9' to end session.

Figure 21: Application example - test procedure.

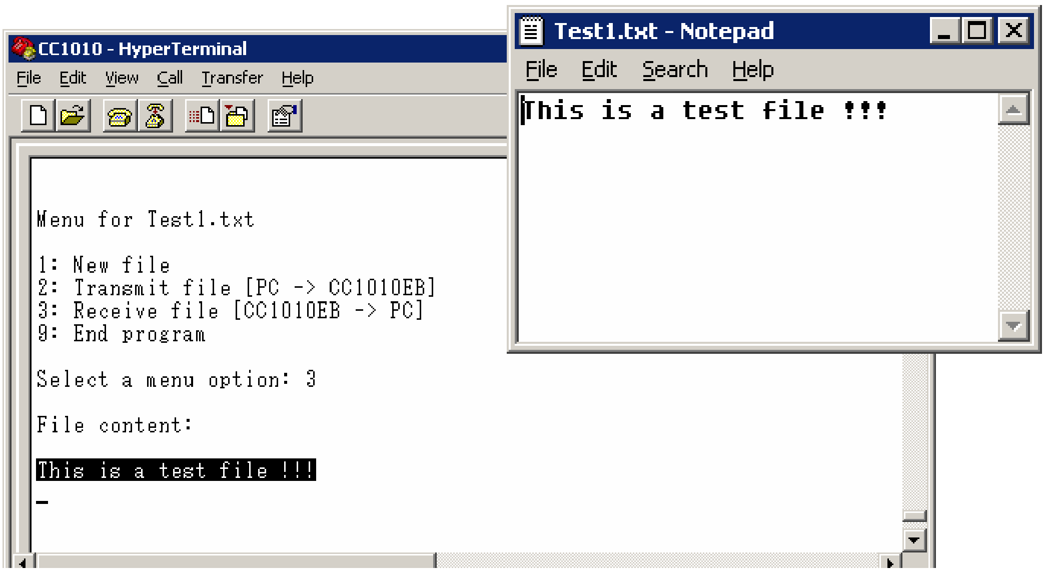
Type ‘2’ to transfer file from the PC to CC1010EB:



```
Menu for Test1.txt

1: New file
2: Transmit file [PC -> CC1010EB]
9: End program

Select a menu option: 2

Terminal program: choose 'Transfer' + 'Send Text File' to transmit

Transferred 25 bytes [PC -> CC1010EB], ok (y/n): _
```

Figure 22: Application example – file transfer from PC to CC1010EB.

Type ‘3’ to transfer file from CC1010EB to the PC, then verify content:



```
This is a test file !!!
```

```
Menu for Test1.txt

1: New file
2: Transmit file [PC -> CC1010EB]
3: Receive file [CC1010EB -> PC]
9: End program

Select a menu option: 3

File content:

This is a test file !!!
_
```

Figure 23: Application example – file transfer from CC1010EB to PC.

Generic examples

In addition to the Chipcon-specific application examples developed for the CC1010 platform Keil ™ provides numerous generic sample programs. To examine these examples and corresponding source files, refer to the directories indicated below:

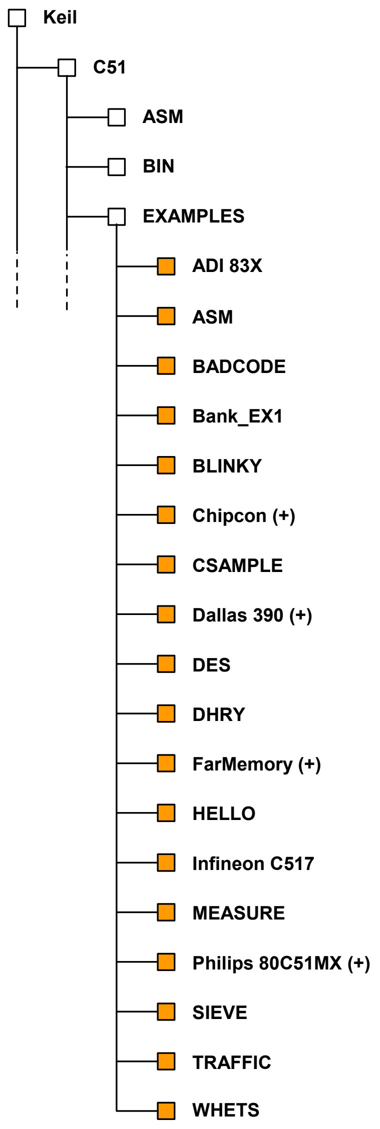


Figure 24: Generic examples.

ADI 83X
Extended features of Analog Devices ADuC83X.

ASM
Assembly code for serial communication on 8052.

BADCODE
Source file with errors; useful as a debugging exercise.

Bank_EX1
Program execution in several code banks.

BLINKY
Blink LED’s on a MCBx51 evaluation board.

Chipcon (+)
CC1010 application examples.

CSAMPLE
Calculator (+/-) and serial communication.

Dallas 390 (+)
Contiguous addressing mode for Dallas 390 CPU.

DES
8051 Data Encryption.

DHRY
8051 code efficiency test with dhrystone benchmark.

FarMemory (+)
Far memory addressing, i.e.: EEPROM access.

HELLO
“Hello World” for 8051 using serial communication.

Infineon C517
Simulate Hewlett Packard calculator with C517.

MEASURE
Simulate data logger with C515.

Philips 80C51MX
Code banking for 80C51MX expanded memory.

SIEVE
Prime number calculation for performance testing.

TRAFFIC
Trafficlight control using RTX51 Tiny OS/Scheduler.

Triscend Code Banking
Triscend code banking.

WHETS
Floatingpoint test using Whetstone benchmark.

Utilities

Flash Programmer

The Flash programmer basically implements a fast synchronous serial link between the PC parallel port and the CC1010EB. It generally supports the complete SPI protocol required for correct CC1010 programming and offers the following main programming options:

Action to perform:

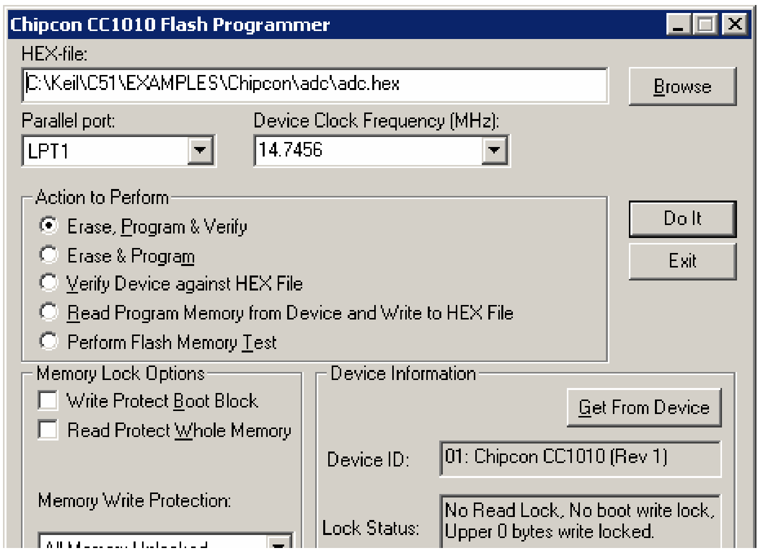
Specifies basic flash memory operations, such as read/write, test and content/file processing/comparison.

Memory lock options:

Specifies read/write protection of specific target memory areas/ranges.

Device clock frequency:

Specifies the target clock frequency, this must be consistent with the actual target.


