IQRF
Quick Start Guide

For IQRF OS v3.07D and higher

For IQRF IDE v4.30 and higher

Smarter wireless. Simply.

Contents

How to start the first IQRF design

IQRF start-up is also illustrated on IQRF Video tutorial set.

Components required

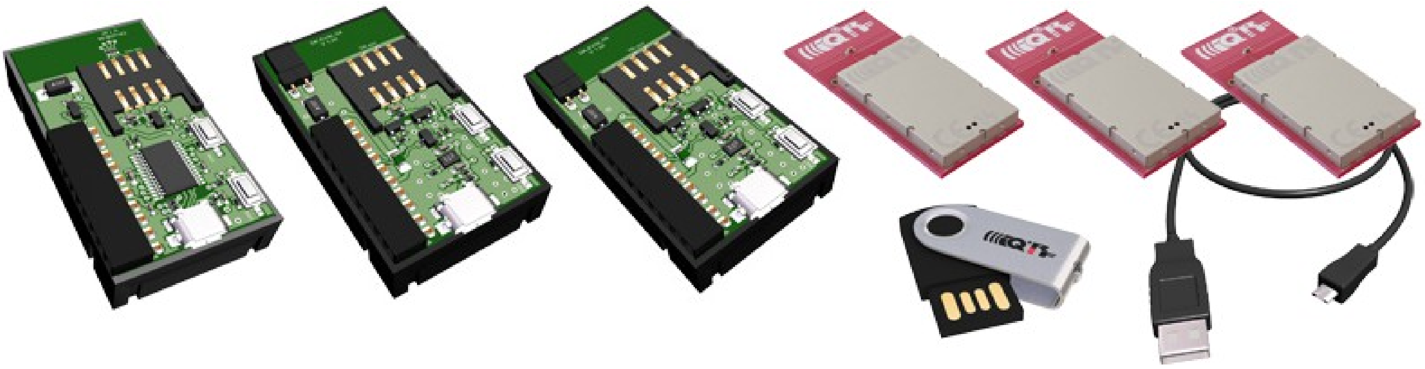
Just the following tools are needed:

- HW: IQRF **development set**
- SW: IQRF **Startup package** (free) including IQRF IDE development environment
- PC: Windows Vista, Windows 7, Windows 8, Windows 8.1 or Windows 10

Development hardware

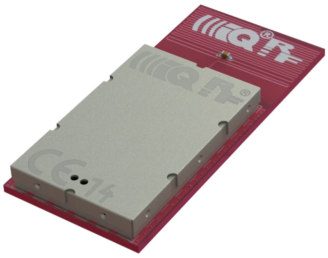
Development set

IQRF development set **DS-START-04** (see below) or **DS-DPA-02** (see chapter *DS-DPA-02 development set*) contains all HW needed for effective start-up.



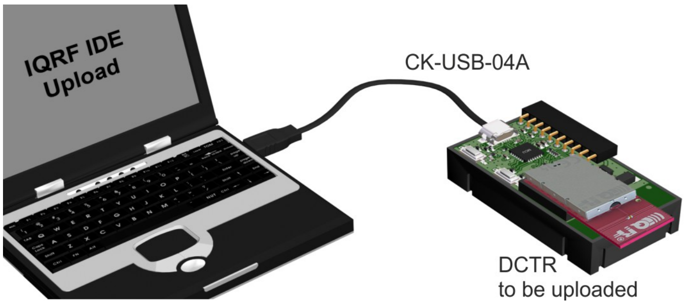
DCTR transceivers

RF transceiver modules **DCTR-72DA** fitting to SIM connector. They are fully programmable under IQRF OS operating system and allow to utilize hardware profiles under DPA framework (see chapter *Quick start with HWP without programming*) for applications without programming.



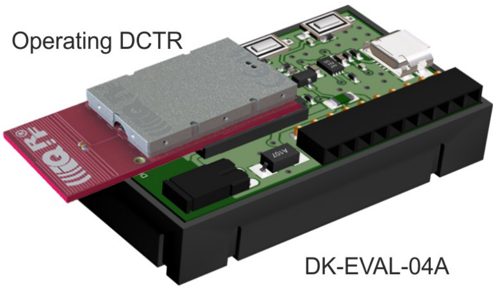
Programmer

To upload application codes in DCTRs and configure DCTR parameters, **CK-USB-04A** kit is intended.



End devices

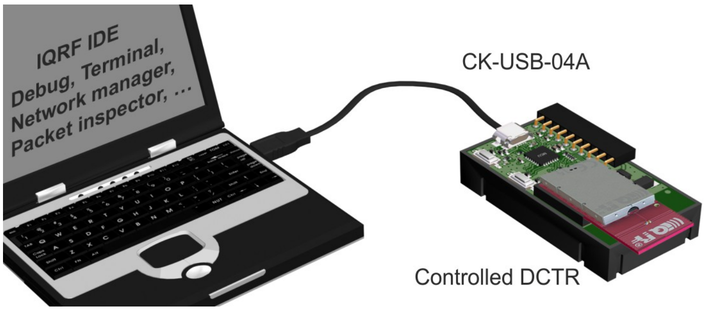
DCTRs (with application functionality codes uploaded using the programmer in advance) should be hosted in portable **DK-EVAL-04A** kits.



USB connector is intended just for accumulator charging but not for USB connectivity.

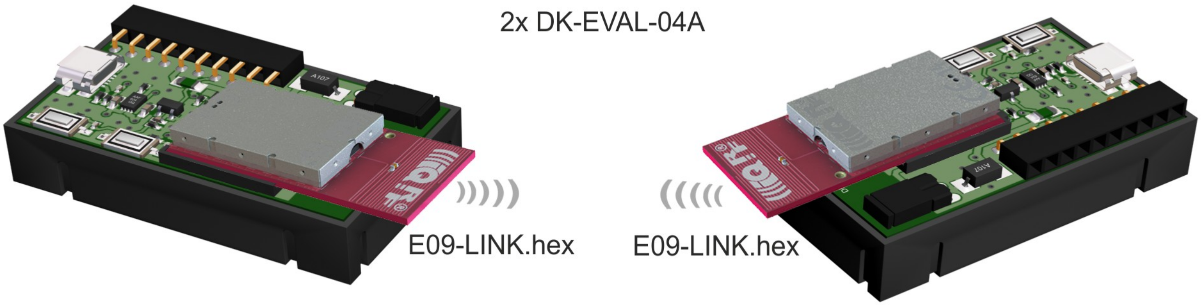
USB device

DCTRs can also be hosted by **CK-USB-04A** connected to PC via USB. It enables to control the DCTR application from PC, first of all by the IQRF IDE powerful tools for communication, testing, network management and visualisation. This is advantageous especially for network Coordinator.



