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4G HIGH PERFORMANCE WITH A SMALL CHIP ANTENNA? RUN mXTEND™ & SmarTune™

APPLICATION NOTE
RUN mXTEND™ (NN02-224)

4G HIGH PERFORMANCE WITH A SMALL CHIP ANTENNA? RUN mXTEND™ & SmarTune™

- **Antenna Component:** RUN mXTEND™ NN02-244
- **Dimensions:** 12.0 mm x 3.0 mm x 2.4 mm
- **Frequency regions:** 698-960 MHz & 1710-2690 MHz
  Impedance Tuner: SmarTune™ 32CK417R or 32CK301R by Cavendish Kinetics

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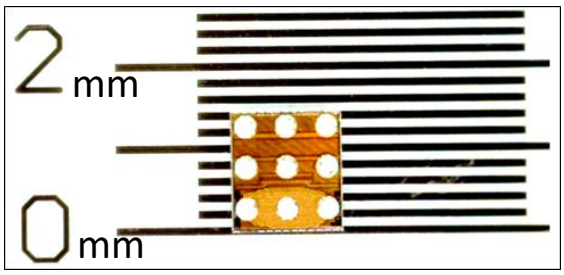
By using RUN mXTEND™ along with the SmarTune™ Impedance Tuner the result is an active and versatile antenna system that supports all mobile frequency bands within the 698 MHz to 2690 MHz frequency range, while optimizing the antenna system performance and minimizing the antenna component size. The main feature of such a booster-tuner combination is that the mobile device can dynamically focus on a specific bandwidth within the entire frequency range to extract the maximum radiation of the mobile platform in every scenario of coverage and user operation.

RUN mXTEND™ antenna booster
NN02-224

Ignion products are protected by Ignion patents.

Ignion is an ISO 9001:2015 certified company. All our antennas are lead-free and RoHS compliant.



SmarTune™ Impedance Tuner
32CK417R and 32CK301R

Cavendish Kinetics products are protected by Cavendish Kinetics patents.

Cavendish Kinetics is an ISO 9001:2015 certified company. All our products are lead-free and RoHS compliant.

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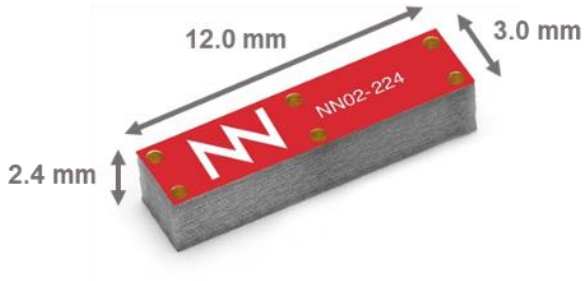
1. PRODUCT DESCRIPTION NN02-224

The RUN mXTEND™ antenna booster (NN02-224) has been specifically designed for providing multiband performance in wireless devices, enabling worldwide coverage by allowing operation in multiple communication standards such as 2G, 3G, 4G, ISM, Zigbee, RFID, GPS, GLONASS, Bluetooth, WIFI, and WLAN, thanks to its flexibility. In this application note, its configuration to operate the 2G, 3G, 4G bands in combination with an impedance tuner is presented.

TOP



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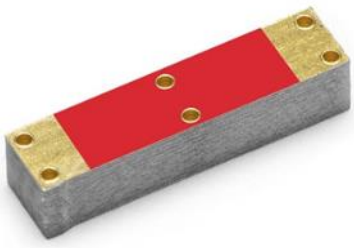


Material: The RUN mXTEND™ antenna booster is built on glass epoxy substrate.

APPLICATIONS

- Handsets and Smartphones
- Tablets and PCs
- Modules
- Routers
- Headsets
- USB Dongles
- Navigators
- Digital Cameras and Smart Watches
- Metering (Gas, Electricity, Water…)
- Sensors (Parking, Speed Control, Optics…)
- IoT Devices

BENEFITS

- High efficiency
- Small size
- Cost-effective
- Easy-to-use (pick and place)
- Multiband behaviour (worldwide standards)
- Off-the-Shelf Standard Product (no customization is required)

The RUN mXTEND™ antenna booster belongs to a new generation of antenna solutions based on the patented Virtual Antenna™ technology owned by Ignion. The technology is mainly focused on replacing conventional antenna solutions by miniature and off-the-shelf chip antenna components that can be seamlessly deployed across a variety of different products and platforms.