Chipcon CC1010 Flash Programmer

HEX-file: C:\Keil\C51\EXAMPLES\Chipcon\adc\adc.hex

Parallel port: LPT1

Device Clock Frequency (MHz): 14.7456

Action to Perform
- [✓ Erase, Program & Verify]
- Erase & Program
- Verify Device against HEX File
- Read Program Memory from Device and Write to HEX File
- Perform Flash Memory Test

Memory Lock Options
- ☐ Write Protect Boot Block
- ☐ Read Protect Whole Memory

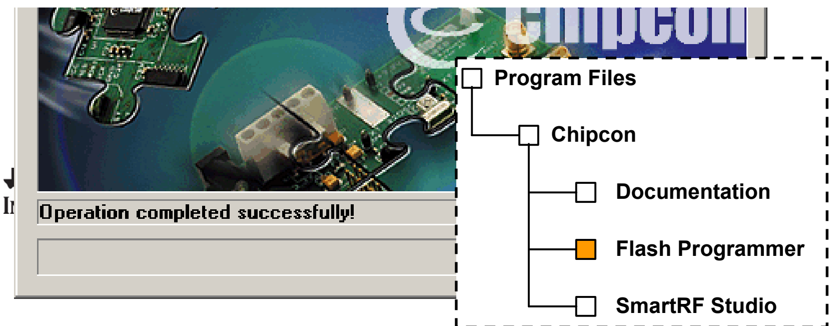
Memory Write Protection:

Device Information

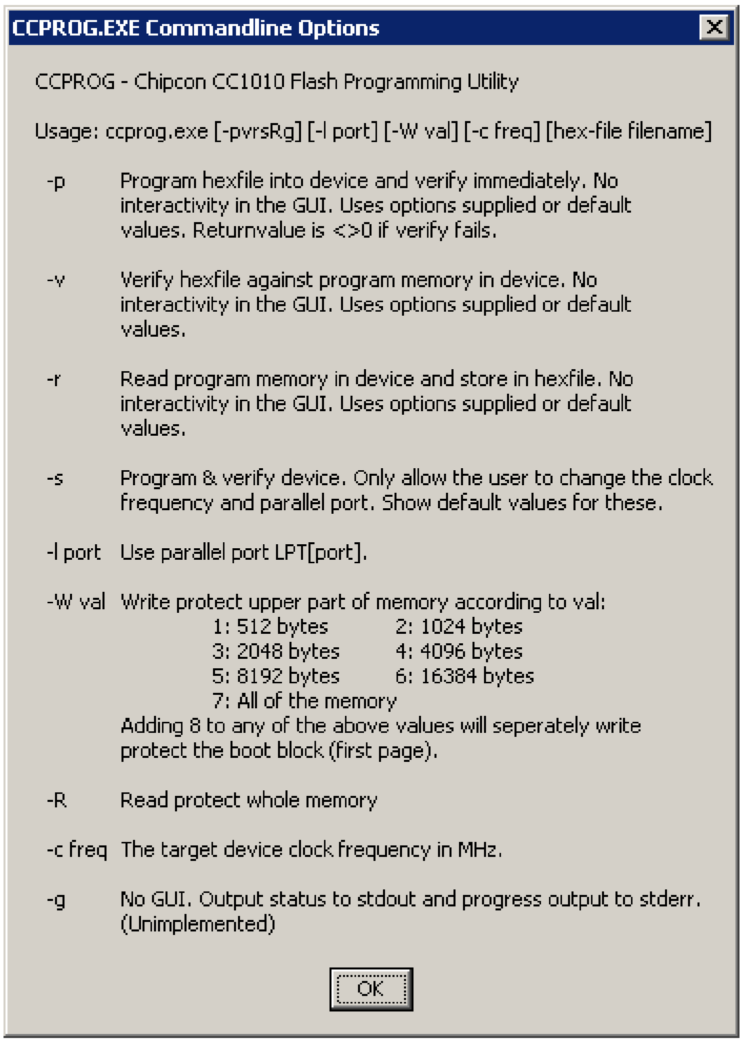
Device ID: 01: Chipcon CC1010 (Rev 1)

Lock Status: No Read Lock, No boot write lock, Upper 0 bytes write locked.

Figure 25: CC1010IDE utility – Flash programmer.



All though the flash programmer normally expects user dialog through the graphical interface, it still maintains full command line support. Execute the following command line to display all flash programming options:
'C:\Program Files\Chipcon\Flash Programmer\ccprog.exe –h'.



```
CCPROG - Chipcon CC1010 Flash Programming Utility

Usage: ccprog.exe [-pvrsRg] [-l port] [-W val] [-c freq] [hex-file filename]

 -p       Program hexfile into device and verify immediately. No
          interactivity in the GUI. Uses options supplied or default
          values. Returnvalue is <>0 if verify fails.

 -v       Verify hexfile against program memory in device. No
          interactivity in the GUI. Uses options supplied or default
          values.

 -r       Read program memory in device and store in hexfile. No
          interactivity in the GUI. Uses options supplied or default
          values.

 -s       Program & verify device. Only allow the user to change the clock
          frequency and parallel port. Show default values for these.

 -l port  Use parallel port LPT[port].

 -W val   Write protect upper part of memory according to val:
                  1: 512 bytes       2: 1024 bytes
                  3: 2048 bytes      4: 4096 bytes
                  5: 8192 bytes      6: 16384 bytes
                  7: All of the memory
          Adding 8 to any of the above values will seperately write
          protect the boot block (first page).

 -R       Read protect whole memory

 -c freq  The target device clock frequency in MHz.

 -g       No GUI. Output status to stdout and progress output to stderr.
          (Unimplemented)
```

Figure 26: CC1010IDE utility - Flash programmer help.

Example usage:

1. ccprog.exe –p -l LPT1 –c 14.7456 c:\chipcon\cc1010\test1.hex

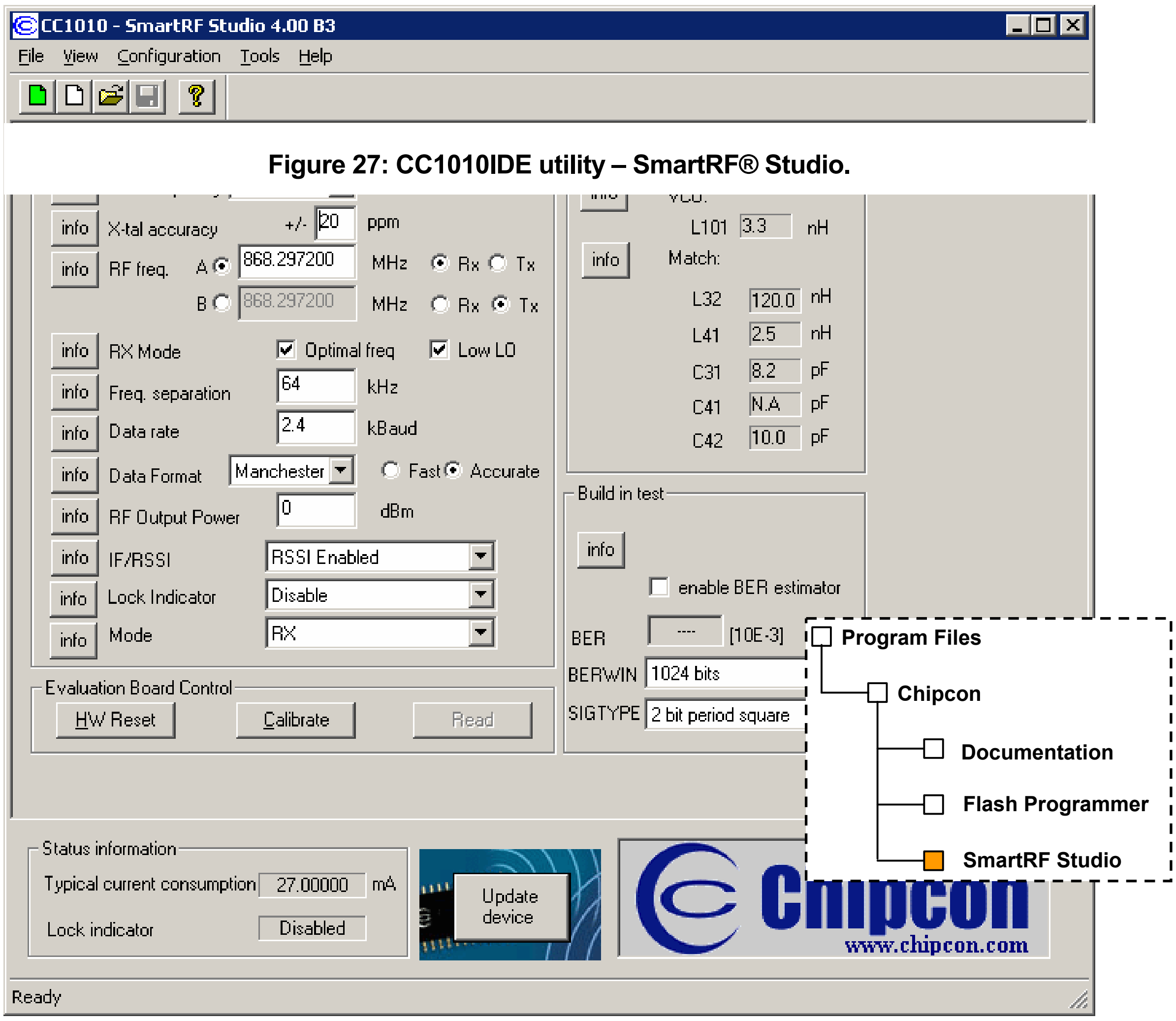
   This command line instructs the flash programmer to write the specified hex file into CC1010 flash memory and then immediately verify the flash memory content against the original hex file. It acquires the parallel port, LPT1, to communicate with CC1010 and sets the clock frequency to 14.7456 MHz.

