IQRF OS

Operating System

Version 3.01D

for TR-52D and TR-54D

Reference Guide

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Quick reference

Values between system functions and superordinate program are passed on via parameters. OS uses 3 parameters in total: `param2` (1 B), `param3` (2 B) and `param4` (2 B). Their location in memory see the RAM map [2]. Individual functions have up to 3 parameters. Several functions use some of these params and W (PIC accumulator) to return output values. Note that they are valid until another function using the same parameter or the `debug` function is called by the user. Additionally, some functions use some params as work variables that is why their previous content can be destroyed.

Five stack levels are available to call all OS functions in subroutines.

Functions

Unless otherwise stated, all functions are the `void` type and all their parameters are the `uns8` type.

OS functions

Control

calibrateTimer

Function	Calibrate tick generator
Purpose	–
Syntax	`void` **`calibrateTimer()`**
Parameters	–
Return value	–
Output values	–
Preconditions	Do not use this function. It is not necessary to calibrate IQMESH timing from OS v3.01D.
Remarks	–
Side effects	–
See also	–
Example	–

iqrfSleep

Function	Setting the TR module in power saving mode (Sleep)
Purpose	Easy and efficient power management. This function, once called, puts the module into the Sleep mode. Wake-up can be caused by power off/on, watchdog timeout or on the C5 (for TR modules in SIM format, e.g. TR-52D) or Q12 (for TR-54D) pin change.
Syntax	`void` **`iqrfSleep()`**
Parameters	–
Return value	–
Output values	–
Preconditions	• This functions operates like the PIC machine instruction Sleep. Additionally, OS suspends all HW resources that are under its control (RF circuitry, timers, internal PIC pins, LEDs etc.). The user should do the same for resources used by the application before entering the Sleep mode to achieve minimal power consumption. • For wake-up on pin change the required sequence shoud be executed. Wake-up on pin change is default disabled. • This function is not time-efficient for subsequent short sleep periods, especially if RF IC is off. For faster operation in such cases use `sleep()` instead but you should ensure minimal consumption by user program. See Example 3.
Remarks	All features are under user's control. RBIF flag is not cleared to allow to distinguish wake-up type. See example E01-TX [10].
Side effects	Global interrupt enable (GIE) is controlled by OS again after wake-up.
See also	`setRFsleep`

Example 1	`// Minimize consumption (depends on resources used by the user)`
	`Motor = 0;  // Stop the motor`
	`ADON = 0;  // Disable A/D converter`
	`SWDTEN = 0;  // Disable watchdog`
	`iqrfSleep();  // Put the module into Sleep mode`

Example 2	`// Wake-up on pin change. See example E01-TX and IQRF-macros.h header file.`
	`GIE = 0;  // Disable all interrupts`
	`IOCBN.4 = 1;  // Negative edge active`
	`IOCBP.4 = 1;  // Positive edge active`
	`IOCIE = 1;  // Interrupt on change enabled`
	`SWDTEN = 0;  // Watchdog disabled`
	`iqrfSleep();  // Sleep`
	`IOCBF.4 = 0;  // Clear Interrupt on change flag`
	`if (buttonPressed)  // If button is pressed`
	`{ ... }  //  ...`

Example 3	`iqrfSleep();  // Sleep`
	`...`
	`...  // Wake-up, RF IC remains off`
	`...`
	`stopLEDR();  // Disable peripherals to minimize consumption`
	`sleep();  // Faster (if RF IC is off). This is not an IQRF function`
	`// but a machine instruction supported by C compiler.`
	`pulseLEDR();  // Continue after wake-up`

setRFsleep

Function	Setting RF circuitry in power saving mode (Sleep)
Purpose	To put all RF circuitry in Sleep mode. Easy and efficient power management.
Syntax	`void` **`setRFsleep()`**
Parameters	–
Return value	–
Output values	• RF IC is set off. • OS system clock (ticks) are derived from MCU internal RC oscillator instead of precise RF IC crystal.
Preconditions	–
Remarks	0.6 mA typ. is saved. RF sesponse is prolonged for 2 ms typ., 7 ms max. due to wake-up. Wake-up can be caused by `setRFready`, `RFTXpacket`, `RFRXpacket`, `checkRF` or `getSupplyVoltage`.
Side effects	–
See also	`setRFready, iqrfSleep, getSupplyVoltage, checkRF, RFTXpacket, RFRXpacket`
Example	`setRFsleep();  // Put the RF circuitry in Sleep mode`

setRFready

Function	Wake RF circuitry up
Purpose	To wake RF circuitry up in advance for faster response. Easy and efficient power management.
Syntax	`void` **`setRFready()`**
Parameters	–
Return value	–
Output values	• RF IC is set on. • IQMESH timing is based on precise RF IC crystal oscillator instead of MCU internal RC one.
Preconditions	–
Remarks	Takes ~7 ms
Side effects	–
See also	`setRFsleep, iqrfSleep, getSupplyVoltage, checkRF, RFTXpacket, RFRXpacket`

Example	`setRFready();  // Wake the RF circuitry up from RF sleep in advance`
	`...  // at least 2 ms before RF operation`
	`RFTXpacket();  // for immediate reaction`

debug

Function	Enter the debug mode
Purpose	IQRF OS directly supports debugging and testing. It is possible to stop the application wherever you need and display internal values (variables, RAM registers, EEPROM etc.) and then continue later on.
Syntax	`void debug()`
Parameters	–
Return value	–
Output values	OS directly returns no value but supports using W (PIC accumulator) to identify which of the debug points is currently active.

Preconditions	• Debug should be used with corresponding development kit (e.g. CK-USB-04) and the IQRF IDE development environment.
	• To avoid possible HW collision with respect to user application, `debug` operates only under the following conditions:
	  • Pins C5 to C8 are configured for SPI slave in respective TRIS bits (C8 out, the others in). It is arranged by OS by default.
	  • The *Check Mode* function is enabled in IQRF IDE. Otherwise no communication on these pins is initiated by debug tools even though TR is in debug mode until the *Check Mode* is enabled.
	  • SPI need not be enabled by `enableSPI`

Remarks	Number of `debug()` instances is unlimited. The application is running until a `debug` function is encountered. Then the program is stopped and the module is switched to the debug mode allowing IQRF IDE to display values. The module stays in the debug mode until the user selects the *Skip Debug* button. Then the application program continues running until another `debug` function is encouneterd and so on. See IQRF IDE Help and example E04-EEPROM [10].
Side effects	• `param1` to `param4` are not displayed • Watchdog is cleared while in Debug mode
See also	–

Example	`if (compareBufferINFO2RF(4))`
	`  W = 1;  // match`
	`else`
	`  W = 2;  // mismatch`
	`debug();  // Skip Debug 1 or 2 will be displayed here according the result`

getSupplyVoltage

Function	Power supply measurement (up to 3.8 V)
Purpose	Battery check (for discharge-sensitive batteries)
Syntax	`uns8 getSupplyVoltage()`
Parameters	–
Return value	level = 1, 2, …15 `Voltage > 2.25 V + level × 0.1 V`
Output values	–
Preconditions	–
Remarks	• Internal power supply voltage is checked. • In case of TR modules with LDO it is the LDO output but not actual battery voltage. This value is 3.0 V typ. if battery is O.K. and drops down if battery is low. • To evaluate the battery, take into consideration your battery type and power supply circuitry with respect to diodes and other possible voltage drops. • The detector circuit has a built-in 50 mV hysteresis.
Side effects	The RF circuitry wakes up (in case of sleeping).
See also	`setRFsleep`

Example	`if (getSupplyVoltage()<7)`
	`  …  // Low battery`
	`else`
	`  …  // Voltage > 2.95V`

getTemperature

Function	Read temperature from on-board sensor
Purpose	Temperature measurement
Syntax	`uns8` **`getTemperature()`**
Parameters	–
Return value	• Temperature in °C, integer part, not rounded • Negative temperatures are in two's complement format (e.g. `0xFB` means -5 °C)
Output values	`param3`: complete 12 b output value of the sensor in 0.0625 °C units. Thus, lower 4 b represent the fractional part and upper 8 b represent the integer part of temperature. Negative temperatures are in two's complement format. See datasheet of the sensor. Examples:

Temperature	Return value	param3
50 °C	0x32	0x320
5 °C	0x05	0x050
5.5 °C	0x05	0x058
0.75 °C	0x00	0x00C

Temperature	Return value	param3
0 °C	0x00	0x000
-0.5 °C	0xFF	0xFF8
-1 °C	0xFF	0xFF0
-8 .25 °C	0xF7	0xF7C

Preconditions	• For TR modules with the "T" postfix only, e.g. TR-52DTx • 100 ms delay is required after wake up from sleep
Remarks	• TMP112 (TI) temperature sensor is used • Resolution 0.0625 °C, accuracy: 0.5 °C • See example E08–TEMPERATURE [10]
Side effects	–
See also	–

Example1

```
   // For positive temperatures only
uns8   tempInt;                    // Temperature, integer part
uns8   tempFract;                  // Temperature, fractional part
tempInt = getTemperature();
tempFract = param3.low8 & 0x0F     // Temperature == tempInt + tempFract/16
                                   // Temperature == param3 * 0.0625 in °C
```

Example2

```
   // Either positive or negative temperatures, fractional part ignored
T = g.7) {
    sign = "-";etTemperature();          // Integer part of temperature
if (T             // Negative
    T = (T ^ 0xFF) + 1;       // Get absolute value in °C
  }
else
   sign = "+";                // Positive
```

Example3

```
   // Either positive or negative temperatures, with fractional part
if (getTemperature() >= 0x80) {
    sign = "-";                // Negative
    T = (param3 ^ 0xFFF) + 1; // Get absolute value, in 0.0625°C units
  }
else
   sign = "+";                // Positive
```

Example4

```
   // Temperature measurement after wake-up from sleep
iqrfSleep();
waitDelay(10);                     // 100 ms delay required
T = getTemperature();
```

Active waiting

waitMS

Function	Wait specified number of miliseconds
Purpose	Time delay generation
Syntax	`void` **`waitMS(ms)`**
Parameters	`ms` - time to wait in miliseconds (1 - 255)
Return value	–
Output values	–
Preconditions	This function can be combined with `waitDelay, startCapture` and `captureTicks`.
Remarks	This is an active waiting (on OS foreground). No other operation runs on OS foreground during waiting. Time precission depends on internal RC oscillator. Thus, the delay can vary with temperature etc. See respective PIC datasheet [8].
Side effects	–
See also	`waitDelay`, `startDelay, startLongDelay`

Example	`waitMS(10);  // Delay 10 ms. Program stays here for the whole 10 ms period`
	`  ...  // and continues here just after the period elapsed.`

waitDelay

Function	Wait specified number of ticks
Purpose	Time delay generation
Syntax	`void` **`waitDelay(ticks)`**
Parameters	`ticks` – time to wait in 10 ms periods (1 - 255)
Return value	–
Output values	–
Preconditions	This function can be combined with `waitMS`.
Remarks	This is the active waiting (on OS foreground). No other operation runs on OS foreground during waiting.
Side effects	• This function must not be combined with `startDelay and startLongDelay`. • Internal ticks are based on internal RC oscillator. Thus, the delay can vary with temperature etc. See respective PIC datasheet [8]. • Delay in first tick can vary from 0 ms to 10 ms. If complete 10 ms is needed also in the first tick, use `waitNewTick` firstly. • For short time delays waitMS is more precise.
See also	`waitMS`, `startDelay, startLongDelay`

Example 1	`  // LED on for 0.5 s`
	`_LED = 1;`
	`waitDelay(50);  // Delay 500 ms. Program stays here for 500 ms`
	`_LED = 0;  // and continues here just after the period elapsed.`

waitNewTick

Function	Wait for a new tick
Purpose	Timing synchronization of user operations
Syntax	`void` **`waitNewTick()`**
Parameters	–
Return value	–
Output values	–
Preconditions	–
Remarks	Active waiting (on OS foreground) until a new tick starts. No other operation runs on OS foreground during this waiting.
Side effects	–
See also	`waitMS`, `waitDelay`

Example	`waitNewTick();  // To generate a pulse as precise as possible`
	`IO1 = 1;`
	`waitDelay(1);  // 10 ms`
	`IO1 = 0;`

