

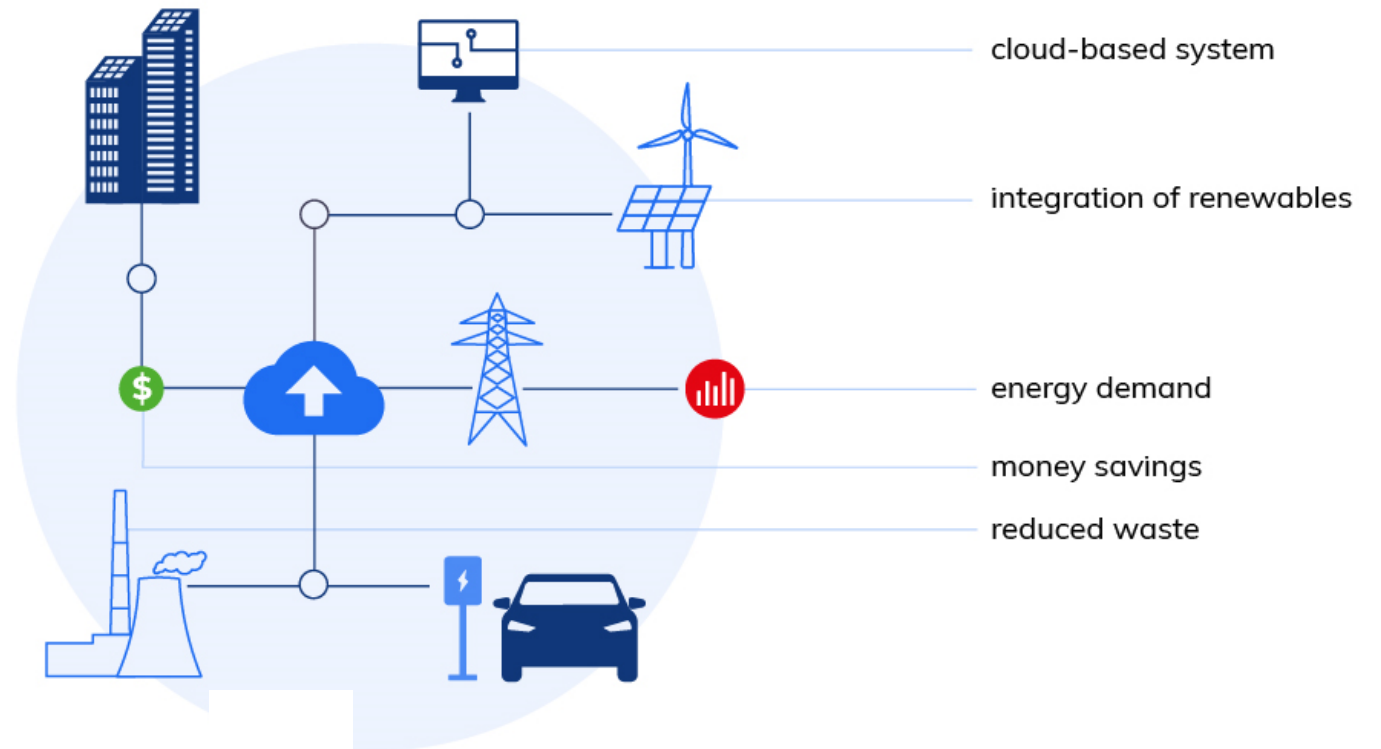
Internet of Energy (IoE)

RAILTRON

What is the IoE?

The Internet of Energy (IoE) describes everything within the smart energy infrastructure system. Anything within this smart energy system must connect with the internet and share data.