2. ccprog.exe –r c:\chipcon\cc1010\test1verify.hex

   This command line instructs the flash programmer to read the content of the flash memory and then store it in the specified hex-file. In this case the flash programmer acquires LPT1 and sets the clock frequency to 14.7456 MHz by default.

SmartRF® Studio

To diagnose the CC1010 RF transceiver after the debug option has been removed Chipcon recommends using 'SmartRF® Studio'. This tool implements a serial communication protocol with the CC1010EB through the PC parallel port. To support SmartRF® Studio communication it is necessary to install/download a so-called "SmartRF® Studio adapter" on the CC1010EB. This enables the user to diagnose, configure and test the CC1010 RF transceiver from the PC. It will also be possible to export a complete set of RF parameter settings from SmartRF® Studio into the application source code, without tedious retyping. See the SmartRF® Studio user manual for more information on this program:



X-tal accuracy +/- 20 ppm
RF freq. A [✓] 868.297200 MHz [✓ Rx] Tx
B 868.297200 MHz Rx [✓ Tx]
RX Mode [✓ Optimal freq] [✓ Low LO]
Freq. separation 64 kHz
Data rate 2.4 kBaud
Data Format Manchester Fast [✓ Accurate]
RF Output Power 0 dBm
IF/RSSI RSSI Enabled
Lock Indicator Disable
Mode RX

VCO:
L101 3.3 nH
Match:
L32 120.0 nH
L41 2.5 nH
C31 8.2 pF
C41 N.A pF
C42 10.0 pF

enable BER estimator
BER ---- [10E-3]
BERWIN 1024 bits
SIGTYPE 2 bit period square

Typical current consumption 27.00000 mA
Lock indicator Disabled

Figure 27: CC1010IDE utility – SmartRF® Studio.

Maintenance

Upgrades

Each CC1010IDE release includes multiple stand-alone submodules with individual revisions. Chipcon guarantees consistent CC1010IDE performance based on integration testing prior to a new release. To maintain and ensure CC1010IDE integrity, separate module upgrades/updates should not be installed without prior Chipcon recommendation. In general Chipcon will notify the user whenever a new CC1010IDE upgrade is available. Depending on what CC1010IDE module(s) are affected, the user will be able to receive a patch or complete upgrade. However, in case of intermediate Keil ™ upgrades/updates, the user will have to refer to technical support at Chipcon in order to verify consistency with the CC1010IDE.

CC1010IDE main modules:

- Keil ™ uVision2 (IDE).
- Flash programmer.
- SmartRF® Studio.
- Debug extensions (DLL plug-in's for in-circuit debugger, etc.).
- Libraries (i.e.: HDF, HAL, CUL).

Support

In order to get upgrades or technical support for CC1010, please access the following links:

- http://www.Keil.com/product/softmaint.htm
- http://www.chipcon.com

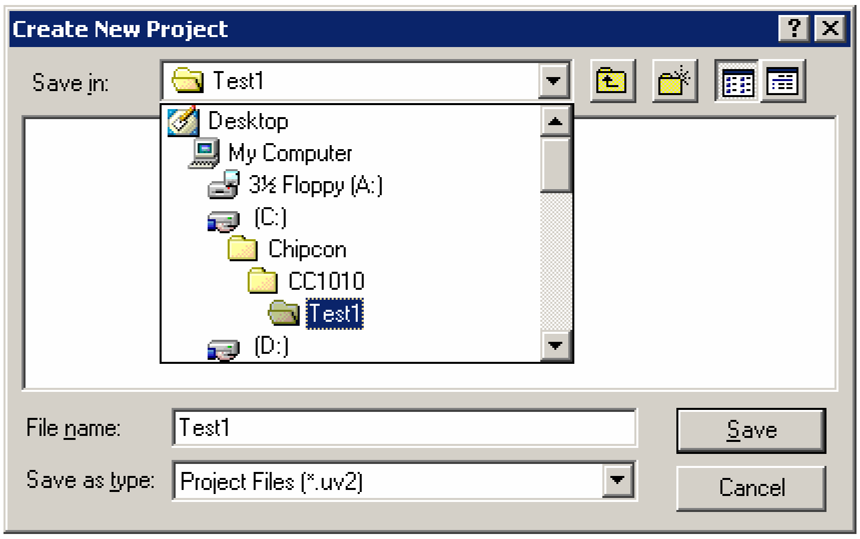
Tutorial

To quickly and safely create a CC1010 application Chipcon recommends that the user begins by creating a software project. This will serve as a reference for the IDE when processing the different source files for the CC1010 target.

Build a CC1010 software application

Create a new software project:

From the 'Project' menu, choose 'New Project'.
Then create/select project folder + name:


Create New Project

Save in: Test1

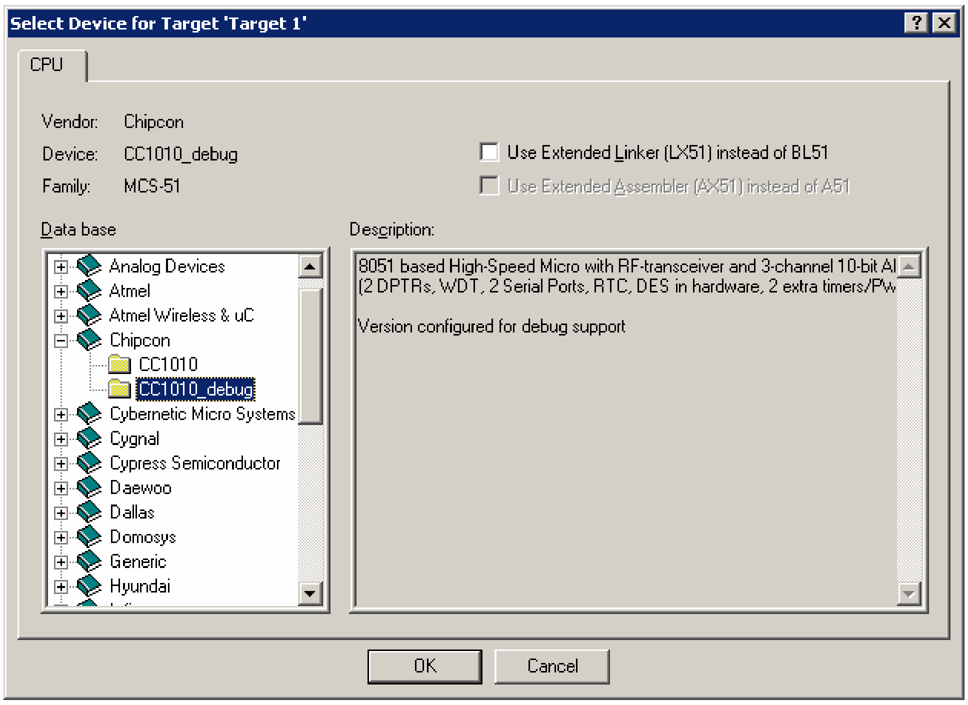
- Desktop
  - My Computer
    - 3½ Floppy (A:)
    - (C:)
      - Chipcon
        - CC1010
          - Test1
    - (D:)

File name: Test1

Save as type: Project Files (*.uv2)

Figure 28: Tutorial - create new software project.

