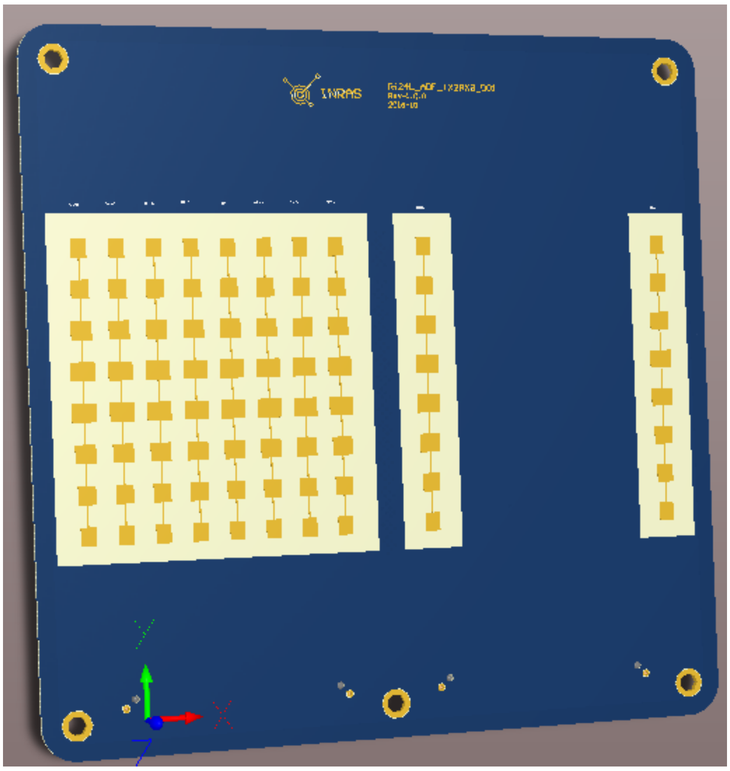
RDL-24G-TX2RX8 Frontend

(User Manual)



Inras GmbH
Altenbergerstraße 69
4040 Linz, Austria
Email: office@inras.at
Phone: +43 732 2468 6384

Linz, Dezember 2016

Contents

1 Document Version

Version	Description	Date	Author
1.0.0	Initial Version	2016-12-01	Andreas Haderer (AnHa)

2 Hardware Version

Board Name	HUID	Revision	Date
Rf24L_ADF_TX2RX8_D01	202	1.0.0	2016-12

3 24-GHz MIMO Frontend for the RadarLog

In Fig. 1 the block diagram of the 24-GHz frontend with two transmit (TX) and eight receive (RX) antennas is shown. The transmit antennas are arranged to enable a virtual array with 15 uniformly spaced antenna elements. According to the block diagram, an ADF5901 (VCO and two output channels) in conjunction with the ADF4159 (fractional-N frequency synthesizer) is used to generate the FMCW transmit signal. The two transmit antennas (TX_1 and TX_2) are fed from the power amplifiers of the ADF5901 and can therefore be activated in an arbitrary sequence. The activation sequence can be programmed with the timing unit and the MIMO sequencer implemented in the FPGA of the RadarLog. Therefore, the angular resolution can be increased by sequentially switching between the two transmit antennas. The receive path is realized with two ADF5904 (four-

