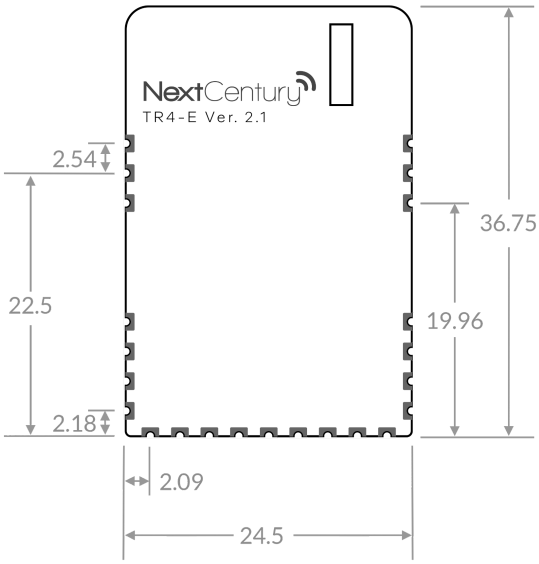
TR4-E Transceiver

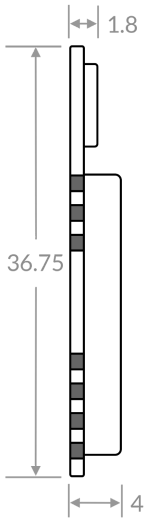
NextCentury Connect™ Embedded Radio Module

Datasheet

1.1 – Dimensions (mm)

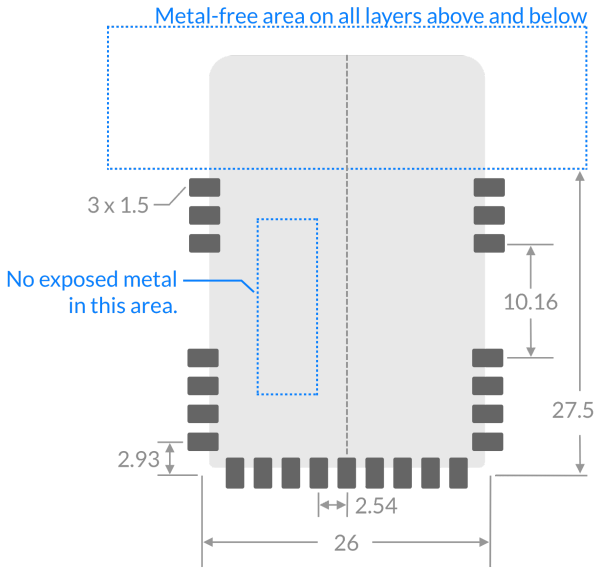


Top View



Side View

1.2 Landing Pattern (mm)



Top View

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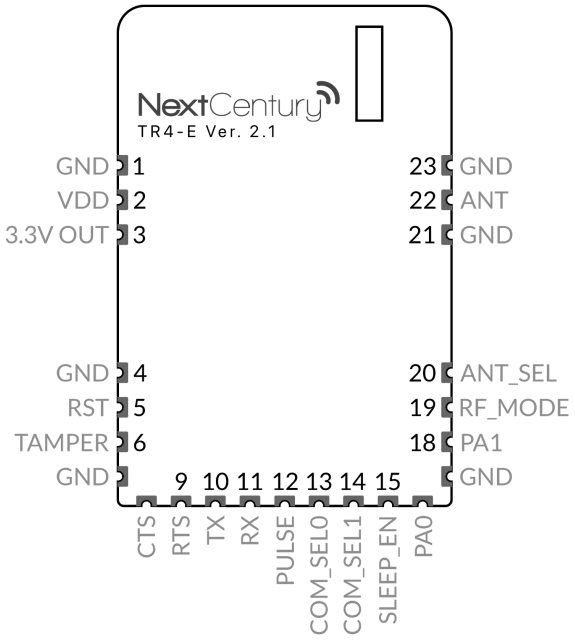
engineering@nextmeters.com

1.3 Pin Assignment



Top View

1.4 Pin Function Descriptions

Pin No.	Pin Name	I/O	Pin Function
1, 4, 7, 17, 21, 23	GND	GND	**Ground Reference Pin** All ground pins should be connected to the host board reference GND plane. It is very important that a good connection is made between these pins and the host board.
2	VDD	VDD	**+2.8V to + 5.5V Supply Voltage Input to Internal DC/DC Regulator** The recommended VDD supply voltage is +3.3V to +5.5V.
3	3.3V_OUT	O	**+3.3V Reference Voltage Output** Output from internal +3.3V DC/DC regulator. Used as reference for all digital I/O pins. Leave disconnected/floating if not used.
5	RST	I	**Reset Input Pin** Open-Drain input internally pulled up to 3.3V. Drive low to disable module. If not used, leave disconnected/floating. RST 1 = Enabled/Running RST 0 = Shutdown/Reset
6	TAMPER	I	**Tamper Input Pin** Open-Drain input internally pulled-up to 3.3V. If not used, drive low (ie connect to GND). TAMPER 1 = Tamper TAMPER 0 = No Tamper