- Advanced extension of IoT for optimizing energy networks
- Data-driven strategies for better energy management and waste reduction
- Integrating IoT technologies into distributed energy systems



Source: <https://www.greenflux.com/spotlights/internet-of-energy/>

Applications and Benefits of IoE

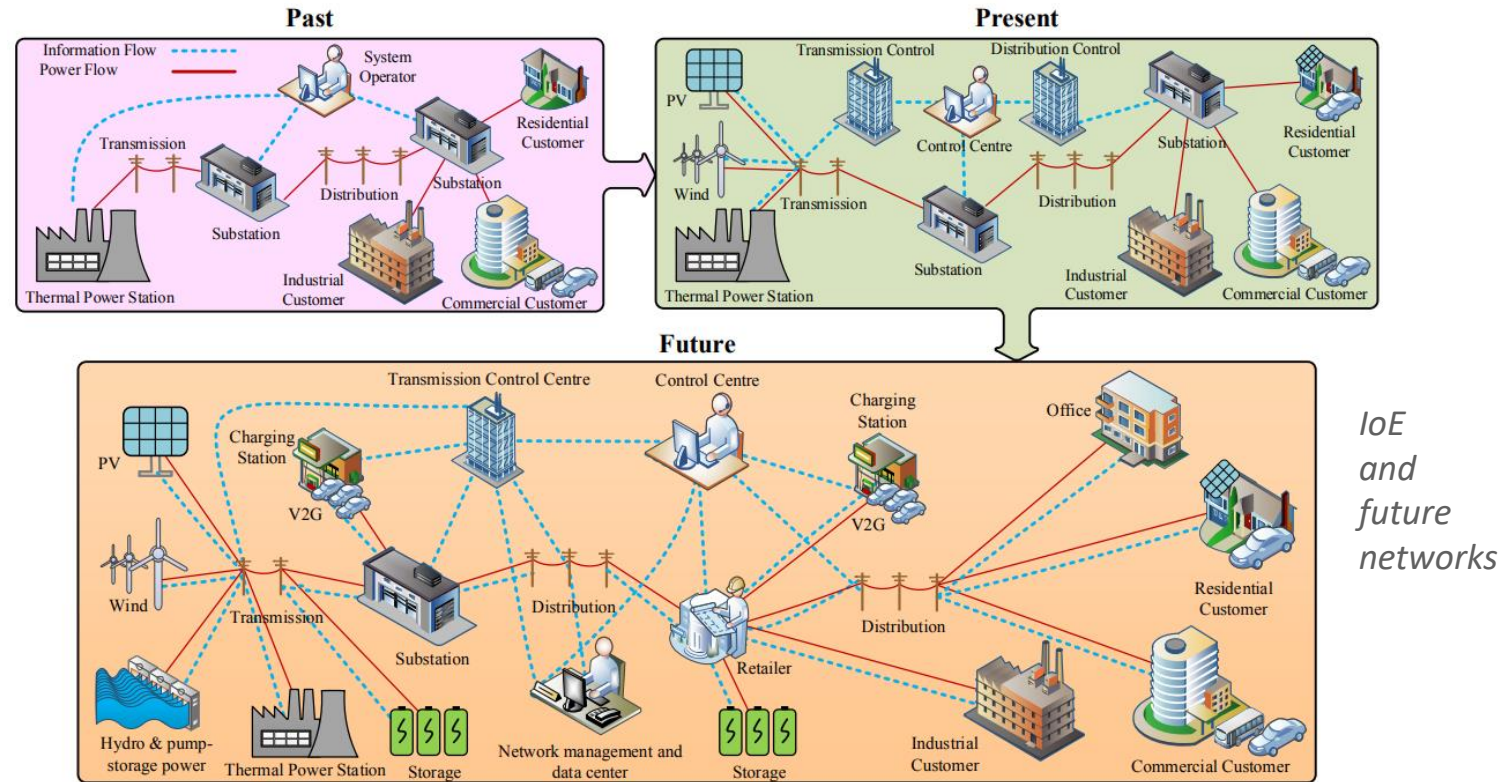
- ✓ Smart grids:
 - Enhanced energy distribution
 - Demand-response mechanisms
 - Supply-demand balance
- ✓ Electric vehicles and Vehicle-to-grid (V2G) technology:
 - Optimized charging
 - Leveraging batteries for grid energy storage
- ✓ Renewable energy integration:
 - Streamlining the adoption of solar, wind, and other clean energy sources
 - Improved energy efficiency in generation and transmission
- ✓ Microgrids and local energy sharing:
 - Empowering communities to utilize decentralized renewable energy
 - Enhanced reliability and flexibility of energy supply
- ✓ IoT-enabled infrastructure:
 - Sensors, communication networks, and cloud-based technologies
 - Advanced energy management and efficiency
 - Inclusive of storage systems, wind farms, energy meters, transmission lines, and generators (e.g., power plants)



UK-based utility company National Grid estimates that consumers could avoid 30-50% of grid fluctuations if they adjusted their power usage during peak periods.