Select target device (i.e.: with debug mode):



Select Device for Target 'Target 1'

CPU

Vendor: Chipcon
Device: CC1010_debug
Family: MCS-51

☐ Use Extended Linker (LX51) instead of BL51
☐ Use Extended Assembler (AX51) instead of A51

Data base

- Analog Devices
- Atmel
- Atmel Wireless & uC
- Chipcon
  - CC1010
  - CC1010_debug
- Cybernetic Micro Systems
- Cygnal
- Cypress Semiconductor
- Daewoo
- Dallas
- Domosys
- Generic
- Hyundai

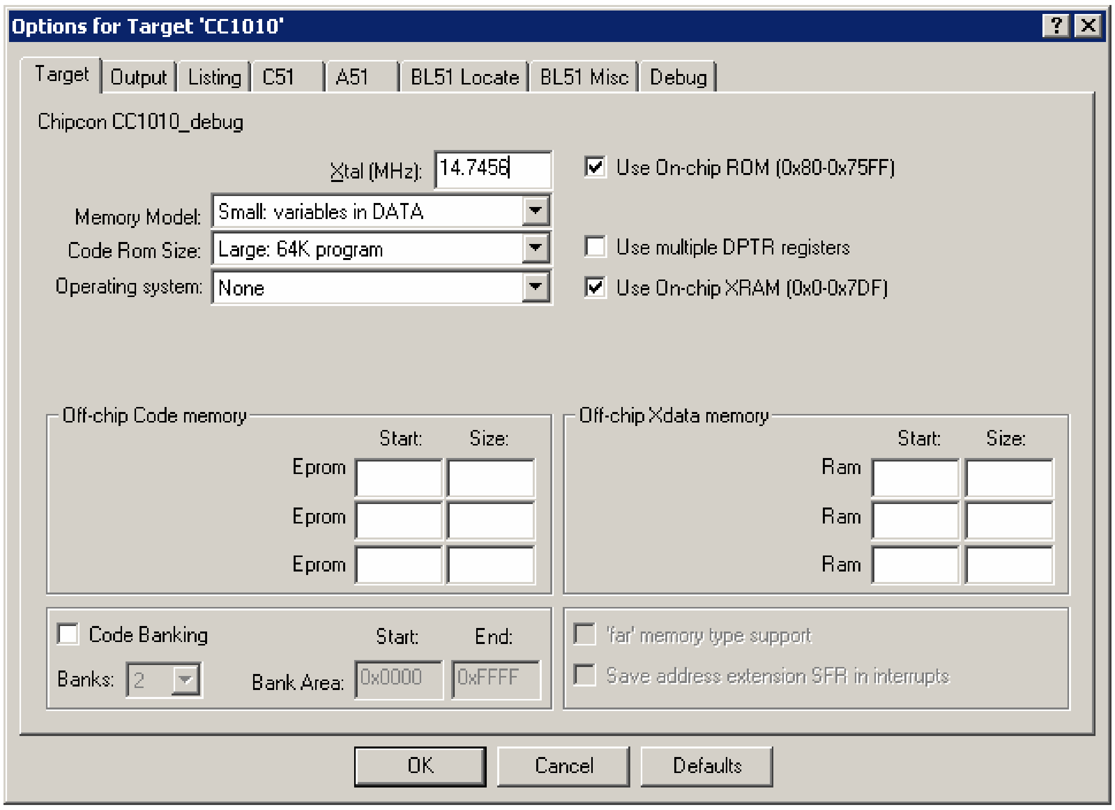
Description:

8051 based High-Speed Micro with RF-transceiver and 3-channel 10-bit Al
(2 DPTRs, WDT, 2 Serial Ports, RTC, DES in hardware, 2 extra timers/Pw

Version configured for debug support

Figure 29: Tutorial - select target device

Select target profile for debug mode (refer to chapter 3 for the remaining configuration tab's):


Options for Target 'CC1010'

Chipcon CC1010_debug

Xtal (MHz): 14.7456

☑ Use On-chip ROM (0x80-0x75FF)

Memory Model: Small: variables in DATA

Code Rom Size: Large: 64K program

Operating system: None

☐ Use multiple DPTR registers

☑ Use On-chip XRAM (0x0-0x7DF)

Off-chip Code memory — Start: Size: Eprom, Eprom, Eprom

Off-chip Xdata memory — Start: Size: Ram, Ram, Ram

☐ Code Banking — Start: End:

Banks: 2 — Bank Area: 0x0000 0xFFFF

☐ 'far' memory type support

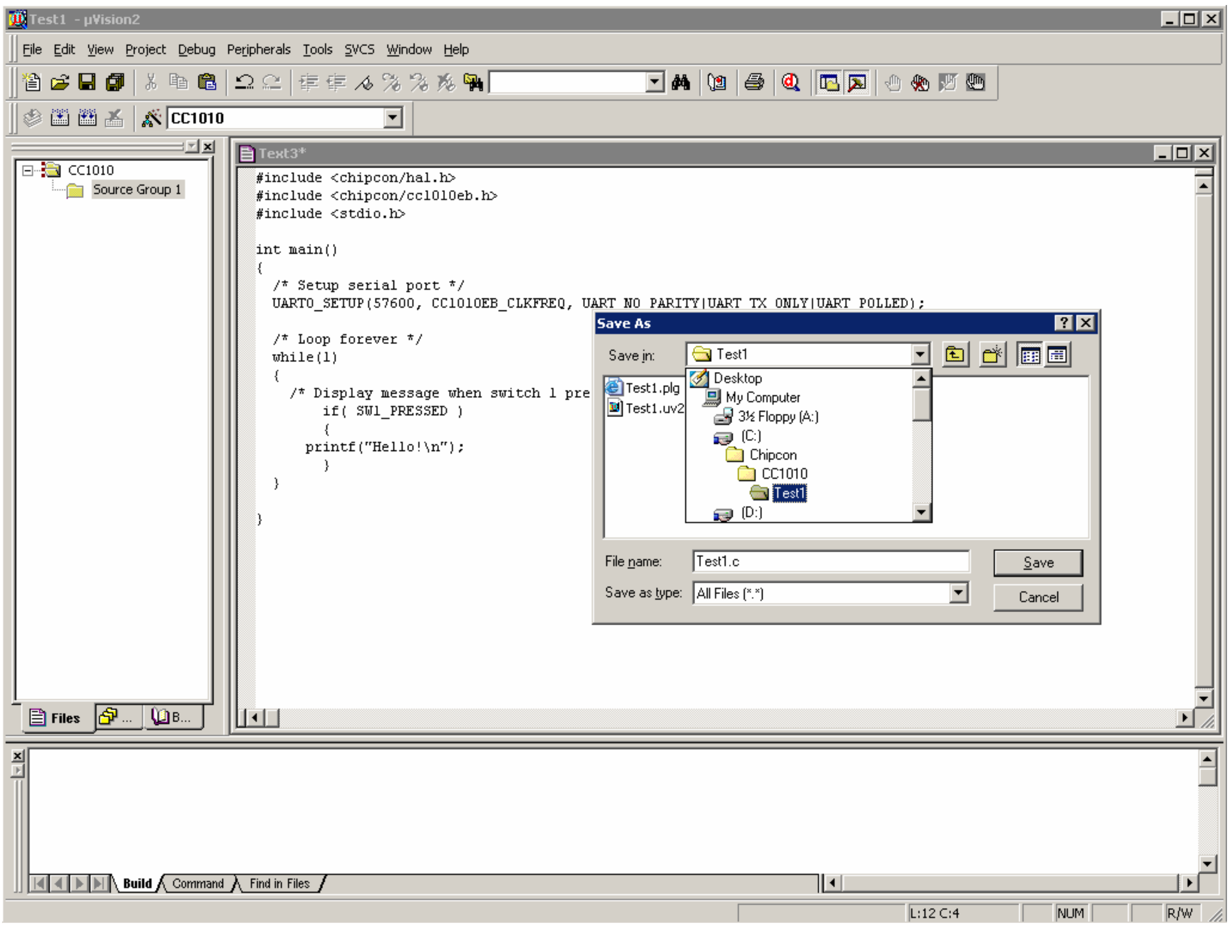
☐ Save address extension SFR in interrupts

Figure 30: Tutorial – configure target profile.

Create source file(s):

After creating a software project the next step in making a CC1010 application is to create one or more source files. Together with referenced library file(s) the source file will provide the actual functionality of the target application.

