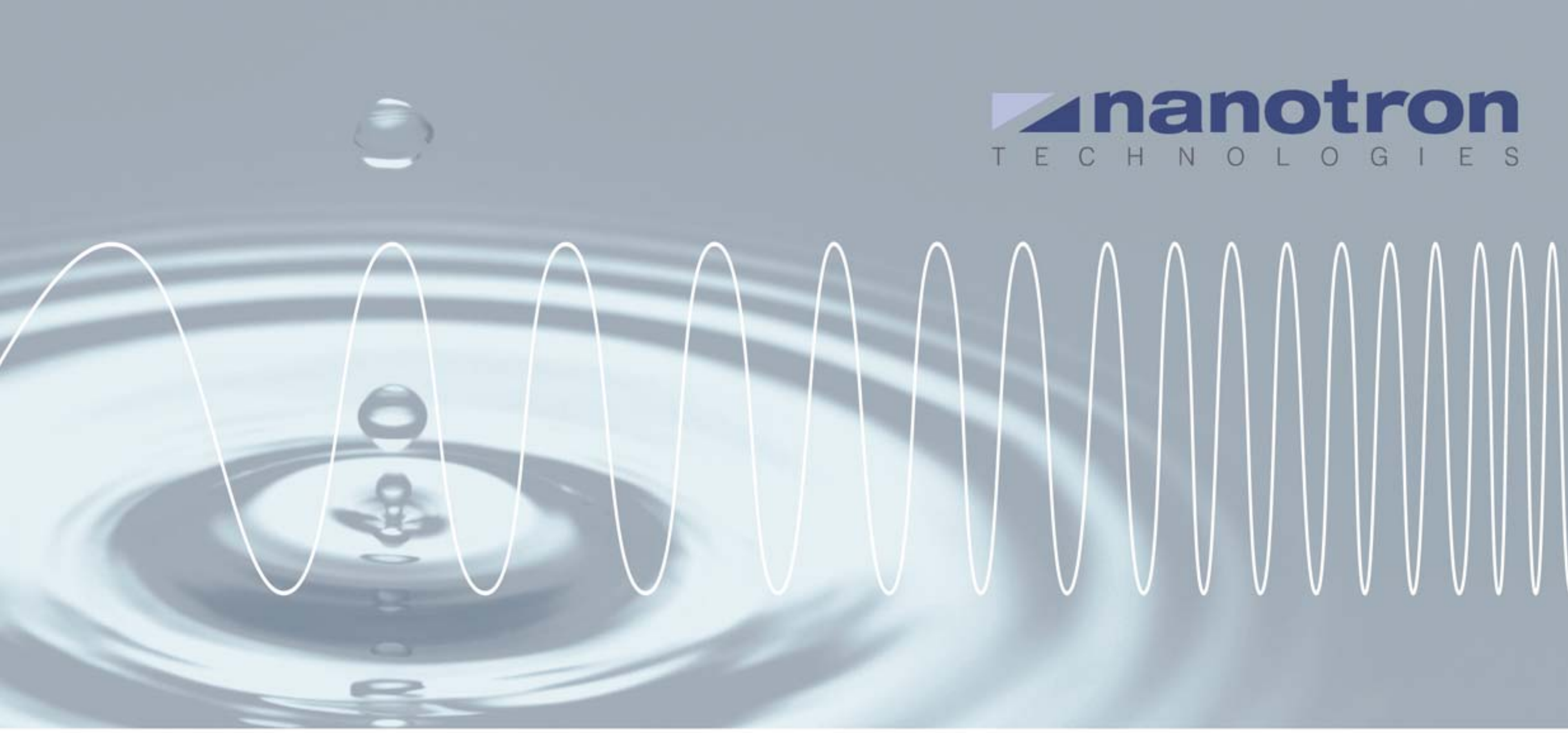

FCC Required Exhibit 12

nanoPAN 5375 RF Module
User Manual (UserMan)

Version 1.0

NA-09-0256-0008-1.0

FCC ID: SIFNANOPAN5375V1

Document Information

Document Title:	nanoPAN 5375 RF Module User Manual (UserMan)
Document Version:	1.0
Published *(yyyy-mm-dd)*:	2009-03-18
Current Printing:	2009-3-18, 11:52 am
Document ID:	NA-09-0256-0008-1.0
Document Status:	Released

Disclaimer

Nanotron Technologies GmbH believes the information contained herein is correct and accurate at the time of release. Nanotron Technologies GmbH reserves the right to make changes without further notice to the product to improve reliability, function or design. Nanotron Technologies GmbH does not assume any liability or responsibility arising out of this product, as well as any application or circuits described herein, neither does it convey any license under its patent rights.

As far as possible, significant changes to product specifications and functionality will be provided in product specific Errata sheets, or in new versions of this document. Customers are encouraged to check the Nanotron website for the most recent updates on products.

Trademarks

nanoNET© is a registered trademark of Nanotron Technologies GmbH. All other trademarks, registered trademarks, and product names are the sole property of their respective owners.

Life Support Policy

These products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. Nanotron Technologies GmbH customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Nanotron Technologies GmbH for any damages resulting from such improper use or sale.

Electromagnetic Interference / Compatibility

Nearly every electronic device is susceptible to electromagnetic interference (EMI) if inadequately shielded, designed, or otherwise configured for electromagnetic compatibility.

To avoid electromagnetic interference and/or compatibility conflicts, do not use this device in any facility where posted notices instruct you to do so. In aircraft, use of any radio frequency devices must be in accordance with applicable regulations. Hospitals or health care facilities may be using equipment that is sensitive to external RF energy.

With medical devices, maintain a minimum separation of 15 cm (6 inches) between pacemakers and wireless devices and some wireless radios may interfere with some hearing aids. If other personal medical devices are being used in the vicinity of wireless devices, ensure that the device has been adequately shielded from RF energy. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

CAUTION! Electrostatic Sensitive Device. Precaution should be used when handling the device in order to prevent permanent damage.

FCC User Information

Statement according to FCC part 15.19:

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Statement according to FCC part 15.21:

Modifications not expressly approved by this company could void the user's authority to operate the equipment.

RF exposure mobil:

The internal / external antennas used for this mobile transmitter must provide a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter."

Statement according to FCC part 15.105:

This equipment has been tested and found to comply with the limits for a Class A and Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation and against harmful interference when the equipment is operated in a commercial environment.