Typical usage of kits

First demonstration



RF link check:

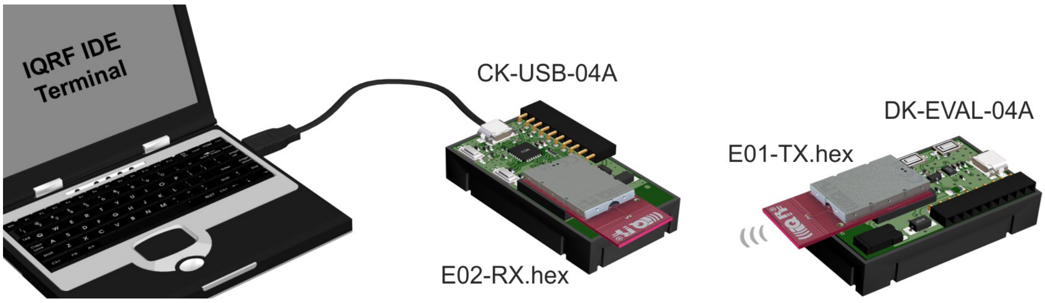
- Unpack two DCTR transceivers from the development set. Do not make any changes in SW inside.
- Plug the TR modules to both DK-EVAL-04A kits and switch the power on by jumpers.
- Bidirectional RF link is automatically established between the kits. Red LED flashing indicates RF connection.
- You can move the kits and check RF link with respect to given environment.

Note: This link works plug and play thanks to the E09-LINK program which is uploaded in all TR modules in development sets delivered from the factory. It is one of Basic examples from the Startup package and can be uploaded whenever needed later on.

Point-to-point

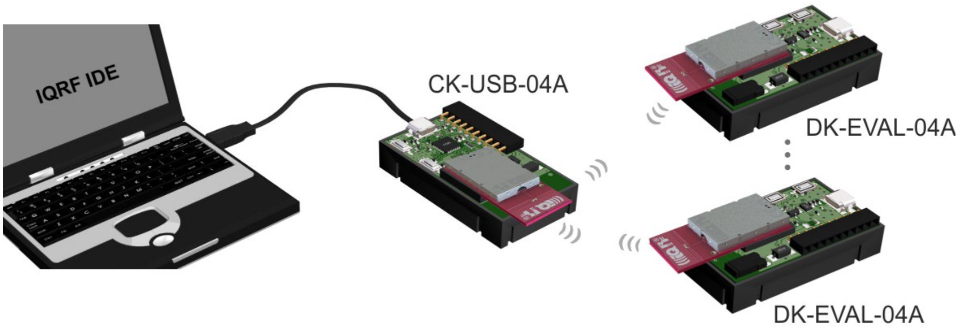
Arrangement with two DK-EVAL-04A kits see above.

Arrangement with CK-USB-04A:



See Basic examples E01-TX, E02-RX, … in IQRF Startup Package.

Network



For networks, it is recommended to apply ready-to-use hardware profiles, which is much easier than writing one's own user-specific application. See chapter *Quick start with HWP without programming*.

Two application levels

Specific functionality can be implemented into DCTR in one of the two application levels:

Data controlled, no programming

Higher level, running under **DPA framework** and utilizing so called Hardware profiles, which are ready-to-use SW plug-ins enabling communication in mesh networks with no need of programming. DCTR is not controlled by an application program but by data flow. All resources of given device are accessed via sending and receiving packets. Requested functionality is achieved without programming. However, even this approach allows user-specific adapting by optional Custom DPA handler programmable in C language.

C-programming, fully programmable

Lower level, running directly under **IQRF OS**. The functionality is given by the application program in C language. This approach can be implemented also with TR transceivers (without the DC prefix, supporting only Demo hardware profiles).

For network applications, using the DPA approach is highly recommended.

Although IQRF OS supports mesh networks by embedded IQMESH protocol with a set of powerful functions, more detailed knowledge about IQRF and IQMESH is still needed for networking under IQRF OS.

To the contrary, the DPA framework utilized in DCTR transceivers solves the networking transparently. Just the addressees must be specified and then the packets are delivered automatically. This, together with data controlled approach with no programming needed makes DCTR very easy to implement. The entire network traffic is based on simple commands only specifying where and what to perform.

Development software

All software and documentation is available in a single **IQRF Startup package** on the IQRF CD or USB Flash drive included in the development set. The newest version should be downloaded from www.iqrf.org/startup.

PC software

IQRF IDE

Integrated development environment by MICRORISC to create, debug and control IQRF applications and manage IQRF network. Required minimal IQRF IDE version depends on IQRF OS version of given TR transceiver and possibly also on DPA version. See IQRF IDE Release notes. The best way is to always use the latest IDE version.

USB drivers

IQRF USB devices primarily utilize Custom class (with VID / PID by MICRORISC when used with IQRF devices). Several IQRF USB devices (e.g. GW-USB-06) can also (optionally) use the CDC class. (CDC is not necessary for IQRF startup.)

- USB drivers implemented in current IQRF devices (e.g. CK-USB-04A or GW-USB-06 with up-to-date firmware) are **by verified publisher** based on the **WinUSB** by Microsoft.
- USB drivers implemented in older IQRF devices (e.g. CK-USB-04) or in older firmware versions of some current devices are based on the **MPUSB** by Microchip.