2. CAVENDISH CHIP 32CK417R or 32CK301R

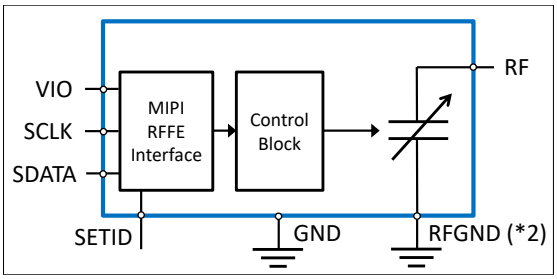
SmarTune™ Antenna Tuners are extremely precise and low-loss variable capacitors that tolerate high RF Voltages, making them ideal for tunable antennas, dynamic load adjustments, tunable filters, and analog RF applications that require high voltage operation. SmarTune™ Antenna Tuners are based on Cavendish Kinetics' patented RF Micro-Electro-Mechanical Systems (MEMS) technology, which eliminates the high insertion loss and RF Voltage handling limitations of traditional Silicon-on-Insulator (SOI) or GaAs devices otherwise used in the RF front-end.

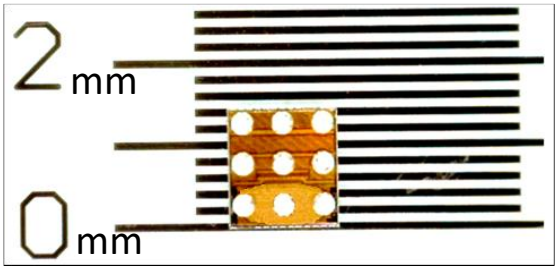
Cavendish Kinetics' patented RF MEMS technology and process produce devices with unprecedented accuracy and reliability, maintaining full specification compliance even after 100 billion cycles.

The 32CK301R SmarTune™ Antenna Tuner is used in this application note. However, this product will be replaced by 32CK417R with a wider capacitor range.

The SmarTune Antenna Tuners are controlled through a MIPI RFFE interface. All functions are self-contained and executed by the logic in the controller.

SmarTune™ Antenna Tuner





FEATURES 32CK417R and 32CK301R

- Extremely compact
- Combining the tuneable capacitor and all required control logic in a small 2 mm^2 Wafer-Level-Chip-Scale Package (WLCSP)
- Easily controlled through the integrated MIPI RFFE controller

- 32CK417R: 0.5pF to 1.65 pF
- 32CK301R: 0.4pF to 1.0pF
- Very high-Quality Factor
- ESR ~ 0.3 Ohm at Cmax
- 5-bit resolution (32 capacitor states)
- SRF > 15GHz
- RF Power handling: +39dBm
- Cycling: > 10^9 cycles
- High Linearity
- MIPI RFFE interface
- Small size: ~ 2mm^2 WLCSP
- Low power: 100µA typical

3. PERFORMANCE FOR DIFFERENT STATES OF THE IMPEDANCE TUNER

3.1. EVALUATION BOARD

This Evaluation Board EB_NN02-224-TA integrates a UFL cable to connect the RUN mXTEND™ antenna booster with the SMA connector. It has a 10-pin socket connecting the evaluation board to a PC using a parallel cable. The software SkyWalker by Cavendish-Kinetics is used to set the impedance tuner 32CK301R to any of its 32 possible states. This Evaluation Board is available under request.