General Electric estimates big data and real-time monitoring with the IoE saved 25% on maintenance costs, reduced unplanned downtime by 5%, and resulted in a 75% drop in false outages.

IoE: Transforming Power Grid Management

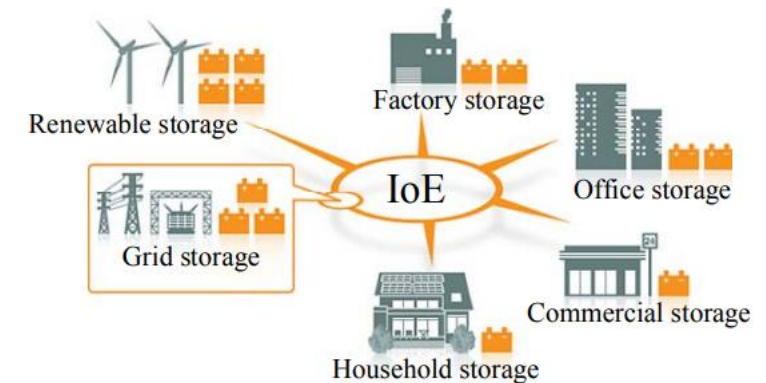


The Internet of Energy (IoE) has the potential to revolutionize power systems by integrating data and communication technologies, enabling better monitoring, control, and optimization. The IoE can be applied to various sectors of the power system, including generation, transmission, distribution, and demand-side management. The implementation of IoE infrastructure can improve efficiency, reliability, and security while reducing costs and emissions.

Source: <https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8735086>

IoE in Power Generation, Transmission, and Distribution

- **IoE and Renewable Energy Sources (RES):** By integrating IoT technologies, renewable energy systems can be optimized, monitored, and controlled more effectively. IoE facilitates the implementation of Virtual Power Plants (VPP), which can be used to manage distributed generation and storage units.
- **IoE and Transmission and Distribution (T&D):** IoT technologies can help monitor the health of transmission and distribution equipment, allowing for better predictive maintenance and fault detection. Additionally, IoT-based Wide Area Monitoring Systems (WAMS) can monitor and analyze grid behavior in real-time, improving grid stability and security.
- **IoE and Thermal Power Plants:** Although the role of thermal power plants is expected to decrease in the future, the IoT can be used to improve efficiency and maintain their operational readiness. Advanced sensors and secure communication platforms enable better preventive maintenance and equipment health monitoring.
- **IoE and Power System Operation and Protection:** IoE can provide better visibility and control over power system operations, helping to manage uncertainty and improve grid security. IoT-based devices can facilitate real-time control over various grid elements, improving scheduling and enabling modern protection schemes.