CC5X

C compiler for the PIC microcontrollers (by B Knudsen Data). The evaluation version (included in IQRF Startup package) is free. *The compiler is not necessary when using hardware profiles without a Custom DPA handler.*

Text editor

For source code creation and modification, any external editor beeing able to save a plain ASCII text, e.g. Windows Notepad can be used. Notepad++ (a great source code editor, free by GPL License) is very recommended. Download it from www.notepad-plus-plus.org. *The editor is not necessary when using hardware profiles without a Custom DPA handler.*

Installation

1. **Do not have any IQRF USB device connected.**
2. **Unzip** the **Startup package** (the `.zip` file). All you need is automatically unpacked to specified directory.
3. **Install** the **IQRF IDE** by invoking the installation file `iqrf-ide-4xx….exe` in subdirectory `IQRF_IDE`. USB drivers and free edition of the C compiler are also installed. Follow the instructions during installation. See the **IQRF USB drivers Installation guide** (in subdirectory `Documentation\SW`) for details depending on Windows version.
4. **Connect** the CK-USB-04A to PC.
5. **Invoke** the **IQRF IDE**.
6. To edit source C files, Windows native Notepad is set as default. You can change it for your favorite editor (e.g. Notepad++) in the *Tools / Options / Editors* menu.

Up to 3 instances of IQRF IDE v4.xx are allowed running at the same time. But only one IQRF IDE can be installed.

Test

Open the default IDE project `E00-START` in the `Examples/IQRF_OS/StartUp` directory and press the *F11* key (*USB Device / Indicate USB Device*). LED1 on the CK-USB-04A should flash thrice which indicates correct connection between CK-USB-04A and PC.

Other PC programs operating with USB

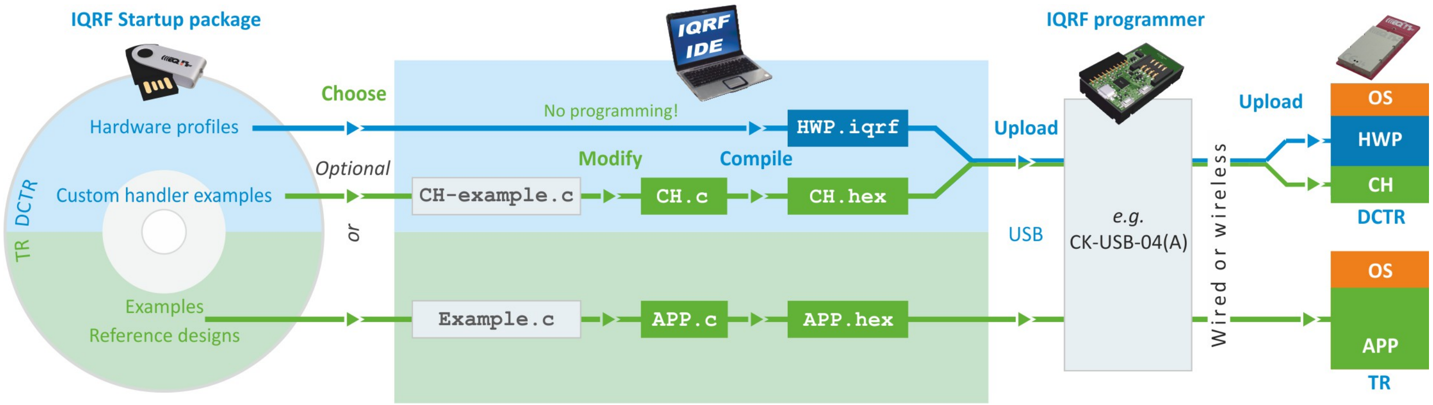
Other PC programs which utilize the same USB driver, e.g. *IQRF UDU* (obsolete) for upgrade a firmware in IQRF devices, *IQRF Router configurator* or some 3rd-party SW (e.g. by Microchip), must not be running at the same time with IQRF IDE.

IQRF IDE

IQRF IDE environment integrates all SW tools needed for application development (and a lot of utilities for following control, maintenance and service). It is project oriented. Thus, a Project containing necessary definitions and files must be specified first. Default Projects are available for immediate start. Project definition files have the iqrfprj extension. See IQRF IDE Help for details.

Programming and uploading procedure

- **Programming** – creation of user specific IQRF application program.
  - **Editing** – creation/modification of source code in C language. *Not necessary when using hardware profiles without a Custom DPA handler.*
  - **Compilation** – compiling the source program from C language to `.HEX` machine code. *Not necessary when using hardware profiles without a Custom DPA handler.*
  - **Upload** – uploading the code into the DCTR module (either a hardware profile, possibly with a Custom handler, or a user-specific application). Wireless upload (RFPGM) is also possible – see IQRF OS User's guide and IQRF OS Reference guide.



Other development, test and service utilities

- **Debug** – allows to stop program execution and watch internal variables (break, watch and continue).
- **Terminal** – utility to control serial communication.
- **Packet inspector** decoding and interpreting packets logged in Terminal Log window.
- **Network management**, **visualization**, **testing**, …

Tip: To switch the project from default (E00-START) to another existing example (e.g. E01-TX), replace the `E00-START.c` and `E00-START.hex` files in the Project with `E01-TX.c` and `E01-TX.hex` and save the Project as `E01-TX` (which creates the `E01-TX.iqrfprj` file).

C-programming

Programming in C language is needed:

- When DPA is used and given ready-to-use hardware profile has to be extended by a user-specific Custom DPA handler.
- When the application is written under IQRF OS, without DPA.

Programming in C language is not needed when DPA is used and some existing Custom handler is to be used or no Custom handler is required at all.

If DPA is used, once the hardware profile is uploaded, it is not necessary to upload it any more when just the Custom DPA handler is changed.

