TECHNICAL PAPER

Active Band Switching Solutions

Alessandro Beretta

KYOCERA AVX Components Corporation
One AVX Boulevard
Fountain Inn, S.C. 29644 USA

Abstract

Today's new and emerging wireless applications are increasingly requiring the support of multiple frequency bands. From laptops to cellular phones to wearables, devices are expected to connect to any cellular, Bluetooth™, GSM, RFID, or other networks. These expectations present challenges when it comes to antenna design, compared to a traditional design. The simplest solution — using discrete antennas for each frequency band required in the application — requires extra physical space. But this ultimately clashes with industry trends that prefer smaller and smaller solutions while still providing more bandwidth.

KYOCERA AVX

ACTIVE BAND SWITCHING SOLUTIONS

INTRODUCTION

Today's new and emerging wireless applications are increasingly requiring the support of multiple frequency bands. From laptops to cellular phones to wearables, devices are expected to connect to any cellular, Bluetooth™, GSM, RFID, or other networks. These expectations present challenges when it comes to antenna design, compared to a traditional design. The simplest solution — using discrete antennas for each frequency band required in the application — requires extra physical space. But this ultimately clashes with industry trends that prefer smaller and smaller solutions while still providing more bandwidth.

So another solution is called for — active band switching. Active band switching permits a single antenna element to be used by actively modifying it to work for different frequency bands on demand. It also permits active tuning to improve RF performance.

METHODOLOGY: BAND SWITCHING OR APERTURE TUNING

Antennas are crucial for reliable radio connections. Good antenna design matches the antenna's electromagnetic radiating mechanism to the frequency band from the transmitting circuitry. A mismatch between the antenna design and the transmitter or receiver's desired frequency band will render the radio useless or unreliable.

Active band switching is when the antenna's resonant frequency switches between different frequency bands, which is beneficial for devices that require a radio to operate across multiple frequency bands but only have the size and space for one antenna.

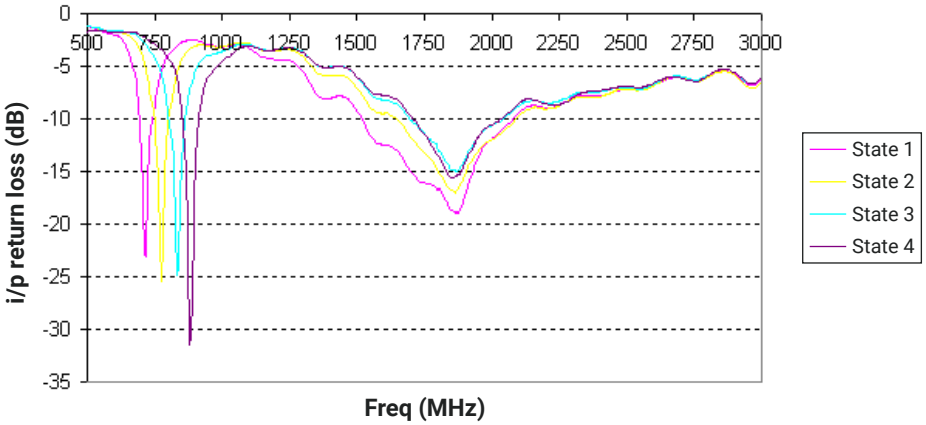


Figure 1: A graph portraying the i/p return loss in dB over varying frequency ranges. Courtesy of AVX

BAND SWITCHING WITH AVX EC686-3

This technique can be implemented using the AVX EC686-3 RF switch with Ether Switch & Tune™ technology. The EC686-3 provides a broader global band coverage (including LTE) with a single antenna element. It achieves this by using parasitic loading and active tuning techniques, especially to meet the stringent low band (LTE) antenna efficiency requirements. Combining extensive antenna systems expertise and proprietary algorithms, the EC686-3 seamlessly adjusts the characteristics of a wireless antenna to:

- Cover all 2G/3G/4G cellular, Bluetooth(R), GSM, ISM, and RFID bands
- Retune the antenna for frequency shifts
- Reduce the antenna's physical volume by up to 50%, without performance tradeoffs
- Help to avoid high losses from the switch due to low on-resistance (R_{ON})