This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions as provided in the user manual, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his or her own expense.

If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to connected.
- Consult the dealer or an experienced technician for help.

Table of Contents

Intentionally Left Blank

1 Overview

The *nanoPAN 5375 Module* integrates all the required components for a complete RF module based on Nanotron's innovative *nanoLOC* TRX *Transceiver*. At only 29 mm by 15 mm and less than 4 mm thick, this RF module includes a balun, a band pass filter, a set of clock crystals, a 20 dBm power amplifier, as well as the *nanoLOC* chip and required circuitry. Figure 1 below shows the *nanoPAN 5375 RF Module* with a shielding cap and label.

Scale 3:1

Figure 1: nanoPAN 5375 RF Module – top showing shielding cap

Figure 2 below shows the pad side of the *nanoPAN 5375 RF Module* with pins 1 and 32 indicated, as well as dimensions.

Scale 3:1

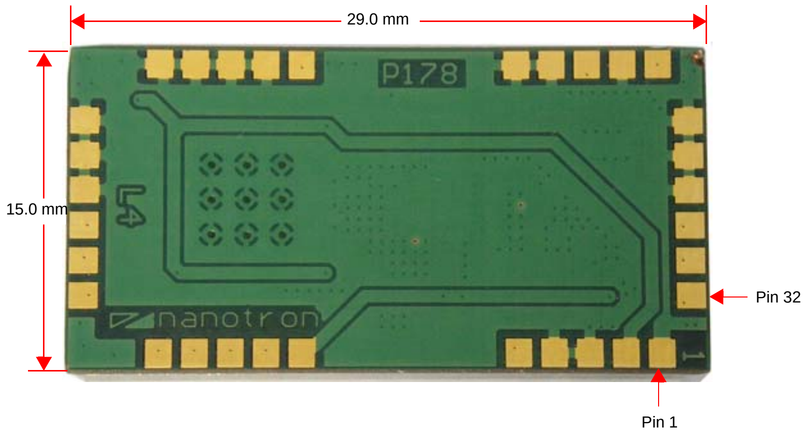

Figure 2: nanoPAN 5375 RF Module – pad side

1.1 Key Components

Figure 3 below shows the key components of the *nanoPAN 5375 RF Module*.

Scale 3:1

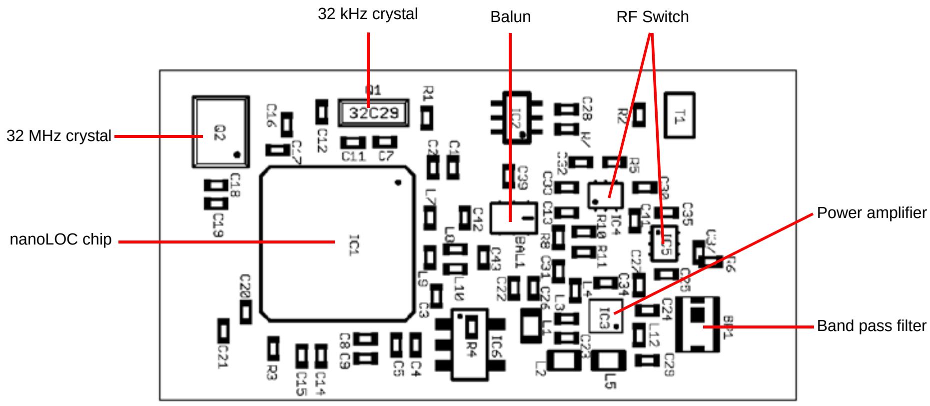

Figure 3: nanoPAN 5375 RF Module – key components

Table 1: Key components

Component	Description
nanoLOC TRX Transceiver	The *nanoLOC* chip supports a freely adjustable center frequency with two sets of 3 non-overlapping frequency channels, as well as 14 overlapping frequency channels, all within the 2.4 GHz ISM band. These channels provide support for multiple physically independent networks and improved coexistence performance with existing 2.4 GHz wireless technologies. Data rates are selectable from 2 Mbps to 250 kbps. Due to the chip's unique chirp pulse, adjustment of the antenna is not critical. This significantly simplifies the system's installation and maintenance ("pick and place"). A sophisticated MAC controller with CSMA/CA and TDMA support is included, as is Forward Error Correction (FEC) and 128 bit hardware encryption. To minimize software and microcontroller requirements, the *nanoLOC* chip also provides scrambling, automatic address matching, and packet retransmission. Integrated into the *nanoLOC* chip is a Digital Dispersive Delay Line (DDDL). This is responsible for distinguishing between two possible incoming signals generated by another *nanoLOC* chip. These are either an Upchirp or a Downchirp, both of which have the same center frequency and the same bandwidth. The difference between an Upchirp and a Downchirp occurs only in the phase information of the complex spectrum. This phase information is enough for the DDDL to compress a pulse at one output port and expand it at the other (that is, to extend the incoming signal to the doubled duration). In this way the DDDL acts like a matched filter for one of the possible transmitted pulses.
Matching circuits (Balun)	At the RF interface of the *nanoLOC* chip, a differential impedance of 200 Ω exists which is matched to the asymmetrical 50 Ω impedance of the antenna port by a 200 Ω to 50 Ω RF balun. Additional external components at the RF interface have a power and noise matching function that allows a sharing of the antenna without an external TX/RX – RF switch.
ISM band pass filter	For an improved robustness against out-of-band inferences, an ISM band pass filter is connected at the antenna port.
32.768 kHz and 32 MHz quartz crystals	The 32.768 kHz quartz is used for the Real Time Clock oscillator. The 32 MHz quartz works with the internal oscillator circuitry of the *nanoLOC* chip.
RF switch	This switch is actually two devices that are used to switch the RX / TX paths between receive and transmit mode.
Power amplifier	This amplifier gives the module high efficiency, high gain, and a high output power of 20 dBm.

2 Absolute Maximum Ratings

Table 2: Absolute maximum rating

Parameter	Value	Unit
Min. operating temperature	-40.0	°C
Max. operating temperature	+85.0	°C
Max. supply voltage (V_{CC})	2.7	V
Max. DC current per I/O pin	2.0	mA

Note: It is critical that the ratings provided in *Absolute Maximum Ratings* be carefully observed. Stress exceeding one or more of these limiting values may cause permanent damage to the *nanoPAN 5375 RF Module*.