8	CTS / SCLK	I/O	**USART Clear to Send** or **SPI Clock Input** **CTS** (Clear to Send) pin when communication mode is USART with HWFC. **SCLK** (Serial Data Clock) function for the 4-line SPI bus when communication mode is SPI. Data is clocked into the module on the positive edge transition. For all other communication modes leave disconnected/floating. *See section 1.5 for setting communication modes.*
9	RTS / CS	I/O	**USART Request to Send** or **SPI Chip Select** **RTS** (Request to Send) pin when communication mode is USART with HWFC. **CS** (Serial Chip Select) function for the 4-line SPI bus when communication mode is SPI. CS = 1 SPI bus disabled CS = 0 SPI bus enabled For all other communication modes leave disconnected/floating. *See section 1.5 for setting communication modes.*
10	TX / SDO	O	**USART TX** or **SPI Data Output** **TX** push-pull output transmission line of the USART Module. **SDO** (Serial Data Output) Serial data output stream of the 4-line SPI bus. For all other communication modes leave disconnected/floating. *See section 1.5 for setting communication modes.*
11	RX / SDI	I	**USART RX** or **SPI Data Input** **RX** input receive line of the USART Module. **SDI** (Serial Data Input) Serial data input readback of the 4-line SPI bus. For all other communication modes leave disconnected/floating. *See section 1.5 for setting communication modes.*
12	PULSE	I	**Pulse Input Pin** Open-Drain input internally pulled up to 3.3V. Can be used to increment the "Pulse Count" if USART/SPI is not used. Pulses are incremented on a low-to-high transition of this pin. If not used, leave disconnected/floating. *See section 1.5 for setting communication modes.*
13 14	COM_SEL0 COM_SEL1	I I	**Communication Mode Selection Pins** Open-Drain inputs internally pulled-up to 3.3V. The state of these pins is only checked upon bootup of the module. Any changes to these pins must be accompanied by a reboot of the module. *See section 1.5 for setting communication modes.*
15	SLEEP_EN	I	**Sleep Enable Pin** Open-Drain input internally pulled up to 3.3V. Can be used to allow the TR4-E to enter its lowest power savings mode when not transmitting. The selection of this pin will not affect the transmission power selected using RF_MODE (Pin 19). SLEEP_EN = 1 Sleep is disabled between transmissions. SLEEP_EN = 0 Sleep is enabled between transmissions.

16, 18	PA0, PA1	I/O	**Reserved for Future Use** PA0, PA1 are reserved for future use. It is recommended to connect to Host GPIO pin, in an open/floating state. If not used, leave disconnected/floating.
19	RF_MODE	I	**RF Transmission Level Selection Pin** Open-Drain input internally pulled-up to 3.3V. Selects between low-power "Legacy" transmission levels, and the long-range mode. RF_MODE = 1 Long-range transmission mode (400mA) RF_MODE = 0 Legacy low-power transmission mode (120mA)
20	ANT_SEL	I	**Antenna Selection Pin** Open-Drain input internally pulled-up to 3.3V. Selects between the built-in module antenna or the external ANT pin. ANT_SEL = 1 built-in antenna ANT_SEL = 0 external ANT pin
22	ANT	RF	**External RF Antenna Pin** 50 ohm external RF output pin. If used, care should be taken to maintain 50 ohm impedance on this pin. If not used, leave this pin disconnected/floating.

1.5 COM_SEL (Communication Mode Selection) Truth Table

COM_SEL0	COM_SEL1	Mode	Description
0	0	USART	USART communication mode enabled (TX and RX only).
0	1	USART w/ HWFC	USART communication mode enabled with Hardware Flow Control (TX, RX, RTS, and CTS).
1	0	SPI	SPI communication mode enabled.
1	1	PULSE IN	Pulse Input Mode with Pulse In (Pin 12) enabled.