Timing on background

startCapture

Function	Reset and start the Capture timer
Purpose	Initialization of time measurement or delay generation
Syntax	`void` **`startCapture()`**
Parameters	–
Return value	–
Output values	–
Preconditions	This function can be combined with `waitMS`.
Remarks	Capture timer is a resettable counter of OS ticks (10 ms system intervals) running on OS background. This function clears the counter and starts counting.
Side effects	Functionality is affected by `bondRequest`, `bondNewNode` and `RFRXpacket`.
See also	`captureTicks`
Example	See `captureTicks`

captureTicks

Function	Get number of ticks counted from the last `startCapture` and `captureTicks` calling.
Purpose	Measurement of elapsed time.
Syntax	`void` **`captureTicks()`**
Parameters	–
Return value	–
Output value	• `param3`: ticks counted from the last `startCapture` (0 - 65535) • `param4`: ticks counted from the last `captureTicks` (0 - 65535)
Preconditions	• `startCapture` should be used at least once before. • To ensure correct operation the counter must not overflow. That is why `captureTicks` should be called max. ~655 s after last `startCapture` or `captureTicks` calling.
Remarks	See example E05–DELAYS [10]
Side effects	Functionality is affected by `bondRequest`, `bondNewNode` and `RFRXpacket`. Internal ticks are based on internal RC oscillator. Thus, the delay can vary with temperature etc. See respective PIC datasheet [8].
See also	`startCapture`

Example	`startCapture();  // Reset counter of ticks`
	`waitMS(200);  // Delay 200 ms`
	`captureTicks();  // param3 == 20`
	`waitMS(150);  // Delay 150 ms`
	`captureTicks();  // param3 == 35, param4 == 15`
	`startCapture();  // Reset counter of ticks`
	`waitMS(100);  // Delay 100 ms`
	`captureTicks();  // param3 == 10`

startDelay

Function	Preset and start the Delay timer
Purpose	Initialization of time measurement or delay generation
Syntax	`void` **`startDelay(ticks)`**
Parameters	`uns8 ticks`: number of ticks (10 ms system intervals) to be measured (1-255)
Return value	–
Output values	–
Preconditions	This function can be combined with `waitMS` and `startLongDelay`.
Remarks	The Delay timer measures specified time period on OS background. The result is available via the `isDelay` function.
Side effects	This function does not work properly if the `waitDelay, startLongDelay` functions are active. • Delay in first tick can vary from 0 ms to 10 ms. If complete 10 ms is needed also in the first tick, use `waitNewTick` firstly.
See also	`isDelay, startLongDelay, waitDelay`
Example	See `isDelay`

startLongDelay

Function	Preset and start the LongDelay timer
Purpose	Initialization of time measurement or delay generation
Syntax	`void` **`startLongDelay(ticks)`**
Parameters	`uns16 ticks`: number of ticks (10 ms system intervals) to be measured (1-65535)
Return value	–
Output values	–
Preconditions	This function can be combined with `waitMS` and `startDelay`.
Remarks	The Delay timer measures specified time period on OS background. The result is available via the `isDelay` function.
Side effects	This function does not work properly if the `waitDelay, startDelay` functions are active. • Delay in first tick can vary from 0 ms to 10 ms. If complete 10 ms is needed also in the first tick, use `waitNewTick` firstly.
See also	`isDelay, startDelay, waitDelay`
Example	See `isDelay`

isDelay

Function	Information whether specified delay is still in progress
Purpose	Time measurement or delay generation
Syntax	`bit` **`isDelay()`**
Parameters	–
Return value	• `1: still in progress` • `0: elapsed`
Output values	–
Preconditions	`startDelay` or `startLongDelay` should be used before.
Remarks	• The (Long)Delay timer measures specified time period. The result is available via the `isDelay` function. • Tip: the `clrwdt instruction` should be used to avoid unintentional watchdog reset during the delay. • See example `E05-DELAYS` [10].
Side effects	–
See also	`startDelay, startLongDelay`

Example1	`// LED on for 1 s`
	`_LED = 1;`
	`startDelay(100);  // Start 1 sec delay counting on OS background`
	`while (isDelay())  // Wait until the delay is over`
	`{`
	`  clrwdt();  // Any useful operation on OS foreground can be`
	`  ...  // performed during waiting`
	`}`
	`_LED = 0;  // Continue here after 1 sec`

Example2	`// LED on for 10 s`
	`_LED = 1;`
	`startLongDelay(1000);  // Start 10 sec delay counting on OS background`
	`while (isDelay())  // Wait until the delay is over`
	`{`
	`  clrwdt();  // Any useful operation on OS foreground can be`
	`  ...  // performed during waiting`
	`}`
	`_LED = 0;  // Continue here after 10 sec`

LED indication

setOnPulsingLED

Function	LEDs On time setting (red as well as green)
Purpose	Specification of the "On" time for LEDs (either for a single flash or for blinking)
Syntax	`void` **`setOnPulsingLED(ticks)`**
Parameters	`uns8 ticks`: number of ticks (10 ms system intervals) (1-255)
Return value	–
Output values	–
Preconditions	–
Remarks	Default value is 5 (50 ms).
Side effects	–
See also	`setOffPulsingLED, pulsingLEDR, pulseLEDR, pulsingLEDG, pulseLEDG`
Example	`See setOffPulsingLED`

setOffPulsingLED

Function	LEDs Off time setting (red as well as green)
Purpose	Specification of the "Off" time for LEDs (for blinking)
Syntax	`void` **`setOffPulsingLED(ticks)`**
Parameters	`uns8 ticks`: number of ticks (10 ms system intervals) (1-255)
Return value	–
Output values	–
Preconditions	–
Remarks	Default value is 20 (200 ms).
Side effects	–
See also	`setOnPulsingLED, pulsingLEDR, pulsingLEDG`

Example	`// Change blinking to 250 ms On / 750 ms Off`
	`setOnPulsingLED(25);  // 250 ms On`
	`setOffPulsingLED(75);  // 750 ms Off`

pulsingLEDR

Function	Red LED blinking
Purpose	Continuous red LED blinking on OS background
Syntax	`void` **`pulsingLEDR()`**
Parameters	–
Return value	–
Output values	–
Preconditions	Blinking times should be defined in advance by `setOnPulsingLED` and `setOffPulsingLED`. The appropriate PIC pin is configured as an output automatically.
Remarks	Blinking continues until it is stopped by the user (e.g. by `stopLEDR`).

Side effects	• The appropriate PIC pin is not restored to the state before `pulsingLEDR` (TRISx.x == 0, _LEDR == 0 after finishing in background).
	• Possible user LEDR pin changes in foreground result in the following:
	  • Changed pin level (in PORT or LATCH register) is overriden in background and pulsing continues.
	  • Changed pin direction (in TRIS register) is not overriden in background and pulsing is stopped.

See also	`setOnPulsingLED, setOffPulsingLED, stopLEDR, pulseLEDR`
Example1	`pulsingLEDR();  // continuous blinking on OS background`

Example1	`  // Blinking for 2 s`
	`pulsingLEDR();  // blinking for 2 s on OS background`
	`waitDelay(200);  // 2 s delay generated on foreground`
	`stopLEDR();  // Stop blinking`

pulseLEDR

Function	Single red LED flash
Purpose	Red LED flash on OS background
Syntax	`void` **`pulseLEDR()`**
Parameters	–
Return value	–
Output values	–
Preconditions	Flash time should be defined in advance by `setOnPulsingLED`. The appropriate PIC pin is configured as an output automatically.
Remarks	The on-board LEDs can also be directly controlled on OS foreground using C commands for manipulating the _LEDR output (the pin the red LED is connected to) and corresponding control bit (TRISx.x - see `IQRF-memory.h` header file).

Side effects	• The appropriate PIC pin is not restored to the state before `pulseLEDR` (TRISx.x == 0, _LEDR == 0 after finishing on background).
	• Possible user LEDR pin changes in foreground result in the following:
	  • Changed pin level (in PORT or LATCH register) is overriden in background and the pulse continues.
	  • Changed pin direction (in TRIS register) is not overriden in background and the pulse is stopped.

See also	`setOnPulsingLEDR, pulsingLEDR, stopLEDR`

Example	`setOnPulsingLEDR(10);  // 100 ms On`
	`pulseLEDR();  // Single red LED flash for 100 ms on OS background`
	`  ...  // Program continues immediately,`
	`  // not waiting until the delay expires.`
	`  // LED will be switched off after 100 ms automatically`

stopLEDR

Function	Red LED off, blinking stopped
Purpose	Stops the red LED activity on OS background
Syntax	`void` **`stopLEDR()`**
Parameters	–
Return value	–
Output values	–
Preconditions	–
Remarks	–
Side effects	• The appropriate PIC pin is not restored to the state before pulsingLEDR/pulseLEDR (TRISx.x == 0, _LEDR == 0 after finishing on background). • Possible user LEDR pin level (in PORT or LATCH register) changed in foreground can be overriden in background.
See also	`pulsingLEDR, pulseLEDR`

Example1	`pulsingLEDR();  // Start blinking on OS background`
	`  ...  // Blinking continues during any operation`
	`stopLEDR();  // Stop blinking`

Example2	`pulseLEDR();  // Red LED On on OS background`
	`  ...  // continuously lighting during any operation`
	`  // until specified time expired`
	`stopLEDR();  // or LED is switched Off by this command`

Example3	`_LEDR = 1;  // LEDR on`
	`  ...`
	`stopLEDR();  // LEDR off`

pulsingLEDG

Function	Green LED blinking
Purpose	Continuous green LED blinking on OS background
Syntax	`void` **`pulsingLEDG()`**
Parameters	–
Return value	–
Output values	–
Preconditions	Blinking times should be defined in advance by `setOnPulsingLED` and `setOffPulsingLED`. The appropriate PIC pin is configured as an output automatically.
Remarks	Blinking continues until it is stopped by the user (e.g. by `stopLEDG`).

Side effects	• The appropriate PIC pin is not restored to the state before `pulsingLEDG` (TRISx.x == 0, _LEDG == 0 after finishing in background).
	• Possible user LEDG pin changes in foreground result in the following:
	  • Changed pin level (in PORT or LATCH register) is overriden in background and pulsing continues.
	  • Changed pin direction (in TRIS register) is not overriden in background and pulsing is stopped.

See also	`setOnPulsingLED, setOffPulsingLED, stopLEDG, pulseLEDG`
Example1	`pulsingLEDG();  // continuous blinking on OS background`

Example1	`  // Blinking for 2 s`
	`pulsingLEDG();  // blinking for 2 s on OS background`
	`waitDelay(200);  // 2 s delay generated on foreground`
	`stopLEDG();  // Stop blinking`

pulseLEDG

Function	Single green LED flash
Purpose	Green LED flash on OS background
Syntax	`void` **`pulseLEDG()`**
Parameters	–
Return value	–
Output values	–
Preconditions	Flash time should be defined in advance by `setOnPulsingLED`. The appropriate PIC pin is configured as an output automatically.
Remarks	The on-board LEDs can also be directly controlled on OS foreground using C commands for manipulating the _LEDG output (the pin the green LED is connected to) and corresponding control bit (TRISx.x - see `IQRF-memory.h` header file).

Side effects	• The appropriate PIC pin is not restored to the state before `pulseLEDG` (TRISx.x == 0, _LEDG == 0 after finishing in background).
	• Possible user LEDG pin changes in foreground result in the following:
	  • Changed pin level (in PORT or LATCH register) is overriden in background and the pulse continues.
	  • Changed pin direction (in TRIS register) is not overriden in background and the pulse is stopped.