From the ‘File’ menu, choose ‘New’. Then edit and save file:



```
#include <chipcon/hal.h>
#include <chipcon/cc1010eb.h>
#include <stdio.h>

int main()
{
  /* Setup serial port */
  UART0_SETUP(57600, CC1010EB_CLKFREQ, UART_NO_PARITY|UART_TX_ONLY|UART_POLLED);

  /* Loop forever */
  while(1)
  {
    /* Display message when switch 1 pre
        if( SW1_PRESSED )
        {
      printf("Hello!\n");
        }
  }

}
```

Save in: Test1

File name: Test1.c

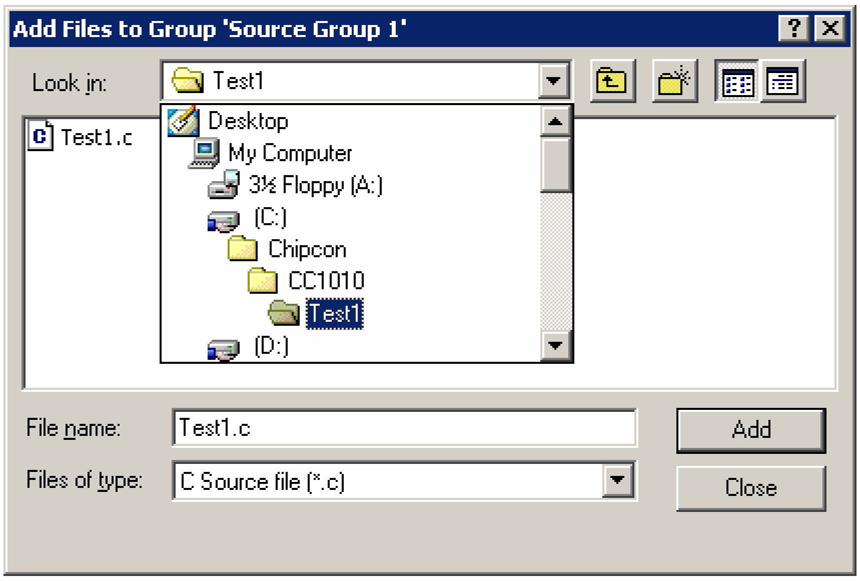
Save as type: All Files (*.*)

Figure 31: Tutorial – create source file.

Add source file(s) to the software project:

Once the source file(s) are created the IDE needs a reference to these files so that it can process (compile, assemble, link, etc.) the file(s).

Right-click on 'Source Group 1' and choose 'Add Files to Group Source Group 1'.
Then locate the file(s) and choose 'add':



File name: Test1.c

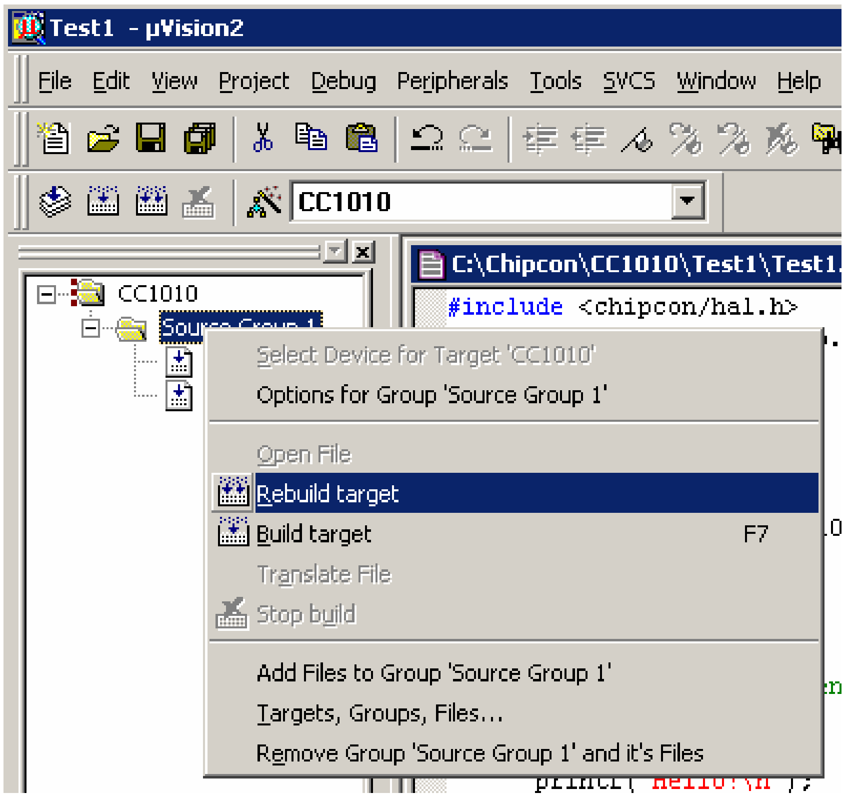
Files of type: C Source file (*.c)

Figure 32: Tutorial – add source file to software project.

Build executable code for the CC1010:

The final step in creating a CC1010 application is the build process. Based on the original source files this will produce an executable file for the CC1010 target.

Right-click on ‘Source Group 1’ and choose ‘Rebuild target’:

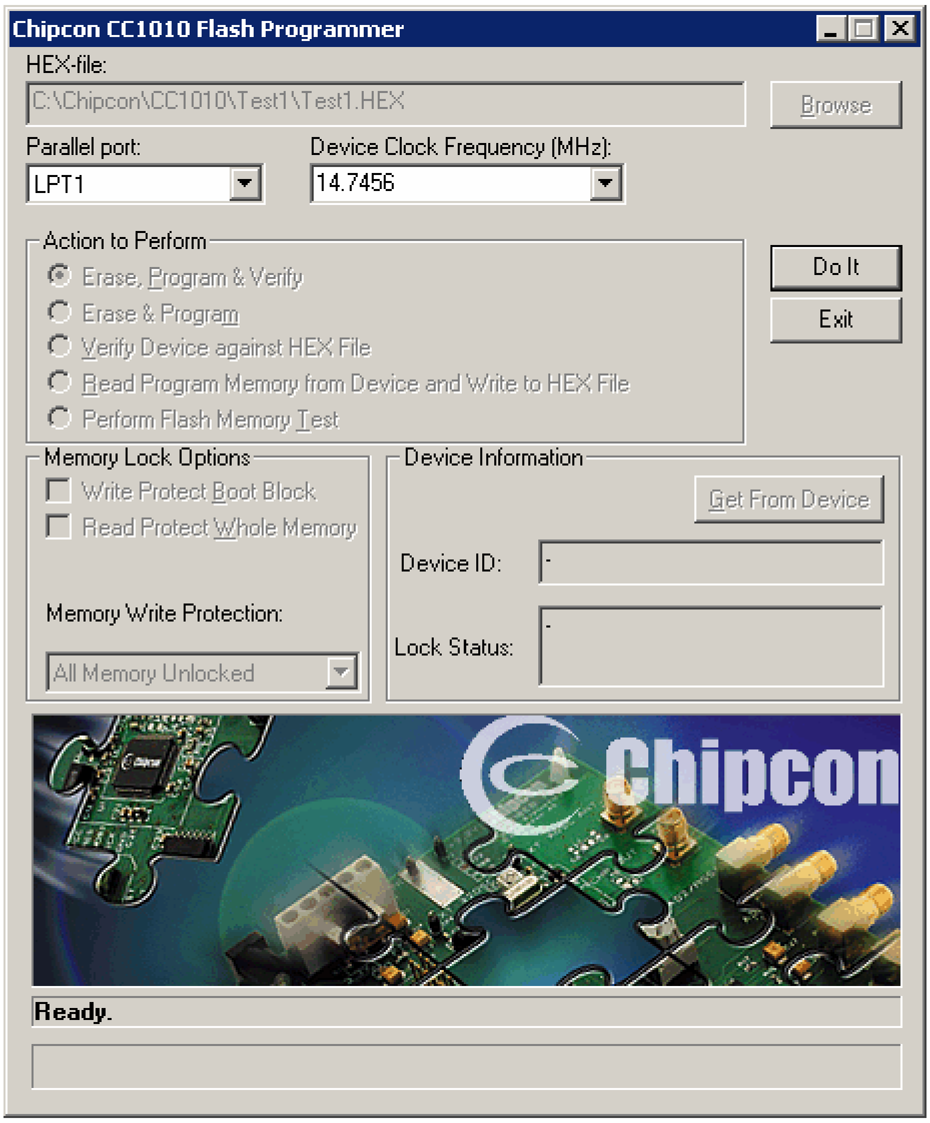

Test1 - µVision2
File Edit View Project Debug Peripherals Tools SVCS Window Help
CC1010
CC1010
Source Group 1
C:\Chipcon\CC1010\Test1\Test1
Select Device for Target 'CC1010'
Options for Group 'Source Group 1'
Open File
Rebuild target
Build target F7
Translate File
Stop build
Add Files to Group 'Source Group 1'
Targets, Groups, Files...
Remove Group 'Source Group 1' and it's Files

```
#include <chipcon/hal.h>
```

Figure 33: Tutorial – build application for CC1010.