KEY BENEFITS

Operation Frequency

- 100 MHz to 3000 MHz

RF Switch

- SP4T (shunt less architecture)
- Ultra-low R_{ON} (900 mΩ)
- Exceptional linearity (IIP3 +80 dBm)

Flexible Control Interface

- GPIO

Small Package

- Total package size is 2.0 x 2.0 x 0.5mm^3
- Package type is QFN 16-pin

Environmental Compliance

- RoHS2 Directive 2011/65/EU REACH Substances of Very High Concern (SVHC) regulation (EC) No 1907/2006

Figure 2: The key benefits and applications of the AVX EC686-3 RF switch. Courtesy of AVX

BAND SWITCHING: APPLICATION EXAMPLE

The following is an example of a band switching application utilizing the EC686-3, where NTWK 1-4 are tuning networks (typically a single inductor (L), capacitor (C), or an open).

Only RF connections are shown:

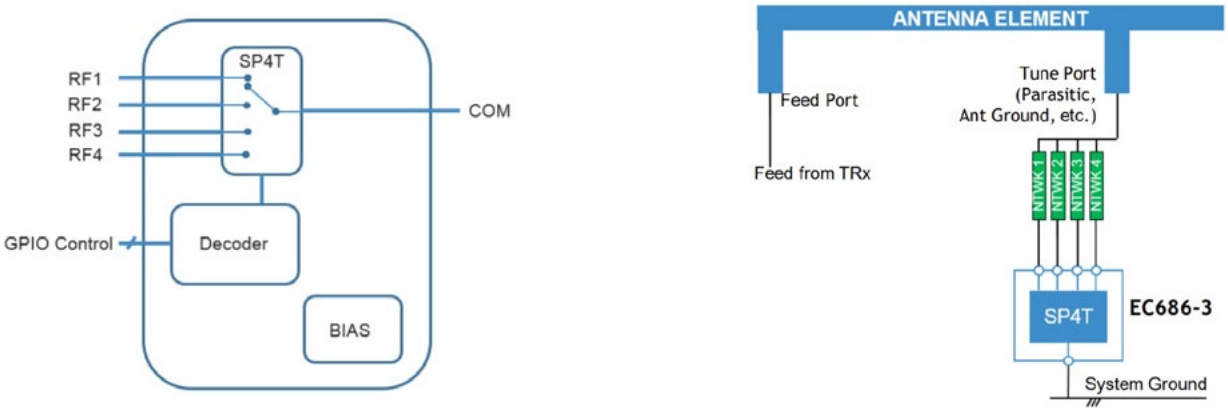


Figure 3: An example of a band switching application utilizing the EC686-3, where NTWK 1-4 are tuning networks (typically a single inductor (L), capacitor (C), or an open). Courtesy of AVX

BAND SWITCHING: APPLICATION EXAMPLE

Grounding the RFC port (COM) is recommended, allowing for a high integrity RF board layout and providing the best performance. The EC686-3 supports a GPIO digital interface to select the best tuning networks for the selected frequency band.

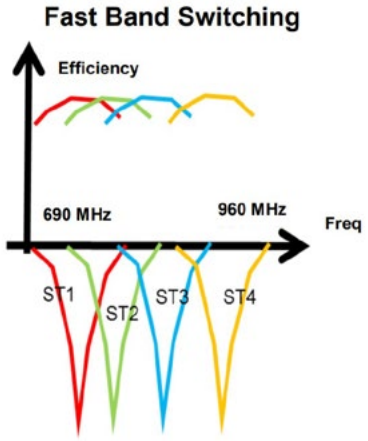


Figure 4: A graph portraying the switch efficiency at varying frequencies. Courtesy of AVX

The EC686-3's GPIO control provides the unique feature of having conventional switch control with only two input pins (allowing the remaining two pins to stay at default), or full 16 state control when using all four pins. Truth table logic is shown in the table below.

