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IceWings™ Evaluation Board (EVB)

2x4 RF Transceiver Card plus Front End

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FR1 IceWings 2T4R

IceWings is a 4T4R transceiver IC and depending on the FEM design it can be used in any number of variations of with different number of transmitter or receivers and covering different frequency bands. The FR1 IceWings Eval board which this document is about, contains a FEM design to achieve a 2T4R system covering the FR1 frequency range of 3400-3600MHz.

The SW to drive FR1 IceWings 2T4R as a standalone board is also covered in the section "FR1 IceWings: SW for the evaluation" on page 13.

The key features of IceWings as shown below.

- Quad Tx/Rx, Analog RF technology
- 4 Wide-band single-ended RF inputs covering RF ranges of 600MHz to 7.2GHz
    - Port 1: 600MHz-965MHz
    - Port 2: 1400MHz-2700MHz
    - Port 3: 3300MHz-5200MHz
    - Port 4: 5200MHz-7125MHz
- Reduces the number of RF switches in multi band designs
- Integrated LNA and PA Pre-amp
- FR1 support: 5/10/15/20/40/50/60/80/100/160/200/300/400 MHz Channel BW
- FR2 support: 400MHz, IF frequency 3.3GHz-7.12GHz
- Analog IQ interface with Baseband SoC
- Wide Band 4 RX paths can be used for DPD observation paths reducing complexity in TDD modes
- Integrated 2 Low phase noise fractional synthesizers supporting TDD, FDD and two 2x2 in TDD
- Sub-1W Power consumption for TDD 4x4 Transceiver

Please refer to the IceWings datasheet if you require additional information regarding the IceWings.

FR1 IceWings 2T4R: Block Diagram

The functional block diagram of FR1 IceWings 2T4R is described below:
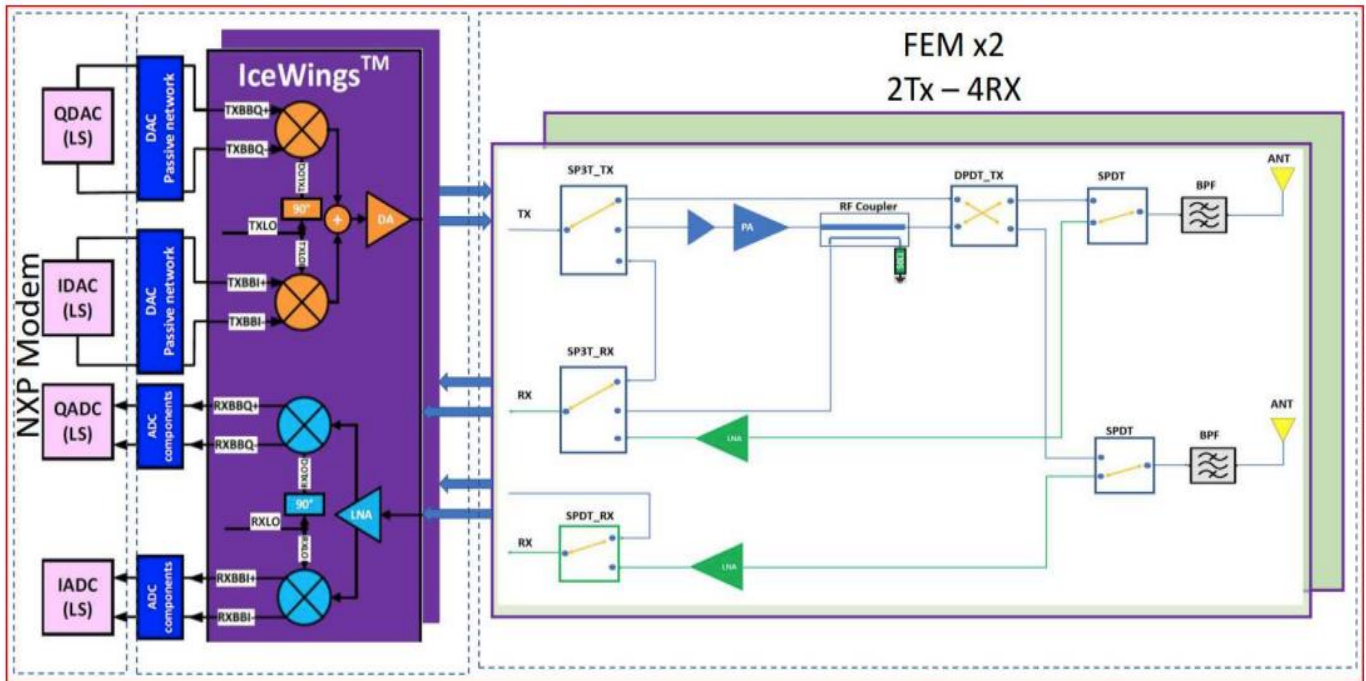