The Startup Package contains a demo Project, either for DPA (`HWP-demo`) or non-DPA (`E00-START`) approach and a series of examples in the `Examples/` subdirectories to be utilized as needed:

1. **Using a ready-made example** (without modifications): Add a `.HEX` file to the Project and upload it into DCTR module plugged in CK-USB-04A by the *F5* key (*Programming/Upload*). (This must be enabled in the Project window.)
2. **Using an example with possible modification:** Add a source program (with the `.C` extension) to the Project, make modifications by editing (if desired) and compile it from the C language to the `HEX` format by the *F10* key *(Project/Build Target).* Upload resulting `.HEX` file similarly as in the case 1 above.
3. **Creation of a new program:** Use the `CustomDpaHandler-Template.c` or `Template.c` empty source file and continue similarly as in the case 2 above.

Refer to the IQRF IDE Help to learn about configuring the Project.

Design steps

1. Plug the TR into CK-USB-04A kit and run IQRF IDE.
2. Open a new Project (*Project/New Project*) and specify TR module type *(Project/Properties/TR Module).*
3. If you do not intend to modify or display a source code but to upload an existing code only, add required `.IQRF` or `.HEX` file to the Project *(Project/Add Existing Item)* and go to step 7.
4. Add required source file (one of examples, e.g. `CustomDpaHandler-Timer`, `E09-LINK.c` or empty template `CustomDpaHandler-Template.c` or `Template.c` to the Project *(Project/Add Existing Item)*.
5. Make possible modifications and save them then (in the text editor).
6. Compile the program by the *F10* key *(Project/Build Target)*. If any error is reported by the compiler, go to step 5 to correct it. The result is a compiled code in the `.HEX` format stored in the Project.
7. Program the code into the module by the *F5* key *(Programming/Upload).*
8. After uploading the application is just invoked. It is possible to debug it by the IQRF IDE. See chapter *Debug* below.
9. Then the transceiver can be carried e.g. to another development kit or to an end user equipment.

Typical repeated "loop" during development is: *Edit*, *Save* (Ctrl+S), *Compile* (F10), *Upload* (F5), *Debug*.

Refer to chapter *DPA* for detailed step by step instructions for DPA usage without programming..

Refer to the IQRF Video tutorial set and IQRF IDE training video.

Caution: *The TR module can be plugged / unplugged into / from the SIM connector while powered off only.*

Tip: *In case of CK-USB-04A the SW2 pushbutton (the one closer to SIM connector) can be used for this. The TR module is not powered while the SW2 pushbutton is held.*

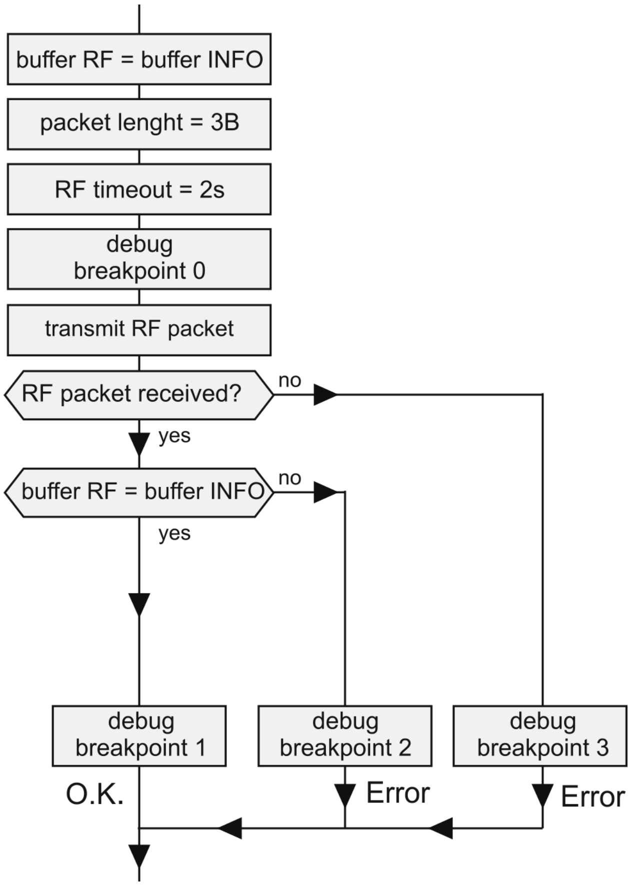
Note: The IQRF IDE reports a state of the TR module at the bottom bar of the main IDE window. The *SPI not active* message need not mean a missing or damaged TR. It is issued if SPI communication is not activated which depends on the application running in the module. SPI communication can be forced by switching the TR module in the programming mode by *F6* key *(Programming/Enter Programming Mode).* The application in the TR module is not running in the programming mode.

Debug

The operating system offers the `debug()` function to be placed in source code wherever you wish to stop and display internal variables and registers. After selecting the *Skip Breakpoint* button the application continues running until next `debug()` function is encountered and so on. If more debug instances is set at the same time, the `W` register (MCU accumulator) should be used to distinguish the active breakpoint location. Macro `breakpoint(w)` can be used for simplicity. See `IQRF-macros.h` header file and basic example E06-RAM for explanation.

Example

```
copyBufferINFO2RF();

DLEN=3;

toutRF=200;

breakpoint(0);

PIN=0;
RFTXpacket();

if (RFRXpacket())

  if (compareBufferINFO2RF(4))

      breakpoint(1);
  else
      breakpoint(2);
  else
      breakpoint(3);
```



Application examples

The Startup Package contains demo programs:

- **For DPA**
  - **Custom DPA handler examples**
- **For non-DPA**
  - **Basic** To get familiar with simple TR operation and OS functions
  - **Advanced** More complex
  - **DDC** For IQRF DDC development kits
  - **IQMESH** Networking

Quick start with HWP without programming

This chapter is intended as a step-by-step guide to get familiar with DPA and HWP. The process is the same for all hardware profiles, either Demo HWP with common transceivers (TR) or General HWP with Data controlled transceivers (DCTR).

Demo HWP vs. General HWP versions

Limitations

- Demo HWP is limited to max. 5 Nodes (with addresses 1 to 5). A node device having an unsupported address flashes periodically red LED after reset.
- Some Custom DPA handler events are not supported. See IQRF DPA Technical guide for specification.
- Only one user peripheral `PNum = 0x20` with one command `PCmd = 0x00` is supported.