Write application to the CC1010 (without debug option)

After the application is built it is ready for the target (CC1010 FLASH). To write the application to the CC1010 target, choose 'Tools' menu and then click on 'Write current Hexfile to CC1010 Flash'. Alternatively, run the flash programming as stand-alone from 'C:\Program Files\Chipcon\Flash Programmer\ccprog.exe'. Verify port and device clock frequency and then choose 'Do it' to execute the write process. The CC1010 application will now execute as soon as the CC1010 target (i.e.: Evaluation Board) is reset:


Chipcon CC1010 Flash Programmer
Browse
Action to Perform
Erase & Program
Verify Device against HEX File
Read Program Memory from Device and Write to HEX File
Perform Flash Memory Test
Do It
Exit
Memory Lock Options
Write Protect Boot Block
Read Protect Whole Memory
Device Information
Get From Device
Chipcon

HEX-file: C:\Chipcon\CC1010\Test1\Test1.HEX

Parallel port: LPT1

Device Clock Frequency (MHz): 14.7456

Action to Perform: [✓ Erase, Program & Verify]

Memory Write Protection: All Memory Unlocked

Device ID: -

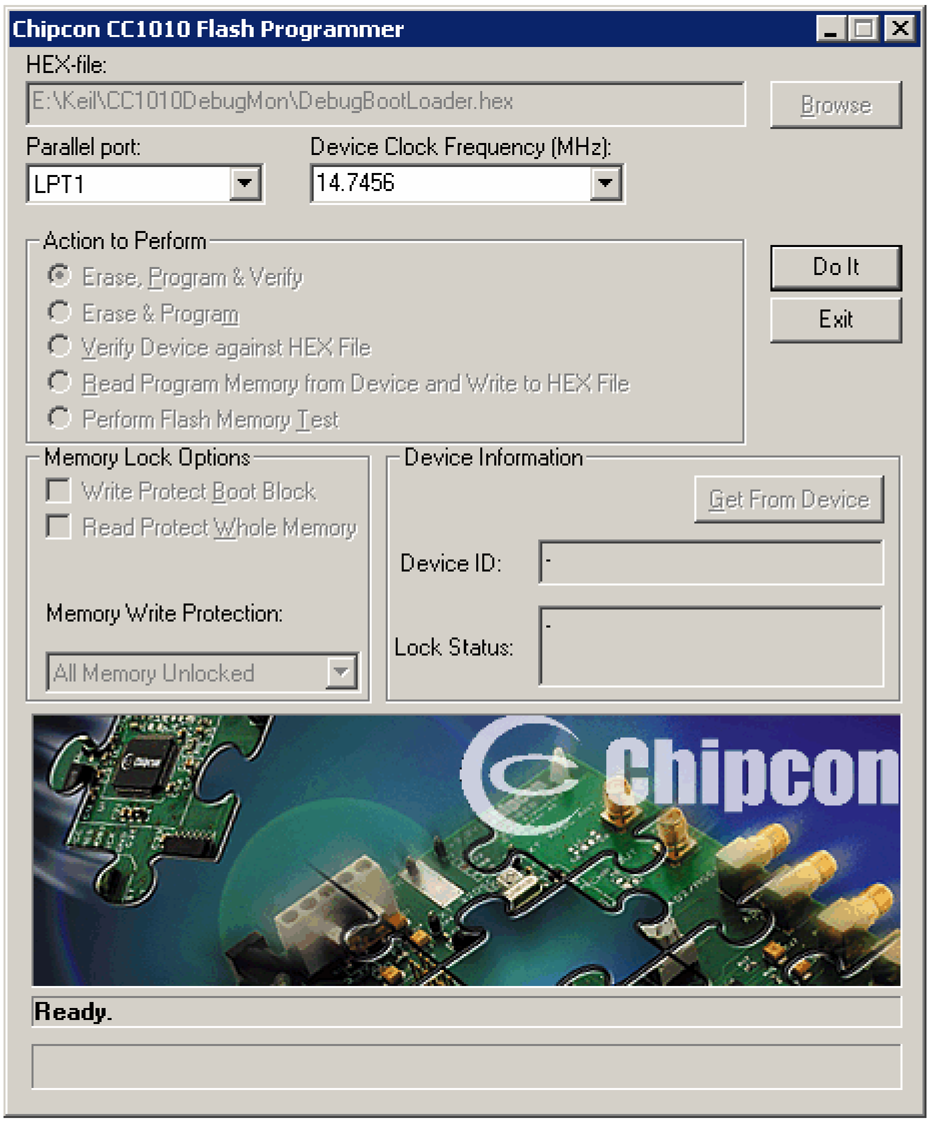
Lock Status: -

Ready.

Figure 34: Tutorial – write application to CC1010 (without debug mode).

Write debug monitor to the CC1010

The CC1010EB supports debugging based on a so-called debug monitor. This embedded software module monitors and schedules debug commands that arrive from the user (PC) on the asynchronous serial link. CC1010EB debugging is enabled by downloading the debug monitor to the CC1010EB. The CC1010 application will be downloaded to the CC1010 when the debug process is initiated. From the 'Tools' menu, choose 'Write Debug Bootloader To CC1010 Flash':


Chipcon CC1010 Flash Programmer

HEX-file: E:\Keil\CC1010DebugMon\DebugBootLoader.hex

Parallel port: LPT1

Device Clock Frequency (MHz): 14.7456

Action to Perform: [✓ Erase, Program & Verify] Erase & Program / Verify Device against HEX File / Read Program Memory from Device and Write to HEX File / Perform Flash Memory Test

Memory Lock Options: Write Protect Boot Block / Read Protect Whole Memory

Memory Write Protection: All Memory Unlocked

Device Information

Device ID: -

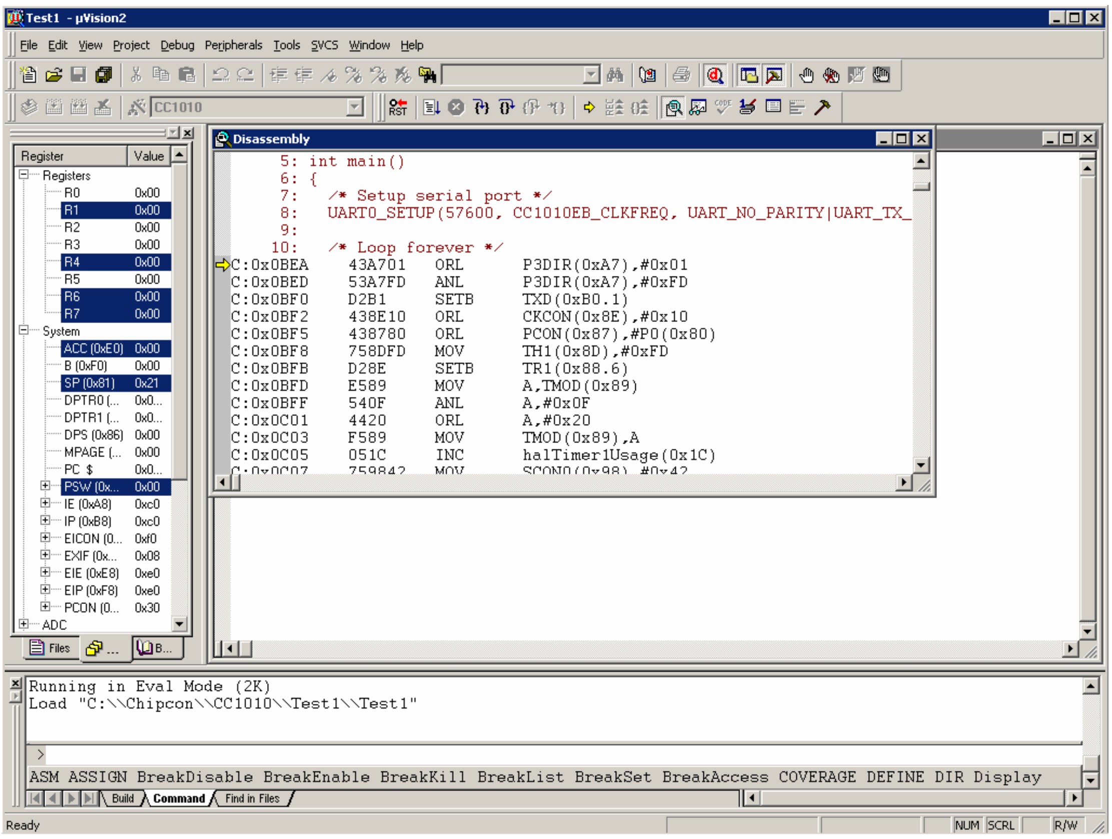
Lock Status: -

Ready.