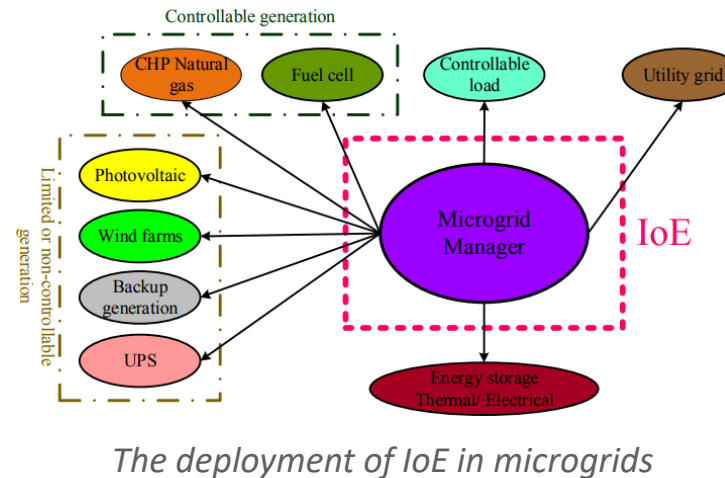


The energy storage management by IoE

Source: <https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8735086>

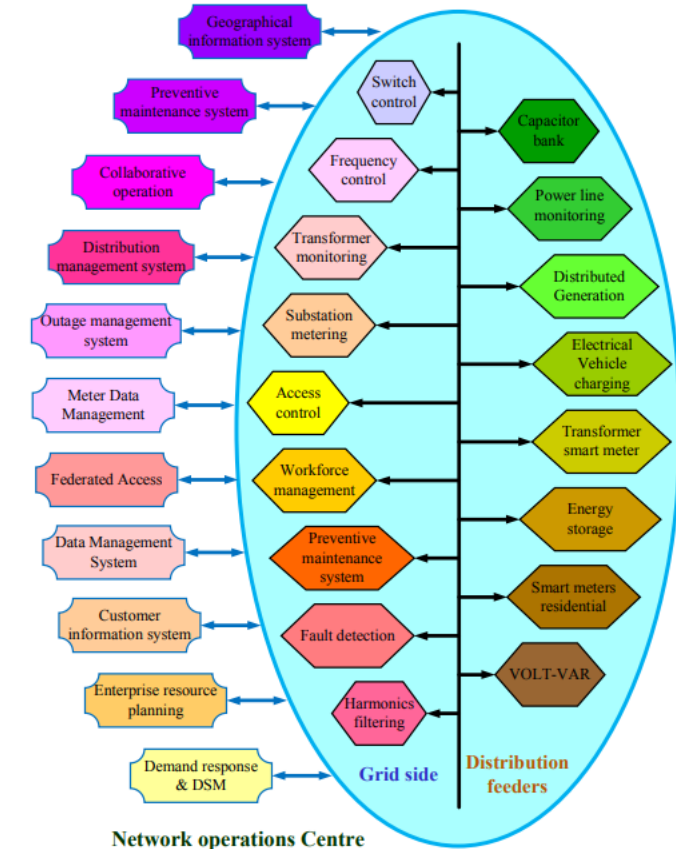
IoE in Demand-side Management

- **IoE and Microgrids:** The implementation of IoE in microgrids can lead to better data sharing, more comprehensive scheduling, and increased efficiency. IoT technologies also enable better security and maneuverability for microgrid operators, as well as improved component behavior analysis.



The deployment of IoE in microgrids

- **IoE and Demand Response:** IoT technologies can facilitate the implementation of demand response programs (DRPs), allowing consumers to manage their electricity consumption in real-time. IoE can also improve control over small-scale loads, automate consumption management, and provide reliable communication systems for DR notifications. The integration of IoT infrastructure in demand response initiatives enables better decision-making by system operators and more options for consumption reduction and load management.



Infographic of IoE in power systems

Source: <https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8735086>

Raltron's Comprehensive Solutions for IoE Applications

- ✓ Raltron's expertise:
 - Leading provider of frequency management components for the Internet of Energy (IoE)
- ✓ Comprehensive product line:
 - From simple tuning fork crystals to high stability, temperature-compensated crystal oscillators and antennas
- ✓ Customized solutions for IoE applications:
 - Meeting ultra-low power, small footprint, and low-cost requirements of the growing IoE market
- ✓ Advantages of partnering with Raltron:
 - Innovative and reliable products tailored for IoE infrastructure and devices
 - Commitment to quality and customer satisfaction
- ✓ Powering the future of energy:
 - Raltron's cutting-edge solutions enable seamless integration and optimized performance in IoE applications



Solutions for Wi-Fi Protocol

The Wi-Fi/IEEE 802.11 has three frequency bands, 2.4/5/6 GHz.