See also	`setOnPulsingLEDG, pulsingLEDG, stopLEDG`

Example	`setOnPulsingLEDG(10);  // 100 ms On`
	`pulseLEDG();  // Single green LED flash for 100 ms on OS background`
	`  ...  // Program continues immediately,`
	`  // not waiting until the delay expires.`
	`  // LED will be switched off after 100 ms automatically`

stopLEDG

Function	Green LED off, blinking stopped
Purpose	Stops the green LED activity on OS background
Syntax	`void` **`stopLEDG()`**
Parameters	–
Return value	–
Output values	–
Preconditions	–
Remarks	–
Side effects	• The appropriate PIC pin is not restored to the state before `pulsingLEDG`/`pulseLEDG` (TRISx.x == 0, _LEDG == 0 after finishing on background). • Possible user LEDR pin level (in PORT or LATCH register) changed in foreground can be overriden in background.
See also	`pulsingLEDG, pulseLEDG`

Example1	`pulsingLEDG();  // Start blinking on OS background`
	`  ...  // Blinking continues during any operation`
	`stopLEDG();  // Stop blinking`

Example2	`pulseLEDG();  // Green LED On on OS background`
	`  ...  // continuously lighting during any operation`
	`  // until specified time expired`
	`stopLEDG();  // or LED is switched Off by this command`

MCU EEPROM

eeReadByte

Function	Read one byte from specified location in EEPROM
Purpose	Access to EEPROM
Syntax	`uns8` **`eeReadByte(addr)`**
Parameters	`uns8 addr`: address in EEPROM (0 to 0xBF). See EEPROM map [2].
Return value	• Value (0 to 255) read from specified EEPROM location • 0 when attempted to read from address 0xC0 or higher
Output values	–
Preconditions	–
Remarks	• Direct user `access` to EEPROM (using registers `EECONx` etc.) is not allowed for security reasons, specialized OS functions are intended for this. • EEPROM area dedicated to OS (locations 0xC0 or higher) is not accessible. See example E04–EEPROM [10].
Side effects	–
See also	`eeReadData, eeWriteByte, eeWriteData`
Example1	`i = eeReadByte(0);  // store 1 byte from EEPROM from address 0 to i`
Example2	`// Illegal access: Avoid access to EEPROM locations 192 (0xC0) or higher` `i = eeReadByte(200);  // Reading from protected area is redirected to 160 (0xA0)`

eeReadData

Function	Read a block of specified length from specified location in EEPROM to `bufferINFO`
Purpose	Block access to EEPROM
Syntax	`void` **`eeReadData(addr, length)`**
Parameters	• `uns8 addr`: address in EEPROM (`0` to `0xBF - length + 1`). See EEPROM map [2]. • `uns8 length`: number of bytes to be read (1 to 32)
Return value	–
Output values	• `bufferINFO[0` to `length - 1]` • `bufferINFO[0 to length - 1]` is cleared when attempted to read from address 0xC0 or higher
Preconditions	–
Remarks	• Direct user `access` to EEPROM (using registers `EECONx` etc.) is not allowed for security reasons, specialized OS functions are intended for this. • EEPROM area dedicated to OS (locations 0xC0 or higher) is not accessible. See example E04–EEPROM [10].
Side effects	–
See also	`eeReadByte, eeWriteByte, eeWriteData`

Example1	`eeReadData(10, 16);  // copy 16B from EEPROM from address 10 to bufferINFO`
	`//  bufferINFO[0] = EEPROM[10]`
	`//  ...`
	`//  bufferINFO[15] = EEPROM[25]`

Example2	`// Illegal access: Avoid access to EEPROM locations 192 (0xC0) or higher`
	`eeReadData(200, 16);  // EEPROM address 160 is used instead of protected area`
	`//  bufferINFO[0] = EEPROM[160]`
	`//  ...`
	`//  bufferINFO[15] = EEPROM[160]`

eeWriteByte

Function	Write one byte to specified location in EEPROM
Purpose	Access to EEPROM
Syntax	`void` **`eeWriteByte(addr, data)`**
Parameters	• `uns8 addr`: address in EEPROM (0xA0 to 0xBF for Coordinator and 0 to 0xBF for other devices). See EEPROM map [2]. • `uns8 data`: value to be written (0 to 255)
Return value	–
Output values	–
Preconditions	–
Remarks	• Direct user access to EEPROM (using registers `EECONx` etc.) is not allowed for security reasons, specialized OS functions are intended for this. • EEPROM area dedicated to OS (locations 0xC0 or higher) is not accessible. See example E04–EEPROM [10]. • Any attempt to write to protected area above 0xBF leads to no operation.
Side effects	–
See also	`eeReadByte, eeReadData, eeWriteData`
Example1	`eeWriteByte(191, 0x75)  // store 0x75 to EEPROM to address 191` `eeWriteByte(0x80, X)    // copy X to EEPROM to address 0x80`
Example2	`  // Illegal access: Avoid access to EEPROM locations 192 (0xC0) or higher` `eeWriteByte(198, 0x75);  // Attempt to write to protected area – nothing is written.`

eeWriteData

Function	Write a block of specified length from `bufferINFO` to specified location in EEPROM
Purpose	Block access to EEPROM
Syntax	`void` **`eeWriteData(addr, length)`**

Parameters	• `uns8 addr`: address in EEPROM . See EEPROM map [2].
	  • (`0xA0` to `0xBF – length + 1`) for Coordinator
	  • (`0` to `0xBF – length + 1`) for other devices
	• `uns8 length`: number of bytes to be written from `bufferINFO` (1 to 32)

Return value	–
Output values	–
Preconditions	–
Remarks	• Direct user access to EEPROM (using registers `EECONx` etc.) is not allowed for security reasons, specialized OS functions are intended for this. • EEPROM area dedicated to OS (locations 0xC0 or higher) is not accessible. See example E04–EEPROM [10].
Side effects	• Any attempt to write to protected area above 0xBF leads to no operation.
See also	`eeReadByte, eeReadData, eeWriteByte`

Example1	`eeWriteData(10,16);  // copy 16B from bufferINFO to EEPROM to address 10`
	`//  EEPROM[10] = bufferINFO[0]`
	`//  ...`
	`//  EEPROM[25] = bufferINFO[15]`

Example2	`  // Illegal access: Avoid access to EEPROM locations 192 (0xC0) or higher`
	`eeWriteData(200,16);  // Attempt to write to protected area – nothing is`
	`// written.`

Serial EEPROM

eeeReadData

Function	Read a 16 B data block from specified location in serial EEPROM to `bufferINFO`
Purpose	Block access to serial EEPROM
Syntax	`void` **`eeeReadData(addr)`**
Parameters	• `uns16 addr`: address in serial EEPROM (`0` to `0x7FF`).
Return value	–
Output values	`bufferINFO[0` to 15`]`
Preconditions	Do not use for Coordinator in networks utilizing Discovery
Remarks	–
Side effects	–
See also	`eeeWriteData`

Example	`eeeReadData(10); // copy 16B from serial EEPROM from address 10 to bufferINFO`
	`// bufferINFO[0] = serial EEPROM[10]`
	`//  ...`
	`// bufferINFO[15] = serial EEPROM[25]`

eeeWriteData

Function	Write a 16 B data block from `bufferINFO` to specified location in EEPROM
Purpose	Block access to serial EEPROM
Syntax	`void` **`eeeWriteData(addr)`**
Parameters	• `uns16 addr`: address in serial EEPROM (`0` to `0x7FF`).
Return value	–
Output values	–
Preconditions	Do not use for Coordinator in networks utilizing Discovery
Remarks	–
Side effects	–
See also	`eeeReadData`

Example	`eeeWriteData(5); // copy 16B from bufferINFO to serial EEPROM from address 5`
	`//  EEPROM[5] = bufferINFO[0]`
	`//  ...`
	`//  EEPROM[20] = bufferINFO[15]`

RAM

readFromRAM

Function	Read one byte from specified location in RAM
Purpose	Indirect access to RAM registers
Syntax	`uns8` **`readFromRAM(addr)`**
Parameters	`uns16 addr`: linear or traditional memory location address
Return value	Value read from specified location
Output values	–
Preconditions	–
Remarks	RAM can be accessed either directly (using common C commands like `X = Y;`) or indirectly. But indirect access using the `INDFx` registers is not allowed. Due to security reasons all instructions using `INDFx` are removed during Upload. To avoid unintended behavior all constructions using addressing via `INDFx` (either by the user or by the compiler) should be omitted. Instead of these IQRF OS provides complete support for indirect RAM addressing using extra system functions `readFromRAM`, `writeToRAM` and `copyMemoryBlock`. See example E06–RAM [10].
Side effects	–
See also	`writeToRAM, copyMemoryBlock`

Example1	`// Not allowed. The compiler uses INDFx in such cases.`
	`for (i=0; i<5; i++)`
	`{`
	`  A = bufferRF[i];`
	`  …`
	`}`

Example2	`// Correct`
	`for (i=0; i<5; i++)`
	`{`
	`  A = readFromRAM(bufferRF + i);`
	`  …`
	`}`

writeToRAM

Function	Write one byte to specified location in RAM
Purpose	Indirect access to RAM registers
Syntax	`void` **`writeToRAM(addr, value)`**
Parameters	• uns16 addr: traditional or linear memory location address • `uns8 value`: value to be written
Return value	–
Output values	–
Preconditions	• Avoid writing to RAM areas dedicated to OS and to PIC special function registers otherwise OS can collapse. See RAM map [2].
Remarks	RAM can be accessed either directly (using common C commands like `X = Y;`) or indirectly. But indirect access using the `INDFx` registers is not allowed. Due to security reasons all instructions using `INDFx` are removed during Upload. To avoid unintended behavior all constructions using addressing via `INDFx` (either by the user or by the compiler) should be omitted. Instead of this IQRF OS provides complete support for indirect RAM addressing using extra system functions `readFromRAM`, `writeToRAM` and `copyMemoryBlock`. See example E06–RAM [10].
Side effects	–
See also	`readFromRAM`, `copyMemoryBlock`

Example1	`// Not allowed. The compiler uses INDFx in such cases.`
	`for (i=0; i<5; i++)`
	`  bufferRF[i] = i;`

Example2	`// Correct`
	`for (i=0; i<5; i++)`
	`  writeToRAM(bufferRF + i, i);`

Buffers

All functions for copying buffers (copyBufferINFO2RF, copyBufferINFO2COM, copyBufferRF2COM, copyBufferRF2INFO, copyBufferCOM2RF, copyBufferCOM2INFO) can use **offsets** memoryOffsetFrom and memoryOffsetTo. Offsets are applied when at least one of them is different from zero only. Then the following principle will take place: memoryOffsetFrom specifies relative offset in the From buffer and memoryOffsetTo specifies relative offset in the To buffer. It means that data is not read starting from bufferXX[0] but from bufferXX[memoryOffsetFrom] and is not stored starting from bufferYY[0] but from bufferYY[memoryOffsetTo]. Just the final part of the bufferXX is copied (from memoryOffsetFrom up to the end of the bufferXX or bufferYY, whichever is reached first).

If both memoryOffsetFrom = 0 and memoryOffsetTo = 0 complete buffers are copied . Offsets are default disabled (cleared after reset as well as after every buffer copy).

copyBufferINFO2COM

Function	Copy bufferINFO to bufferCOM
Purpose	Data transfer between buffers
Syntax	void **copyBufferINFO2COM()**
Parameters	–
Return value	–
Output values	–
Preconditions	Offsets memoryOffsetFrom and memoryOffsetTo are applied (see above).
Remarks	• If memoryOffsetFrom = 0 and memoryOffsetTo = 0 complete 64 B is copied. • See example E06 - RAM [10].
Side effects	–
See also	clearBufferINFO, copyBufferINFO2RF, copyBufferRF2COM, copyBufferRF2INFO, copyBufferCOM2RF, copyBufferCOM2INFO, compareBufferINFO2RF, copyMemoryBlock
Example1	`copyBufferINFO2COM();`