Figure 1: FR1 IceWings 2T4R Functional Block Diagram.

FR1 IceWings 2T4R: System Power Block

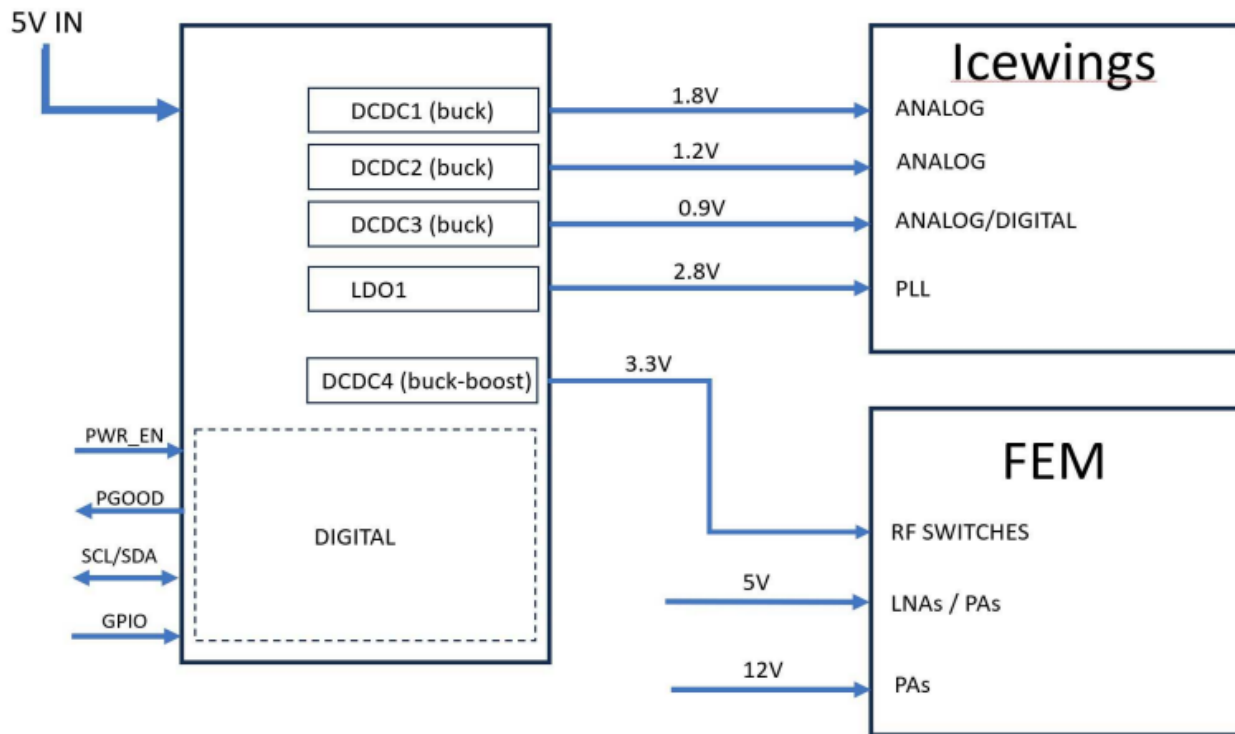The FR1 IceWings 2T4R system power block is described below:

Figure 2: FR1 IceWings power block.