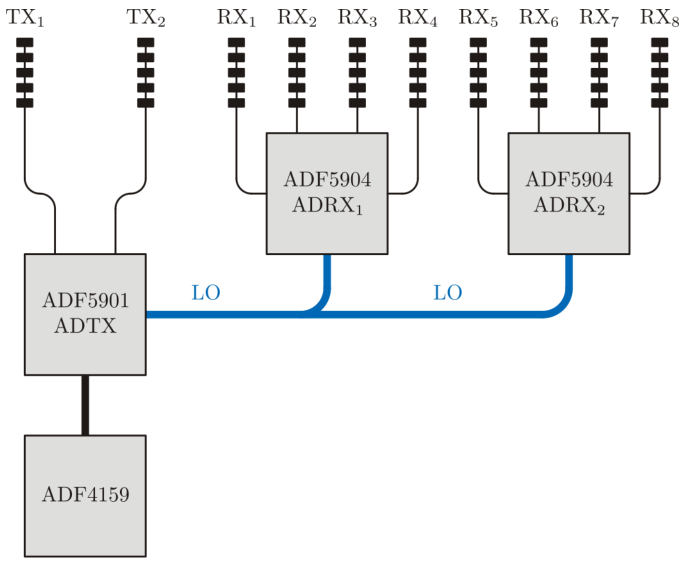


Figure 1: Antenna configuration and naming convention for 24-GHz frontend.

channel RX down-converter). The LO signal for the receiver chips is provided by the ADF5901 and an additional Wilkinson divider. The naming convention for the transmit chip (ADTX) and the receive chips ($ADRX_1$ and $ADRX_2$), depicted in the block diagram, is used in the software framework to access the different devices. This is required to program defined activation sequences for the transmit antennas and to configure the receive path.

4 Features of the 24-GHz FMCW Radar System

The frontend is designed to operate with the RadarLog and can be configured freely to the needs of the application at hand. The main features of the frontend include

- Two TX channels (ADF5901),
- Eight RX channels (two ADF5904) with differential IF outputs,
- Amplitude power control for the transmit channels,

- Differential signals for clock synchronization (input and output of RF clock), and
- Frontend identification and storage of calibration data by means of an integrated EEPROM.

The frontend can be operated with the RadarLog. The RadarLog offers a USB 3.0 interface, which can be used to configure the modes of operation for the FMCW radar system. The timing of the FMCW waveform as well as the FMCW ramp parameters can be programmed and the IF signals can be recorded in real-time. The main features provided by the RadarLog include

- Sampling rates up to 65 MSPS per IF channel,
- FMCW ramp synchronous sampling for precise range-Doppler processing,
- Arbitrarily programmable FMCW timing including non-uniform ramp scenarios,
- MIMO processing with arbitrary antenna activation,
- Configurable signal processing, and
- USB 3.0 interface.

5 Technical Data of the 24-GHz Frontend

In the following sections the mechanical and the electrical parameters of the frontend are summarized. In addition, the antenna arrangement and the beam patterns of the antennas are summarized.

5.1 Mechanical Data

The frontend is built to interface with the RadarLog. In Fig. 2 the dimensions of the board as well as the position of the mounting holes are depicted. In Tab. 1 the dimensions of the frontend and its

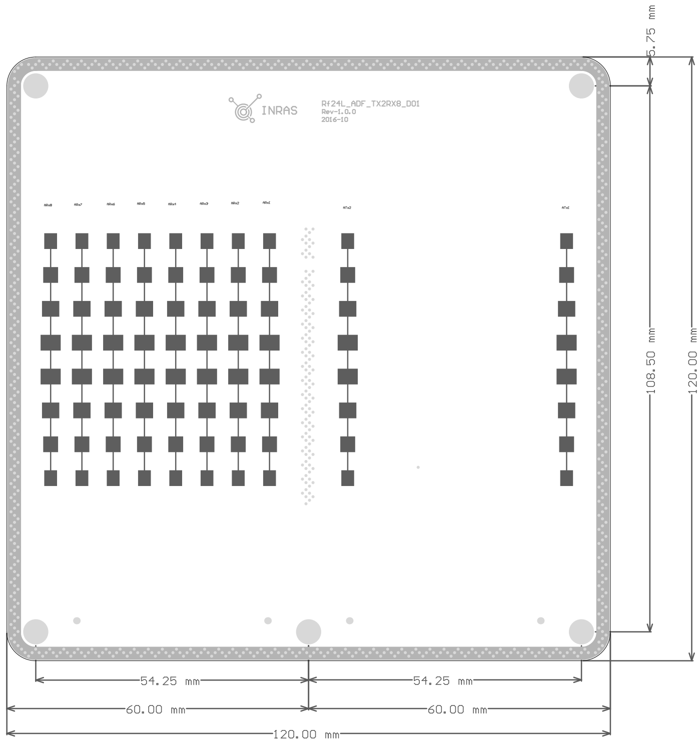


Figure 2: Dimensions of the 24-GHz frontend including the positions of the mounting holes.