1.6 Absolute Maximum Ratings

Symbol	Min	Max	Units	Description
VDD	-0.3	6	V	Power supply voltage
VIO	-0.6	3.9	V	IO pin voltage
3.3V_Out	-	500	mA	3.3V reference voltage output
T	-20	60	ºC	Operating temperature
T	-4	140	ºF	Operating temperature
Tstorage	-60	150	ºC	Storage temperature
Tstorage	-76	302	ºF	Storage temperature

1.7 General Operation Conditions

Symbol	Min	Typ	Max	Units	Description
VDD	2.8	3.3	5.5	V	Recommended Power supply voltage
IVDD	 - - -	 30 20 20	 400 120 -	 mA mA µA	Power supply current (see RF_MODE Pin) Long-range transmission mode Legacy low-power transmission mode Sleep Current (see SLEEP_EN Pin)
IVDD		500		ms	RF transmission pulse time
VIO	 - 1.8 -	 - - 150	 990 - -	 mV V mV	I/O voltage threshold Falling (Low) Rising (High) Hysteresis
IVIO	 50 2 2.5	 80 - -	 170 5 6	 µA mA mA	I/O Current Input Output High Level Output Low Level
IO_{Pull}	20	40	60	Kohm	Pull-up resistor value
RST	-	2.5	-	ms	Startup time
V_{BOD+}	1.95	2.05	2.15	V	Brownout detection rising threshold (module enabled)
V_{BOD-}	1.85	1.95	2.05	V	Brownout detection falling threshold (module disabled)
$V_{BOD\ Hys}$	47	-	155	mV	Brownout detection hysteresis
TX	 - -	 +29 +20	 - -	 dBm dBm	RF Transmission Power Long-range transmission mode Legacy low-power transmission mode
RX	-	-130	-	dBm	Average achieved receiver sensitivity (with over-sampling)
Freq	902	-	928	MHz	Frequency Hopping Spread Spectrum utilizes 50 pseudo- random channels in the sub-GHz ISM band

2.1 VDD Power Pin

Power is provided to the TR4-E via the VDD pin. This power is then regulated by an on-board 3.3V DC/DC regulator. The regulator has very low drop-out voltage, and is capable of running at ~3.3V from 3.3V VDD power. See Brownout Detection (section 2.4) for details on cut-off voltage levels.

2.2 Output Reference Voltage (3.3V)

The output of the on-board 3.3V DC/DC regulator is routed to Pin 3. This reference is intended for use, as needed, for any digital signals provided to the TR4-E I/O pins. Most I/O pins on the TR4-E are Open-Drain driven with built-in 3.3V pull-up resistors. Because of this Open-Drain design, I/O pins can be driven by sources with higher voltage levels than the TR4-E directly supports (ie 5V voltag- level devices). If voltage-level translation is required for USART or SPI pins, this reference voltage pin should be used to provide voltage levels for the TR4-E.

The built-in 3.3V DC/DC regulator can be used to source power for other devices. It is not recommended to externally source more than 300mA output from this pin to power other devices.

Note: Do not source voltage into the 3.3V Reference Output pin.

2.3 Reset

Driving the Reset Pin (Pin 5) low will force the onboard circuits to enter a reset/disabled mode. Most pins will enter a high-z state, and thus current consumption in this state can not be guaranteed. For always-on operation, this pin should be left disconnected/floating. An internal circuit exists to protect against any EMS interference on this line. If driving this line, care should be taken to allow the pin to settle before toggling power.

2.4 Brownout Detection

Although the built-in DC/DC regulator is capable of running down to 0.5V, an internal Brownout Detection circuit will ensure that the main controller shuts down when voltage levels go below 1.95V. Operation will continue to be disabled until voltage levels rise back above 2.05V. This circuit ensures proper operation and prevents data corruption during power-down, or dirty power situations. It is recommended that care be taken in designing the VDD power supply to ensure that during RF transmissions, the voltage levels do not fall below the brownout detection threshold.

2.5 Tamper and Pulse Pin

The Tamper and Pulse Input Pins (Pin 6 and Pin 12) provide a simple transition from the standard TR4 to the TR4-E. These digital pins allow for designs that are not able to support serial communication between the TR4-E and the host meter controller.

Note: It is recommended that new designs prefer utilization serial communications (USART or SPI) and do not use these pins.

2.6 USART

USART is the preferred method of communication between the TR4-E and host meter controller. USART is enabled through the COM_SEL (Pin 13 and Pin 14) pins. See Table 1.5 for more details on enabling USART mode. It uses a transmitter and receiver to transmit/receive in full-duplex operation. It supports transmission with no delay between frames. The USART will automatically adjust its BAUD rate to match the host controller. It can support:

- 5, 6, 7, 8 data bits
- 1 or 2 stop bits
- Odd, even, or no parity check
- LSB or MSB first data transfer
- RTS and CTS hardware flow control (see HWFC Pin13 and Pin14)
- Baud Rates up to 115,200

Note: The TR4-E is designed to automatically detect the host controller, and adjust its UART line accordingly. Contact engineering@nextmeters.com for more information.