Figure 35: Tutorial - write debug monitor to CC1010.

Debug the CC1010 code

From the 'Debug' menu, choose 'Start/Stop Debug Session'. This initiates a process that downloads the application to the CC1010. Inspect the embedded CC1010 code using common debug commands, such as step, breakpoint, etc.:



Register	Value
Registers	
R0	0x00
R1	0x00
R2	0x00
R3	0x00
R4	0x00
R5	0x00
R6	0x00
R7	0x00
System	
ACC (0xE0)	0x00
B (0xF0)	0x00
SP (0x81)	0x21
DPTR0 (...	0x0...
DPTR1 (...	0x0...
DPS (0x86)	0x00
MPAGE (...	0x00
PC $	0x0...
PSW (0x...	0x00
IE (0xA8)	0xc0
IP (0xB8)	0xc0
EICON (0...	0xf0
EXIF (0x...	0x08
EIE (0xE8)	0xe0
EIP (0xF8)	0xe0
PCON (0...	0x30
ADC	

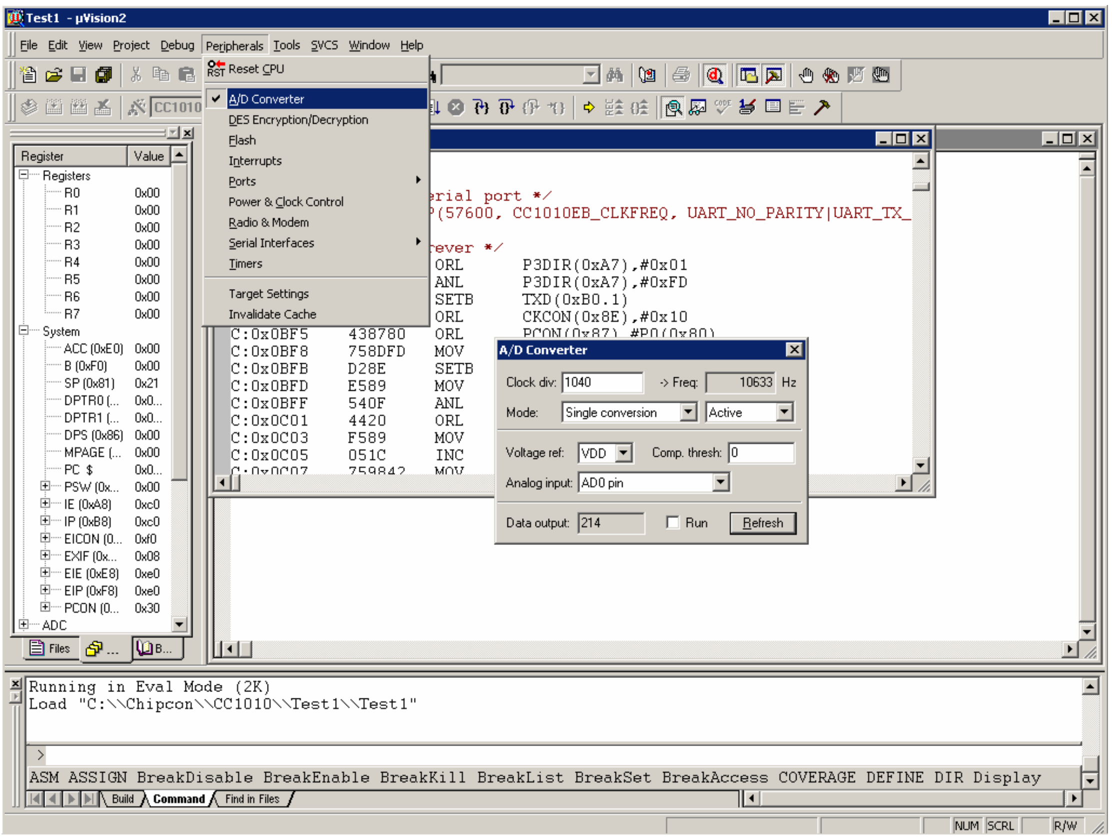
```
     5: int main()
     6: {
     7:   /* Setup serial port */
     8:   UART0_SETUP(57600, CC1010EB_CLKFREQ, UART_NO_PARITY|UART_TX_
     9:
    10:   /* Loop forever */
C:0x0BEA    43A701   ORL      P3DIR(0xA7),#0x01
C:0x0BED    53A7FD   ANL      P3DIR(0xA7),#0xFD
C:0x0BF0    D2B1     SETB     TXD(0xB0.1)
C:0x0BF2    438E10   ORL      CKCON(0x8E),#0x10
C:0x0BF5    438780   ORL      PCON(0x87),#P0(0x80)
C:0x0BF8    758DFD   MOV      TH1(0x8D),#0xFD
C:0x0BFB    D28E     SETB     TR1(0x88.6)
C:0x0BFD    E589     MOV      A,TMOD(0x89)
C:0x0BFF    540F     ANL      A,#0x0F
C:0x0C01    4420     ORL      A,#0x20
C:0x0C03    F589     MOV      TMOD(0x89),A
C:0x0C05    051C     INC      halTimer1Usage(0x1C)
C:0x0C07    759842   MOV      SCON0(0x98),#0x42
```

```
Running in Eval Mode (2K)
Load "C:\\Chipcon\\CC1010\\Test1\\Test1"

>
ASM ASSIGN BreakDisable BreakEnable BreakKill BreakList BreakSet BreakAccess COVERAGE DEFINE DIR Display
```

Figure 36: Tutorial – debug the CC1010 code.

Debug the CC1010 peripherals

From the peripherals menu it is possible to access the CC1010's peripheral hardware directly. One of the peripheral dialogs, 'A/D Converter', enables the user to access the CC1010 A/D converter directly from the PC. Browse this dialog to set up the A/D converter and then click 'Refresh' to read the current value on the selected analogue channel. Similar debugging actions can be carried out on other CC1010 peripherals. To activate a parameter-change in the peripherals dialog, make sure to press enter after each entry. For more details on direct debugging of the CC1010 peripherals, please study the peripherals menu:



Register	Value
Registers	
R0	0x00
R1	0x00
R2	0x00
R3	0x00
R4	0x00
R5	0x00
R6	0x00
R7	0x00
System	
ACC (0xE0)	0x00
B (0xF0)	0x00
SP (0x81)	0x21
DPTR0 (...	0x0...
DPTR1 (...	0x0...
DPS (0x86)	0x00
MPAGE (...	0x00
PC $	0x0...
PSW (0x...	0x00
IE (0xA8)	0xc0
IP (0xB8)	0xc0
EICON (0...	0xf0
EXIF (0x...	0x08
EIE (0xE8)	0xe0
EIP (0xF8)	0xe0
PCON (0...	0x30
ADC	

```
erial port */
P(57600, CC1010EB_CLKFREQ, UART_NO_PARITY|UART_TX_

rever */
                        ORL      P3DIR(0xA7),#0x01
                        ANL      P3DIR(0xA7),#0xFD
                        SETB     TXD(0xB0.1)
                        ORL      CKCON(0x8E),#0x10
C:0x0BF5     438780     ORL      PCON(0x87),#P0(0x80)
C:0x0BF8     758DFD     MOV
C:0x0BFB     D28E       SETB
C:0x0BFD     E589       MOV
C:0x0BFF     540F       ANL
C:0x0C01     4420       ORL
C:0x0C03     F589       MOV
C:0x0C05     051C       INC
C:0x0C07     759842     MOV
```

A/D Converter

Clock div: 1040 -> Freq: 10633 Hz
Mode: Single conversion · Active
Voltage ref: VDD · Comp. thresh: 0
Analog input: AD0 pin
Data output: 214 · ☐ Run · Refresh

```
Running in Eval Mode (2K)
Load "C:\\Chipcon\\CC1010\\Test1\\Test1"

>
ASM ASSIGN BreakDisable BreakEnable BreakKill BreakList BreakSet BreakAccess COVERAGE DEFINE DIR Display
```

Figure 37: Tutorial – debug the CC1010 peripherals.