3 Electrical Characteristics

3.1 General / DC Parameters

Table 3: General / DC-Parameters

Note	Symbol	Parameter	Condition	Min.	Typ.	Max.	Units
–	T_{op}	Operating temperature	–	-40.0	–	+85.0	°C
–	V_{CC}	Supply voltage	–	2.3	–	2.7	V
2	I_{CC}	Supply current TX	Low power TX Reg 0x00		75.0		mA
2	I_{CC}	Supply current TX	Mid power TX Reg 0x1F		80.0		mA
2	I_{CC}	Supply current TX	Full power TX Reg 0xx3F	–	210.0	–	mA
1	I_{CC}	Supply current RX	Unsync (80/1/1)		51.0		mA
1	I_{CC}	Supply current RX	Sync (80/1/1)		46.0		mA
2	I_{CC}	Supply current	Ready (3)		4.0		mA
2	I_{CC}	Supply current	StandBy (4)		2.5		mA
2	I_{CC}	Supply current	Power Up		750.0		uA
1	I_{CC}	Supply current	PD Pad	550.0	625.0	900.0	µA
1	I_{CC}	Supply current	PD FULL	3.0	3.8	5.0	uA

Note 1: Tested in production @ 2.5 V, Temp= 25°C ± 5°C.
Note 2: Not tested in production. Only by characterization.
Note 3: RX off, TX off, Baseband Clock on.
Note 4: RX off, TX off, Baseband Clock off.

3.2 RF Parameters

Table 4: RF parameters

Note	Symbol	Parameter	Condition	Min.	Typ.	Max.	Units
–	Z_{ant}	Line impedance of antenna signal ANT	–	–	50.0	–	Ω
–	R_{data}	Data rate	–	250.0	–	2000	kb/s
2	P_{sens}	Receiver sensitivity	22/4, FECoff	–	-92.0	-95.0	dBm
2	P_{sens}	Receiver sensitivity	22/4, FECon	–	-95.0	-97.0	dBm
1	P_{sens}	Receiver sensitivity	80/1, FEC 0ff	–	-85	-86	dBm
2	P_{sens}	Receiver sensitivity	80/4, FEC 0n	–	-92	-94	dBm
2	Ptx MIN	Transmit power	TX Reg 0x00	–	-17.5	–	dBm
2	Ptx MID	Transmit power	TX Reg 0x1F	–	6.0	–	dBm
1	Ptx FULL	Transmit power	TX Reg 0x3F	18.0	19.5	–	dBm
1	P_{tx}	Transmit power - 2 harmonics	TX Reg 0x3F	–	-60.0	–	dBm
1	P_{tx}	Transmit power - 3 harmonics	TX Reg 0x3F	–	-65.0	–	dBm

Note 1: Tested in production @ 2.5 V, Temp= 25°C ± 5°C.
Note 2: Not tested in production. Only by characterization.
Note 3: The displayed value is the minimum receive signal power required for BER = 10e-3, which is equivalent to the maximum receiver sensitivity

3.3 Offset Clock Parameters

Table 5: Offset clock parameters

Note	Symbol	Parameter	Condition	Min.	Typ.	Max.	Units
1	f32m	Offset Clock 32.000 MHz	25 °C, 2.5V		0.0		ppm
1	f32k	Offset Clock 32.768 kHz	25 °C, 2.5V		25.0		ppm

Note 1: Tested in production @ 2.5 V, Temp= 25°C ± 5°C.

3.3.1 Nominal Conditions

Table 6 below lists the nominal conditions, except otherwise noted:

Table 6: Nominal conditions

■ T_{junct} = 30°C ■ V_{SSA} = V_{SSD} = GND ■ V_{DDA} = V_{CC} = +2.5 V ■ Transmission / reception @ 250 kbps ■ Nominal frequency bandwidth (TX/RX) B = 22 MHz @ -30 dBr ■ Raw data mode ■ No CRC ■ No FEC ■ No encryption ■ Receiver synchronized ■ Bit scrambling	■ BER = 0.001 during receive mode ■ RF output power (PEP) during transmit phase = 20 dBm EIRP measured during continuous transmission ■ Nominal process ■ All RF ports are impedance matched according to the specification ■ All RF power are measured on the IC terminals (pins) ■ For link distance measurement, two identical *nanoLOC* systems are used

3.4 Digital Interface

Note: Table 7 below lists the parameters and values for the following digital IOs:

- DIIO0, DIIO1, DIIO2, DIIO3
- UCRESET, UCIRQ
- SPITXD, SPIRXD, SPICLK, SPISSN
- /TX_RX
- /PONRESET

Table 7: Digital Interface to Sensor / Actor

Symbol	Parameter	Value	Unit
–	Number of general purpose input/outputs	4	Number
–	Width of each interface	1	Bit
–	Direction	In/Out (bi-directional, open-drain with pull-up	–
–	Type	Programmable	–
C_{IN}	Logic Input Capacitance	2.5	pF
	Input Voltage		
V_{IL}	Low level input voltage (minimum)	0.2 x V_{CC}	V
V_{IH}	High level input voltage (maximum)	0.7 x V_{CC}	V
	Output Voltage		
V_{OL}	Low level output voltage (maximum)	0.3	V
V_{OH}	High level output voltage (minimum)	V_{CC} - 0.3	V
–	Maximum output current	2	mA
R_{UP}	Equivalent pull-up resistance (minimum)[1]	50	kΩ
R_{UP}	Equivalent pull-up resistance (maximum)[1]	193	kΩ
R_{DN}	Equivalent pull-down resistance (minimum)[1]	50	kΩ
R_{DN}	Equivalent pull-down resistance (maximum)[1]	275	kΩ