2.7 SPI

The SPI interface is the secondary method of communication between the TR4-E and host meter controller. SPI is enabled through the COM_SEL (Pin 13 and Pin 14) pins. See Table 1.5 for more details on enabling SPI mode. It can be setup in host or client modes.

Note: The TR4-E is designed to automatically detect the host controller, and adjust its SPI line accordingly. Contact engineering@nextmeters.com for more information.

2.8 Sleep Enable Pin

The TR4-E is designed for both battery-powered, and non-battery powered operation. If battery-powered operation is desired, the SLEEP_EN (Pin 15) should be set low. After each transmission/reception of data the TR4-E will enter a deep sleep mode, where average power usage will be ~20µA. In deep sleep mode the TR4-E will still receive pulses, and periodically communicate with the host controller via USART or SPI communication interface.

In line-powered situations, or other times that battery life is not crucial, the SLEEP_EN (Pin 15) can be left disconnected/floating. In this mode, the TR4-E will leave the receiver on between transmissions. This will result in an average power usage of ~20mA. This is the recommended configuration for most electric meter designs.

2.9 RF Modes

The TR4-E can be configured to run in one of two modes. Legacy mode utilizes the same transmission power levels as the NextCentury TR201 Transceiver. It transmits at approx. +20dBm and utilizes a peak current of 120mA for 400ms during transmissions. Rx sensitivity levels remain the same between both modes. To setup legacy mode, drive RF_MODE (Pin 19) low. It is recommended to use Legacy mode only if the host power supply is unable to support long-range mode.

Long-range mode of the TR4-E utilizes the same transmission levels achieved by the latest line of products by NextCentury (TR4, RR4-TR, TR4-I, etc). It transmits at approx. +29dBm and utilizes a peak current of 400mA for 400ms during transmissions. This is the recommended mode of operation. Care should be taken in the design of the host power supply to ensure minimum voltage drop during transmission. To setup long-range mode, leave RF_MODE (Pin 19) disconnected/floating.

2.10 External Antenna Pin

The TR4-E contains a built-in antenna with approx. 1dBi of gain. The TR4-E module has been FCC and IC pre-certified with this built-in antenna. If the built-in antenna is used, the external ANT (Pin 22) can be left disconnected/floating. To enable the external ANT (Pin 22) drive ANT_SEL (Pin 20) low. When utilizing the external antenna pin, care should be taken to ensure that a 50 ohm impedance is maintained on the line.

3.1 NextCentury RF Connect Overview

The NextCentury RF Connect protocol stack is designed to help create large multi-hop, lightweight, redundant, and secure networks with very little overhead. The stack reflects IEEE 805.15.4 standards but does not adhere to them and is not 805.15.4 compatible. The stack has been designed to take up a very small footprint, and manage power making it suitable to run on both line-powered devices as well as low-power battery devices. The stack can be used to send and receive virtually any message smaller than 124 bytes in length.

3.2 NextCentury RF Connect Features

- Up to 10,000 end devices on a single network (Gateway)
- No dedicated device required to start a network
- No unnecessary periodic service traffic occupying bandwidth
- No special network joining procedures
- Redundant software and hardware encryption
- Automatic route discovery and optimization
- Frequency hopping with interference detection and avoidance
- Low-power consumption
- Automatic network loop detection
- Proprietary long-range modulation schema with oversampling and corruption repair

3.3 Gateways and Repeaters

The TR4-E is compatible with all NextCentury devices, including all Repeaters (RE4, RE4-X, RE201) and Gateways (GW4, GW4-L, GW301, GW301-L, GW201).

3.4 NextCentury Cloud

The TR4-E is part of an integrated end-to-end system that collects and stores all reads securely in the NextCentury Cloud. The data can then be retrieved via the NextCentury Website, Mobile App, or documented API.

3.5 Check-in Interval

The TR4-E will checkin, by default every 6 hours. This check-in contains 6 historical data points, and thus, with a 6-hour check-in interval, will provide hourly read data. Utilizing the NextCentury Website or mobile app, the check-in interval can be adjusted.

When the TR4-E is set up for an hourly check-in interval, it will automatically configure itself to provide 15-min interval data. This is to help satisfy electrical metering requirements.

When communicating with a NextCentury Gateway, device check-in times will automatically be adjusted by the Gateway to optimize network performance and prevent network congestion. When a TR4-E loses power, it will wait a random interval of time within its configured check-in window. This enhancement ensures that a whole property power outage will not cause all TR4-Es to try and check in simultaneously.