Extensions

- Demo HWP supports the PWM peripheral (simple pulse-width modulated digital output).
- Discovery and FRC processes are indicated by LEDs flashing by default.

DS-DPA-02 development set

To learn DPA usage, development set DS-DPA-02 can be used.

• DCTR-72DAT	IQRF smart transceiver	6 pcs
• CK-USB-04A	IQRF programmer and debugger	2 pcs
• DK-EVAL-04A	Universal portable development kit for (DC)TR modules	4 pcs
• CAB-USBABMICRO	Micro USB cable 18.5 cm	2 pcs
• USB flash drive	Software and documentation	1 pc

1. Preparation

All SW, plug-ins, documentation etc. are available on the flash disk and on www.iqrf.org/downloads.

- Prepare 5 pieces of DCTR-72DAT with OS 3.07D or higher as Nodes and one DCTR-72DAT module with OS 3.07D or higher as the Coordinator.
- Prepare 4 (5) pieces of DK-EVAL-04A and 1 (2) piece(s) of CK-USB-04A.
- Install IQRF IDE 4.30 or higher. Refer to chapter *Installation* above.
- Launch IQRF IDE and open Project `HWP-demo.iqrfprj` from IQRF Startup package. All necessary files and macros are included in the Project.

2. HWP upload

Creating Nodes

A. Plug a DCTR module in CK-USB-04A, select the `DemoHWP-Node-STD-SPI_*.iqrf` file in Project window and click the *Upload Plug-ins* button on the Toolbar (or use the *F5* key). The plug-in should be uploaded then.

B. Double-click on the configuration file `DPA-config.xml` in IDE Project window to open the *TR Configuration* window. Make the following settings:

- Select desired RF channel (RF Channel A) in the OS tab.
- Select desired RX Filter in the HWP tab.
    - For short range testing (within the room) select 15.
    - For operating in real conditions select 0 (for TR-7xD) or 5 (for TR-5xD).

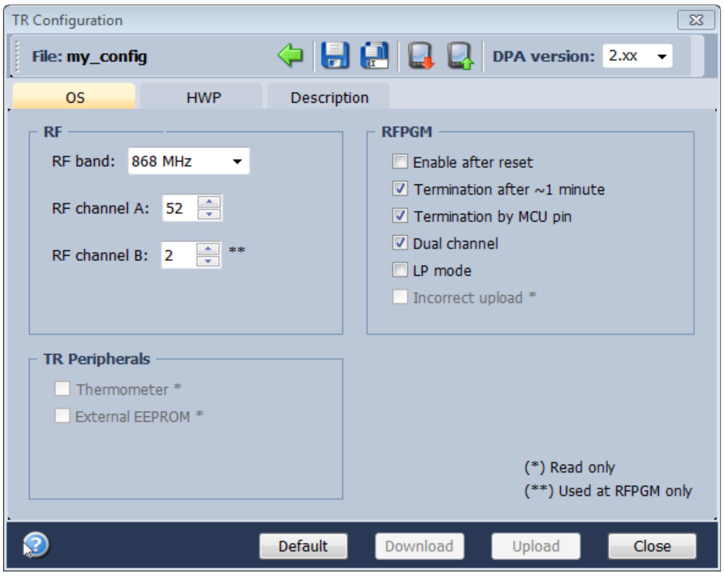
This settings must be the same in the entire network!
Do not change other parameters for now.
Save the configuration into the DCTR module by button *Upload*.

C. Plug this DCTR module in the DK-EVAL-04A kit.

Repeat steps A to C for all Nodes.

Creating the Coordinator

Use the same procedure but with the `DemoHWP-Coordinator-STD-SPI_*.iqrf` and `DPA-config.xml` files. Then leave the DCTR module plugged in CK-USB-04A.


TR Configuration

File: my_config — DPA version: 2.xx

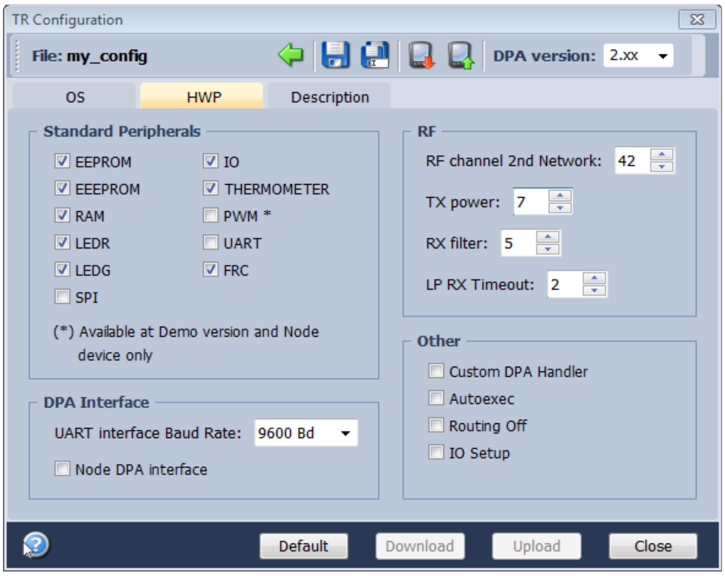
OS | HWP | Description

RF
RF band: 868 MHz
RF channel A: 52
RF channel B: 2 **

RFPGM
□ Enable after reset
☑ Termination after ~1 minute
☑ Termination by MCU pin
☑ Dual channel
□ LP mode
□ Incorrect upload *

TR Peripherals
□ Thermometer *
□ External EEPROM *

(*) Read only
(**) Used at RFPGM only


TR Configuration

File: my_config — DPA version: 2.xx

OS | HWP | Description

Standard Peripherals
☑ EEPROM ☑ IO
☑ EEEPROM ☑ THERMOMETER
☑ RAM □ PWM *
☑ LEDR □ UART
☑ LEDG ☑ FRC
□ SPI

(*) Available at Demo version and Node device only

DPA Interface
UART interface Baud Rate: 9600 Bd
□ Node DPA interface

RF
RF channel 2nd Network: 42
TX power: 7
RX filter: 5
LP RX Timeout: 2

Other
□ Custom DPA Handler
□ Autoexec
□ Routing Off
□ IO Setup

Warning: If you use a stronger filter during the development, do not forget to reduce it then in final application.