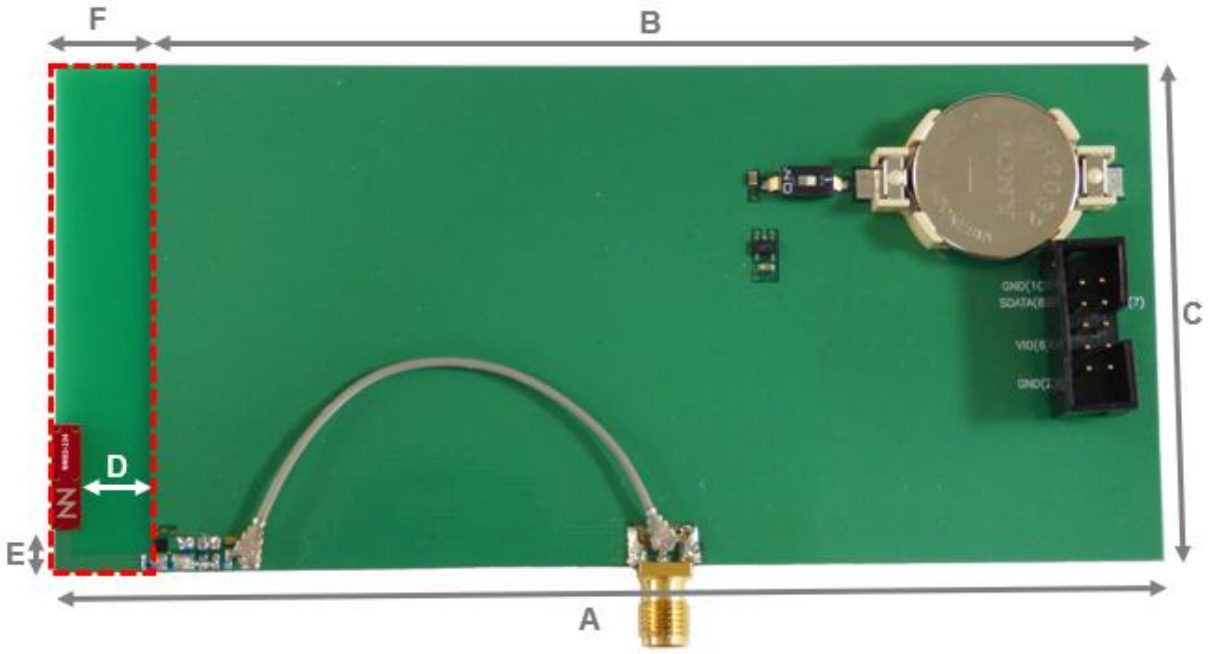


Figure 1 – Evaluation board EB_NN02-224-TA with Cavendish chip 32CK301R providing operation from 698 MHz to 2690 MHz as a function of the selected state of the impedance tuner.

Measure	mm
A	131
B	120
C	60
D	8
E	5
F	11

Tolerance: ±0.2 mm

D: Distance between the RUN mXTEND™ antenna booster and the ground plane.
Material: The evaluation board is built on FR4 substrate. Thickness is 1 mm.
Clearance Area: 11 mm x 60 mm (F x C)

This product and/or its use is protected by at least one or more of the following patents and patent applications http://www.ignion.io/patents. Additional information about patents related to this product is available at www.ignion.io/virtual-antenna/.

3.2. VSWR AND EFFICIENCY

VSWR (Voltage Standing Wave Ratio) and Total Efficiency versus Frequency (GHz) for four states of the impedance tuner. Other 28 states can be also used for fine tune purposes. The proposed four states have been selected as to be compatible with carrier aggregation if needed as shown in section 3.4.