Example2	`memoryOffsetFrom = 0;  // bufferINFO to be copied`
	`memoryOffsetTo = 10;  // to  bufferCOM starting from bufferCOM[10].`
	`copyBufferINFO2COM;  // Just first 54 B is copied (until bufferCOM full).`

copyBufferINFO2RF

Function	Copy bufferINFO to bufferRF
Purpose	Data transfer between buffers
Syntax	void **copyBufferINFO2RF()**
Parameters	–
Return value	–
Output values	–
Preconditions	Offsets memoryOffsetFrom and memoryOffsetTo are applied (see above).
Remarks	• If memoryOffsetFrom = 0 and memoryOffsetTo = 0 complete 64 B is copied. • See example E06 - RAM [10].
Side effects	–
See also	clearBufferINFO, copyBufferINFO2COM, copyBufferRF2COM, copyBufferRF2INFO, copyBufferCOM2RF, copyBufferCOM2INFO, compareBufferINFO2RF, copyMemoryBlock
Example	`copyBufferINFO2RF();`

copyBufferRF2COM

Function	Copy `bufferRF` to `bufferCOM`
Purpose	Data transfer between buffers
Syntax	`void` **`copyBufferRF2COM()`**
Parameters	–
Return value	–
Output values	–
Preconditions	Offsets `memoryOffsetFrom` and `memoryOffsetTo` are applied (see above).
Remarks	• If memoryOffsetFrom = 0 and memoryOffsetTo = 0 complete 64 B is copied. • See example E06 - RAM [10].
Side effects	–
See also	`clearBufferINFO, copyBufferINFO2RF, copyBufferINFO2COM, copyBufferRF2INFO, copyBufferCOM2RF, copyBufferCOM2INFO, compareBufferINFO2RF, copyMemoryBlock`
Example	`copyBufferRF2COM();`

copyBufferRF2INFO

Function	Copy `bufferRF` to `bufferINFO`
Purpose	Data transfer between buffers
Syntax	`void` **`copyBufferRF2INFO()`**
Parameters	–
Return value	–
Output values	–
Preconditions	Offsets `memoryOffsetFrom` and `memoryOffsetTo` are applied (see above).
Remarks	• Copying is limited up to first 64 B of `bufferRF` only. • If memoryOffsetFrom = 0 and memoryOffsetTo = 0 complete 64 B is copied. • See example E06 - RAM [10].
Side effects	–
See also	`clearBufferINFO, copyBufferINFO2COM, copyBufferINFO2RF, copyBufferRF2COM, copyBufferCOM2RF, copyBufferCOM2INFO, compareBufferINFO2RF, copyMemoryBlock`
Example	`copyBufferRF2INFO();`

copyBufferCOM2RF

Function	Copy `bufferCOM` to `bufferRF`
Purpose	Data transfer between buffers
Syntax	`void` **`copyBufferCOM2RF()`**
Parameters	–
Return value	–
Output values	–
Preconditions	Offsets `memoryOffsetFrom` and `memoryOffsetTo` are applied (see above).
Remarks	• If memoryOffsetFrom = 0 and memoryOffsetTo = 0 complete 64 B is copied. • See example E06 - RAM [10].
Side effects	–
See also	`clearBufferINFO, copyBufferINFO2COM, copyBufferINFO2RF, copyBufferRF2COM, copyBufferRF2INFO, copyBufferCOM2INFO, compareBufferINFO2RF, copyMemoryBlock`
Example	`copyBufferCOM2RF();`

copyBufferCOM2INFO

Function	Copy `bufferCOM` to `bufferINFO`
Purpose	Data transfer between buffers
Syntax	`void` **`copyBufferCOM2INFO()`**
Parameters	–
Return value	–
Output values	–
Preconditions	Offsets `memoryOffsetFrom` and `memoryOffsetTo` are applied (see above).
Remarks	• If memoryOffsetFrom = 0 and memoryOffsetTo = 0 complete 64 B is copied. • See example E06 - RAM [10].
Side effects	–
See also	`clearBufferINFO, copyBufferINFO2COM, copyBufferINFO2RF, copyBufferRF2COM, copyBufferRF2INFO, copyBufferCOM2RF, copyMemoryBlock`
Example	`copyBufferCOM2INFO();`

compareBufferINFO2RF

Function	Compare `bufferINFO` and `bufferRF` with respect to specified length
Purpose	Buffer comparison
Syntax	`bit` **`compareBufferINFO2RF(length)`**
Parameters	`uns8 length`: number of bytes to be compared (1 to 64)
Return value	• 1 – match • 0 – mismatch
Output values	–
Preconditions	–
Remarks	• Comparing is limited up to first 64 B of bufferRF only. • If memoryOffsetFrom = 0 and memoryOffsetTo = 0 complete 64 B is compared. • See example E06 - RAM [10].
Side effects	–
See also	`clearBufferINFO, copyBufferINFO2RF, copyBufferRF2INFO, swapBufferINFO`
Example	`if (!compareBufferINFO2RF(32))  // Compare 32 B` `  then Error = 1;  // Error if mismatch`

swapBufferINFO

Function	Swap `bufferINFO` and `bufferAUX`
Purpose	Temporary `bufferINFO` saving
Syntax	`void` **`swapBufferINFO()`**
Parameters	–
Return value	–
Output values	Content of `bufferINFO` and `bufferAUX` (64 B) is swapped. See example E06 - RAM [10].
Preconditions	–
Remarks	–
Side effects	–
See also	`moduleInfo, appInfo`

Example	`swapBufferInfo();  // Temporarily save bufferInfo to bufferAUX`
	`appInfo();  // Get user data from EEPROM`
	`...`
	`swapBufferInfo();  // and restore previous data in bufferInfo`

clearBufferINFO

Function	Clear `bufferINFO`
Purpose	bufferINFO clearing
Syntax	`void` **`clearBufferINFO()`**
Parameters	–
Return value	–
Output values	–
Preconditions	–
Remarks	Complete `bufferINFO` (64 B) is cleared (filled with zeros). See example E06 - RAM [10].
Side effects	–
See also	`copyBufferINFO2COM, copyBufferINFO2RF, copyBufferRF2INFO, copyBufferCOM2INFO, compareBufferINFO2RF, copyMemoryBlock, swapBufferINFO`
Example	`clearBufferINFO();`

clearBufferRF

Function	Clear `bufferRF`
Purpose	bufferRF clearing
Syntax	`void` **`clearBufferRF()`**
Parameters	–
Return value	–
Output values	–
Preconditions	–
Remarks	Complete `bufferRF` (128 B) is cleared (filled with zeros). See example E06 - RAM [10].
Side effects	–
See also	`copyBufferRF2COM, copyBufferRF2INFO, copyBufferCOM2RF, copyBufferINFO2RF, compareBufferINFO2RF, copyMemoryBlock`
Example	`clearBufferRF();`

Data blocks

copyMemoryBlock

Function	Copy specified RAM block to specified location
Purpose	Copy memory block within RAM
Syntax	`void` **`copyMemoryBlock`** `(from, to, length)`
Parameters	• `uns16 from`: starting address of the block to be copied • `uns16 to`: destination address • `uns8 length`: block length in bytes
Return value	–
Output values	–
Preconditions	• Either traditional or linear addresses can be used. • Upward overlapping the source and the destination RAM blocks being copied is not allowed. • Avoid writing to RAM areas dedicated to OS otherwise OS can collapse. See the RAM map [2].
Remarks	• See RAM map [2] and example E06 - RAM [10].
Side effects	–
See also	`writeToRAM`, `readFromRAM`
Example1	`copyMemoryBlock(0x2390, 0x23C0, 10); // copy 10 B block from 0x2390 to 0x23C0`
Example2	`copyMemoryBlock(bufferRF+10, bufferCOM+1, 8);  // 8 bytes copied:` `  // bufferCOM[1] = bufferRF[10] ...  bufferCOM[8] = bufferRF[17]`
Example3	`copyMemoryBlock(array+0, array+1, sizeof(array)-1);  // Upward, not allowed`
Example4	`copyMemoryBlock( array+1, array+0, sizeof(array)-1 );  // Downward, allowed`

moduleInfo

Function	Store Module data to `bufferINFO`
Purpose	Get information about transceiver module and OS
Syntax	`void` **`moduleInfo()`**
Parameters	–
Return value	–
Output values	`bufferINFO[0 to 7]`:

address in `bufferInfo`	7	6	5	4	3	2	1	0
meaning	OS build		MCU type	OS version	Serial number			
					Module ID			

Serial number (Module ID): 4 B identification code unique for each TR module.

OS version:

upper nibble (4 b): Major version
lower nibble (4 b): Minor version. Postfix "D" is not stated in Module identification but can be recognized by MCU type ("D" for PIC16LF1938).

MCU type:

3: PIC16F886
4: PIC16LF1938

OS build: OS subversion for the manufacturer only.

Example (all in hexadecimal):

```
                  [0] [1] [2] [3] [4] [5] [6] [7]
bufferINFO[0-7] =  1C  10  00  01  31  04  39  11
```

Meaning: Coordinator, Module ID = 0100101C, IQRF OS version 3.01D, PIC16LF1936, build 0x1139.

Preconditions	–
Remarks	–
Side effects	–
See also	`appInfo`
Example	

```
uns24 SN @ bufferInfo;
uns8 OSv  @ bufferInfo[4];
moduleInfo();                  // Now SN == module serial number
                               // and OSv == OS version
```

appInfo

Function	Store Application information from EEPROM to `bufferINFO`
Purpose	Get information about user application
Syntax	`void` **`appInfo()`**
Parameters	–
Return value	–
Output values	`bufferINFO[0 to 31]`
Preconditions	–
Remarks	See IQRF OS User's guide [1] (Identification and Appendix, Memory maps).
Side effects	–
See also	`moduleInfo`

Example1	`appInfo();  // Copy Application info from EEPROM to bufferINFO`
	`copyBufferINFO2RF();  // and then to bufferRF`

Example2	`#pragma packedCdataStrings 0  // Application data to EEPROM after compilation`
	`#pragma cdata[__EEAPPINFO] =  "Application data, I'm user #01  "`
	`bufferINFO[0] = '2';  // Dynamic change of application data`
	`eeWriteData(__EEAPPINFO+29,1); // #01 changed to #02`
	`appInfo();  // "Application data, I'm user #02  " is read`

SPI

enableSPI

Function	Activate SPI communication module and related pins
Purpose	Enable SPI communication
Syntax	`void` **`enableSPI()`**
Parameters	–
Return value	–
Output values	SPI Status is switched to *SPI ready, communication mode*.
Preconditions	–
Remarks	• The PIC internal SPI hardware module and appropriate pins (C5 to C8 or Q6, Q7, Q8 and Q11) are configured and activated as SPI Slave. • See SPI Implementation in IQRF TR modules [5] and example E07-SPI [10].
Side effects	Related pins can not be used as general I/Os until SPI is disabled via `disableSPI`.
See also	`disableSPI, startSPI, stopSPI, getStatusSPI, restartSPI`
Example	`See getStatusSPI`

disableSPI

Function	Switch SPI HW module off and configure SPI pins as I/Os
Purpose	Disable SPI communication
Syntax	`void` **`disableSPI()`**
Parameters	–
Return value	–
Output values	SPI Status is switched to *SPI not active*.
Preconditions	–
Remarks	The PIC internal SPI hardware module is disabled and related pins (C5 to C8 or Q6, Q7, Q8 and Q11) are reconfigured as general I/Os. See SPI Implementation in IQRF TR modules [5] and example E07-SPI [10].
Side effects	• The appropriate PIC pins are not restored to the state before enableSPI calling. • Current packet is lost by both sides if SPI communication is running on background at this moment.
See also	`enableSPI, startSPI, stopSPI, getStatusSPI, restartSPI`
Example	`See getStatusSPI`

startSPI

Function	Indicate ready to Master.
Purpose	• Initiate SPI packet transmission from Slave (request to Master). Provide data from `bufferCOM` to Master according to Master's clock (on OS background). • `startSPI(0)` indicates to Master that the Slave is ready to receive data (`bufferCOM` not full).
Syntax	`void` **`startSPI(length)`**
Parameters	`uns8 length`: number of bytes to be sent (0 to 64)
Return value	–
Output values	SPI Status is switched to: • *SPI data ready* – after `startSPI(1` to 64`)` • *SPI ready, Communication mode* – after `startSPI(0).`
Preconditions	SPI must be enabled by the `enableSPI` function before.
Remarks	• SPI runs on OS background. • `startSPI(0)` is also useful for recovering SPI from communication failures (e.g. the CRC mismatch). • See SPI Implementation in IQRF TR modules [5] and example E07-SPI [10].
Side effects	–
See also	`enableSPI, disableSPI, stopSPI, getStatusSPI, restartSPI`

Example1	`// Slave -> Master`
	`bufferCOM[0] = "I";`
	`bufferCOM[1] = "Q";`
	`enableSPI();`
	`startSPI(2);  // Request to Master is active on backgroung from now`
	`...  // and the program just continues here`