For example: If a TR4-E is configured to check in every 6 hours, then loses power, it will choose a random check-in time between 6 and 12 hours. Once the Gateway receives this message, the TR4-E will return to its previous check-in interval of 6 hours.

3.6 Direct Connect (DC301)

Advanced configuration and troubleshooting can be achieved utilizing the NextCentury Direct Connect (DC301) with the NextCentury Mobile App. Direct Connect can be used to configure: Meter Serial Number, Meter Model Type, Check-in Interval, etc. If Direct Connect configuration is desired, it is recommended to disable Sleep Mode (see SLEEP_EN Pin 15).

4.1 Typical Applications

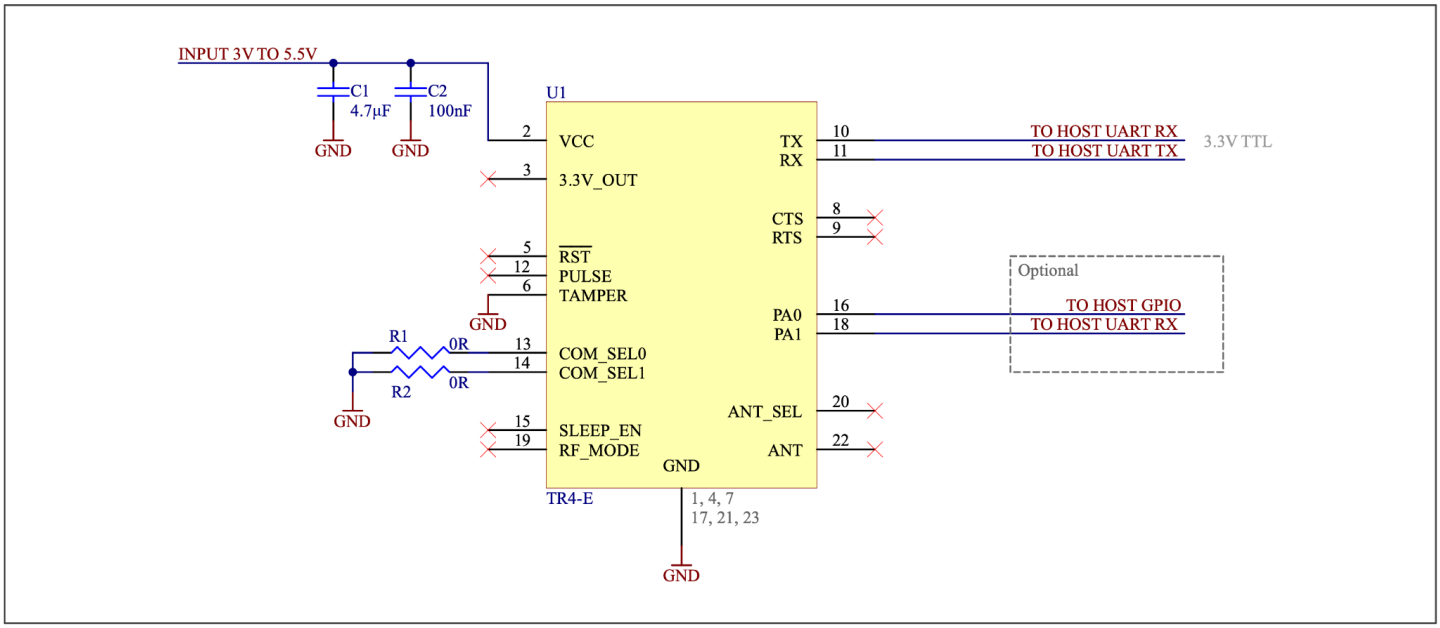


Figure 1. UART (without HWFC) and RF Long Range Mode

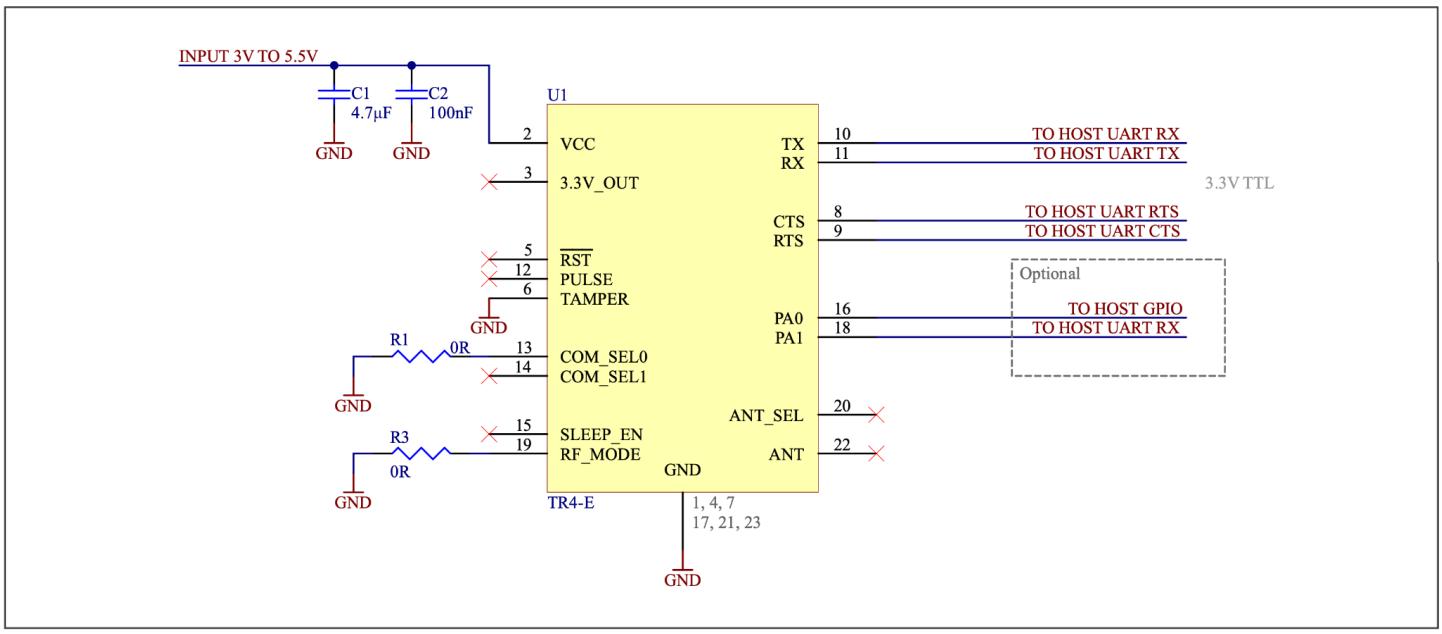


Figure 2. UART (with HWFC) and RF Legacy Low-Power Mode

4.1 Typical Applications (Cont.)

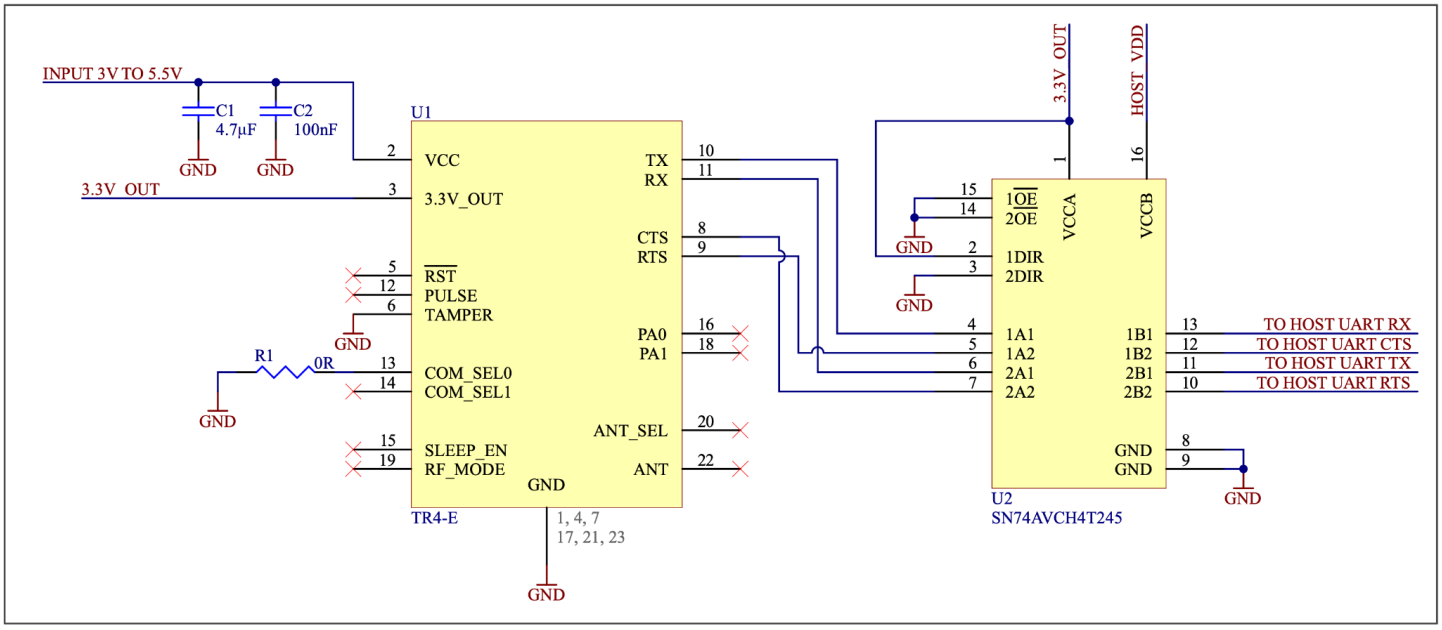


Figure 3. UART (with HWFC), Logic level translator, and RF Long Range Mode