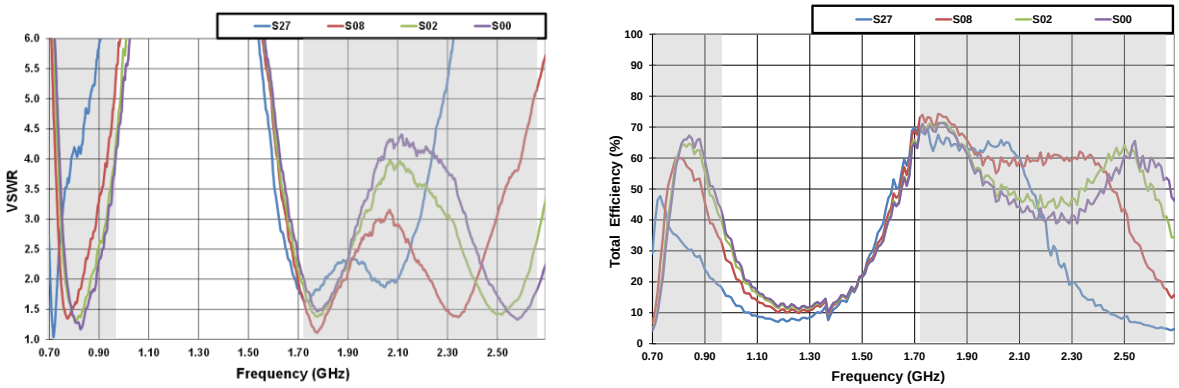


Figure 2 – VSWR and Total Efficiency for the 700 – 2690 MHz frequency range (Figure 1).

	LFR (698 – 960MHz), HFR (1710 – 2690MHz)								
States	**Av. η_a 700 $_{12*}$** [699 - 746]	**Av. η_a 700 $_{13,14}$** [746 - 798]	**Av. η_a 850 $_5$** [824 - 894]	**Av. η_a 900 $_8$** [880 - 960]	**Av. η_a 1800 $_3$** [1710 – 1880]	**Av. η_a 1900 $_2$** [1850 - 1990]	**Av. η_a 2100 $_1$** [1920 - 2170]	**Av. η_a 2300 $_{30}$** [2305 - 2360]	**Av. η_a 2500 $_{41}$** [2496 - 2690]
S27	41.5	37.7	29.0	22.3	65.8	65.3	59.9	17.2	6.0
S08	19.0	53.6	54.0	41.5	71.5	63.8	59.1	60.4	26.2
S02	13.0	46.8	62.5	50.2	69.0	59.6	50.1	48.8	50.6
S00	11.5	44.1	65.4	53.7	68.4	58.5	47.7	42.5	57.2

Table 1 – Average total efficiency (%) for four different states of the impedance tuner. *) The number in the sub index indicates the LTE band.

3.3. MATCHING NETWORK

The specs of a Ignion standard product are measured in their evaluation board, which is an ideal case. In a real design, components nearby the antenna, LCD's, batteries, covers, connectors, etc. affect the antenna performance. This is the reason why it is highly recommended placing pads compatible with 0402 and 0603 SMD components for a matching network as close as possible to the feeding point. Do it in the ground plane area, not in the clearance area. This provides a degree of freedom to tune the RUN mXTEND™ antenna booster once the design is finished and taking into account all elements of the system (batteries, displays, covers, etc.).

Please notice that different devices with different ground planes and different components nearby the RUN mXTEND™ antenna booster may need a different matching network. To ensure optimal results, the use of high Q and tight tolerance components is highly recommended (Murata components).

Please, if you need assistance contact support@ignion.io for more information related to the antenna booster matching service.