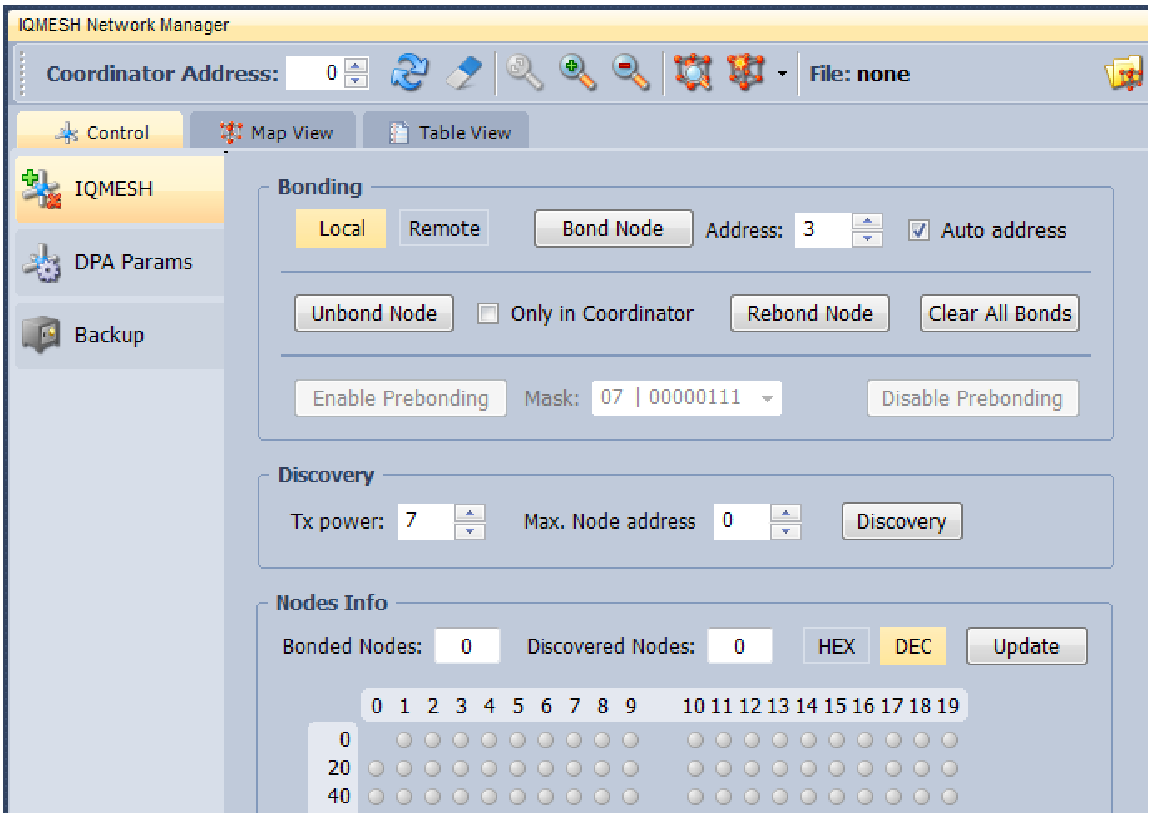
3. Bonding

To use DPA, all Nodes in the network must be bonded to the Coordinator. To get all nodes bonded, follow next procedure:

A. **All Nodes must be unbonded** and located in direct RF range to the Coordinator before bonding (local bonding).

- In case the Node is already bonded the red LED once shortly flashes. **Go to step Unbonding** below in this case.
- If the node is not bonded the red LED is flashing for 10 s and then the module falls into sleep.

B. The Coordinator may possibly have stored some bonded Nodes from previous DCTR module usage. Thus, such bonding information should be cleared from the Coordinator memory first. Click the *Clear All Bonds* (in *IQMESH Network Manager* window, tab *Control* → *IQMESH*). Number of bonded Nodes should be 0, see the screenshot below.



IQMESH Network Manager

Coordinator Address: 0

File: none

Bonding: Local, Address: 3, ☑ Auto address, □ Only in Coordinator

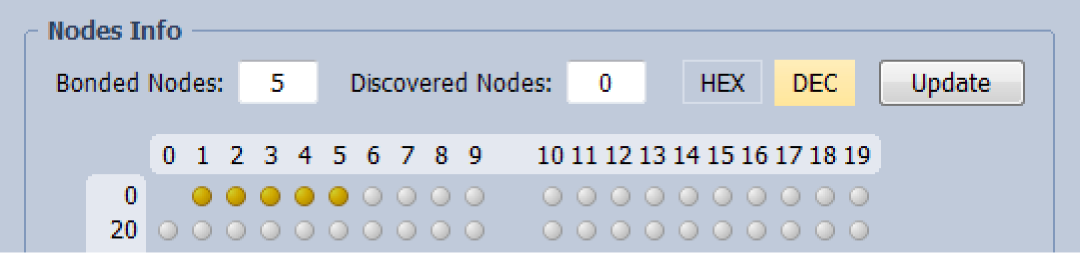
Mask: 07 | 00000111

Discovery: Tx power: 7, Max. Node address 0

Nodes Info: Bonded Nodes: 0, Discovered Nodes: 0, DEC

C. Activate the *Auto address* checkbox. Thus, addresses will be assigned automatically in ascending order starting from 1. Click the *Bond Node* button. The Coordinator stays cca 10 s in bond mode. During this period press the SW1 pushbutton (the one close to USB connector) on the DK-EVAL-04A kit containing the Node you are just going to bond. It is convenient to mark the assigned address on the DCTR module (e.g. by a label).