weight are summarized. The frontend is very lightweight as no additional heat sink is integrated on the frontend. An Altium template containing the contour and position of the frontend connector

Parameter	Value
Substrate	RO-4350
RF-Substrate thickness	0.25 mm
Dimension x-direction	120 mm
Dimension y-direction	120 mm
Weight frontend	50 g

Table 1: Mechanical parameters of the 24-GHz frontend.

is available on request.

5.2 Antenna Configuration and Positions

The positions of the transmit and receive antennas are shown in Fig. 3. The origin of the Cartesian coordinate system is located at the first transmit antenna TX_1. In Tab. 2 the x-coordinates of the antennas are summarized. All mentioned positions are in mm. The transmit antennas are spaced by

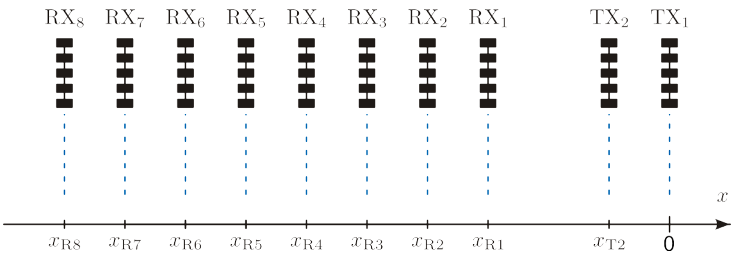


Figure 3: Antenna positions of the 24-GHz RF frontend.

$\frac{7\lambda_0}{2}$. In this case a virtual uniformly spaced array with one overlapping element can be generated by switching sequentially between the TX antennas. In Fig. 4 the virtual array with one overlapping element is depicted. The overlapping element can be used to implement motion compensation algorithms.

TX Antenna	x-Position (mm)	RX Antenna	x-Position (mm)
TX_1	0.000	RX_1	-59.067
TX_2	-43.523	RX_2	-65.285
		RX_3	-71.503
		RX_4	-77.720
		RX_5	-83.938
		RX_6	-90.155
		RX_7	-96.373
		RX_8	-102.591

Table 2: Positions of transmit and receive antennas.

The receive and transmit antennas are built by serial fed patch antennas with eight elements, which are fed from the backside of the PCB. In Fig. 5 the realized gain for the E- and H-plane of a single antenna element are shown.

In Tab. 3 the parameters of the antennas are summarized.

	Parameter	Value
G	Realized Gain	13.2 dBi
ΔS	Sidelobe suppression	-18 dB
Θ_H	Horizontal 3 dB beamwidth	76.5°
Θ_V	Vertical 3 dB beamwidth	12.8°

Table 3: Antenna parameters.

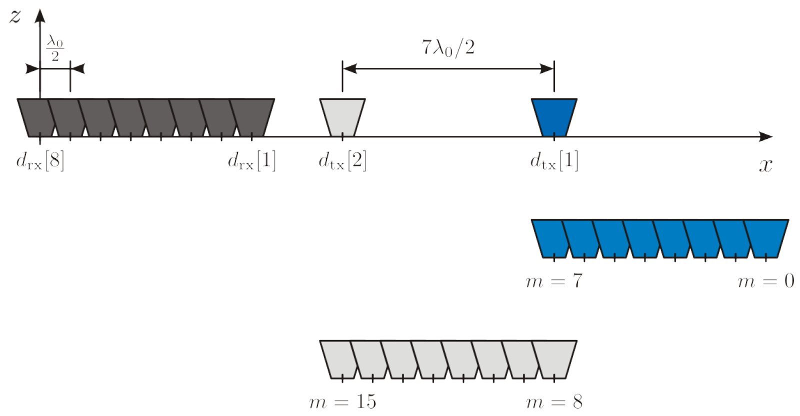


Figure 4: Virtual array with one overlapping element for motion compensation.