FR1 IceWings 2T4R requires five power supplies: 5V, 3.3V, 1.8V, 1.2V, and 0.8V. The 5V and 3.3V supplies are used for the external RF Front-End components (PAs, LNAs and switches).

FR1 IceWings 2T4R: FEM Components

The Bill of Material (BOM) is available upon request. A short list of the FEM components is provided below (RF components and ICs):

Name	Description	Part Number	Manufacturer
Power Amplifier Driver	RF Amplifier 3.3-4.2GHz NF 1.1dB Gain 22dB 3.3-5.0V	QPL9097TR7	Qorvo
Power Amplifier	IC PWR AMP 3.3GHZ-3.8GHZ 4.75-5.25V LGA16	SKY66520-11	Skyworks
Switch	IC SW SP3T 0.1-8.0GHz 50 OHM 2.5-4.8V QFN12	SKY13373-460LF	Skyworks
	IC SW RF SPDT 0.1-7.2GHz 50OHM 2.3-4.8V QFN12	SKY13918-397LF	Skyworks
Low Noise Amplifier	IC BROADBAND LOW-NOISE AMPLIFIER 400-6000MHZ 5.5V DFN8	SKY67183-396LF	Skyworks
Filter	Signal Conditioning 3.4-3.6GHz BAW Filter	QPQ3500SR	Qorvo
Coupler	IC DIRECTIONAL COUPLER 20DB 2300-3700MHZ 0805	DC2337J5020AHF	Anaren.Inc
RF Antenna	CONN U.FL RCPT STR 50 OHM SMD	U.FL-R-SMT(01)	Hirose Electric Co Ltd

Table 1: FEM components list

FR1 IceWings 2T4R: IF Signals

The IF signals are coming through a 50 ohms SMP connector: these are differential in phase (I) and quadrature (Q) inputs and outputs signals.

These IQ signals are:

- Output signals:
    - I_OUT1+ / I_OUT1- ➔ J5/J4
    - Q_OUT1+ / Q_OUT1- ➔ J1/J3
    - I_OUT2+ / I_OUT2- ➔ J8/J13
    - Q_OUT2+ / Q_OUT2- ➔ J6/J7
    - I_OUT3+ / I_OUT3- ➔ J11/J12
    - Q_OUT3+ / Q_OUT3- ➔ J9/J34
    - I_OUT4+ / I_OUT4- ➔J15/J16
    - Q_OUT4+ / Q_OUT4- ➔J13/J14
- Input signals:
    - I_IN1+ / I_IN1- ➔J21/J22
    - Q_IN1+ / Q_IN1- ➔ J23/J24
    - I_IN2+ / I_IN2- ➔ J19/J20
    - Q_IN2+ / Q_IN2- ➔ J17/J18
    - I_IN3+ / I_IN3- ➔ J29/J30
    - Q_IN3+ / Q_IN3- ➔ J31/J32
    - I_IN4+ / I_IN4- ➔ J28/J27
    - Q_IN4+ / Q_IN4- ➔ J26/J25

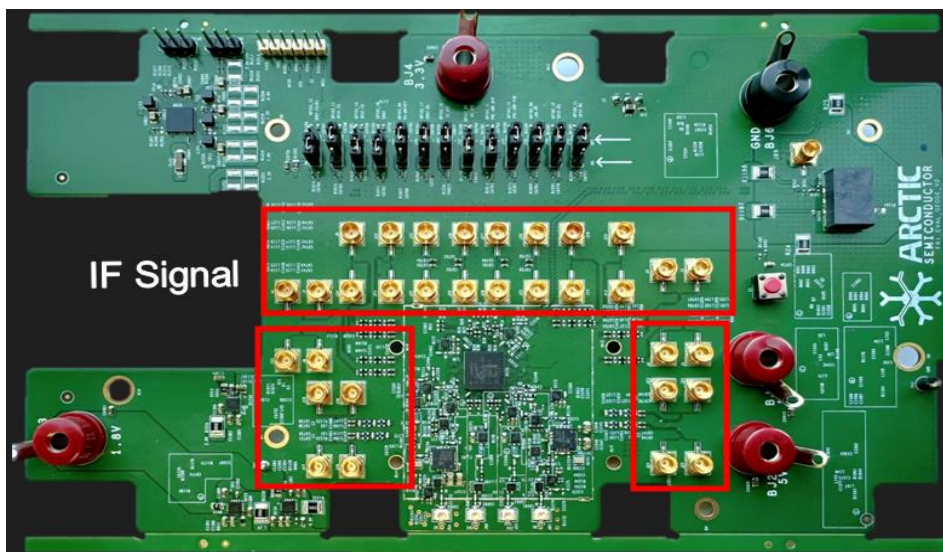These signals can be accessed on the FR1 IceWings 2T4R board.