1. *Can be programmed in nanoLOC TRX. Default is off.*

4 Power Management

4.1 Overview – I_{cc}

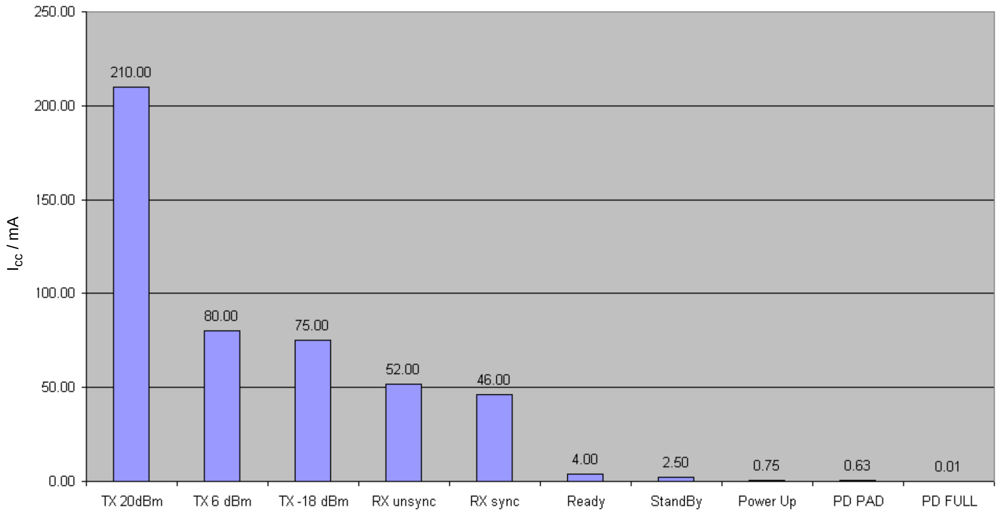

Figure 4: Typical I_{cc} current drain for different operating modes

4.2 Power Down Pad / Power Down Full

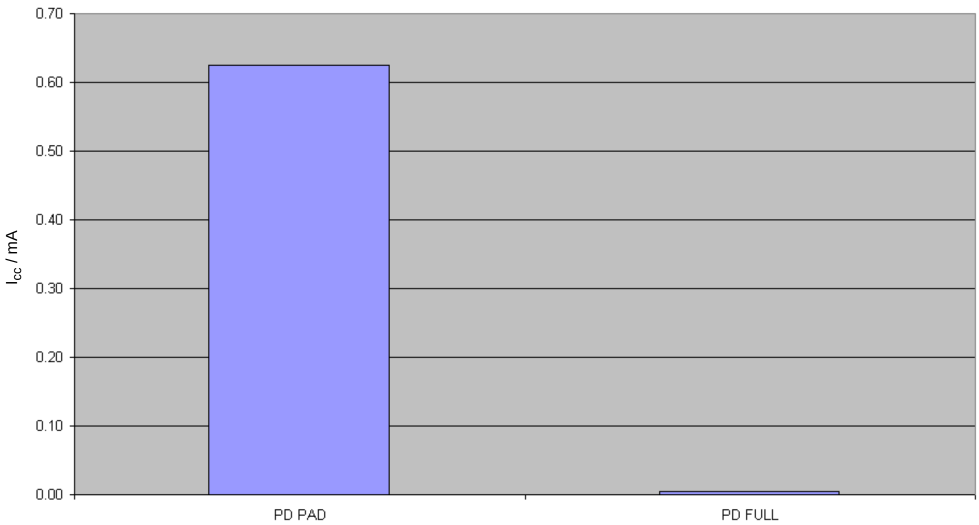

Figure 5: Typical I_{cc} current drain for Power Down Pad / Full

4.3 P_{out} as a Function of Tx Register (Typical)

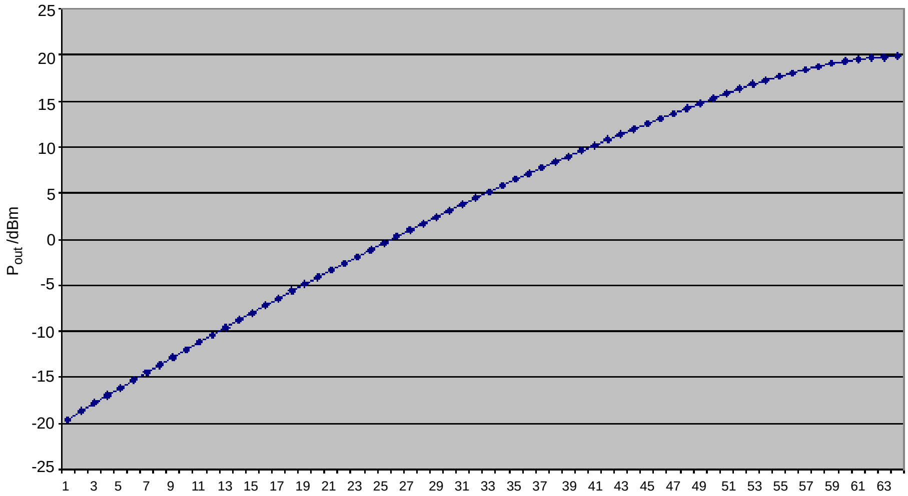

Figure 6: Power management – P_{out} as a function of Tx register (typical)

4.4 I_{cc} as a Function of P_{out} (Typical)

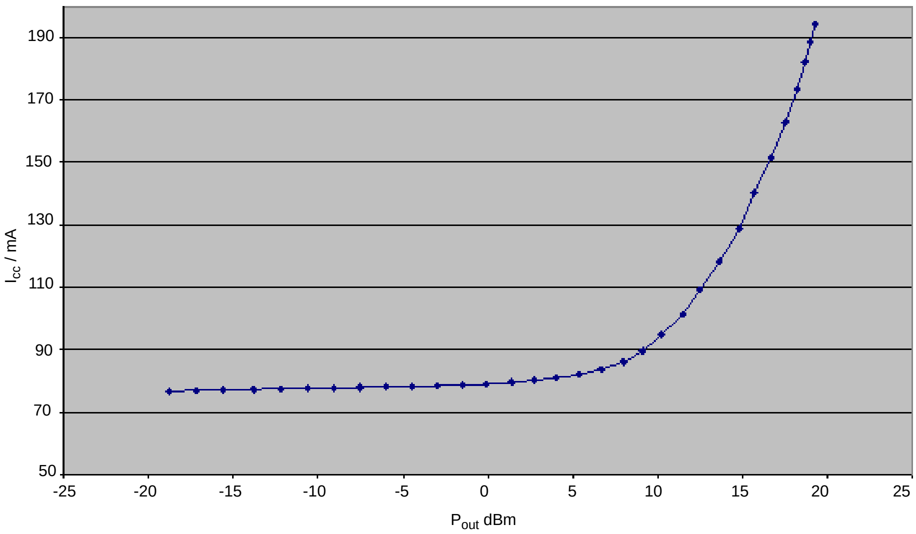

Figure 7: Power management – I_{CC} as a function of P_{out} (typical)