Some Typical Crystal or TCXO frequencies for **Wi-Fi** IoT Applications ICs:

Infineon - CYW43012 - 37.4 MHz, 32.768 kHz
CY8C62xA - 16 to 35 MHz, 32.768 kHz

Silicon Labs - WF200 - 38.4 MHz, 32.768 kHz
RS9116 - 40 MHz, 32.768 kHz

Microchip - ATWINC3400A-MU - 26 MHz, 32.768 kHz

Raltron Stub Antennas Solutions

[RST-2400-P-190-IPEX-H](#)

[RST-MB-P-153-SMA-G](#)



The Wi-Fi 6/IEEE 802.11ax has two frequency bands, 2.4/5 GHz.

The Crystals for lower frequencies of Wi-Fi 6 such as 38.4 and 48 MHz, and for higher are 76.8 and 96 MHz

Some Typical Crystals or TCXO frequencies for **Wi-Fi 6** IoT Applications ICs:

SparkLan - WNFB-266AXI(BT) - 37.4 MHz, 32.768 kHz
AP6281 - 59.97 MHz, 32.768 kHz

[See All Crystal Products](#)

[See Antenna Products for Wi-Fi](#)

Solutions for Bluetooth & BLE Protocol

Bluetooth Low Energy uses the same 2.4 GHz radio frequencies as classic Bluetooth
Some Typical Crystal or TCXO frequencies for **Bluetooth & BLE** IoT Applications ICs:

Infineon - PSoC 6 MCU: CY8C63x6, CY8C63x7 - 16 MHz/32 MHz Crystal Oscillator
16 to 35 MHz, 32.768 kHz On-chip Crystal Oscillators
- 2.4 GHz Chip Antenna

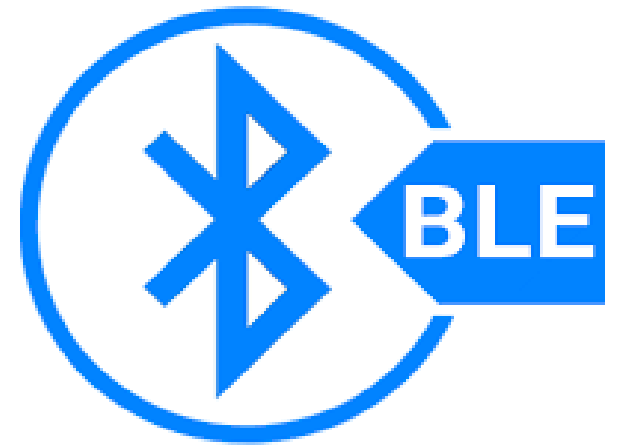
Nordic Semiconductor - nRF52810 - 64 MHz Crystal Oscillator, 32 MHz Crystal
32.768 kHz Crystal Oscillator, 32.768 kHz Crystal
1 MHz/16 MHz/32 MHz Peripheral Clock
- 2.4 GHz Antenna

Texas Instruments - CC2640R2F - 32.8 kHz/48 MHz RC Oscillator, 24 MHz Crystal Oscillator
32.768 kHz Crystal Oscillator
- 2.4 GHz Antenna

NXP Semiconductors - MKW39/38/37 - 26 MHz/32 MHz Crystal, 32.768 kHz Crystal Oscillator
- 2.4 GHz Antenna

Dialog Semiconductor - DA1469x - 32 MHz Crystal, 32.768 kHz Crystal Oscillator
- 2.4 GHz Antenna

STMicroelectronics - BlueNRG-LPS - 32 MHz Crystal, 32.768 kHz Crystal
- 2.4 GHz Antenna



[See All Crystal Products](#)

[See Antenna Products for Bluetooth](#)

Solutions for Near-field Communication Protocol

NFC operates at 13.56 MHz on ISO/IEC 18000-3 air interface. The technology is a simple extension of the ISO/IEC14443 proximity-card standard(contactless card, RFID).