Figure 3: IF signals

FR1 IceWings 2T4R: GPIO Signals
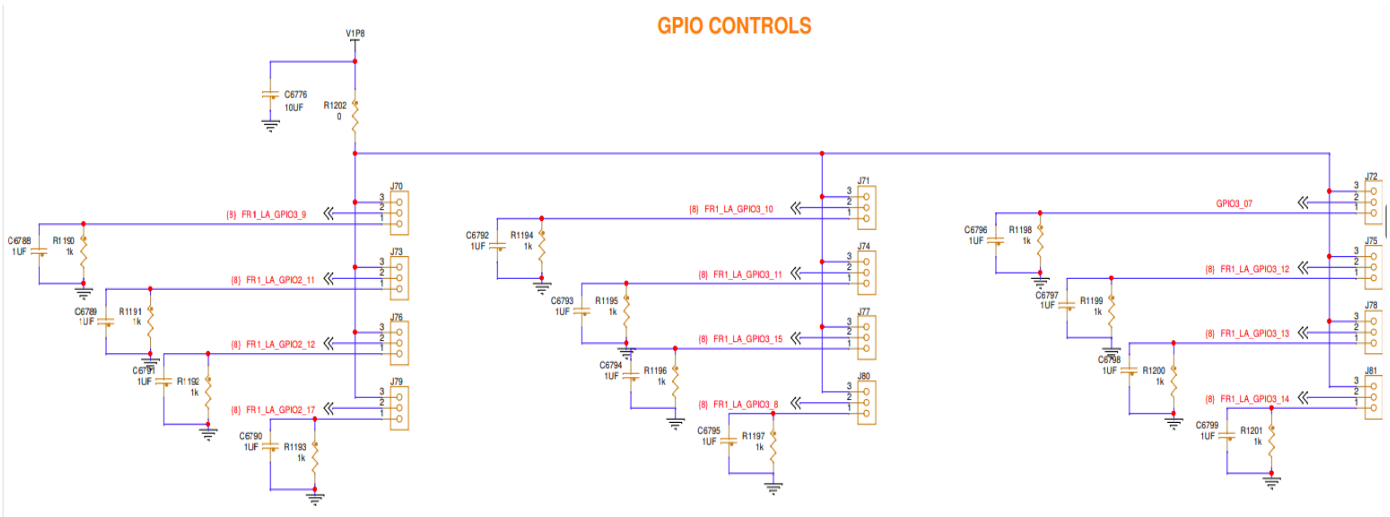
The GPIO controls are connected to heads shown below.

Figure 4: GPIO control

Figure 5: GPIO control headers

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The FEM components are controlled by jumper to turn the GPIO on and off. The table below shows the truth table for the GPIO controls.

TX/RX	Mode	GPIO3_13	GPIO3_14	GPIO3_12	GPIO3_10	GPIO3_11	GPIO3_15	GPIO3_8	GPIO3_07	GPIO3_16	GPIO3_9	GPIO2_11	GPIO2_12	GPIO2_17
		SP3T_V1_TX	SP3T_V2_TX	SP3T_V1	SP3T_V2	TX_LNA_VBYP	TX_LNA_VSD	PA_EN	RX_OFF	TX_OFF	RX_LNA_EN	SP3T_V1_RX	SP3T_V2_RX	SPDT_CTRL_RX
TX	4 (Bypass)	0	1	1	1	0	1	0	1	0	1	0	0	0
	3 (Driver_Off)	1	0	0	1	0	0	0	1	0	1	0	0	0
	2 (Max_Power)	1	0	0	1	0	0	1	1	0	1	0	0	0
RX	8 (Rx_On)	0	0	1	0	0	1	0	0	1	0	1	1	0
	12 (DPD)	1	0	0	0	0	0	1	0	0	1	1	0	0