4.5 I_{cc} as a Function of Tx Register (Typical)

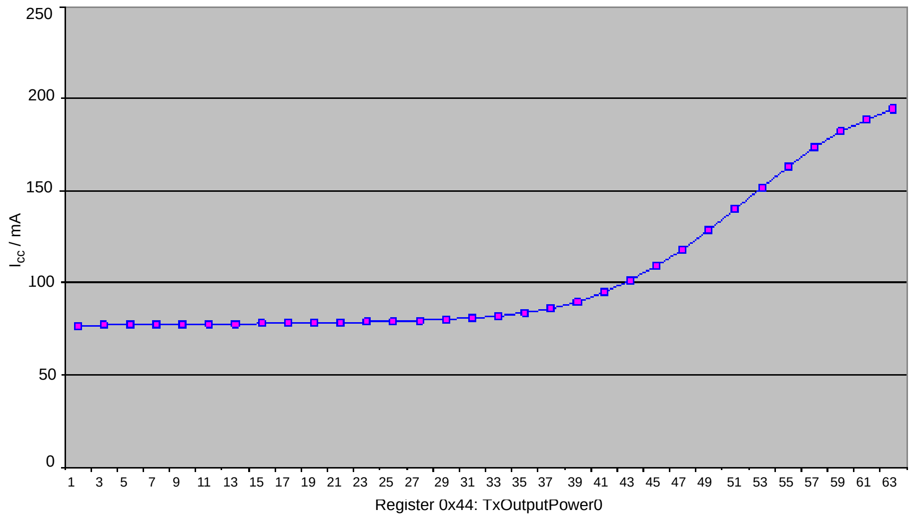

Figure 8: Power management - I_{CC} as a function of Tx register (typical)

5 Module Layout

5.1 Measures

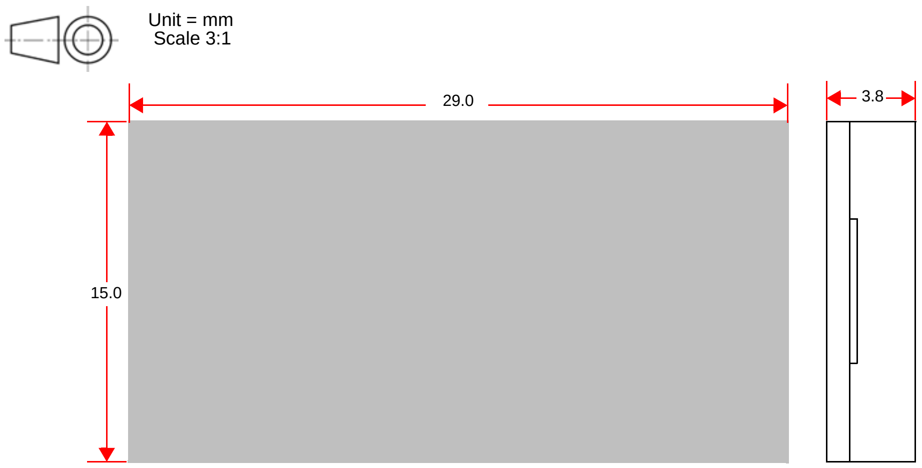

Figure 9: nanoPAN 5375 RF Module – measures

5.2 Pin Layout

Scale 3:1

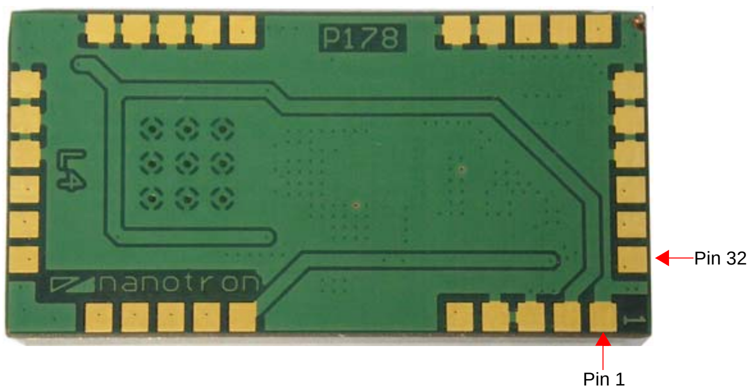

Figure 10: nanoPAN 5375 RF Module – pins (bottom view)

Scale 3:1

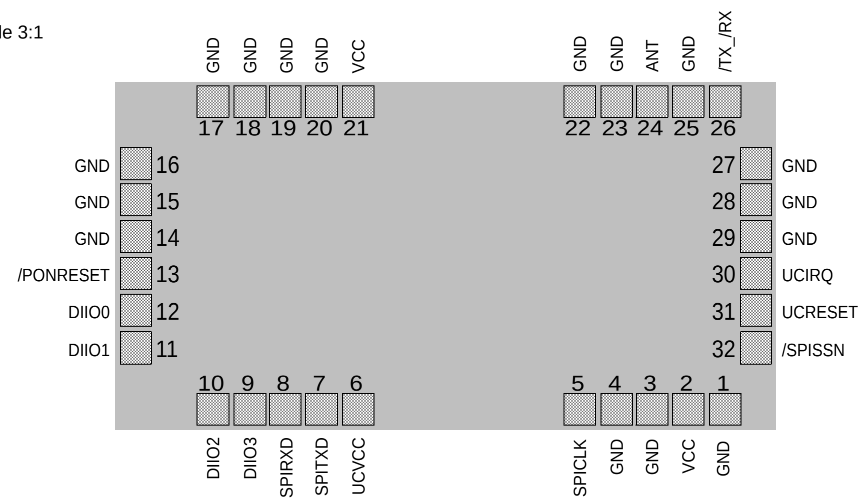

Figure 11: nanoPAN 5375 RF Module – pin layout (bottom view)

Note: See section *5.3: Pin Description* on page 10 for details on the nanoPAN 5375 RF Module pinning.

