

Internet of Energy (IoE)

Apr. 2023

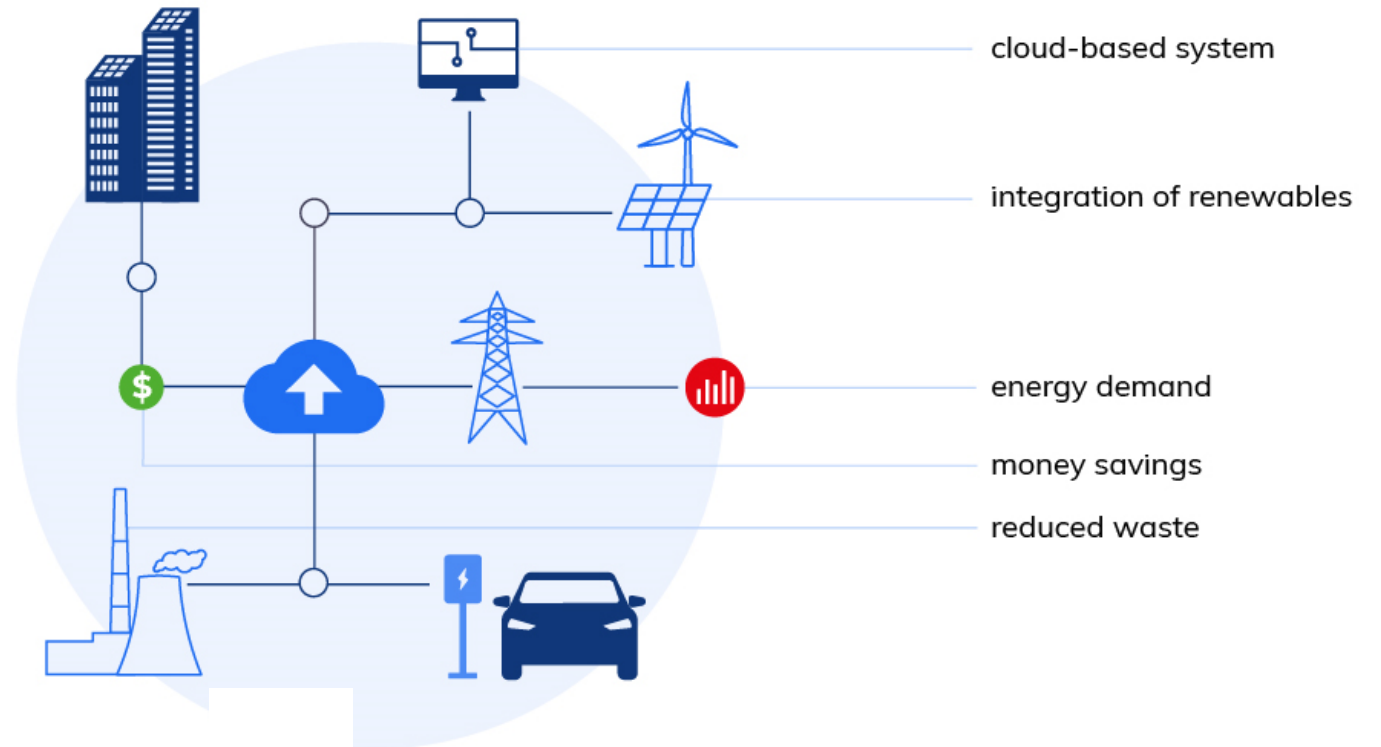


RALTRON

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

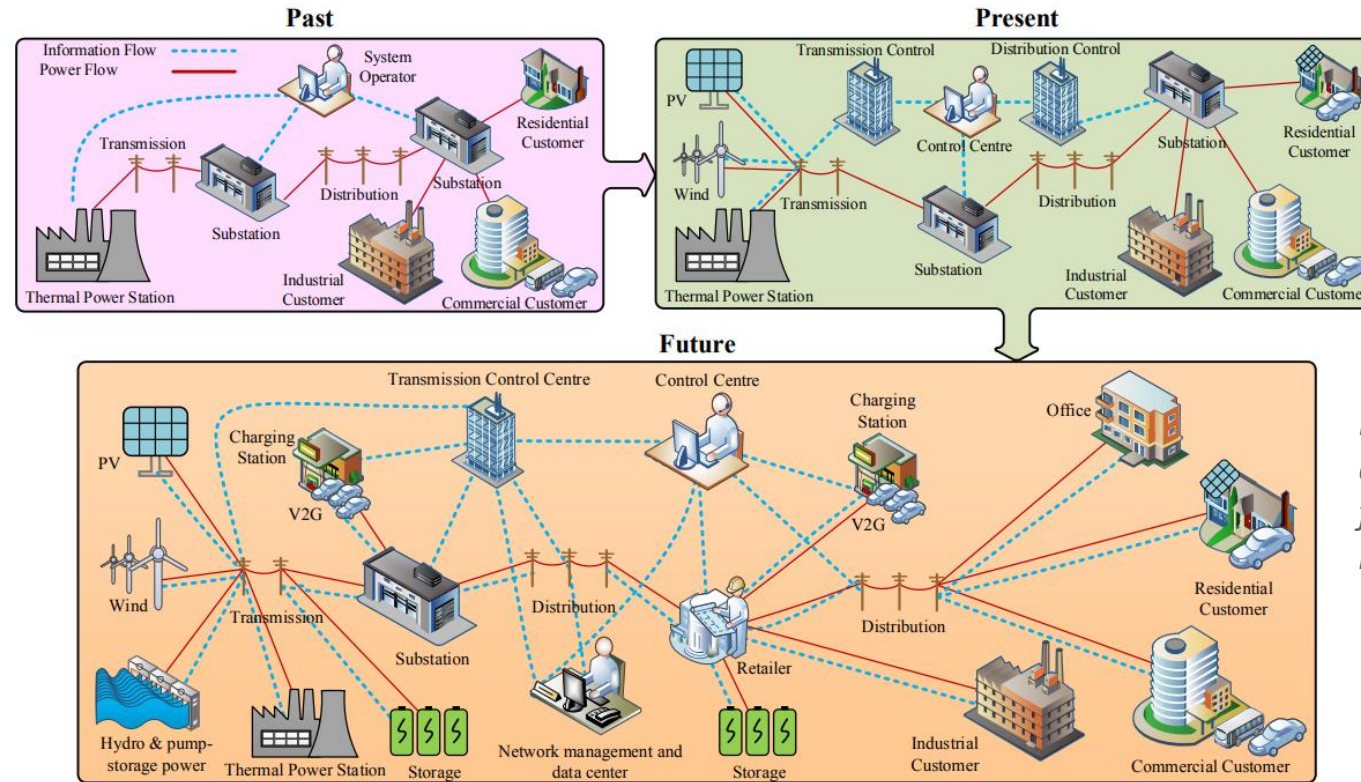
- ✓ Smart grids:
 - Enhanced energy distribution
 - Demand-response mechanisms
 - Supply-demand balance
- ✓ Electric vehicles and Vehicle-to-grid (V2G) technology:
 - Optimized charging
 - Leveraging batteries for grid energy storage
- ✓ Renewable energy integration:
 - Streamlining the adoption of solar, 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

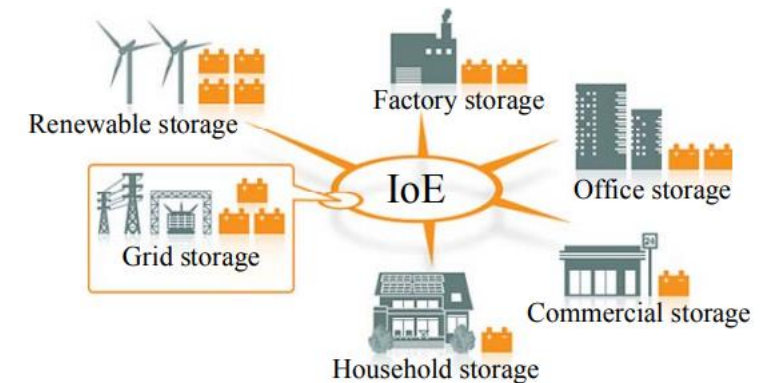


The Internet of Everything (IoE) has the potential to revolutionize power systems by integrating data and communication technologies, enabling better monitoring, control, and optimization. The IoE can be applied to various sectors of the power system, including generation, transmission, distribution, 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.