Table 2: GPIO truth table

The FR1 IceWings Eval board supports 4 modes to operate for TX and 2 modes for RX. The modes are explained below:

TX modes:

- Mode 1: TX off

- Mode 2: Max power, this means that the LNA and PA are both turn ON.

- Mode 3: Driver_Off, only the LNA (as the pre-diver) is ON, while PA is in a bypass mode.

- Mode 4: Bypass, LNA and PA are bypassed, the TX output of IceWings is directly connected.

RX modes:

- Mode 8: RX_On, turn ON the RX path.

- Mode 12: closed-loop DPD, where IceWings RX is used as the observation path for DPD purposes.

FR1 IceWings 2T4R used as a "standalone" board

When using as a "standalone" board, the board is connected directly without using any interface board.

FR1 IceWings 2T4R: communication overview

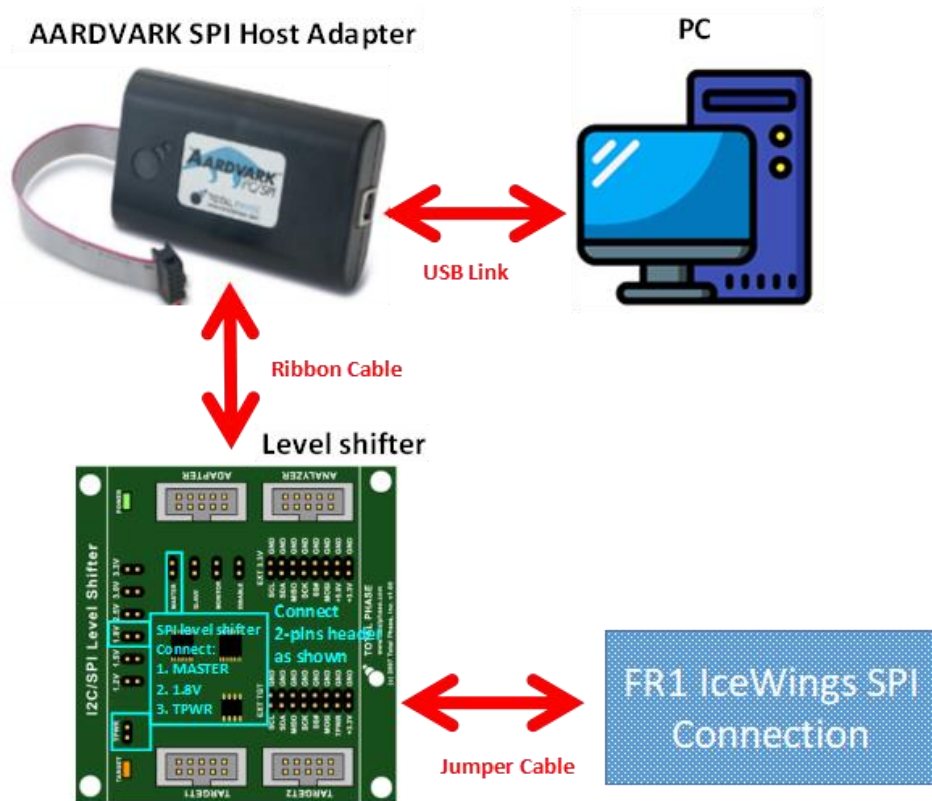The figure below describes the system and how it should be connected:

Figure 7: Communication overview.

The EVB is controlled by the following components:

- USB AARDVARK SPI Host Adapter connected to a PC.
- Level shifter board:
    o Translation to 1.8V polarity for EVB.
    o Note the 2-pins headers settings on Figure 6: they must be set the exact same way than described here.
    o It is connected through a cable to the AARDVARK and through SPI headers on FR1 IceWings 2T4R.