D. Repeat step C for all Nodes. It should result in 5 bonded Nodes according to the screenshot below.



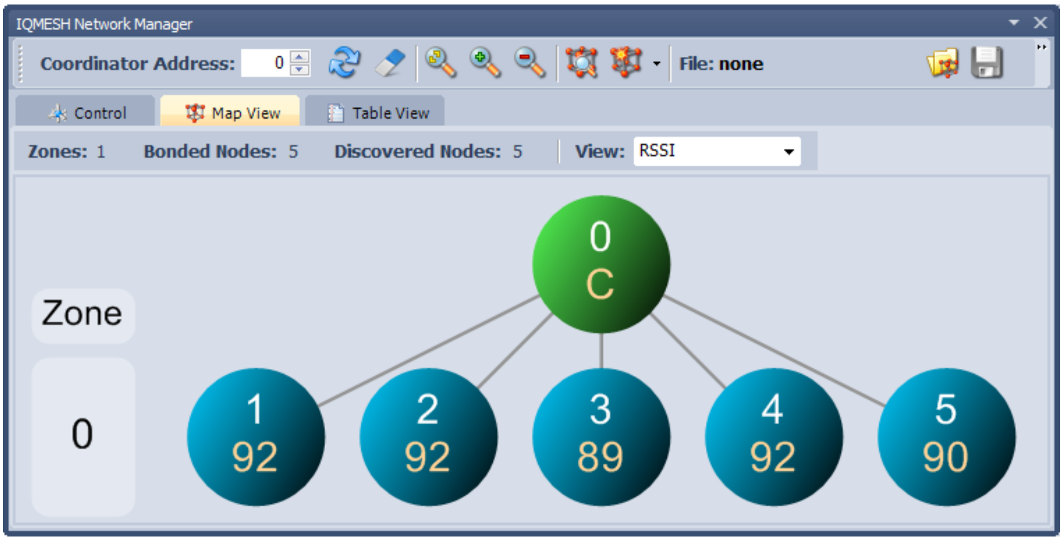
Nodes Info

Bonded Nodes: 5, Discovered Nodes: 0, DEC

4. Discovery

Discovery is a process that sets up network topology to be able to deliver data or commands to Nodes out of the Coordinator direct range. Thanks to HWP just a couple of clicks and all is done. Discovered topology can directly be reviewed in window *IQMESH Network Manager*, the *Map View* tab. Follow next steps to run Discovery and create different types of topologies.

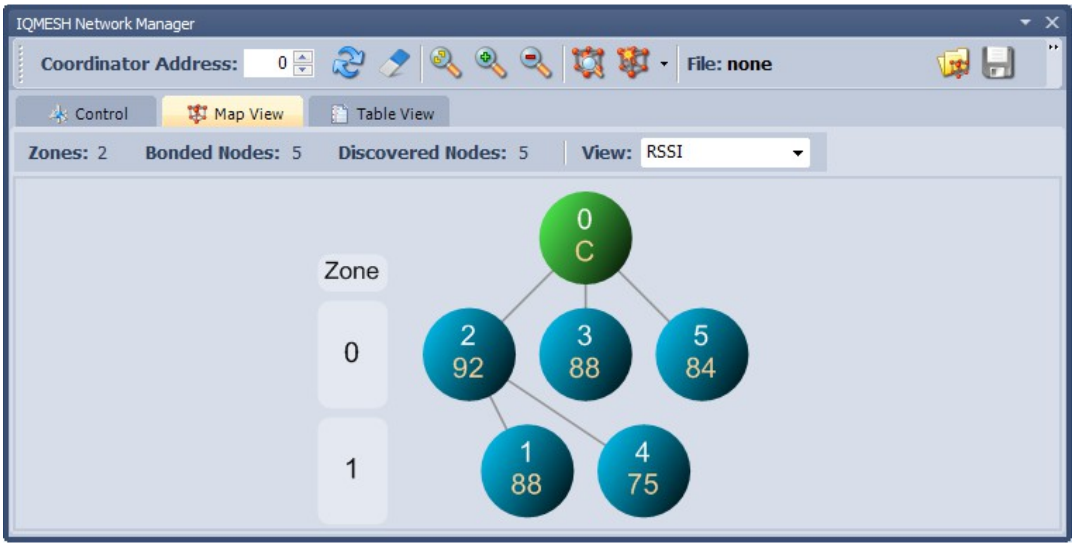
A. Place all Nodes close to the Coordinator and click the *Discovery* button (in window *IQMESH Network Manager*, the tab *Control* → *IQMESH*). If all Nodes are in direct range to the Coordinator the Discovery should take a few seconds only. Switch to the *Map View* tab after finishing Discovery. The topology like in the screenshot below should appear.



Zones: 1 Bonded Nodes: 5 Discovered Nodes: 5 View: RSSI

B. Place Nodes in longer distance between each other (with respect to current *RX Filter* selected in *TR Configuration*). For test purpose it is recommended to reduce the range using a shielding, e.g. by inserting the kits with DCTR modules into plastic bags with anti-static proofing.

D. Click the *Discovery* button. If not all Nodes are in direct range now, the Discovery process will take a bit longer. The result can look like on the screenshot below:



Zones: 2 Bonded Nodes: 5 Discovered Nodes: 5 View: RSSI

Note

Displayed “topology” is only a tree visualization of parent Nodes (illustrating just the path which has been used to discover individual Nodes) but not the routing structure. This does not mean that packets can be delivered through displayed links only. Packets are delivered based on Directed flooding routing algorithm described in IQRF OS User 's guide.

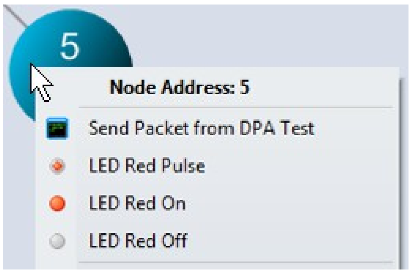
5. Examples

A quick test of the network functionality can be performed by the pop-up menu (example A below). For detailed testing of DPA commands the *Terminal – DPA Test* tool provides two ways how to set up a specific DPA command: using macros (example B) or manual arrangement of DPA packet (example C).

A. Pop-up menu

For the simpliest checking, a command to switch the red LED On/Off on selected Node can be immediately sent by clicking the left mouse button on the symbol of given Node in the map.