Example2	`startSPI(0);  // Reset SPI communication`
Example3	`See getStatusSPI`

stopSPI

Function	Stop SPI communication
Purpose	Suspend SPI transmissions whenever it suits to Slave
Syntax	`void` **`stopSPI()`**
Parameters	–
Return value	–
Output values	SPI Status is switched to *User stop*.
Preconditions	–
Remarks	• `stopSPI` is useful e.g. to avoid violation during preparation data to `bufferCOM`. • SPI transmission is stopped but SPI remains active (enabled). Communication can continue after next `startSPI`. • `stopSPI` is not needed after successful SPI reception to protect data received in `bufferCOM`. Data is protected by OS (and SPI status stays in mode 3F) until the slave allows further communication e.g. by the `startSPI(0)`. • `startSPI` and `stopSPI` are not fully complementary. Receiving is allowed just after `enableSPI` without previous `startSPI`, `startSPI` is meaningful after previous `startSPI` not followed by `stopSPI` etc. • See SPI Implementation in the IQRF TR modules [5] and example E07-SPI [10].
Side effects	Current packet is lost by both sides if SPI communication is running on background at this moment.
See also	`enableSPI, disableSPI, startSPI, getStatusSPI, restartSPI`

Example	`if (!getStatusSPI())  // If SPI is not in progress`
	`{`
	`  stopSPI();  // Prohibit Master from transmitting`
	`  //  (not to destroy bufferCOM in background)`
	`  bufferCOM[0] = ...  // Prepare data to send`
	`  bufferCOM[1] = ...`
	`  startSPI(2);  // Request to send`
	`}`

restartSPI

Function	Indicate ready to continue SPI transfer to Master .
Purpose	Allow to continue SPI transmission (request to Master).
Syntax	`void` **`restartSPI()`**
Parameters	–
Return value	–
Output values	
Preconditions	Intended after preceeding `stopSPI`.
Remarks	SPI can continue from the state just before `stopSPI`.
Side effects	–
See also	`startSPI, stopSPI`

Example1	`startSPI(16);  // SPI started`
	`  ...`
	`stopSPI();  // SPI stopped temporarily`
	`  ...  // to make some operations`
	`restartSPI();  // and allow to continue`

getStatusSPI

Function	Update SPI flags and packet length and check whether SPI is busy
Purpose	Provide application program with information about current SPI status
Syntax	`bit` **`getStatusSPI()`**
Parameters	–
Return value	• 1 – SPI busy • 0 – SPI not busy
Output values	• `SPIpacketLength`: received packet length • `param2.3` (`_SPIRX`): `1 - Something received on SPI.` • `param2.4` (`_SPICRCok`): 1 – The last received SPI CRCM was O.K.
Preconditions	SPI must be enabled by `enableSPI`
Remarks	• Output values (`param2`) has different format than SPI status sent to the Master. • See SPI Implementation in IQRF TR modules [5] and example E07-SPI [10].
Side effects	–
See also	`enableSPI, disableSPI, startSPI, stopSPI, restartSPI`

Example1

```
     // Master  ->  Slave
  enableSPI();              // Master is allowed to transmit from now

Receive:
  clrwdt();
  if (getStatusSPI())       // Wait until SPI is not busy
    goto Receive;

  if (_SPIRX)               // Anything received?
  {                         // Yes:
    if (!_SPICRCok)         //   CRCM matched?
    {                       //   No:
      startSPI(0);          //     Restart SPI
      goto Receive;         //     and try to receive again.
    }
                            //  Yes:
                            //    BufferCOM is automatically protected now
                            //    not to be overwritten by next SPI packet.
                            //    Thus, stopSPI is not necessary here.
                            //    Packet length is in SPIpacketLength.
    copyBufferCOM2INFO();   //    Store received packet
    startSPI(0);            //    and then allow Master to transmit again.
  }
  else
    goto Receive;           // Nothing received yet

// ...                         Continue here after successful receiving

  waitMS(1);                // Time for finishing startSPI(0) on background
  disableSPI();             // otherwise Master's CRCS check fails.
                            // The delay depends on Master application.
```

Example2

```
enableSPI();
startSPI(2);                // 2 B to send to master
while (getStatusSPI())      // Wait until SPI is not busy
  waitMS(1);
...                         // Now the transfer is finished
```

RF

setTXpower

Function	Set RF output power
Purpose	Change RF range
Syntax	`void` **`setTXpower(level)`**
Parameters	`uns8 level:` 0 (min.) to 7 (max. – default) See datasheet of TR module, Table 2.
Return value	–
Output values	Available read only in the `RFpower` register
Preconditions	–
Remarks	–
Side effects	–
See also	`RFTXpacket`
Example	`setTXpower(7);  // Max. RF output power`

setRFspeed

Function	Select RF bit rate
Purpose	Select RF bit rate
Syntax	**`void setRFspeed(speed)`**
Parameters	`uns8 speed:` • 1 1.2 kb/s (preliminary) • 2 19.2 kb/s (default) • 3 57.6 kb/s (preliminary) • 4 86.2 kb/s (preliminary)
Return value	–
Output values	Available read only in the `RFspeed` register
Preconditions	Bit rates different from 19.2 kb/s are preliminary, for experimental purpose only.
Remarks	• Non-default bit rates are provisionally intended for experimental purposes only. • Routing is supported for 19.2 kb/s only
Side effects	RF channel must be specified after every bit rate change.
See also	`setRFchannel`
Example1	`setRFspeed(1);  // 1.2 kb/s selected` `setRFchannel(...);  // channel must be selected then`
Example2	`setRFspeed(2);  // 19.2 kb/s selected` `setRFchannel(...);  // channel must be selected then`

setRFband

Function	Select RF frequency band
Purpose	Select 868 MHz or 916 MHz band
Syntax	**`void setRFband(band)`**
Parameters	`uns8 band:` • 0 868 band MHz (default) • 1 916 band MHz
Return value	–

Output values	Flag `_916MHz` in the `userInterface` register:
	`_916MHz: 0 – 868 MHz band`
	`1 – 916 MHz band`

Preconditions	–
Remarks	Default channel is set (52 for 868 MHz band or 104 for 916 MHz band).
Side effects	RF channel must be specified after every band change.
See also	`setRFchannel`
Example1	`setRFband(1);  // 916 MHz band selected`
Example2	`setRFband(0);  // 868 MHz band selected`

setRFchannel

Function	Set RF channel
Purpose	Select free RF channel for not interfered communication
Syntax	**`void setRFchannel(channel)`**
Parameters	• `uns8 channel`: see IQRF OS User's guide, Appendix 2, Channel map • Default: `52 (for 868 MHz band)` `104 (for 916 MHz band)`
Return value	–
Output values	Available read only in the `RFchannel` register
Preconditions	–
Remarks	–
Side effects	RF channel must be specified after every bit rate or band change.
See also	`setRFspeed`

Example	`setRFband(0);  // 868 MHz band selected`
	`setRFspeed(3);  // 57.6 kb/s bit rate selected`
	`setRFchannel(25);  // 868.15 MHz channel selected`

setRFmode

Function	Set RF mode
Purpose	Specify power management and signal filtering modes for RF transmission and receipt
Syntax	**`void setRFmode(mode)`**
Parameters	`uns8 mode: SWTTFFRR` in binary • S: **Stay in RX mode** (for fast response for following `checkRF`, `RFRXpacket` or `RFTXpacket`) 1 RX chain stays enabled after `RFRXpacket` and `RFTXpacket` 0 RX chain is disabled after `RFRXpacket` and `RFTXpacket` • W: **Wait packet end** 1 Waits until receipt is finished if it is actually started even though toutRF timeout is over meanwhile. 0 `RFRXpacket` is unconditionally finished when toutRF timeout is over. • TT: **TX mode** 00 for STD RX mode (standard preamble ~3 ms) 01 for LP RX mode (prolonged preamble ~50 ms) 10 for XLP RX mode (prolonged preamble ~1 s) 11 LP/XLP RX termination on pin change enabled. If enabled, low level on pin C5 (for TR modules in SIM format) or Q12 (for TR-54D) terminates RF reception in LP/XLP mode. • FF: **Filter incoming signal** in LP, XLP and RFIM RX modes (RR ≠ 0). Signal with lower level is ignored. Relative RF range is shortened due to this filtration. The level corresponds to the `checkRF(x)` parameter: 00 x = 5 01 x = 20 10 x = 35 11 x = 50 • RR: **RX mode** 00 STD RX mode (Standard, transmitting device should have TT=00) 01 LP RX mode (Low power, transmitting device should have TT=01) 10 XLP RX mode (Extra low power, transmitting device should have TT=10) 11 RFIM mode (`RFRXpacket` is terminated when signal strength falls below the FF level)
Return value	–
Output values	Available read only in the `RFmodeByte` register.
Preconditions	Non-STD RX modes are intended for bit rate 19.2 kb/s only.
Remarks	Default value is mode = 0. See example E10-RFMODE.
Side effects	RF circuitry and MCU is temporarily set to sleep during low power RX modes. Thus, all tasks running on OS background can be untimely canceled. To avoid this, use `setRFmode` after finishing background tasks. See Example 2.
See also	`checkRF`

Example1	`setRFmode(0b00000000); // RX: STD, no filtering`
	`// TX: for STD RX (standard preambles)`
	`setRFmode(0b00010001); // RX: LP, lowest filtering (5)`
	`// TX: for LP RX (prolonged preambles ~50 ms)`
	`setRFmode(0b00101110); // RX: XLP, highest filtering (50)`
	`// TX: for XLP RX (prolonged preambles ~1 s)`
	`setRFmode(0b00000101); // RX: LP, low filtering (20)`
	`// TX: for STD RX (standard preambles)`
	`setRFmode(0b10001011); // RX: RFIM, high filtering (35), stay in RX mode`
	`// TX: for STD RX (standard preambles)`
	`setRFmode(0b01000000); // RX: STD, no filtering, wait packet end`
	`// TX: for STD RX (standard preambles)`

Example2	`while (getStatusSPI()) // wait for finishing SPI on background`
	`clrwdt();`
	`disableSPI();`
	`SWDTEN = 0; // possibly disable watchdog for lower consumption`
	`setRFmode(0b00010001); // and go to LP mode then`

checkRF

Function	Check incoming RF signal strength for specified level.
Purpose	Incoming RF signal detection to start RF receiving.
Syntax	**`bit checkRF(level)`**

Parameters	`uns8 level = DQI + RSSI_FILTER`
	• `DQI` (Data Quality Indicator):
	  • `0x80` DQI enabled
	  • `0` DQI disabled
	  If DQI is enabled `checkRF` returns true when there is an extended probability that just the FSK modulation is detected. See the RF IC datasheet. This can help to distinguish noise from valid signal.
	• `RSSI_FILTER`: 0 to 64
	Higher level requires stronger signal. Relative RF range is shortened due to this filtration according the datasheet of the TR module, Table 3. RSSI offset is 32, e.g. level 16 means a signal with RSSI > 48.

Return value	• `0`: Signal with specified level or higher not detected
	  RSSI < RSSI_FILTER, with respect to possible DQI
	• `1`: Signal with specified level or higher detected
	  RSSI > RSSI_FILTER, with respect to possible DQI

Output values	Signal strength is also available as a relative value in the ADRESH (one of PIC SFR registers). Higher value means stronger signal.
Preconditions	• This function is intended for STD and RFIM receive modes but not for LP and XLP. • If DQI enabled `PORTA.6 = 1` must be set before every `checkRF` usage. See Example 4.
Remarks	• Higher level means lower sensitivity which requires stronger signal resulting in higher immunity against interefrences but allows lower range – see TR datasheet, table Relative RF range vs. level. • Checking takes 1.4 ms or ~690 µs if RX chain is on (bit S = 1 in `setRFmode`) • Checking consumes ~9.5 mA. • This function is intended for fast response and power consumption reduction in STD RX mode.
Side effects	A/D converter control registers are changed
See also	`setRFmode, RFRXpacket`

Example1	`// Fast response receiving in STD mode`
	`if (checkRF(5))  // Detect signal with RSSI > 37`
	`{`
	`  if (RFRXpacket())  // Duration according to toutRF only if packet is sent.`
	`  {  // toutRF can be optimized for expected packet length.`
	`  ...`
	`  }`
	`}  // Otherwise only ~1 ms is spent.`
	`... time-critical section can be placed here`

Example2	`if (checkRF(10))  // Detect signal with RSSI > 42` `  ...`

Example3	`// RF signal strength analyzer`
	`SWDTEN = 0;  // disable watchdog`
	`while (1)`
	`  if (checkRF(3)) pulseLEDR(); // LED flash if signal level >= 3 detected`

Example4	`PORTA.6 = 1;  // Necessary if using DQI`
	`if (checkRF(0x85))  // Detect signal with RSSI > 37 using DQI`
	`  ...`

RFTXpacket

Function	Send RF packet of specified length from `bufferRF`.
Purpose	RF transmission
Syntax	`void` **`RFTXpacket()`**
Parameters	–
Return value	–
Output values	–

Preconditions	• Peer-to-peer topology:
	  • `PIN = 0` (Peer-to-peer)
	  • `DLEN =` packet length in bytes (0 to 64)
	  • Prepare data to send in `bufferRF[0] to bufferRF[DLEN - 1]` (if `DLEN ≠ 0`)
	  • Set RF output power via `setTXpower`
	• IQMESH:
	  • `PIN = 0x80` (IQMESH)
	  • Other network related parameters should also be specified
	See IQRF OS User's guide [1] and IQMESH specification [4].