5.3 Pin Description

Table 8: nanoPAN 5375 RF Module – pin description

Pin	Signal	Description	Direction
1	GND	Ground connection (0Vdc)	–
2	VCC	Positive supply voltage	Power
3	GND	Ground connection (0Vdc)	–
4	GND	Ground connection (0Vdc)	–
5	SPICLK	SPI: CLK[3]	Input
6	UCVCC[1]	Power Supply for µc	Output
7	SPITXD[2]	SPI: TX Transmit Data (MISO)[3]	Output
8	SPIRXD	SPI: RX Receive Data (MOSI)[3]	Input
9	DIIO3[4]	Digital IO pin 3 for nanoLOC chip	Input/Output
10	DIIO2[4]	Digital IO pin 2 for nanoLOC chip	Input/Output
11	DIIO1[4]	Digital IO pin 1 for nanoLOC chip	Input/Output
12	DIIO0[4]	Digital IO pin 0 for nanoLOC chip	Input/Output
13	/PONRESET	Power on reset signal	Input
14	GND	Ground connection (0Vdc)	–
15	GND	Ground connection (0Vdc)	–
16	GND	Ground connection (0Vdc)	–
17	GND	Ground connection (0Vdc)	–
18	GND	Ground connection (0Vdc)	–
19	GND	Ground connection (0Vdc)	–
20	GND	Ground connection (0Vdc)	–
21	VCC	internally connected to V_{CC} (Pin 2)	Power
22	GND	Ground connection (0Vdc)	–
23	GND	Ground connection (0Vdc)	–
24	ANT	50 Ohm RX/TX connection to antenna	Input / Output
25	GND	Ground connection (0Vdc)	–
26	/TX_RX[5]	Status Tx / Rx[6]	Output
27	GND	Ground connection (0Vdc)	–
28	GND	Ground connection (0Vdc)	–
29	GND	Ground connection (0Vdc)	–
30	UCIRQ[7]	Interrupt request for µc	Output
31	UCRESET[8]	Reset for µc	Output
32	/SPISSN[9]	SPI: Slave Select	Input

1. *Should have a pull-down of between 100 kΩ and 1 MΩ if power-down mode is used.*
2. *SPITXD is SPI data output from the module to the microcontroller. This pin is open-drain as default. This pin must have a pull-up to V_{cc} because the pin is driven only when a logical 0 is sent from nanoLOC to the SPI marker. Reconnected value: 100 kΩ. This pin can be programmed as push-pull output. (For more details, see the nanoLOC TRX Transceiver (NATR1) User Guide and the nano-LOC SPI Application Note.)*
3. *nanoLOC TRX is always a SPI slave device.*
4. *This pin should have a Pull-Down to GND, if not used. Recommended value: 1 MΩ*
5. */TX_RX is Open-Drain output. It must have a Pull-Up to UCVCC if used. I_{max}: 2mA.*
6. *Should be used as input signal to a logical input.*
7. *This pin should have a Pull-Up to V_{cc} if used. Recommended value: 1 MΩ. Default is Open-Drain. and can be programmed as Push-Pull. (For more details, see the nanoLOC TRX Transceiver (NATR1) User Guide.)*
8. *This pin should have a pull-up of 75 KΩ and a capacitor of 1 nF to GND if used as controller input signal.*
9. *This pin should have a Pull-Up to V_{cc} if used. Recommended value: 1 MΩ*

6 Soldering Information

6.1 Recommended Temperature Profile for Lead Free Reflow Soldering

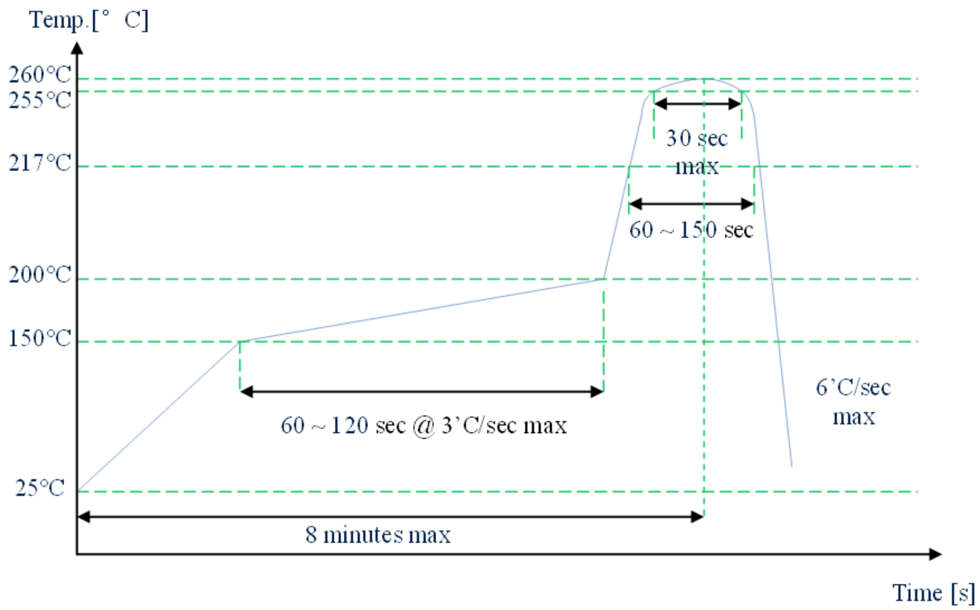

Figure 12: Recommended temperature profile for reflow soldering (J-STD-020C)

6.2 Footprint and Recommended Landing Pattern

The same dimensions for the solder paste screen are recommended, depending on the solder screen thickness.

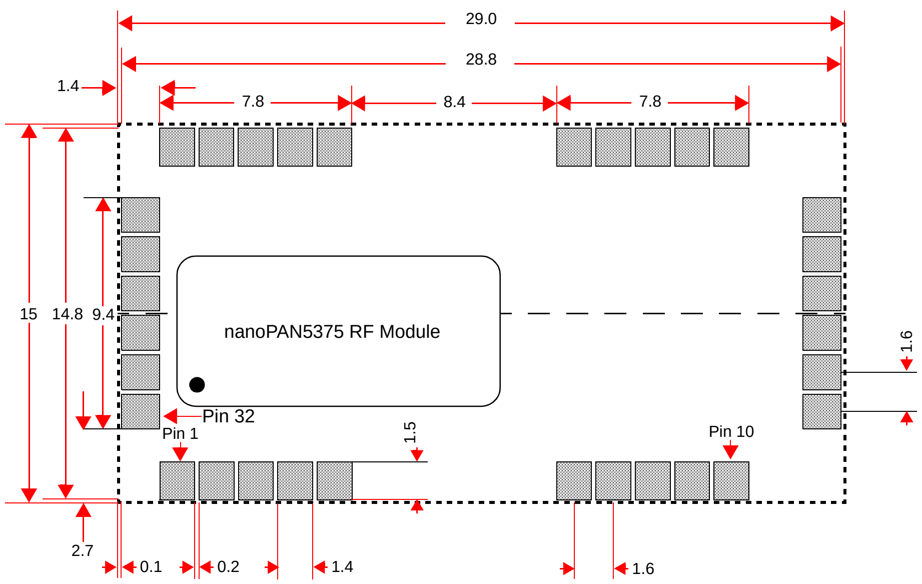

Figure 13: nanoPAN 5375 RF Module footprint – pad configuration (top view)