Some Typical Crystal or TCXO frequencies for **Near-field communication** IoT Applications ICs:

NXP Semiconductors - PN7160_PN7161 - 27.12 MHz Crystal, 40 MHz Oscillator
PN7150 - 27.12 MHz Crystal, 40 MHz Oscillator

STMicroelectronics - ST25R3916 - 27.12 MHz Crystal, 27 kHz RC Oscillator, 32.768 kHz Crystal
ST25RU3993 - 20 MHz TCXO
ST95HF - 27.12 MHz Crystal



[See All Crystal Products](#)

[See Antenna Products for NFC](#)

Solutions for GNSS

Global Navigation Satellite System (GNSS) is the standard generic term for all navigation satellites systems like GPS, GLONASS, GALILEO, BeiDou, QZSS, NAVIC.

Some Typical Crystal or TCXO frequencies
for **GNSS** IoE Applications ICs:

Unicore Communications - UC6228CI - 26 MHz TCXO, 32.768 kHz Crystal

STMicroelectronics - STA8100GA - 32.768 kHz Crystal

Maxim Integrated - MAX2769 - 16.368 MHz Crystal

Raltron GNSS Antennas Solutions

[RPA-GP-1575-A-18-IPEX-27-G](#)

[RPA-GP-P-18-G](#)

[See All Products for GNSS](#)

GPS	BeiDou
L1: 1575.42 MHz / L2: 1227.6 MHz / L5: 1176.45 MHz	B1: 1561.098 MHz – 1589.742 MHz / B2: 1207.14 MHz / B3: 1268.52 MHz
GALILEO	NAVIC
E1: 1575.42 MHz / E6: 1278.75 MHz / E5: 1176.45 – 1204.14 MHz	L5: 1176.45 MHz / S: 2492.028 MHz
GLONASS	QZSS
L1: 1598.0625 - 1604.40 MHz L2: 1242.9375 - 1248.63 MHz	L1C/A, L1C, L1AIF, L1S, L1Sb: 1575.42 MHz / L2C: 1227.60 MHz / L5, L5S: 1176.45 MHz / LEX: 1278.75 MHz / S-band: 2GHz

Frequency Band

Solutions for ZigBee Protocol

The ZigBee/IEEE 802.15.4 has three frequency bands, allowing operation in all regions of the world: 2.4 GHz for worldwide applications, 868 MHz for Europe and 915 MHz for the American.

Some Typical Crystal or TCXO frequencies for ZigBee IoT Applications ICs :

Texas Instruments - CC2652RSIP - 48 MHz Crystal
48 MHz Crystal Oscillator
32.768 kHz Crystal Oscillator
- 2.4 GHz Inverted F Antenna

Nordic Semiconductor - nRF52832 - 64 MHz Crystal Oscillator
32 MHz Crystal, 32.768 kHz Crystal Oscillator
- 2.4 GHz Chip Antenna

NXP Semiconductors - JN5189 - 32 MHz Crystal Oscillator
32.768 kHz Crystal Oscillator
- 2.4 GHz Antenna

Raltron Stub Antennas Solutions

[RST-2400-P-190-IPEX-H](#)

[RST-MB-P-153-SMA-G](#)



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Raltron Solutions - MHz Crystals









Available Crystal Packages

Part #	Size(mm)
R1612-27.120-8-F-3030-EXT-TR	1.60 x 1.25 x 0.32
R2016-48.000-8-F-1030-EXT-TR	2.00 x 1.60 x 0.50
R2520-27.120-10-F-1515-TR-NS1	2.50 x 2.00 x 0.65
RH100-24.000-9-1010-TR	3.20 x 2.50 x 0.70

Typical Frequencies:

16 MHz, 26 MHz, 32 MHz, 37.4 MHz, 38.4 MHz, 40 MHz, 48 MHz, 59.97 MHz , 64 MHz

Stock at our Distributors

Product Series	Datasheet	Image	Contact Us / Buy Now
R1612 View products in stock	 PDF		Buy Now
R2016 View products in stock	 PDF		Buy Now
R2520 View products in stock	 PDF		Buy Now
RH100 View products in stock	 PDF		Buy Now

[See All Crystal Products](#)