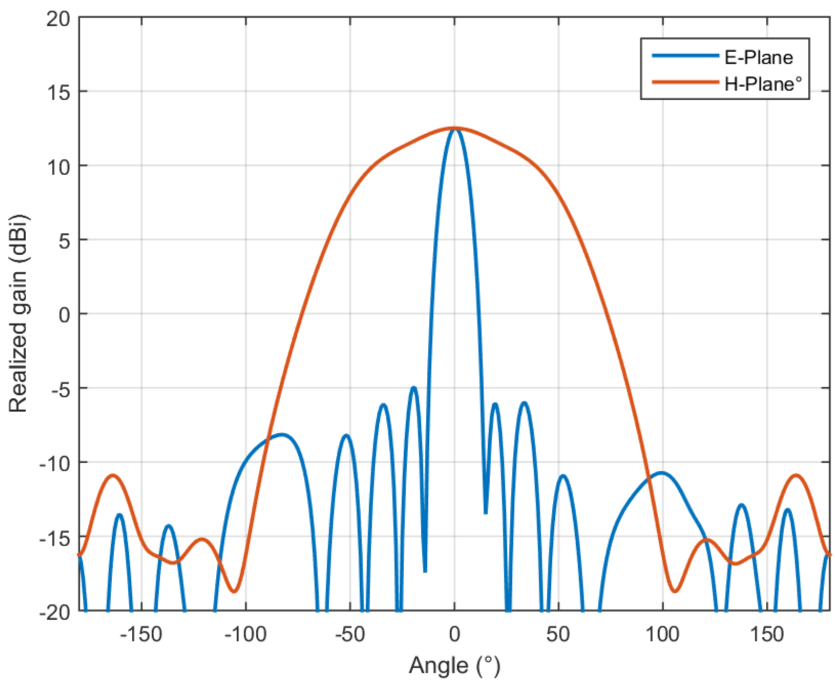


Figure 5: Realized gain for the antenna elements at 24.125 GHz.

5.3 Electrical Parameters

In Tab. 4 the electrical parameters of the frontend are specified.

	Parameter	Condition	Min	Typ	Max	Unit
V_{C1}	Supply Voltage C1	-	3.2	3.3	3.4	V
V_{C2}	Supply Voltage C2	not used	4.9	5.0	5.1	V
V_{C3}	Supply Voltage C3	-	3.2	3.3	3.4	V
I_{C1}	Supply Current C1	@ 3.3 V / all TX enabled	-	-	200	mA
I_{C2}	Supply Current C2	@ 5.0 V	-	-	-	mA
I_{C3}	Supply Current C3	@ 3.3 V	-	-	600	mA
P_t	Max RF Output Power			8		dBm
	TX ON/OFF Isolation		-	30		dB
f_t	Transmit Frequency		24	-	24.25	GHz
	TX-RX Isolation		-	TBD		

Table 4: Electrical parameters of the 24-GHz frontend.

For a more detailed description of the electrical parameters refer to the data sheet of the transceivers (ADF5901 and ADF5904) from Analog Devices.

6 List of Abbreviations

FIFO	...	First In First Out
FMCW	...	Frequency-Modulated Continuous Wave
FPGA	...	Field Programmable Gate Array
MMP	...	Memory Mapped Peripheral
MIMO	...	Multiple Input Multiple Output
MISO	...	Master In Slave Out
MOSI	...	Master Out Slave In
RF	...	Radio Frequency
RX	...	Receive
SEQTRIG	...	Sequence Trigger Unit
SPI	...	Serial Peripheral Interface
TX	...	Transmit
USPI	...	Universal Serial Peripheral Interface