Evaluating the CC1010 performance

To evaluate the CC1010 performance Chipcon offers a CC1010EB which integrates a number of components to facilitate thorough testing of the CC1010. See the CC1010DK User Manual for details regarding setup and operation.

Basic setup procedure:

1. Connect CC1010EB to power supply.
2. Connect parallel cable between parallel port on the PC and CC1010EB.
3. Connect serial cable between serial port on the PC and CC1010EB.
4. Use the CC1010IDE to build an executable program for the CC1010.
5. Use the Chipcon Flash programmer to download the program on the CC1010.

Evaluation Module:

The Evaluation Module contains the CC1010 chip, the needed external circuitry for operation, pull-up resistors for all general I/O pins, test points and a temperature sensor. Not all components are needed in an actual application. Please see the datasheet for a typical application circuit. The Evaluation Module is produced in two versions; the difference between them is the frequency band of operation. One version is optimized for use at 433 MHz, the other for use at 868 MHz and at 915 MHz. This covers the most used frequency bands, the 433 MHz band in Europe and the US, the 868 MHz band in Europe, and the 902-928 MHz band in the US. See application note AN001 for more information about applicable regulations. The operating frequency band is marked on the PCB.

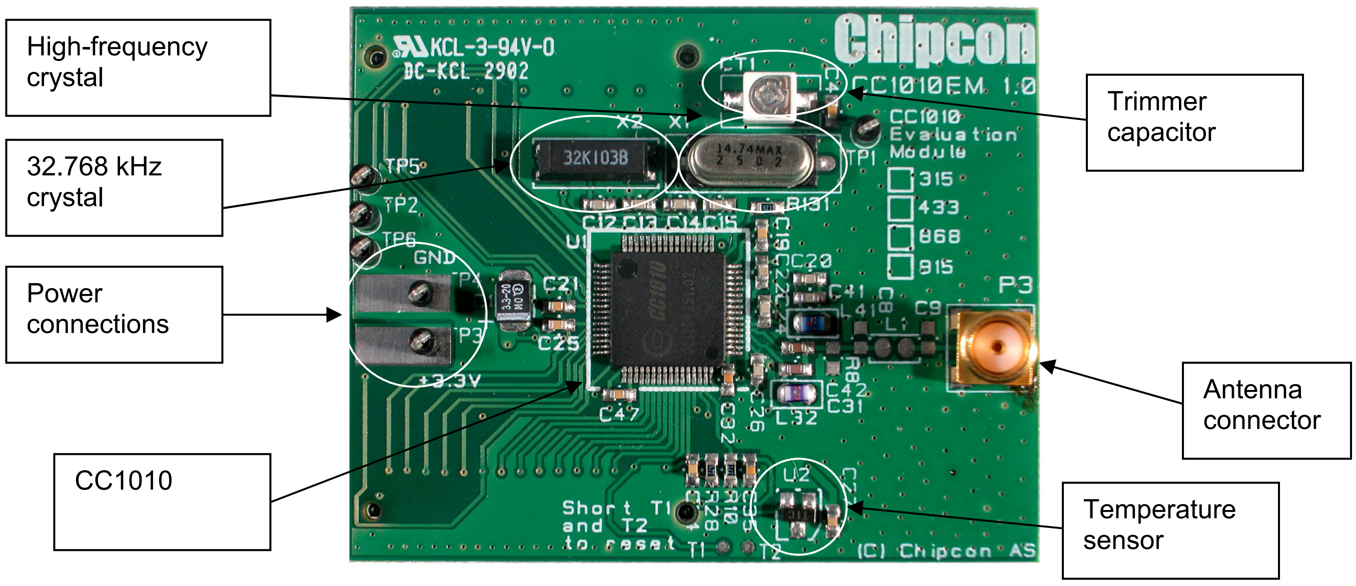


Figure 38: CC1010EM Evaluation Module

Evaluation Board:

The Evaluation Board is used as a motherboard for the Evaluation Modules, providing external circuitry for easy prototyping and connectors for easy connection to external equipment.

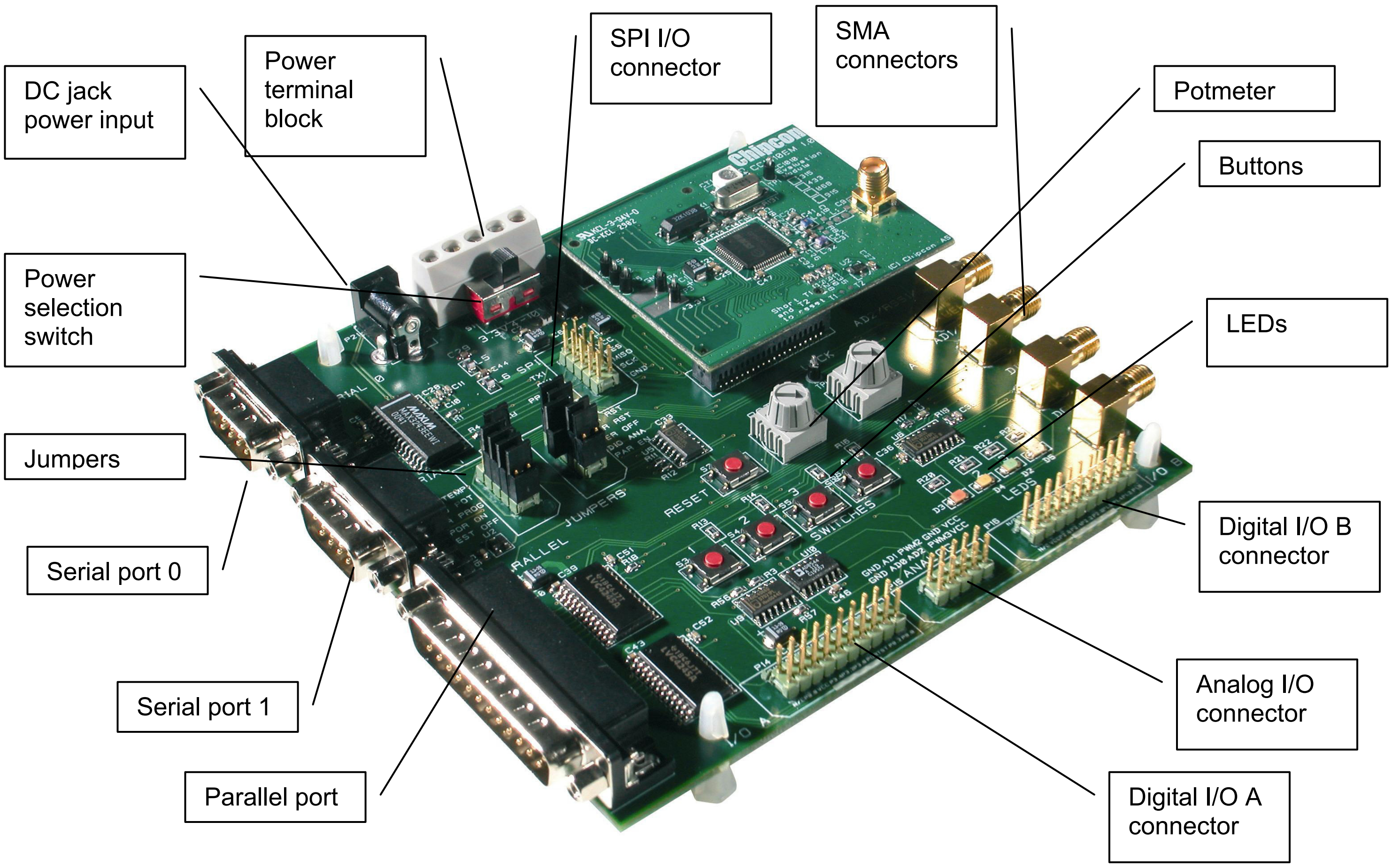


Figure 39: CC1010EB Evaluation Board (with CC1010EM plugged in)

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