Raltron Solutions - Tuning Fork 32.768 kHz

Available Tuning Fork Crystal Packages

Part #	SIZE(mm)
RT1210-32.768-9-TR	1.2 x 1.0
RT1610-32.768-12.5-TR	1.6 x 1.0
RT2012-32.768-7-20-EXT-TR	2.0 x 1.2
RT3215-32.768-12.5-TR	3.2 x 1.5
RSE-32.768-12.5-H14-TR	6.9 x 1.4
RSM200S-32.768-12.5-TR	8.0 x 3.8

Load capacitance values: 6 pF, 7 pF, 9 pF and 12.5 pF

Frequency Tolerances: ± 20 ppm and ± 10 ppm



Stock at our Distributors

Product Series	Datasheet	Image	Contact Us / Buy Now
RT1210 View products in stock			Buy Now
RT1610 View products in stock			Buy Now
RT2012 View products in stock			Buy Now
RT3215 View products in stock			Buy Now
RSE H14			Buy Now
RSM200S View products in stock			Buy Now

[See All Crystal Products](#)

Raltron Solutions - TCXOs and VCTCXOs

Raltron TCXOs Solutions

Part #	Size(mm)
RTX-1612BD32-S-52.000-TR	1.6 x 1.2
RTX-2016AD333-S-26.000-TR	2.0 x 1.6
RTX-2520AD31-S-26.000-TR	2.5 x 2.0
RTX-2520AF32-S-48.000-TR	2.5 x 2.0

[See All TCXOs Products](#)

- Tighter Stability: ± 0.5 ppm ~ ± 2.5 ppm, $-40 \sim +85^{\circ}\text{C}$
- Improved Frequency Tuning Characteristic
- Superior Phase Noise Performance (-130 dBc/Hz on the floor)
- Range Supply Voltage: $1.8\text{ V} \sim 3.3\text{ V}$
- Typical Frequencies: 10.0 MHz, 16.0 MHz, 19.2 MHz, 20.0 MHz, 26.0 MHz, 32.0 MHz, 38.4MHz, 48.0 MHz, 50.0 MHz, 52.0 MHz













Stock at our Distributors

Product Series	Datasheet	Image	Contact Us / Buy Now
RTX-1612 View products in stock			Buy Now
RTV-2016 View products in stock			Buy Now
RTX-2520 View products in stock			Buy Now



Raltron Solutions – Antennas

Raltron Antennas Solutions

Part #	Datasheet	Image	Frequency(MHz)	Contact Us / Buy Now
RCA-3216-A1-TR			BLUETOOTH: 2450±50	Contact Us
RCA-5220-A0-TR			BLUETOOTH: 2450±50	Buy Now
RCA-E-3216-A2-TR			BLUETOOTH: 2400~2483.5	Contact Us
RCA-E-3216-E1-TR			GPS: 1575	Contact Us
RCA-W2-P-3216-A29-G			BLUETOOTH: 2545	Contact Us
RCA-W2A1-3216-Z-040			2400~2500	Buy Now

[See Antenna Products for Wi-Fi](#)

[See Antenna Products for Bluetooth](#)

[See Antenna Products for GNSS](#)

[See Antenna Products for ZigBee](#)

[See Antenna Products for NFC](#)



Raltron Solutions – VCOs

Raltron VCOs Solutions

VCO SIZE (mm)	FREQUENCY(GHz)
5 x 4	300 to 2.6
8 x 6	Up to 12
7.6 x 7.6	Up to 12
12.5 x 12.5	Up to 12

Raltron VCOs:

Frequency Range: up to 12.00 GHz

Low Phase Noise and Fast Settling Time

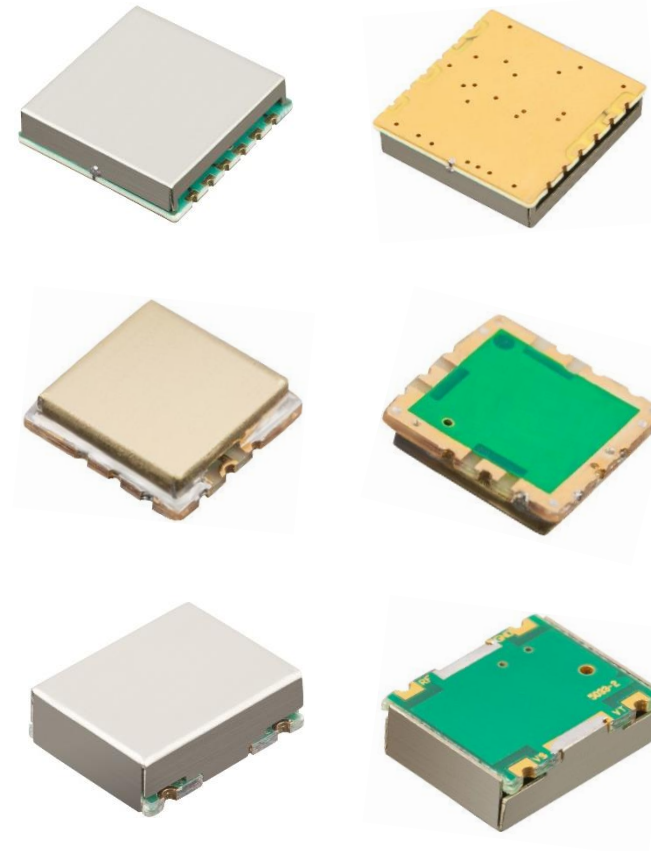
Excellent Return Loss

Supply Voltage: +2.2 to +12.0 VDC

Ultra Wide Tuning Ranges





Packages: 5 x 4 to 20 x 20 mm footprint

[See All VCOs Products](#)



Raltron Products – LTCC Filters, Baluns and Diplexers

Raltron LTCC Filters, Baluns and Diplexers Solutions













Part #	Datasheet	Size(mm)	Contact Us / Buy Now
RCF-5500.000-700000-1005-W-001	 PDF	1.00 x 0.50 x 0.40	Contact Us
RBL-2430.000-1005-EV-001	 PDF	1.00 x 0.50 x 0.40	Contact Us
RCDI-24-49-1608-W-TR	 PDF	1.60 x 0.80 x 0.60	Contact Us
RCDI-W2A1-W5A17-1608-W-TR	 PDF	1.60 x 0.80 x 0.60	Contact Us

[See All LTCC Filters, Baluns and Diplexers Products](#)



Raltron Solutions - RF Connectors











Raltron RF connectors with low insertion loss and excellent voltage standing wave ratio support the high-level performance demanded by IoE Applications.

Product #	Datasheet	Image	Connector Family	Description
RCN-3F-3108-K-001			BNC	BNC Straight Jack PCB Receptacle
RCN-4F-28012-K-001			MCX	MCX Straight Jack PCB Receptacle
RCN-5F-33106-K-001			MMCX	MMCX Straight Jack PCB Receptacle
RCN-17M-12816-K-001			N	Type N Right Angle Plug
RCN-1M-21419-K-001			SMA	SMA Straight Plug (Quick Fit) for Semi Rigid Cable
RCN-9F-16801-K-001			TNC	TNC Straight Jack Bulkhead Crimp



Raltron Solutions - RF Cable Assemblies

Raltron cable assemblies range from simple jumpers to power and high-speed data cables.

Product #	Datasheet	Image	Cable Assemblies	Description
RCB-16-F-95-11-SD	 PDF		SMA to IPEX	RP SMA Jack S/T For RF1.13 Cable
RCB-21-174-150-DO-001	 PDF		MCX to MCX	MCX Plug to MCX R/A Plug For RG174 Cable
RCB-14-H-100-12-SD	 PDF		MCX to SMA	SMA Jack to MCX Plug For RF1.37 Cable
RCB-15-A-100-12-SD	 PDF		MMCX to SMA	SMA to MMCX For RG174 Cable
RCB-13-J-600-13-SD	 PDF		TNC to SMA	TNC Jack S/T For RG316 Cable



[CABLE ASSEMBLIES SHORT FORM CATALOG](#)

Contact



<http://www.raltron.com>

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