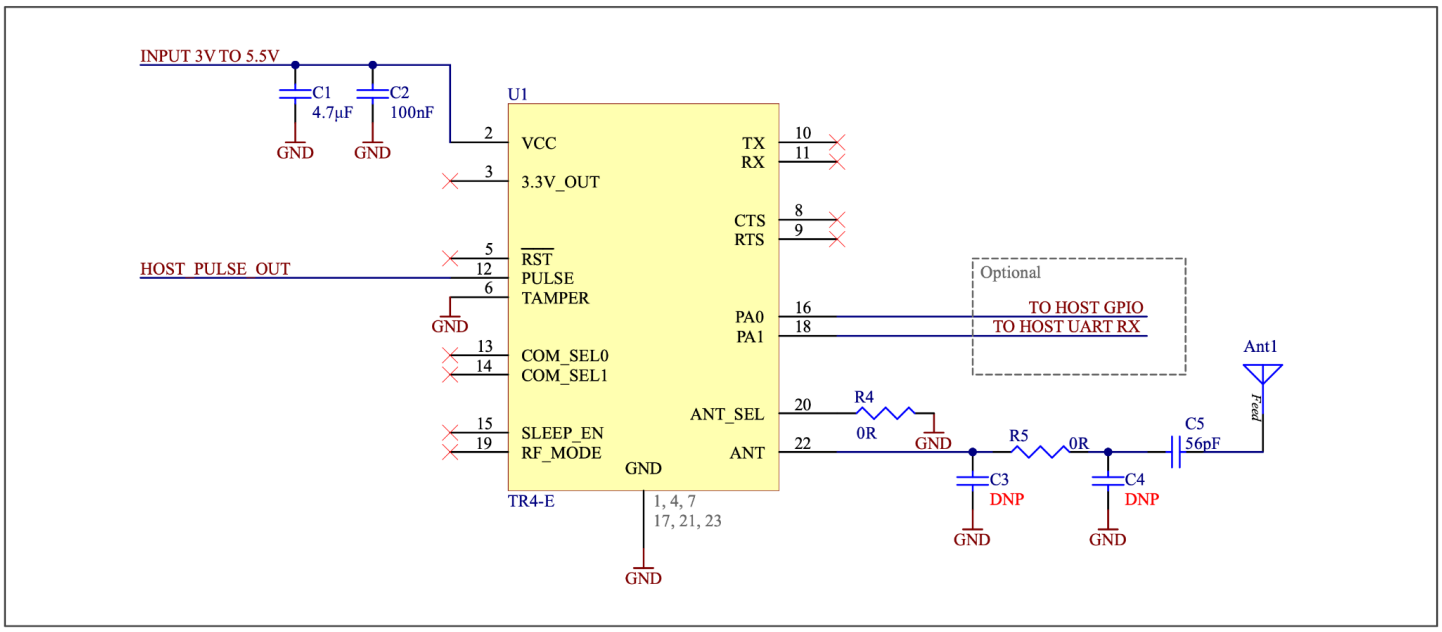


Figure 4. Pulse Input, RF Long Range Mode, and external antenna

4.2 Typical Applications (Bill of Materials)

Designator	Value	Description	Footprint
U1	TR4-E	Transceiver (Embedded) Module	Custom
C1	4.7µF	Capacitor, NP0, ±20 %	0402
C2	100nF	Capacitor, X5R, ±10 %	0402
C3, C4			0402
C5	56pF	Capacitor, NP0, ±2 %	0402
R1, R2, R3, R4, R5	0R	Jumper	0402
U2		MPN: SN74AVCH4T245	16-UFQFN

Note: C3, R5, and C4 in figure 4 can be used for a matching network of an external 915MHz antenna.