System ready to be used: HW configuration

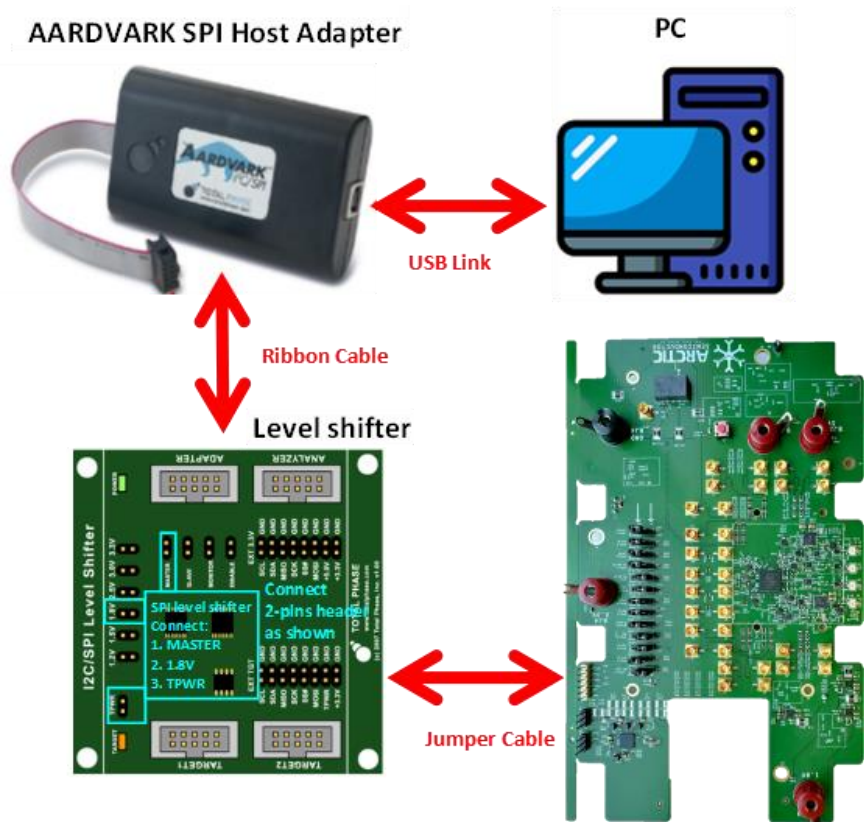The system will look like the picture shown below when all boards are connected and ready to use:

Figure 8: System overview when everything is connected.

After connecting the FR1 IceWings 2T4R, the SPI and power supplies, the board can be powered-up. Before programming, it is recommended to reset the board by pressing down the reset button shown here.
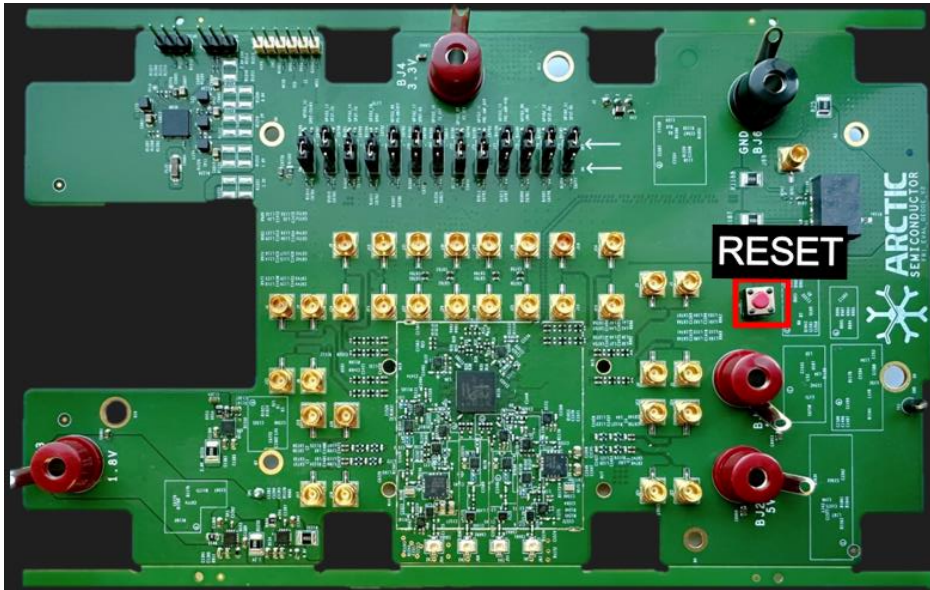