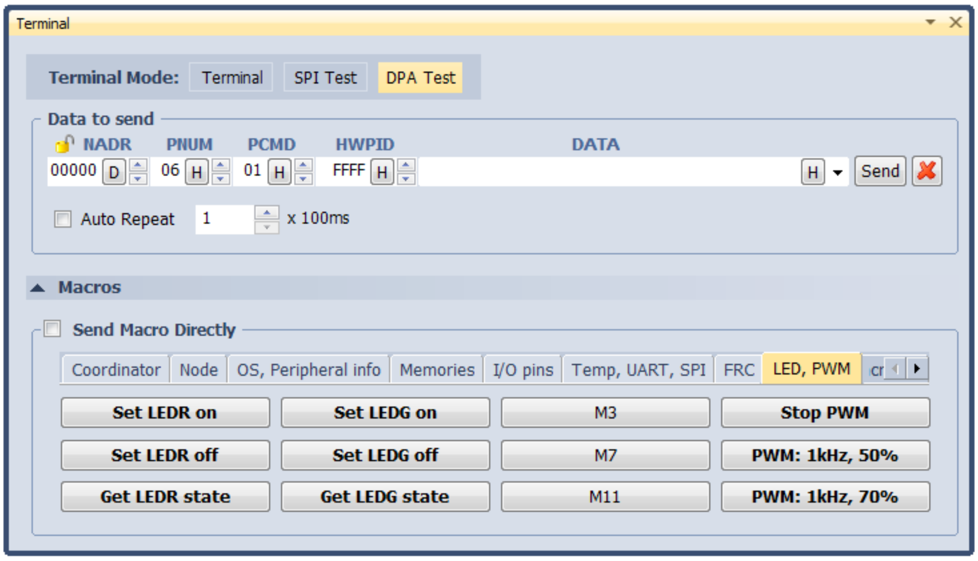
The command currently selected in the *DPA Test – Data to Send* window can be executed by the right mouse button click on the symbol of given Node in the map and by selecting the *Send Packet from DPA Test* item. `NADR` is set automatically according to selected Node.



B. Macros

Click on the particular macro and `PNUM`, `PCMD`, `HWPID` and `DATA` are automatically filled in. Then select *Node Address* in `NADR` box (for Broadcast use address `0xFF`) and click the *Send* button.

- Go to LED macros and click on macro *Set LEDR on*. To switch all LEDs on, fill in `0xFF` in `NADR` and Click *Send* button.
- Use various macros and Node addresses to test the functionality.


Terminal Mode: DPA Test

Data to send: NADR 00000 D, PNUM 06 H, PCMD 01 H, HWPID FFFF H

□ Auto Repeat 1 x 100ms

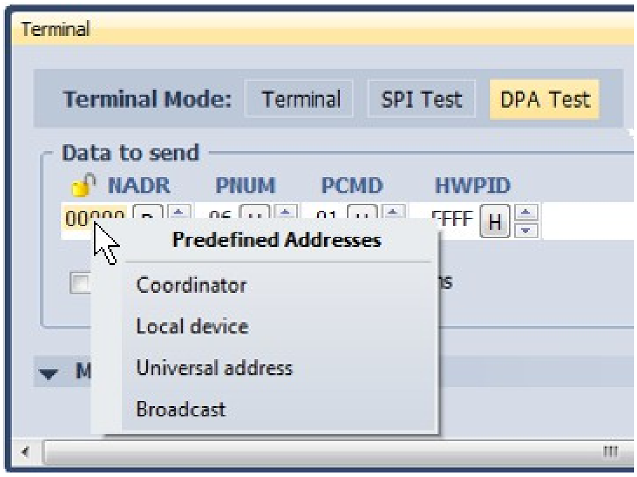
□ Send Macro Directly

C. DPA packet arranged manually

To get better understanding of DPA packet structure, you can also fill in the DPA packet manually. By clicking the right mouse button to the area for selecting *NADR*, *PNUM, PCMD* or *HWPID*, menu *Predefined Addresses, Predefined Peripherals, Predefined Commands* or *Predefined HWP* is displayed. These lists allow to select items defined by the DPA specification and directly arrange the packet.

- From menu *Predefined Addresses* select *Broadcast* or directly specify the address of given Node.
- From menu *Predefined Peripherals* select the LEDR peripheral.
- From menu *Predefined Commands* select the *Set on* command.
- From menu *Predefined HWP* select the *To All HWP* item.
- Click the *Send* button.

Test other peripherals and commands in the same way.



6. Unbonding

Unbonding a Node on the Coordinator side

- Select the desired address of the Node in the *Address* field (IQMESH Network Manager – the *Control → IQMESH* tab).
- If the network is not created yet or given Node is not reachable, activate the *Only in Coordinator* checkbox.
- Click the *Unbond Node* button.

Unbonding a Node on the Node side

- Press and hold button *SW1* (close to USB connector).
- Shortly press button *SW2*. Green LED shines for about 2 s.
- Release the *SW1* button immediately once the green LED stops shining.
- If the node is successfully unbonded, red LED is flashing and module falls asleep after 10 s.

Note

Besides of *IQMESH Network Manager* and *DPA Test*, IQRF IDE provides also further tools (*Terminal Log* and *Packet Inspector*) for working with DPA especially for developers implementing or testing the DPA protocol. They are described in IQRF IDE Help.

Recommended documentation

- IQRF Video tutorial set
- IQRF DPA Framework Technical guide. For DPA approach only.
- IQRF OS User's guide.
- IQRF OS Reference guide – description of IQRF OS functions. For non-DPA approach or for DPA with Custom DPA handler only.
- SPI User's guide – implementation in IQRF TR modules. It is needed only if you design one's own SPI master to communicate with the TR module.
- TR module datasheet
- User's guides of development kits used
- IQRF USB drivers Installation guide

Document history

- 150805 First release for IQRF Quick start guide merged with IQRF DPA Quick start guide.
  Updated for (DC)TR-7xD transceivers, IQRF OS v3.07D, DPA v2.20 and IDE v4.30 or higher.

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