4.3 Manufacturing and Mounting Options

The TR4-E module can be surface mounted to a printed circuit board (host board), utilizing the recommended landing pattern (See 1.2 Landing Pattern).

All metal pads are to be non-solder mask defined (NSMD). Clearance between the solder mask and metal pad is to be 60 µm minimum, all the way around the pad.

A stainless steel, laser-cut, electro-polished stencil with trapezoidal walls should be used to assure good solder paste release.

A No-Clean, Type-3 solder paste is recommended. The recommended card reflow profile is per the JEDEC/IPC J-STD-020 specification for large module body components.

4.4 Connecting IO Pins

Unused IO Pins can be left disconnected/floating. There is no need to drive unused pins as all pins have been designed to be disabled, or internally biased when not used. If BOM cost and space constraints allow, it is recommended to drive IO pins through a 0 ohm (jumper) resistor. This design will allow for troubleshooting or adjustments of design during the prototype and testing phase of projects.

5.1 FCC and IC Modular Approval

This device complies with Part 15 of the FCC Rules.

Compliance with the appropriate regulatory agencies is essential in the deployment of all transceiver devices. NextCentury has obtained modular approval for this RF product. As such, an OEM need only meet a few basic requirements in order to utilize their end product under this approval.

5.2 Agency Identification Numbers

Part Number	US FCC	Canada IC
TR4-E	2A8EC-TR4E	28950-TR4E

5.3 Antennas

The TR4-E is pre-approved for use with its built-in chip antenna. If utilization of an external antenna is desired, please contact NextCentury for additional information.

5.4 FCC/IC Requirements for Modular Approval

Any modification made to the TR4-E printed circuit board or built-in antenna could void the user's authority to operate this equipment.

5.5 Warnings

This device is intended for use under the following conditions:

1. The transmitter module may not be co-located with any other transmitter or antenna; and,
2. The module has been approved using the FCC's "unlicensed modular transmitter approval" method.

As long as these two conditions are met, further transmitter testing will not be required. However, the OEM integrator is still responsible for testing their end product for any additional compliance measures necessitated by the installation of this module (i.e. digital device emissions, PC peripheral requirements, etc.).

This device complies with part 15 of the FCC Rules and Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

This portable equipment with its antenna complies with FCC's and IC's RF radiation exposure limits set forth for an uncontrolled environment. Users are advised to maintain a separation distance of 20cm to comply with FCC and IC RF exposure limits.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Note: In the event that these conditions cannot be met (i.e. co-location with another transmitter), then the FCC authorization is no longer valid, and the corresponding FCC ID may not be used on the final product. Under these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate FCC authorization.

5.6 OEM Product Labeling

The end product containing the TR4-E must be labeled in a visible area with the following text:

"Contains FCC ID: 2A8EC-TR4E"

L'étiquette d'homologation d'un module d'Innovation, Sciences et Développement économique Canada devra être posée sur le produit hôte à un endroit bien en vue, en tout temps. En l'absence d'étiquette, le produit hôte doit porter une étiquette sur laquelle figure le numéro d'homologation du module d'Innovation, Sciences et Développement économique Canada, précédé du mot « contient », ou d'une formulation similaire allant dans le même sens et qui va comme suit:

"Contient IC: 28950-TR4E est le numéro d'homologation du module."

5.7 RF Exposure

This equipment complies with FCC and IC RSS-102 radiation-exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with a minimum distance of 20 cm between the radiator and a human body. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

Cet équipement est conforme aux limites d'exposition aux radiations fac et IC CNR-102 établies pour un environnement non contrôlé. Cet équipement doit être installé et utilisé avec une distance minimale de 20 cm entre le radiateur et votre corps. Cet émetteur ne doit pas être co-implanté ou fonctionner en conjonction avec toute autre antenne ou transmetteur.

5.8 Additional Information For OEM Integrators

The end user should not be provided with any instructions on how to remove or install the TR4-E module. This device has been certified to operate with the built-in antenna.

6.1 Disclaimer

This product and its documentation are supplied on an as-is basis, and no warranty as to their suitability for any particular purpose is either made or implied. The company will not accept any claim for damages whatsoever arising as a result of the use or failure of this product. Your statutory rights are not affected.

This product or any variant of it is not intended for use in any medical appliance, device, or system in which the failure of the product might reasonably be expected to result in personal injury.

This document provides preliminary information that may be subject to change without notice.

6.2 Document Revisions

- 23-Sep-2021
  - Initial mechanical draft revision
- 08-Oct-2022
  - Added detailed electrical and usage information
- 04-Nov-2022
  - Added Typical Applications and BOM

7.1 Contact Information

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