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T1000 Series Embedded RF Transmitter Product Manual

6 GHz

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HAROGIC

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T1000 Series Embedded RF Transmitter Product Overview

Product Overview

The T1060 integrates a high-performance single-channel RF transmitter with a Raspberry Pi host in an ultra-compact embedded RF transmitter platform. With powerful edge computing capabilities, it can independently handle complex tasks and is well suited for distributed field deployments.

Advanced RF Performance

The T1060 delivers leading RF performance in its class, including output power range, harmonic performance, phase noise, and spurious emissions. The baseband subsystem uses a high-performance 16-bit DAC to ensure high-quality baseband signal output. Built-in high-speed memory supports up to 100 MHz FPGA onboard-memory playback and 50 MHz embedded-host storage playback. An FPGA-based high-ratio interpolator enables fine sample-rate adjustment, providing highly flexible sample-rate settings while significantly reducing the processing load on the host. Despite these performance and functional advantages, the T1060 remains highly cost-effective.



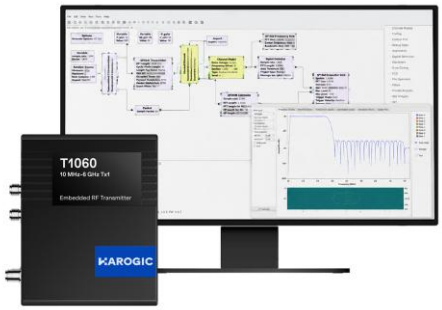
Compact Design and Easy Deployment

The T1060 features a compact design that enables easy integration into a wide range of systems. The integrated Raspberry Pi 5 host, featuring a quad-core 2.4 GHz processor, 4 GB of memory, and 32 GB of flash storage, supports standalone operation. This significantly reduces deployment complexity while maintaining RF performance, making the T1060 particularly suitable for applications where space and cost are key considerations.



Powerful API and Comprehensive Ecosystem

The T1060 provides a unified API and supports development environments including C/C++, C#, Python, MATLAB, Qt, LabVIEW, and GNU Radio. It supports both Windows and Linux operating systems.



Key Features

- Single-channel embedded RF transmitter with integrated Raspberry Pi 5
- Frequency range: 10 MHz to 6 GHz
- Maximum real-time bandwidth: 100 MHz
- Maximum IQ sample rate: 125 MS/s
- DAC resolution: 16 bits
- Maximum output power: 7 dBm to 14 dBm, optional 25 dBm
- Minimum output power: ≤ −100 dBm across the full frequency range
- Harmonics: ≤ -50 dBc at 0 dBm output (typ.)
- Phase noise at 1 GHz: -124 dBc/Hz @ 10 kHz
- Built-in GNSS supporting timing, positioning, and frequency calibration
- Remote data interface: Gigabit Ethernet (1 GbE)
- Comprehensive APIs and example applications
- Supports GPIO, external reference input, and PPS triggering
- Supports Windows and Linux operating systems

Applications

- **Remote Unattended Signal Source**

  Waveforms can be stored on the local host, while tasks are issued and the device is controlled remotely over the network. This makes the T1060 suitable for remote laboratories, antenna test ranges, and field test sites.

- **Portable Signal and Waveform Playback**

  Supports playback of custom waveform files or previously recorded signal waveform files. The device can be controlled over the network or deployed as a lightweight payload on platforms such as UAVs.