Remarks	• Unlike SPI, RF communication does not run on OS background. This function is active on foreground until the packet is sent. • Duration depends on TR type, routing algorithm, packet length and timeslot. • See examples E01–TX, E03–TR, E09–LINK [10] and E11–IQMESH-C [10].
Side effects	• bufferRF[DLEN] and bufferRF[DLEN+1] are destroyed • System tick timing is slightly affected. • The RF circuitry wakes up (in case of sleeping).
See also	`RFRXpacket, setTXpower, setRFmode` and (in case of IQMESH) also other RF functions

Example1

```
   // Peer-to-peer topology
PIN=0;                // Peer-to-peer (update also after every RFRXpacket
                      // before every RFTXpacket)
setNonetMode();
bufferRF[0] = "I";    // Data to send
bufferRF[1] = "Q";
DLEN = 2;             // 2 B packet
RFTXpacket();         // Send the packet to all Peer-to-peer Nodes in range
                      // and to all IQMESH Nodes having set filtering off
                      // Program stays here until the packet is sent
  ...                 // and then continues
```

Example2

```
   // IQMESH without routing, packet from Coordinator to Node #10
PIN = 0;              // PIN preclearing (update also after every RFRXpacket
                      // before every RFTXpacket)
setCoordinatorMode(); // The NTWF flag (PIN.7) is set here.
bufferRF[0] = "I";    // Data to send
bufferRF[1] = "Q";
DLEN = 2;             // 2 B packet
RX = 10;              // Packet for Node #10
// _ROUTEF = 0;       // Routing disabled - not necessary (default by OS)
RFTXpacket();         // Send the packet to IQMESH Node #10 in this network
                      // Reception depends on the Node (its current network
                      // or filtering)
```

Example3

```
   // IQMESH with routing
   // Packet from Coordinator to Node #10
PIN = 0;              // PIN preclearing (update also after every RFRXpacket
                      // before every RFTXpacket)
setCoordinatorMode(); // The NTWF flag (PIN.7) is set here.
bufferRF[0] = "I";    // Data to send
bufferRF[1] = "Q";
DLEN = 5;             // 5 B packet
RX = 10;              // Packet for Node #10
_ROUTEF = 1;          // Routing enabled for outgoing packets
RTDEF = 1;            // SFM (Static Full MESH)
// RTDEF = 2;         // DFM (Discovered Full MESH)
RTDT0 = 10;           // 10 hops
// RTDT0 = eeReadByte[0]; // # hops = # bonded nodes

RTDT1 = 2;            // Time slot = 2 ticks (20 ms is enough for DLEN=5)
RFTXpacket();         // Send the packet to IQMESH Node #10 in this network
                      // Reception depends on the Node (its current network
                      // or filtering)
```

RFRXpacket

Function	Receive RF packet to `bufferRF` and provide related information
Purpose	RF receiving
Syntax	`bit` **`RFRXpacket()`**
Parameters	–
Return value	• 1 – packet received • 0 – packet not received

Output values	• `lastRSSI` – the RSSI value after successful receipt (single sample). Quiet level (noise) is 25 - 28.
	• `DLEN =` packet length. This variable is destroyed if the receipt is not successful.
	• PIN is updated according to packet received. This variable is destroyed if the receipt is not successful.
	• `_NTWPACKET`: valid if `RFRXpacket` return value == 1 only:
	  • 1 – networking packet received
	  • 0 – non-networking packet received
	• Other related networking information in case of IQMESH.

Preconditions	• Timeout should be specified in `toutRF` (1 to 255) in number of 10 ms ticks or for LP and XLP modes in cycles, see IQRF OS User's guide, RF RX and TX modes). • Peer-to-peer topology: nothing else • IQMESH: network related parameters (filtering, ...) should be predefined See IQRF OS User's guide [1] and IQMESH specification [4].
Remarks	• Unlike SPI, RF communication does not run on OS background. This function is active on foreground until the packet is received or timeout expired. Timeout during packet receiving terminates the reception except of the Wait packet end mode – see `setRFmode`. • If the packet is sent when the addresse (or a routing device) is not executing this function the packet is lost. • Peer-to-peer topology: All non-networking packets in range are received. • IQMESH: Device receives only packets intended for it and non-networking packets depending on filtering mode – see `setNetworkFilteringOn` and `setNetworkFilteringOff`. • See examples E02–RX, E03–TR, E09–LINK and E11-IQMESH-N [10].
Side effects	• Update PIN before every `RFTXpacket` followed after `RFRXpacket`. • Result of `captureTicks` is destroyed if `startCapture` is active on background at the same time. • System tick timing is slightly affected. • bufferRF[DLEN] and bufferRF[DLEN+1] is destroyed. • The RF circuitry wakes up (in case of sleeping). • If a packet received the A/D converter control registers are changed.
See also	`RFTXpacket, setRFmode, checkRF` and (in case of IQMESH) also other RF functions

Example 1

```
   // Peer-to-peer topology
toutRF = 10;              // RF timeout 100 ms
if RFRXpacket();          // Try to receive RF packet.
                          // Program stays here until the packet is received
                          // or the timeout is expired. Packet received?
{                         // Yes:
  copyBufferRF2INFO();    //   Store received data
  PacketLength = DLEN;    //   and possibly other info (packet length, ...)
}
else
{                         // No:
  ...                     //   Timeout expired. Arrange respective operations.
}
```

Example 2

IQMESH: See `setNodeMode` and `setNetworkFilteringOn`.

Example 3

```
if (RFRXpacket())
{
  if (_ROUTEF)             // Was the packet routed?
  {                        // Yes - wait for finish of routing
    while (RTDT0)          // RTDT0 - rest of hops
    {
      waitDelay(RTDT1);    // RTDT1 - timeslot
      RTDT0--;             // Do not answer until all hops are finished
    }
  }
  ...                      // Now the Node is allowed to answer
}
```

Networking

setCoordinatorMode

Function	Set Coordinator mode
Purpose	Assign the TR module as a network Coordinator
Syntax	`void` **`setCoordinatorMode()`**
Parameters	–
Return value	–
Output values	• Flag `_networkingMode` (`userInterface.7`) = 1 • Flag `_networkTwo (userInterface.6) = 0` • In Coordinator mode the `_NTWF` flag (`PIN.7`) is automatically set before calling `RFTXpacket`
Preconditions	For IQMESH only
Remarks	Every TR module can work as a Coordinator or a Node. Just one Coordinator in single network is allowed. Avoid dynamic switching the Coordinator from device to device in a network. This settings affects both `RFRXpacket` and `RFTXpacket`.
Side effects	–
See also	`setNodeMode, setNonetMode, RFTXpacket`
Example	

setNodeMode

Function	Set Node mode
Purpose	Assign the TR module as a network Node
Syntax	`void` **`setNodeMode()`**
Parameters	–
Return value	–
Output values	• Flag `_networkingMode (userInterface.7) = 1` • Flag `_networkTwo (userInterface.6) = 1` • In Node mode the `_NTWF` flag (`PIN.7`) is automatically set before calling `RFTXpacket`
Preconditions	For IQMESH only
Remarks	Every TR module can work as a Coordinator or a Node. This settings affects both `RFRXpacket` and `RFTXpacket`.
Side effects	–
See also	`setCoordinatorMode, setNonetMode, RFTXpacket`
Example	

setNonetMode

Function	Select Peer-to-peer mode
Purpose	Switch from IQMESH to Peer-to-peer
Syntax	`void` **`setNonetMode()`**
Parameters	–
Return value	–
Output values	• Flag `_networkingMode` (`userInterface.7`) = `0`
Preconditions	–
Remarks	• Default OS mode is Peer-to-peer. • This settings affects `RFRXpacket` and `RFTXpacket` features. • PIN is not affected immediately but it is cleared after subsequent `RFRXpacket` or `RFTXpacket`. • Flag `_networkTwo (userInterface.6)` is not changed.
Side effects	–
See also	`setCoordinatorMode, setNodeMode`

Example	`setNetworkOne();  // TR communicates in IQMESH networking mode here`
	`  ...  //`
	`setNonetMode();  // Switch to Peer-to-peer mode`
	`  ...  // Now TR communicates without networking support`

setNetworkFilteringOn

Function	Start filtering incoming non-networking packets and packets coming from non-current network.
Purpose	To receive packets from current network only.
Syntax	`void` **`setNetworkFilteringOn()`**
Parameters	–
Return value	–

Output values	Flag `_filterCurrentNetwork` in register `userInterface`:
	`_filterCurrentNetwork: 0 – filtering off`
	`1 – filtering on`
	• This affects the `RFRXpacket` return value.

Preconditions	For IQMESH only. Default OS condition is Filtering Off.
Remarks	–
Side effects	–
See also	`setNetworkFilteringOff, RFRXpacket`

Example	`setNetworkFilteringOn();  // Start filtering incoming packets`
	`RFRXpacket();  // Return value == 1 if the packet came`
	`// from current network only.`
	`// Return value == 0 if`
	`// the packet came from non-current network(s)`
	`// or it is a non-networking packet`
	`// or no packet came in time at all.`

setNetworkFilteringOff

Function	Stop filtering incoming packets from the point of view the packet is coming from.
Purpose	To receive all packets (non-networking packets as well as packets from all network).
Syntax	`void` **`setNetworkFilteringOff()`**
Parameters	–
Return value	–

Output values	• Flag `_filterCurrentNetwork` in register `userInterface`:
	`_filterCurrentNetwork: 0 – filtering off`
	`1 – filtering on`
	• This affects the RFRXpacket return value.