Figure 9: FR1 IceWings 2T4R need to reset before starting the programming.

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FR1 IceWings: SW for the evaluation

This section will describe briefly how to setup the SW used to communicate and program IceWings.

SW: before starting

Each customer has access to a "shared folder": all required documents and drivers are available there. Make sure to download the driver before running the IceWings EVB software.

In this "shared folder", see the picture below that shows the full directory after extraction -, where the **IceWingEV.exe** is located in the **"Release"** folder. Please see example 1 and 2 for more information on how to run commands in receiver and transmitter modes.
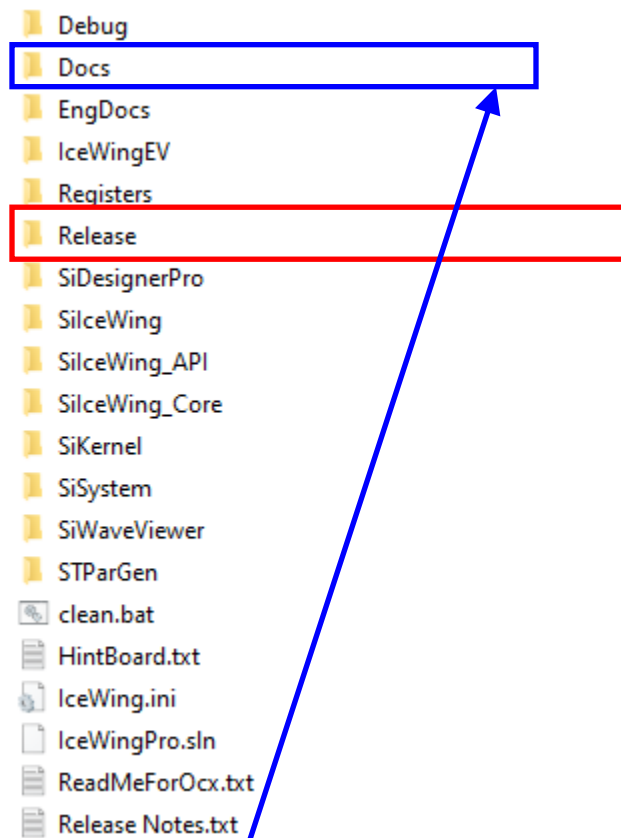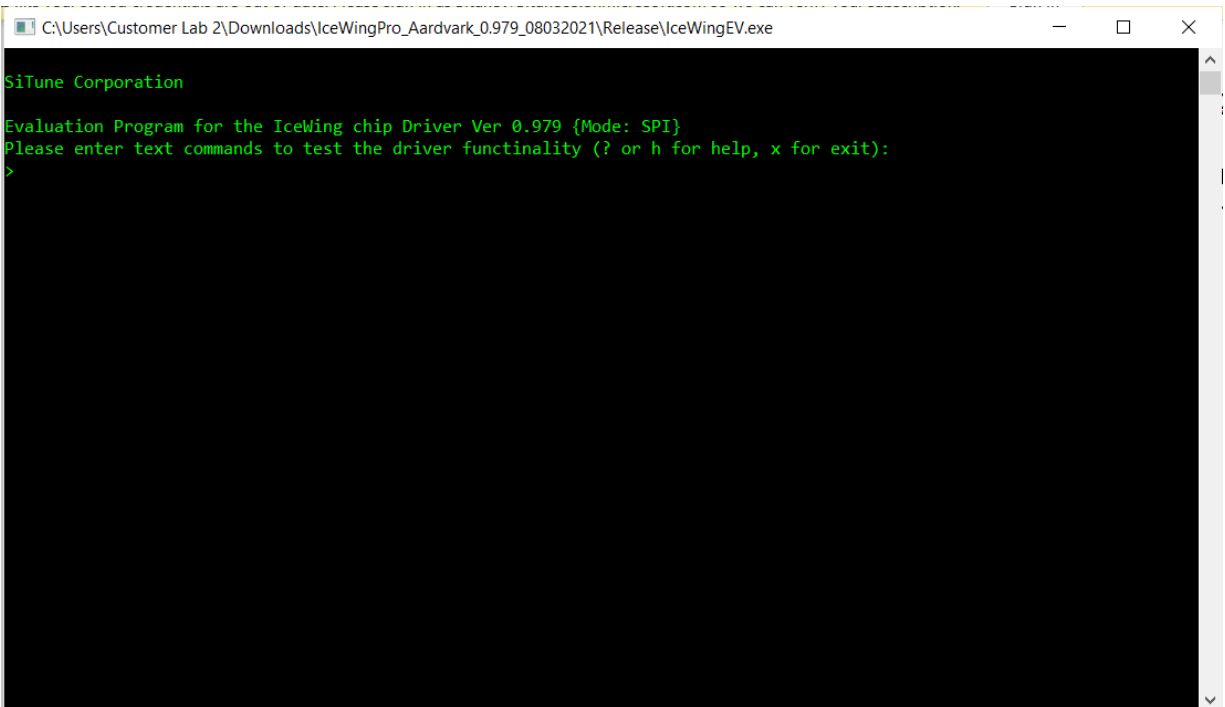