- **Education and Radio Enthusiasts**

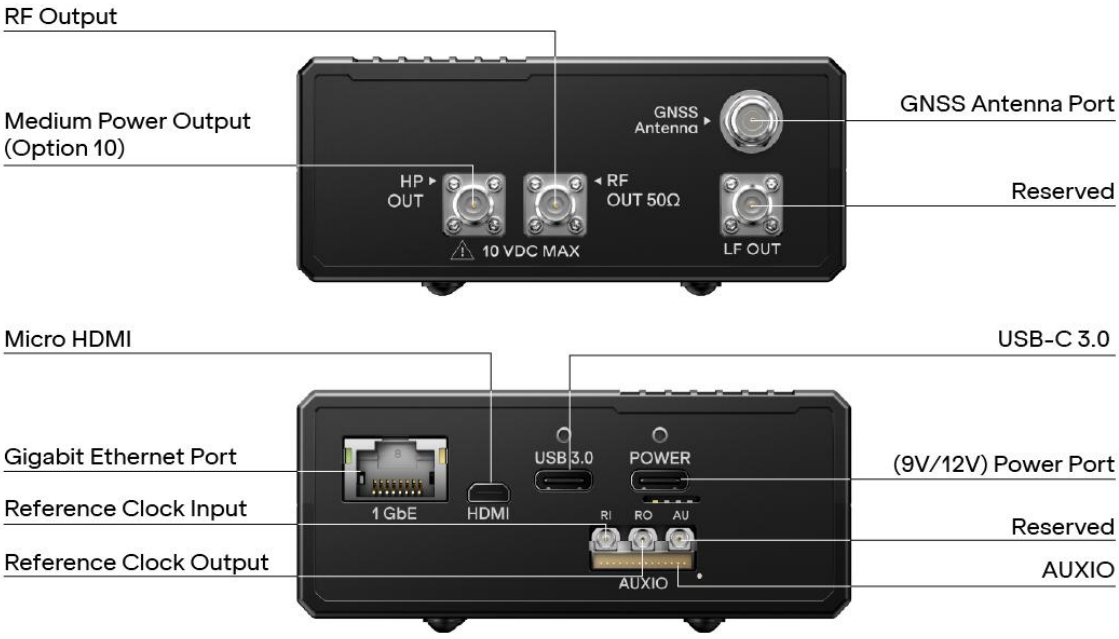
  A software development kit (SDK) based on a unified API is provided and is compatible with mainstream open-source tools such as GNU Radio, helping students and developers quickly perform initial signal transmission and custom waveform verification.

- **Distributed Synchronized Excitation Nodes**

  With a standalone host and GNSS synchronization capability, the T1060 can be used over Ethernet to build distributed multi-site test systems, perform receiver-system timing calibration, and support distributed experiments.