Preconditions	For IQMESH only. Default OS condition is Filtering Off.
Remarks	Network 1 or 2 is automatically selected according to last received packet in this mode (except of non-networking packets).
Side effects	–
See also	`setNetworkFilteringOn, RFRXpacket`

Example	`setNetworkFilteringOff();  // Stop filtering incoming packets`
	`RFRXpacket();  // Return value == 1 if`
	`// the packet came from current network`
	`// or from non-current network(s)`
	`// or it is a non-networking packet`
	`// Return value == 0 if`
	`// no packet came in time at all`

setUserAddress

Function	Assign a user address to a Node
Purpose	User addressing of Nodes
Syntax	`void` **`setUserAddress(address)`**
Parameters	`uns16 address`: user address 1 to 65 000
Return value	–
Output values	–
Preconditions	For IQMESH Node and DFM2B only.
Remarks	• 0xFFFF is intended for broadcast. • Groups can be created by assigning the same address to more Nodes. • See Routing algorithms in the IQRF OS user's guide for details. • It is often convenient to set this as a part of bonding procedureby the user (to keep user program the same for all Nodes etc.). • Node User address is stored in EEPROM and is accessible via `getNetworkParams`. See Example 4.
Side effects	It is not allowed to set addresses with lower byte = 0, e.g. 256 (0x01 0x00), 512 (0x02 0x00) etc. This will tbe fixed in OS v4.00.
See also	`bondNewNode`
Example 1	`setUserAddress(2000);  // The Node has got user address 2000`

Example 2	`setUserAddress(2000);`
	`  ...`
	`reset();  // User address is lost after reset`
	`setUserAddress(2000);  // User address restored`

Example 3	`setUserAddress(UA);`
	`eeWriteByte(EEUA, UA)  // User address stored to EEPROM`
	`  ...`
	`reset();  // User address lost after reset`
	`setUserAddress(eeReadByte(EEUA));  // User address restored from EEPROM`

Example 4	`getNetworkParams();  // Get User address`
	`uns16 myAddress = ntwUSERADDRESS;  // See IQRF-memory.h`

getNetworkParams

Function	Get network parameters
Purpose	Get some information about curent system, RF and network parameters
Syntax	**`getNetworkParams()`**
Parameters	–
Return value	–
Output values	• `param2`: Address of current device in network (0 - 239). For unbonded device 0 is returned. • `bit _NTWPACKET` 1 – IQMESH packet 0 – Peer-to-peer packet • `param3`: Network identification (`param3.high=NID1`, `param3.low=NID0`). If the device is bonded `NID0` and `NID1` refer to Coordinator otherwise to the device itself. These features are not guaranteed for future OS versions. • Network parameters (registers with names beginning with the `ntw` prefix) are updated. See IQRF OS User's guide, Appendix 2, table OS, RF and network parameters.
Preconditions	For IQMESH only.
Remarks	See example E11 - IQMESH-N [10].
Side effects	–
See also	`amIBonded`

Example	`if (amIBonded())  // Is the Node bonded?`
	`{  // Yes:`
	`  getNetworkParams();  //  Get Node number`
	`  myAddr = param2;`
	`}`

Routing

setRoutingOn

Function	Routing enabled
Purpose	Allow the Node to route packets on background.
Syntax	`void` **`setRoutingOn()`**
Parameters	–
Return value	–
Output values	• Flag `_disableRouting = 0` • This state is stored in EEPROM and initialized after reset.
Preconditions	For IQMESH Nodes only.
Remarks	• Routing must be enabled for a Node to be assigned to the routing backbone during Discovery. • Routing can be enabled in all receive modes (STD, LP, XLP and RFIM). • Flag `_disableRouting` in register `_ntwCFG` is available read only after calling `getNetworkParams`: `_disabledRouting: 0` – Routing on `1` – Routing off
Side effects	–
See also	`setRoutingOff, discovery, isDiscovederedNode, wasRouted`
Example	–

setRoutingOff

Function	Routing disabled
Purpose	Forbid the Node to route packets on background.
Syntax	`void` **`setRoutingOff()`**
Parameters	–
Return value	–
Output values	• Flag `_disableRouting = 1` • This state is stored in EEPROM and initialized after reset.
Preconditions	For IQMESH Nodes only.
Remarks	• If routing is disabled the Node will not be assigned to the routing backbone during Discovery. • Flag `_disableRouting` in register `_ntwCFG` is available read only after calling `getNetworkParams`: `_disabledRouting: 0` – Routing on `1` – Routing off
Side effects	–
See also	`setRoutingOn, discovery, isDiscovederedNode, wasRouted`
Example	–

discovery

Function	Discover Nodes for routing and asign VRN (Virtual Routing Number) to individual Nodes
Purpose	Routing backbone creation (for routing transparent from the user's point of view)
Syntax	`uns8` **`discovery(zones)`**
Parameters	`uns8: zones`: max. number of zones to be established
Return value	Number of discovered Nodes (≤ number of Nodes which should route)
Output values	• Routing backbone is stored in EEPROM
Preconditions	• For IQMESH Coordinator only. • Nodes must be in the `answerSystemPacket` loop routine during Discovery.
Remarks	• Nodes in current network only are discovered. • Discovery should be invoked after every change in network topology. • Nodes use the TX output power currently set in Coordinator during the discovery process. • It is recommended to run `discovery` under stronger conditions than ones that will be used in normal communication. It should be achieved by lower RF power or by filtering of incoming RF signal (`checkRF`). Filtering should be preferred due to better signal-to-noise ratio. See example E11-IQMESH-N [10], function `answerSystempacket`. • See example E11-IQMESH-C [10]. • See IQRF OS User's guide, routing algorithms.
Side effects	• Watchdog is disabled during this operation and enabled after finishing. • All OS buffers (`bufferINFO`, `bufferCOM`, `bufferRF` and `bufferAUX`) are destroyed • `toutRF` variable is changed • `_STAY_RX` flag is set. See `setRFmode`. • A/D converter control registers are changed
See also	`setRoutingOn`, `setRoutingOff`, `isDiscovederedNode`, `bondNewNode`, `answerSystemPacket`

Example1	`setTXpower(DISCOVERY_POWER);  // Set RF power for discovery`
	`nodes = discovery(10);  // Limit to max. 10 hops`
	`SWDTEN = 0;  // Possibly restore WDT`

Example2	`nodes = discovery(eeReadByte(0x00));  // Limit to number of bonded Nodes`
	`//  e.g. for Chain MESH`

answerSystemPacket

Function	Enable response to Coordinator for Discovery
Purpose	Discovery support from the Node's side
Syntax	`void` **`answerSystemPacket()`**
Parameters	–
Return value	–
Output values	Routing information exchanged between Coordinator and the Node via system packets.
Preconditions	• For IQMESH Node only. • Nodes must be in the `answerSystemPacket` loop routine when Discovery is running. • WDT should be disabled before `answerSystemPacket`
Remarks	• Nodes use the TX output power currently set in Coordinator for discovery. • It is recommended to run `discovery` under stronger conditions than ones that will be used in normal communication. It should be achieved by lower RF power or by filtering of incoming RF signal (`checkRF`). Filtering should be preferred due to better signal-to-noise ratio. See the example below and example E11-IQMESH-N [10].
Side effects	• `toutRF` is changed after Discovery • TX power can be affected during discovery
See also	`setRoutingOn`, `setRoutingOff`, `isDiscovederedNode`, `discovery`
Example	

```
toutRF = MY_TOUT_RF;
if (RFRXpacket())
{
  …
}
else
{
  if (lastRSSI > discovery_threshold) // discovery_threshold is a user
                                      // constant to ensure stronger
                                      // conditions – see Remarks.
  {
    SWDTEN = 0;
    answerSystemPacket();   // to be discovered
    SWDTEN = 1;
    setTXpower(MY_POWER);
  }
}
```

isDiscoveredNode

Function	Check for being discovered
Purpose	Ask whether the Node has been discovered
Syntax	`bit` **`isDiscoveredNode(address)`**
Parameters	`uns8 address`: Node address
Return value	• `true`: Specified Node has been discovered • `false`: Specified Node has not been discovered
Output values	–
Preconditions	For IQMESH Coordinator only.
Remarks	See E11-IQMESH-C [10].
Side effects	–
See also	`discovery, answerSystemPacket, optimizeHops`

Example	`DiscoveredNodes = discovery(3);  // Discovery (up to 3 zones)`
	`if (DiscoveredNodes < BondedNodes)  // (BondedNodes and DiscoveredNodes`
	`  // are user variables)`
	`{  // There are some bonded but not discovered Nodes`
	`  if (isDiscoveredNode(1))  // Is the Node 1 discovered?`
	`  …`
	`}`
	`else`
	`{  // All bonded Nodes discovered`
	`  …`
	`}`

wasRouted

Function	Indicate incoming packet routing
Purpose	To distinguish whether incoming packet has been routed for other recipient(s).
Syntax	`bit` **`wasRouted()`**
Parameters	–
Return value	• `true` packet has been routed • `false` packet has not been routed
Output values	–
Preconditions	For IQMESH Nodes only.
Remarks	Addressees route broadcast packets only. See E11-IQMESH-N [10].
Side effects	–
See also	`setRoutingOn, setRoutingOff, discovery, isDiscovederedNode`

Example	`if (RFRXpacket())`
	`{`
	`  if (wasRouted())`
	`  pulseLEDG();  // indicate routing received packet for broadcast`
	`  …`
	`}`
	`else`
	`{`
	`  if (wasRouted())`
	`  pulseLEDG();  // indicate routing incoming packet for another addressee`
	`}`

optimizeHops

Function	Optimize number of hops for given Node
Purpose	Set optimized number of hops according to a topology, without flooding
Syntax	`void` **`optimizeHops(x)`**
Parameters	`uns8 x`: optimizing method • 0xFF DOM – Discovered optimized MESH: sets `RTDT0` to `VRN` of addressed Node • 0x00 DRM – Discovered reduced MESH: sets `RTDT0` to `VRN` of the first Node in the zone of the addressed Node. *Not implemented yet.*
Return value	–
Output values	`RTDT0` (number of hops) is set
Preconditions	• For IQMESH Coordinator and DFM routing algorithm only. • Intended to be called before sending a packet from Coordinator. • Node address must be set before (`RX = …`). • The Node must be discovered.
Remarks	See E11-IQMESH-C [10] and IQRF OS User's guide.
Side effects	–
See also	`discovery, isDiscovederedNode`

Example	`setCoordinatorMode();`
	`RX = MY_NODE;`
	`RTDT0 = eeReadByte(0x00);  // Hops according to a number of bonded Nodes`
	`  if (isDiscoveredNode(RX))  // For routing using Discovery only`
	`    optimizeHops(0xFF);  // Modifies RTDT0 (number of hops)`
	`    .`
	`    .`
	`    .`
	`RFTXpacket();`

Bonding – Node only

bondRequest

Function	Ask Coordinator via RF for bonding to its network. Bond the Node in cooperation with Coordinator and record it to EEPROM.
Purpose	Request by the Node to be included to the network on both Coordinator's and Node's sides.
Syntax	`bit` **`bondRequest()`**
Parameters	–
Return value	• 1 – Node has been bonded • 0 – Node has not been bonded
Output values	• The `amIBonded` function starts to return value == 1 whenever is called while the Node is bonded by `bondRequest` not beeing unbonded by `removeBond` or `wipeBondNR`. • Coordinator is not affected at all. • `param2`: Node address (if successfully bonded only). Not guarranted for future OS versions.
Preconditions	For IQMESH only.
Remarks	• Bonding is a mutual relationship between Coordinator and Node. Coordinator assigns a Node number (1 to 239 or 0xEF) to the Node which serves as Node address within the network. (Coordinator itself has the address 0.) Bonding accomplishes via exchanging system RF packets and results are stored in system part of internal EEPROMs.The user can access results and change them via other functions related to bonding. See example E11 - IQMESH-N, E11 - IQMESH-C [10]. This function is active until successfully finished or fixed 10 s timeout expired. RF power is not affected.
Side effects	• `DLEN`, `PIN`, `toutRF`, `bufferRF` and `bufferINFO` are modified • Result of `captureTicks` is destroyed if `startCapture` is active on background at the same time. • Watchdog is disabled during this operation and enabled after finishing • IQMESH mode must be restored by `setNodeMode` after `bondRequest` • A/D converter control registers are modified
See also	`bondNewNode, amIBonded, removeBond, rebondNode, getNetworkParams, setNodeMode`

Example1	`pulsingLED(); // LED blinking indicates attempt to bond (max. 10 s)`
	`if (bondRequest())`
	`{ // if successfully bonded`
	`  stopLED();`
	`  _RLED=1; // LED On`
	`  waitDelay(100); // for 1 s`
	`}`
	`setNodeMode(); // Restore`
	`stopLED();`

Example2	See `amIBonded`

amIBonded

Function	Is the Node bonded?
Purpose	Test whether the Node is bonded on Node's side
Syntax	`bit` **`amIBonded()`**
Parameters	–

Return value	• 1 – Node is bonded (after `bondRequest` not beeing unbonded by `removeBond`)
	• 0 – Node is not bonded:
	  • no `bondRequest` has ever been successfully executed
	  • after `removeBond`

Output values	–
Preconditions	For IQMESH only. Result is not depended on the Coordinator at all.
Remarks	See example E11 - IQMESH-N [10].
Side effects	–
See also	`bondRequest, removeBond`

Example	`while (!amIBonded())  // Request for beeing bonded (if not bonded yet)`
	`{`
	`  bondRequest();  // Repeatedly try to bond`
	`  clrwdt();`
	`}  // until successful`

removeBond

Function	Remove the Node from the network and record it to EEPROM.
Purpose	Exclude the Node from the network on Node's side and keep its Node number reserved for possible future rebonding.
Syntax	`void` **`removeBond()`**
Parameters	–
Return value	–
Output values	• The amIBonded `function` starts to return value == 0 whenever is called until the Node is bonded again via `bondRequest`. • Just this value is affected but the Node keeps the Node number still stored (for possible future rebonding with the same Node number). • Coordinator is not affected at all.
Preconditions	For IQMESH only.
Remarks	• See example E11 - IQMESH-N [10]. • For rebonding use bondRequest again. • removeBond relates to Node only and removeBondedNode and rebondNode relate to Coordinator only. The other side is not informed by OS about changes made by these functions. If synchronization is needed it should be done by the application.
Side effects	–
See also	`bondRequest, bondNewNode, amIBonded, rebondNode`
Example	`removeBond();  // Remove the bond.`