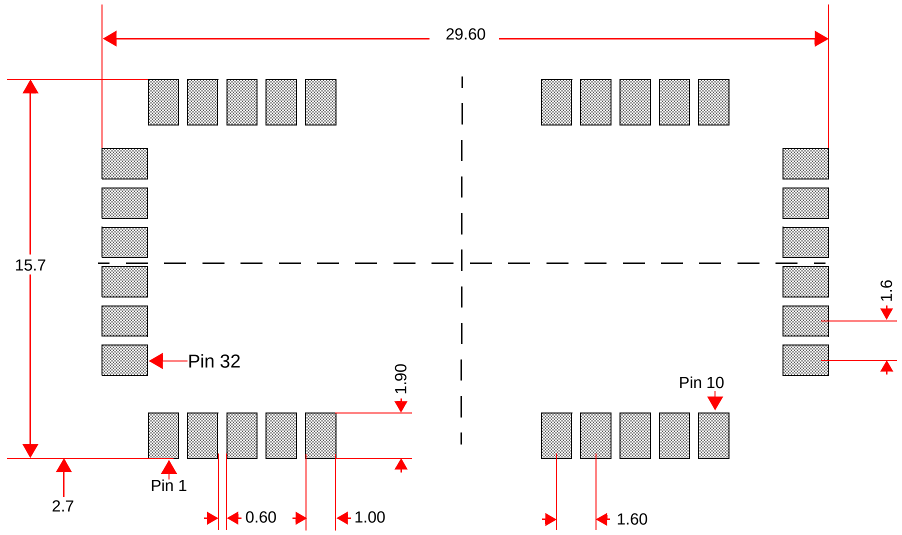

Figure 14: nanoPAN 5375 RF Module – landing pattern

1 Details of the landing pattern are dependent on the technology and should be defined by the assembler.

2 For manual setting of the module, it is recommended to use the corner or side marker in the top layer (copper) or stop mask.

3 For automatic assembly use pattern marker of the carrier board.

7 PCB Layout

Scale 3:1

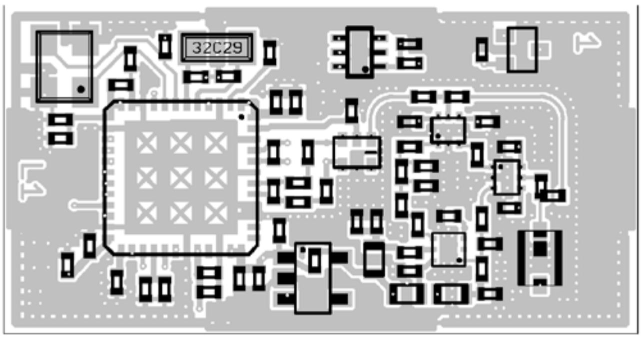

Figure 15: nanoPAN 5375 RF Module – top side

Scale 3:1

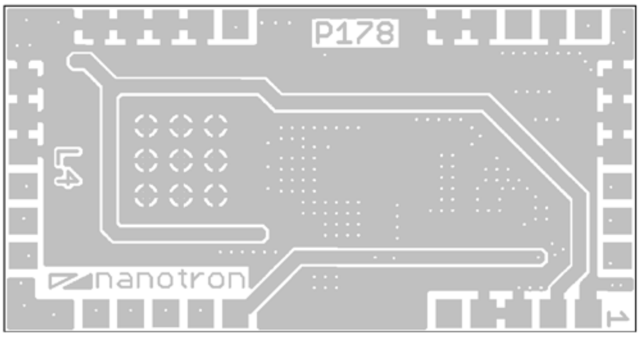

Figure 16: nanoPAN 5375 RF Module – bottom side (inverted)

Scale 3:1

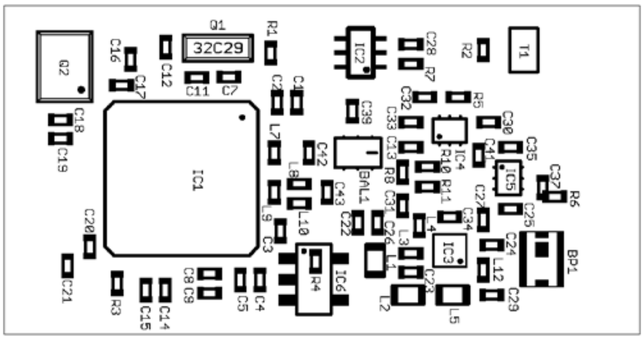

Figure 17: nanoPAN 5375 RF Module – components top side

Intentionally Left Blank

8 nanoPAN 5375 RF Test Module

8.1 Overview

The *nanoPAN 5375 RF Test Module* was designed for testing and measurement purposes only. It was used during measurements and simulations to determine parameters published in this document, unless otherwise specified. For conducting tests purposes, the *nanoPAN 5375 RF Test Module* includes a 50 Ω coaxial SMA connector.