T1060 Interface Description





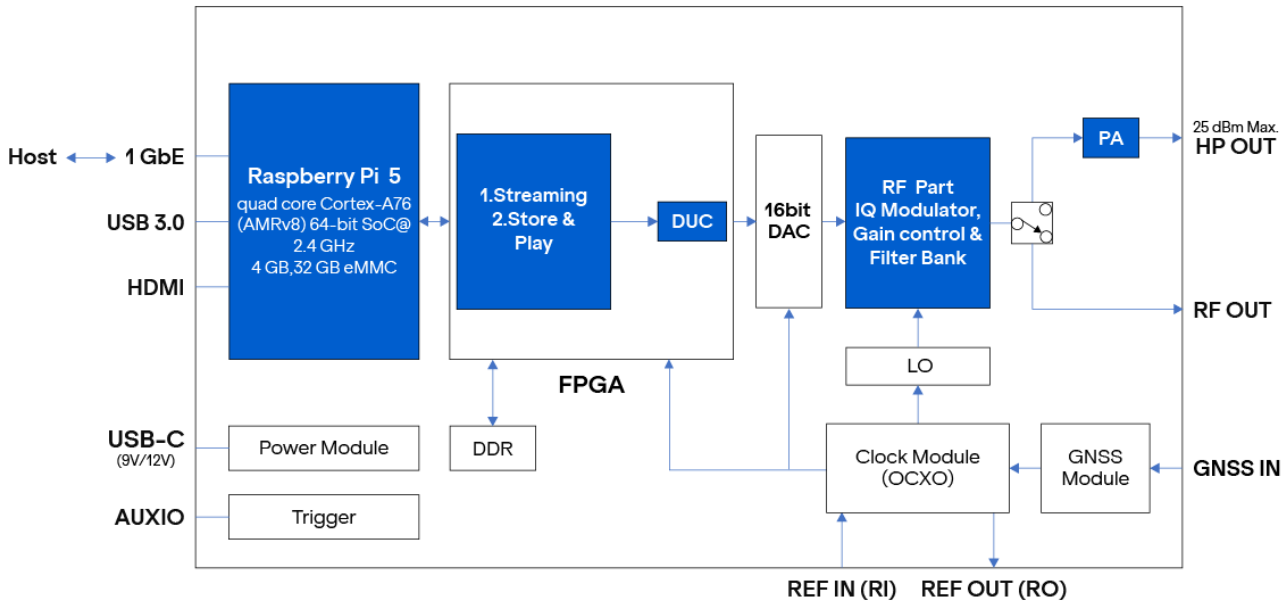
Specifications*

Frequency and Clock

Number of channels	1	
Frequency range*	10 MHz to 6 GHz	
Frequency step	Output frequency < 500 MHz	1 Hz
	Output frequency ≤ 6 GHz	0.1 Hz
LO switching time	≤ 100 µs, preprogrammed; ≤ 50 ms, software-controlled	
Reference clock	Internal or external; supports manual correction or calibration using the built-in GNSS	
Frequency accuracy	≤ 0.5 ppm	≤ 0.05 ppm
	Manual correction available	After GNSS-based frequency correction
Aging and temperature stability	≤ 1 ppm/year, ≤ 1 ppm	
Built-in GNSS 1PPS accuracy	≤ 100 ns / ≤ 20 ns (Option 05), under clear-sky conditions	

* The T1060 can be tuned from 9 kHz to 10 MHz; performance specifications in this frequency range are not guaranteed.

System Block Diagram



Spectrum Purity SSB Phase Noise (dBc/Hz)

Carrier frequency	1 GHz	3 GHz	6 GHz
1 kHz	-115	-105	-98
10 kHz	-124	-114	-108
100 kHz	-125	-116	-110
1 MHz	-138	-128	-122

Harmonics CW, 0 dBm	100 MHz	≤ -45 dBc
	1 GHz	≤ -50 dBc
	3 GHz	≤ -60 dBc
	6 GHz	≤ -75 dBc
Non-harmonic Spurs	9 kHz – 500 MHz	Worst-case spurious ≤-50 dBc
	500 MHz – 6 GHz	With a 1 MHz step size and a 20 MHz observation bandwidth, spurious levels are ≤ −80 dBc at approximately 98% of frequency points; worst-case spurious is ≤ −55 dBc.
EVM (Typical)	1 GHz	≤ 0.3% 1MSPS QAM 16, Alpha = 0.35 ≤ 0.5% 10MSPS QAM 64, Alpha = 0.35
	6 GHz	≤ 0.5% 1MSPS QAM 16, Alpha = 0.35 ≤ 1.0% 10MSPS QAM 64, Alpha = 0.35

Amplitude

	100 MHz	1 GHz	3 GHz	6 GHz
Max. output power (dBm)	≥ 7	≥ 14	≥ 14	≥ 7
Min. output power (dBm)	≤ -100	≤ -100	≤ -100	≤ -100

Power accuracy	Output power: ≥ -45 dBm	±1.2 dB
	Output power: -80 dBm to -45 dBm	±1.5 dB
	Output power: -100 dBm to -80 dBm	±2.0 dB
Power setting step size	0.1 dB	