Bonding – Coordinator only

bondNewNode

Function	Look for bond requesting devices and bond a new Node by Coordinator on a Node's request via RF. Allocate the Node number and assign the Network number and send both to Node via RF. If successful, the Node is bonded to the network on both Coordinator's and Node's sides and is included to the list of bonded Nodes provided by Coordinator in EEPROM.
Purpose	Include a new Node to the network
Syntax	`bit` **`bondNewNode(address)`**
Parameters	`uns8 address` • 1 to 239 Assign requested address to the Node. This must be unique in the whole network. If an existing number is used the Node is not bonded and the function immediately returns 0. Only these Nodes can be a part of routing backbone. • 0 The first free address is assigned (like the only way in IQRF OS v2.xx). It equals to a number of bonded nodes + 1. It assumes a continuous block of addresses and possible vacations are ignored. Thus, this way is suitable for the initial bonding without discontinuities. • 0xFE The universal address. Nodes with this address are included in the network but outside the routing backbone (not being discovered). Particular address can be assigned by `setUserAddress`. It is intended especially for networks with more than 239 Nodes.
Return value	• 1 – bonding successful, Node included to the list of bonded Nodes • 0 – bonding unsuccessful, Node not included to the list of bonded Nodes
Output values	• `param2`: Node number • `bufferRF[0 to 1]`: two lower ID bytes of the Node (is successfully bonded), LSB in `bufferRF[0]`. • The `isBondedNode` function starts to return value == 1 whenever is called while the Node is in the list of bonded Nodes.
Preconditions	• For IQMESH Coordinator only. • Coordinator accomplishes bonding on request from Node via RF. When this function is executing the `bondRequest` function must just be active in the Node.
Remarks	• See example E11 - IQMESH-C [10] and IQRF OS User's guide – routing algorithms. • If no requesting Node is detected during 10 s period this function terminates. • Network number is derived from Coordinator ID which ensures unique identification of various networks. • RF power is not affected. • An occupied address can be unblocked by `removeBondedNode(address)`.
Side effects	The following values are modified and not restored: • `PIN`, `DLEN`, `toutRF`, `bufferRF` and `bufferINFO` are modified • Result of `captureTicks` is destroyed if `startCapture` is active on background at the same time. • Watchdog is disabled during this operation and enabled after finishing • IQMESH mode must be restored by `setCoordinatorMode` after `bondNewNode` • A/D converter control registers are modified
See also	`bondRequest, removeBondedNode, rebondNode, isBondedNode, setUserAddress, setCoordinatorMode`

Example	`if (bondNewNode())  // Bonding successful ?`
	`{  // Yes:`
	`  NodeNumber = param2;`
	`  ...`
	`}`
	`else`
	`{  // No:`
	`  ...  //  Arrange necessary steps`
	`}`
	`setCoordinatorMode();  // Restore`

isBondedNode

Function	Is specified Node in the list of bonded Nodes?
Purpose	Test whether the Node is bonded on Coordinator's side
Syntax	`bit` **`isBondedNode(n)`**
Parameters	`uns8 n`: Node number
Return value	• 1 – Node is in the list of bonded Nodes • 0 – Node is not in the list of bonded Nodes
Output values	–
Preconditions	For IQMESH only. The result is not affected by the Node at all.
Remarks	–
Side effects	–
See also	`bondNewNode, removeBondedNode, rebondNode, clearAllBonds`

Example	`if isBondedNode(28) // Is Node #28 bonded ?`
	`{ // Yes:`
	`  ... // Coordinator assumes Node #28 to be bonded`
	`}`
	`else`
	`{ // No:`
	`  ... // Coordinator assumes Node #28 not to be bonded`
	`}`

removeBondedNode

Function	Remove a Node from the list of bonded Nodes by Coordinator in EEPROM
Purpose	Exclude the Node from the network on Coordinator's side
Syntax	`void` **`removeBondedNode(n)`**
Parameters	`uns8 n`: Node number
Return value	–
Output values	The `isBondedNode` function starts to return value == 0 whenever is called while the Node is not in the list of bonded Nodes. The Node is not affected at all.
Preconditions	For IQMESH only
Remarks	`removeBondedNode` and `rebondNode` relate to Coordinator only and `removeBond` relates to Node only. The other side is not informed by OS about changes made by these functions. If synchronization is needed it should be done by the application.
Side effects	–
See also	`bondNewNode, isBondedNode, clearAllBonds, removeBond`

Example	`removeBondedNode(28); // Coordinator assumes Node #28 to be`
	`// out of the network from now on`

rebondNode

Function	Put a Node back to the list of bonded Nodes by Coordinator in EEPROM
Purpose	Include the Node to the network again on Coordinator's side
Syntax	`bit` **`rebondNode(n)`**
Parameters	`uns8 n`: Node number
Return value	reserved for future OS versions
Output values	The `isBondedNode` function starts to return value == 1 whenever is called while the Node is in the list of bonded Nodes. The Node is not affected at all.
Preconditions	For IQMESH only. Avoid rebonding a Node not beeing bonded ever before.
Remarks	`removeBondedNode` and `rebondNode` relate to Coordinator only and `removeBond` relates to Node only. The other side is not informed by OS about changes made by these functions. If synchronization is needed it should be done by the application.
Side effects	–
See also	`bondNewNode`, `removeBondedNode`, `isBondedNode`

Example	`rebondNode(28);  // Coordinator assumes Node #28 to be`
	`// back in the network from now on`

clearAllBonds

Function	Remove all Nodes from the list of bonded Nodes by Coordinator in EEPROM
Purpose	Excluding all Nodes from the network on Coordinator's side
Syntax	`void` **`clearAllBonds()`**
Parameters	–
Return value	–
Output values	The `isBondedNode` function starts to return value == 0 whenever is called while the Node is not in the list of bonded Nodes. Nodes are not affected at all.
Preconditions	For IQMESH only
Remarks	• See example E11 - IQMESH-C [10]. • After subsequent bondNewNode(0) the Coordinator will start to assign Node numbers from 0.
Side effects	`bufferINFO` modified
See also	`removeBondedNode`
Example	`clearAllBonds();  // Exclude all currently bonded nodes from the network`

RFPGM – wireless upload

enableRFPGM

Function	Request to configure OS for switching to RFPGM mode after TR module reset
Purpose	Enable switching to RFPGM mode after reset
Syntax	`void` **`enableRFPGM()`**
Parameters	–
Return value	–
Output values	OS configured
Preconditions	–
Remarks	This function must be executed first to modify OS and just the following reset will switch to RFPGM.
Side effects	–
See also	`disableRFPGM`, `runRFPGM`, `setupRFPGM`
Example	See `disableRFPGM`

disableRFPGM

Function	Request to configure OS for not switching to RFPGM mode after TR module reset
Purpose	Disable switching to RFPGM mode after reset
Syntax	`void` **`disableRFPGM()`**
Parameters	–
Return value	–
Output values	OS configured
Preconditions	–
Remarks	This function must be executed first to modify OS and just the following reset will not switch to RFPGM.
Side effects	–
See also	`enableRFPGM`, `setupRFPGM`

Example	`enableRFPGM();  // During development`
	`// disableRFPGM();  // For final application`

runRFPGM

Function	Switch to RFPGM mode
Purpose	One-shot immediate switching to RFPGM mode
Syntax	`void` **`runRFPGM()`**
Parameters	–
Return value	–
Output values	RFPGM mode initiated
Preconditions	• Parameters like RF band, RF channel and bit rate are fixed to OS default values in the Lite version. If the application uses different ones, they must be set to default before using `runRFPGM` and then (just for the case of RFPGM refusal) restored to desired values. • Non-networking and STD modes must be selected
Remarks	• RFPGM mode can be refused by low level on the C5 pin for at least ~0.7 s (if enabled) or by the *End RFPGM* button in IQRF IDE (unconditionally). Then the application continues without reset. • After successful RFPGM finishing the application is reset.
Side effects	`toutRF` is modified if RFPGM did not take place.
See also	`enableRFPGM, setupRFPGM`
Example 1	`if (jumperSet) runRFPGM();  // Enter RFPGM mode on special request`

Example 2	`setNonetMode();  // Disable networking (if enabled)`
	`setRFmode(0);  // Default mode (if a different one is used)`
	`setRFchannel(52);  // If a different channel is used`
	`// default (52 for 868 MHz or 104 for 916 MHz)`
	`runRFPGM();`
	`setNodeMode();  // or CoordinatorMode(); (restoring)`
	`setRFchannel(my_channel);  // channel restoring`
	`setRFmode(my_mode);  // mode restoring`

Example 3	`setNonetMode();`
	`setRFmode(0);`
	`setRFchannel(52);`
	`runRFPGM();`
	`reset();  // Reset (for continuing without RFPGM only)`
	`// Restoring is not necessary here`

setupRFPGM

Function

Setup RFPGM parameters

Purpose

Configure behavior for RFPGM invoking and termination

Syntax

`void` **`setupRFPGM(x)`**

Parameters

`uns8 x:` Factory default: 0x80

bit	7	6	5	4	3	2	1	0
	RFPGM termination by MCU pin(s)	RFPGM termination ~1 min after reset	0	RFPGM enable	0	0	0	0

bit 4: RFPGM invoking by reset. H – enabled, L – disabled (default). This bit operates like `enableRFPGM` / `disableRFPGM` functions.
bit 6: RFPGM termination automatically ~1 minute after reset. H – enabled, L – disabled (default)
bit 7: RFPGM termination by MCU pins RA5 or RB4. H – enabled (default), L – disabled.

- C5 for TR modules in SIM format, e.g. TR-52D
- Q11 or Q12 for TR-54D

Return value

–

Output values

OS is modified and setup values are applicable anytime later.

Preconditions

–

Remarks

RFPGM invoking by `runRFPGM()` is unconditional, independent on parameter `x`
RFPGM termination by IQRF IDE is unconditional, independent on parameter `x`

Side effects

–

See also

`runRFPGM, enableRFPGM`

Example 1

```
setupRFPGM(0x10);     // RFPGM entered:   after reset or runRFPGM
                      // RFPGM abandoned: by End RFPGM button only
```

Example 2

```
setupRFPGM(0x90);     // RFPGM entered:   after reset or runRFPGM
                      // RFPGM abandoned: by C5 pin or End RF PGM button only
```

Example 3

```
setupRFPGM(0xD0);     // RFPGM entered:   after reset or runRFPGM
                      // RFPGM abandoned: by C5 pin or End RFPGM button or
                                          automatically ~1 min after reset
```

Documentation and Information

1 IQRF OS User's guide www.iqrf.org/weben/downloads.php?id=155
2 **RAM map** and **EEPROM map**, IQRF OS User's guide, Appendix 1 [1]
3 **IQRF** website www.iqrf.org
4 **IQMESH** specification www.iqmesh.org/iqmesh
5 **SPI** specification www.iqrf.org/weben/downloads.php?id=85
6 **IQRF support** support@iqrf.org
7 **TR-52D** datasheet www.iqrf.org/213
TR-54D datasheet www.iqrf.org/220
8 **PIC16LF1938** datasheet: www.iqrf.org/214
9 **IQRF IDE:** www.iqrf.org/weben/downloads.php?id=86
10 **Examples** (included in the StartUp Package): www.iqrf.org/weben/downloads.php?id=112

If you need a help or more information please contact IQRF support [6]. A lot of information is also available in the IQRF OS User's guide [1] and on the IQRF home page [3].

Document revision

- 120810 SPI description precised (64 B packets), `setRFmode` enhanced, `calibrateTimer` obsolete, some minor improvements, side effects updated.
- 120425 Chapter Documentation and Information revised. Preliminary.
- 120403 checkRF Remarks changed. Preliminary.
- 120322 Preliminary release,for TR-5xD with OS v3.01D. Side effects are not updated.

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