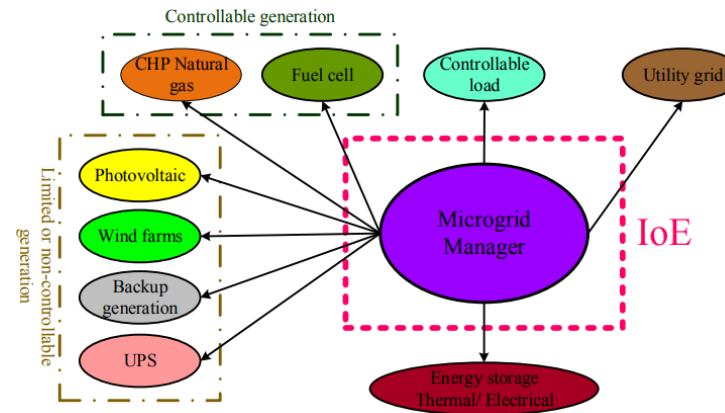


The energy storage management by IoE

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** IoE 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** Wireless IoE 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

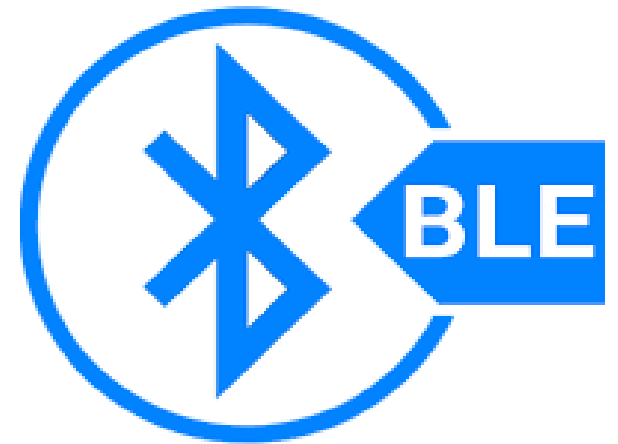
Nordic Semiconductor - nRF52810 - 64 MHz Crystal Oscillator, 32 MHz Crystal
32.768 kHz Crystal Oscillator, 32.768 kHz Crystal
1 MHz/16 MHz/32 MHz Peripheral Clock
- 2.4 GHz Antenna

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](#)

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

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

[See Antenna Products for GNSS](#)

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](#)



[See All Crystal Products](#)
[See Antenna Products for Zigbee](#)

Raltron Solutions - MHz Crystals

Available Crystal Packages


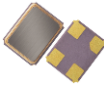



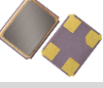

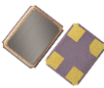
Part #	Size(mm)
R1612-27.120-8-F-3030-EXT-TR	1.60 x 1.25 x 0.32
R2016-48.000-8-F-1030-EXT-TR	2.00 x 1.60 x 0.50
R2520-27.120-8-F-3030-EXT-TR	2.50 x 2.00 x 0.65
RH100-24.000-9-1010-TR	3.20 x 2.50 x 0.70

[See All Crystal Products](#)

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			Buy Now
R2016 View products in stock			Buy Now
R2520 View products in stock			Buy Now
RH100 View products in stock			Buy Now



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

Typical example of IC for Matter using a 32.768 kHz crystal as frequency reference:

Texas Instruments - CC1352P7

Using 32.768 kHz crystal

CL: 6, 7 or 12 pF

ESR: 90 kΩ max

Raltron Solutions - TCXOs and VCTCXOs







Raltron TCXOs IC 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 V ~ 3.3 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 /RTV-1612			Buy Now
RTX /RTV-2016 View products in stock			Buy Now
RTX /RTV-2520 View products in stock			Buy Now