General

Input and output		
RF output	SMA (F), impedance 50 Ω	
Power	USB Type-C, 9 V / 3 A or 12 V / 2.5 A	
Wired Data Connection	1 GbE	
Wireless Data Connection	Wi-Fi, Bluetooth 5.0; disabled by default and must be enabled manually. (For a product version without the wireless module, please contact HAROGIC)	
Peripheral Interfaces	Micro HDMI (HDMI 2.0); USB 3.0	
External trigger input	available through AUXIO, 3.3 V CMOS, high input impedance	
Trigger Types	Bus trigger, digital edge trigger, level trigger, etc.	
Trigger Output	Integrated into AUXIO, 3.3 V CMOS	
GNSS Antenna Input	SMA (F)	
External Reference Clock Input	MMCX(F), 10 MHz, amplitude ≥ 1.5 Vpp; input impedance 200 Ω	
Reference Clock Output	MMCX(F), output impedance 50 Ω, 100 MHz	
Overall/Core Weight	≤ 281 g / ≤ 178 g	
Overall/Core Dimensions (L × W × H)	≤ 87 × 78 × 38 mm / ≤ 74 × 74 × 30 mm	
Power Consumption	≤ 25 W	
Package Contents	1 × USB flash drive; 1 × 1GbE Ethernet cable; 1 × USB power cable; 1 × power adapter	
Host System Requirements	Windows 11/10 Ubuntu 24.04/22.04/20.04/18.04 (x64, AArch64)	
Operating/Storage Temperature (Ambient)	T0 class T1 class (Option 40)	0 °C to 50 °C / −20 °C to 70 °C −20 °C to 65 °C / −40 °C to 85 °C

Computing Platform

Processor	Raspberry Pi 5, Broadcom BCM2712, quad-core Cortex-A76 (ARMv8) 64-bit SoC @ 2.4 GHz
Memory	4 GB LPDDR4-4267 SDRAM with ECC
Storage	32 GB eMMC flash memory
Operating System	Debian 12 Bookworm 64-bit

Baseband

DAC Resolution	16 bits
Maximum IQ Sample Rate	125 MS/s
FPGA Onboard DDR Memory	128 MB

Signal Processing

Standard Functions	Single tone, multitone, frequency sweep, power sweep, amplitude modulation, frequency modulation, phase modulation, pulse modulation, digital ramp sweep, Gaussian white noise, IQ playback, and real-time IQ streaming	
Maximum Modulation Bandwidth	High-Speed RAM Playback	100 MHz, maximum 128 MB (32 M samples)
	Continuous Streaming from Embedded Host eMMC	50 MHz (62.5 MS/s)
IQ Sample Rate	195.3125 KS/S to 125 MS/S, setting step ≤ 10 Hz	
Basic modulation signal generation	APSK: 16APSK ASK: 2ASK, 4ASK, 8ASK FSK: 2FSK, 4FSK, 8FSK, 16FSK QAM: 16QAM, 64QAM, 256QAM, 1024QAM PSK: BPSK, QPSK, 8PSK, 16PSK, DBPSK, DQPSK, D8PSK, Pi/4 DQPSK	

Medium Power Output (Option 10)

Frequency range	10 MHz to 6 GHz	
Max. output power	≥ 25 dBm (typical)	
Min. output power	≤ -80 dBm (typical)	
Power accuracy (Guaranteed/Typical)	Output power: ≥ -20 dBm	±1.2 dB / 0.7 dB
	Output power: -60 dBm to -20 dBm	±1.5 dB / 0.7 dB
	Output power: -80 dBm to -60 dBm	±2.5 dB / 1.2 dB
Harmonics	100 MHz	≤ -55 dBc
CW, 0 dBm	1 GHz	≤ -50 dBc

	3 GHz	≤ -42 dBc
	6 GHz	≤ -46 dBc

*Technical specifications apply under the following conditions:

(1) The instrument is warmed up for 10 minutes after power-on. Unless otherwise specified, all specifications are typical values.

(2) Ambient temperature: 25 °C.

(3) Specifications are subject to change with hardware and software revisions without prior notice.

OPTIONS

Code	Option	Type
05	Built-in High-Precision GNSS	Built-in hardware
10	Medium power RF output	Built-in hardware
40	T1 temperature class	Built-in hardware

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