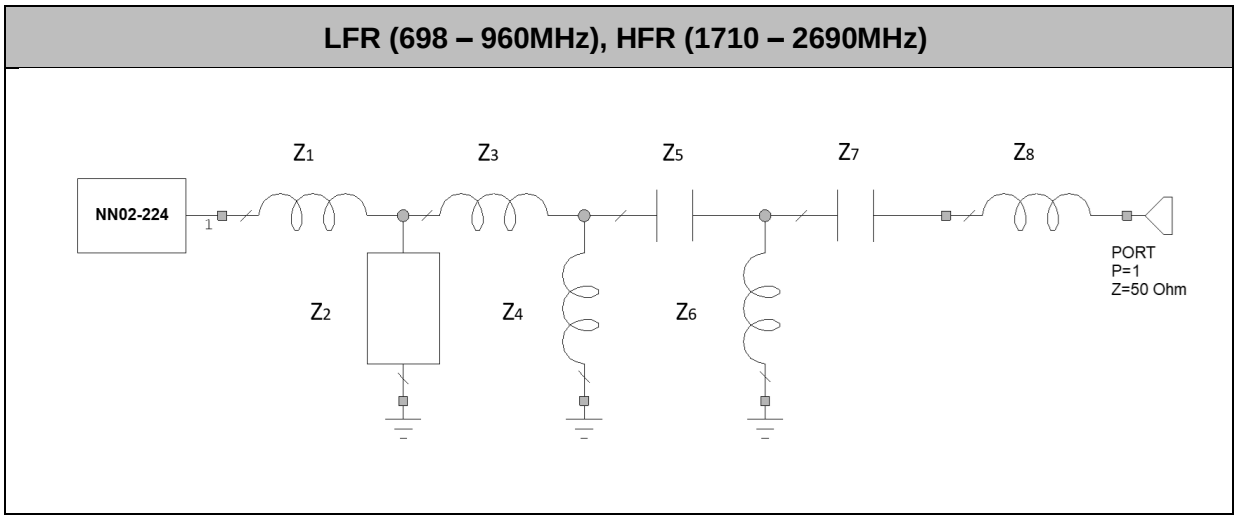


Figure 3 – Topology of matching network implemented in the evaluation board.

Value		Part Number
Z1	8.0 nH	LQW15AN8N0G80
Z2	Impedance tuner	32CK301R
Z3	7.3 nH	LQW15AN7N3G80
Z4	11 nH	LQW15AN11NG80
Z5	0.8 pF	GJM1555C1HR80WB01D
Z6	13 nH	LQW15AN13NG80
Z7	1.9 pF	GJM1555C1H1R9WB01
Z8	2.5 nH	LQW15AN2N5B80D

Table 2 - Values and part numbers of the components used for the matching network.

For additional information, please visit www.ignion.io or contact info@ignion.io.

If you need assistance to design your matching network, please contact support@ignion.io, or try our free-of-charge[1] **NN Wireless Fast-Track** design service, you will get your chip antenna design including a custom matching network for your device in 24h[1]. Other related to NN's range of R&D services is available at: https://www.ignion.io/rdservices/

[1] See terms and conditions for a free NN Wireless Fast-Track service in 24h at: https://www.ignion.io/fast-track-project/

3.4. CARRIER AGGREGATION

The evaluation board provides performance suitable for carrier aggregation (CA). CA in LTE-Advanced uses several frequency bands in order to increase the bitrate. Table 3 shows which state of the impedance tuner is recommended for each pair of inter-band carrier aggregation.

CA configuration	Band#1	Band#2	State	Average Efficiency % (Band#1, Band#2)
CA_1A_5A	2100	850	S08	59.1 – 53.7
CA_1A_18A	2100	850	S08	59.1 – 56.0
CA_1A_19A	2100	850	S08	59.1 – 54.0
CA_2A_17A	1900	700	S27	63.3 – 41.8
CA_2A_29A	1900	700	S27	63.3 – 44.6
CA_3A_5A	1800	850	S00	68.4 – 64.8
CA_3A_7A	1800	2600	S00	68.4 – 57.2
CA_3A_8A	1800	900	S00	68.4 – 53.7
CA_3A_20A	1800	800	S00	68.4 – 64.1
CA_4A_5A	1700	850	S08 / S02	64.4 – 53.7 (S08) / 58.4 – 61.9 (S02)
CA_4A_7A	1700	2600	S00	56.8 – 57.2
CA_4A_12A	1700	700	S27	62.8 – 41.8
CA_4A_13A	1700	700	S08	64.4 – 50.4
CA_4A_17A	1700	700	S27	62.8 – 41.8
CA_4A_29A	1700	700	S27	62.8 – 44.6
CA_5A_12A	850	700	S27	28.7 – 41.8
CA_5A_17A	850	700	S27	28.7 – 41.8
CA_7A_20A	2600	800	S00	57.2 – 64.1
CA_8A_20A	900	800	S00	53.7 – 64.1

Table 3 - Configurations to support carrier aggregation (CA)

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