Figure 10: SW directory.

The directory "**Docs**" has documented that help understand how to run the APIs of the SW.

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Running the Evaluation Program

This section explains the sequence of commands that should be applied to IceWings.

After installing and setting up the evaluation board and connecting the SPI connectivity to the host system, the Evaluation Program (*IceWingEV.exe*) located in the "**Release**" folder should be run. The resulting console should look like the following picture (note the release version may not match since updates are frequently released):

Figure 11: Console message after starting IceWings evaluation SW.

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Inside the directory "**Docs**" (refer to Figure 10 on page 13), a file named "**IceWings API Reference Manual**" describes all the commands that are available to program IceWings: be aware that some of these commands are "work in progress" and might not be available.
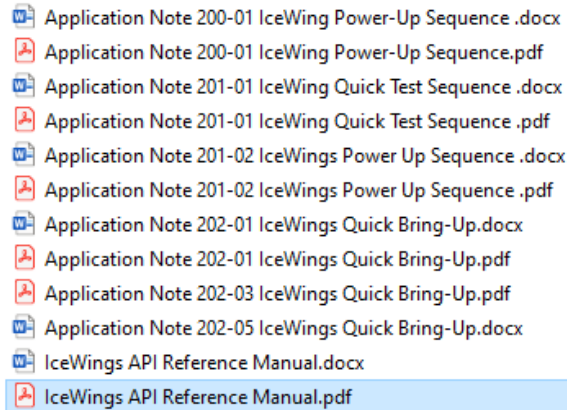

Figure 12: "Docs" directory.

Some of the commands are listed here:

- SiAPISPItest
    - Checking SPI
- SiAPIOpen
    - Initialisations
- SiAPIRXon4tdd
    - Power-up IceWings in RX mode
- SiAPITXon2tdd
    - Power-up IceWings in TX mode
- SiAPITXoff2tdd
    - Power-down the TX mode
- SiAPIRXoff4tdd
    - Power-down the RX mode
- SiAPIRXGain
    - Set the RX gain
- SiAPITXGain
    - Set the TX gain

When using *IceWingEV.exe*, the typed commands must be truncated of the "SiAPI": for example, powering-up RX, the typed command will be RXon4tdd and NOT SiAPIRXon4tdd. The full name SiAPIRXon4tdd is called when dealing with APIs and higher-level SW programming.