Raltron Solutions – Antennas

Raltron Stub Antennas Solutions

Part #	FREQUENCY(MHz)
RST-W2-P-195-RPSMA-G	2400 ~ 2500
RST-W2A1-20022-17M-TE-001	2400 ~ 2500
RST-W7-30-A-G	2400 ~ 2500

Raltron Chip Antennas Solutions

Part #	FREQUENCY(MHz)
RCA-3216-A1-TR	2450

Raltron GPS Antenna	FREQUENCY(MHz)
RPA-GP-A-16-IPEX-25-G	1575.42

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



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

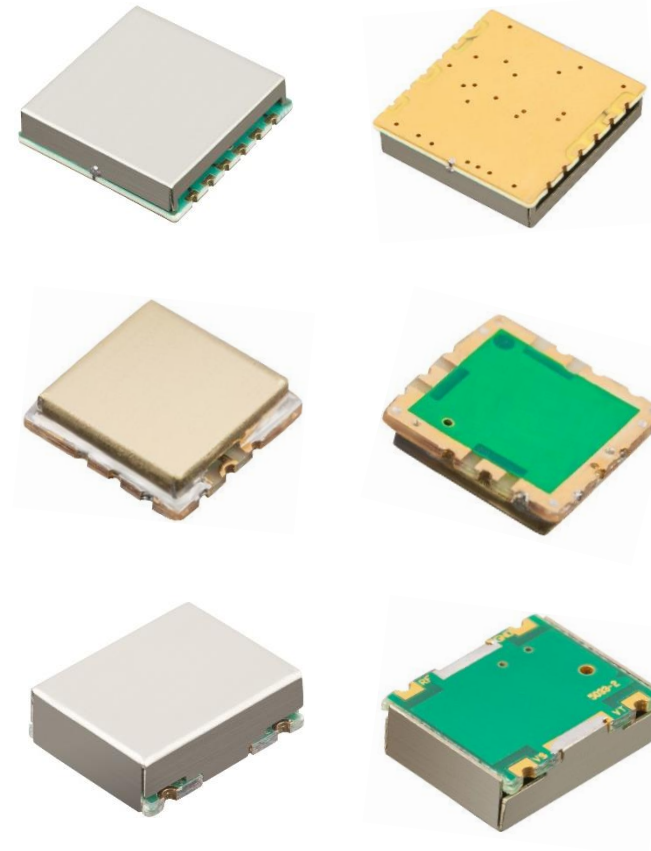
Excellent Return Loss

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 #	Size(mm)
RCF-5500.000-700000-1005-W-001	1.00 x 0.50
RBL-2430.000-1005-EV-001	1.00 x 0.50 x 0.40
RCDI-24-49-1608-W-TR	1.60 x 0.80 x 0.60
RCDI-W2A1-W5A17-1608-W-TR	1.60 x 0.80 x 0.60

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



Raltron Solutions RF Connectors and RF Cable Assemblies

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



SMA CONNECTORS - [RCN-1M-21419-K-001](#)

BNC CONNECTORS - [RCN-3F-3108-K-001](#)

MCX CONNECTORS - [RCN-4F-28012-K-001](#)

MMCX CONNECTORS - [RCN-5F-33106-K-001](#)

TNC CONNECTORS - [RCN-9M-16205-K-001](#)

N CONNECTORS - [RCN-17M-12816-K-001](#)

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

SMA TO IPEX CABLE - [RCB-16-F-95-11-SD](#)

MCX TO MCX CABLE - [RCB-21-174-150-DO-001](#)

MCX TO SMA CABLE - [RCB-14-H-100-12-SD](#)

MMCX TO SMA CABLE - [RCB-15-A-100-12-SD](#)

TNC TO SMA CABLE - [RCB-13-J-600-13-SD](#)



[CABLE ASSEMBLIES SHORT FORM CATALOG](#)

Contact



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