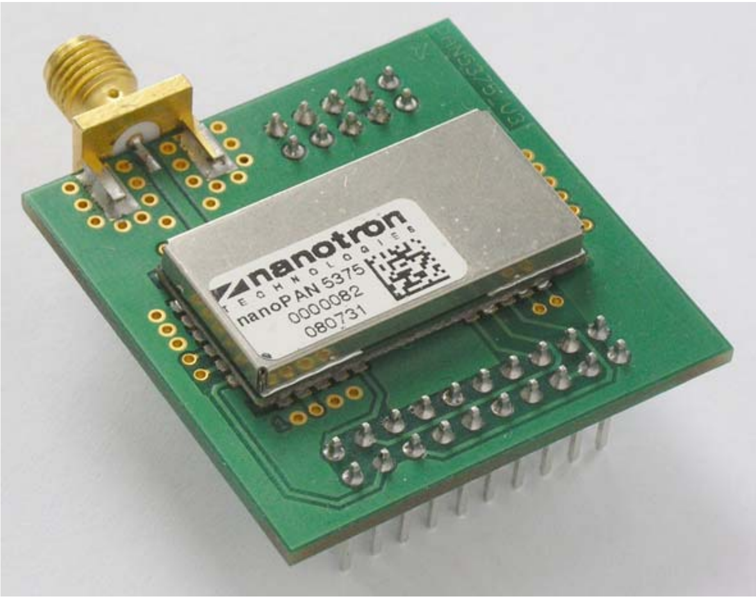

Figure 18: nanoPAN 5375 RF Test Module

8.2 PCB Layout

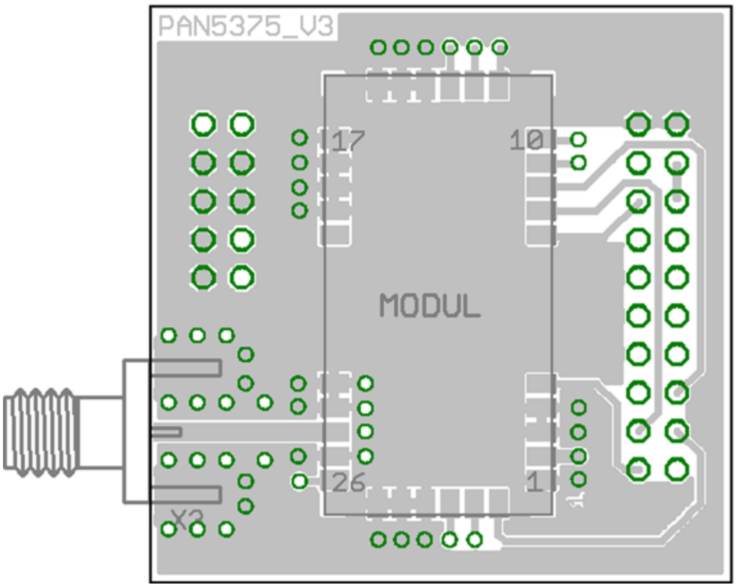

Figure 19: nanoPAN 5375 RF Test Module – top layer

Scale = 2:1

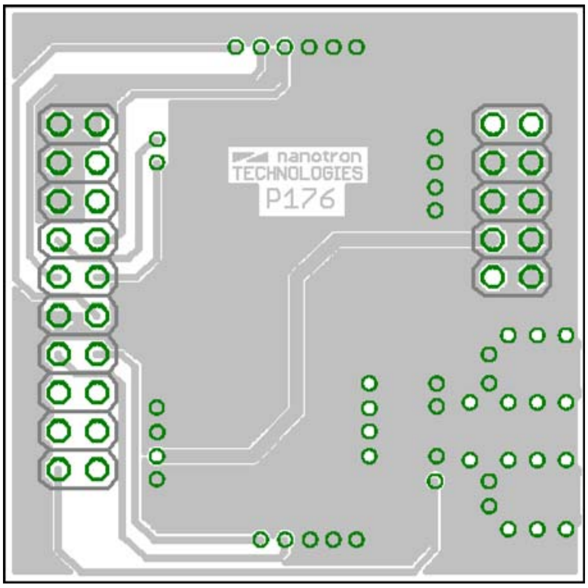

Figure 20: nanoPAN 5375 RF Test Module – bottom layer (inverted)

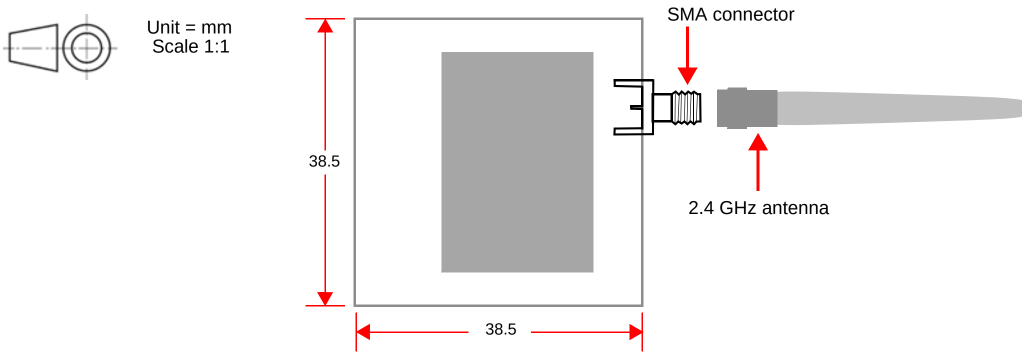

Figure 21: nanoPAN 5375 RF Test Module – measures

Revision History

Version	Date	Description/Changes
1.0	2009-03-18	Initial version.

About Nanotron Technologies GmbH

Nanotron Technologies GmbH develops world-class wireless products for demanding applications based on its patented Chirp transmission system - an innovation that guarantees high robustness, optimal use of the available bandwidth, and low energy consumption. Since the beginning of 2005, Nanotron's Chirp technology has been a part of the IEEE 802.15.4a draft standard for wireless PANs which require extremely robust communication and low power consumption.

ICs and RF modules include *nanoNET TRX Transceiver*, *nanoLOC TRX Transceiver*, and ready-to-use or custom wireless solutions. These include, but are not limited to, industrial monitoring and control applications, medical applications (Active RFID), security applications, and Real Time Location Systems (RTLS). *nanoNET* and *nanoLOC* are certified in Europe, United States, and Japan and supplied to customers worldwide.

Headquartered in Berlin, Germany, *Nanotron Technologies GmbH* was founded in 1991 and is an active member of IEEE and the ZigBee alliance.

Further Information

For more information about this product and other products from Nanotron Technologies, contact a sales representative at the following address:

Nanotron Technologies GmbH
Alt-Moabit 60
10555 Berlin, Germany
Phone: +49 30 399 954 - 0
Fax: +49 30 399 954 - 188
Email: sales@nanotron.com
Internet: www.nanotron.com