EC686-3 (GPIO) TRUTH TABLE

GPIO Inputs				Path States			
GPIO	GPIO	GPIO	GPIO	RF1	RF2	RF3	RF4
0	0	0	0	OFF	OFF	OFF	ON
0	0	0	1	OFF	OFF	OFF	OFF
0	0	1	0	ON	ON	OFF	OFF
0	0	1	1	OFF	OFF	ON	ON
0	1	0	0	OFF	ON	OFF	OFF
0	1	0	1	OFF	ON	OFF	ON
0	1	1	0	OFF	ON	ON	OFF
0	1	1	1	OFF	ON	ON	ON
1	0	0	0	ON	OFF	OFF	OFF
1	0	0	1	ON	OFF	OFF	ON
1	0	1	0	ON	OFF	ON	OFF
1	0	1	1	ON	OFF	ON	ON
1	1	0	0	OFF	OFF	ON	OFF
1	1	0	1	ON	ON	OFF	ON
1	1	1	0	ON	ON	ON	OFF
1	1	1	1	ON	ON	ON	ON

Figure 5: The AVX EC686-3 (GPIO) Truth Table. Courtesy of AVX

BAND SWITCHING: SOFTWARE REQUIREMENTS

Active band switching requires software for implementation. Thankfully, the implementation is not complicated or challenging, so that it can be accomplished with minimal resources.

The EC686-3 must be connected to the application processor using 2 or 4 GPIOs, depending on how many states are needed. There are two possibilities:

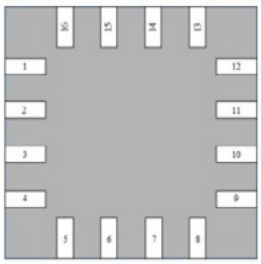
1) **The network carrier is known - In this case, the frequency band can be found in a pre-loaded matrix, and the EC686-3 configuration can be chosen according to a Look-Up Table (LUT), which contain the optimum EC686-3 configuration for each band. This LUT is defined by AVX during the development process.**

2) **There is no favored carrier - In this case, a first configuration of the EC686-3 can be chosen on power-up, and then a full scan is done to find the available network.**

   - Once the network has been identified, the frequency band can be found within a pre-loaded matrix. The EC686-3 configuration can then be chosen according to a Look-Up Table (LUT) that contains the optimum EC686-3 configuration for each band.
   - If no network is found, then the next configuration for the EC686-3 is chosen, and the process starts again.

PACKAGING AND PINOUT

The AVX EC686-3 comes in a small QFN-16 pin package (2.0 mm x 2.0 mm) and is RoHS and REACH compliant. The small size and wide temperature range (-40°C to 85°C) make the EC6866-3 ideal for cellular phones, tablets, and other handheld wireless devices.



EC686-3 Footprint
- Top View -

Size (mm)	2.0 x 2.0 x 0.5
Mounting	Surface Mount
Packaging	Tape & Reel

Figure 6: The AVX EC686-3 comes in a small QFN-16 pin package (2.0 x 2.0mm). Courtesy of AVX

Pin Number	Pin Name	Pin Type	Description
1	RFC	Input	RF Common Input
2	RFC	Input	RF Common Input
3	VDD	Power	Power Supply
4	GND	Ground	Ground
5	GPIO3	Input	GPIO Input
6	GPIO2	Input	GPIO Input
7	GPIO1	Input	GPIO Input
8	GPIO0	Input	GPIO Input
9	GND	Ground	Ground
10	NC	No Connect	No internal connection, ground in application
11	RFC	Input	RF Common Input
12	RFC	Input	RF Common Input
13	RF4	Output	RF Output 4
14	RF3	Output	RF Output 3
15	RF2	Output	RF Output 2
16	RF1	Output	RF Output 1

Figure 7: The different pin package types for the AVX EC686-3. Courtesy of AVX

AVX EC686-3 INDUSTRY-LEADING SOLUTIONS

The AVX EC686-3 offers an industry-leading device for active band switching. Small and simple, the part allows for a compact design that enables multiple RF bands with a single antenna, with minimal software development required. AVX is a leading supplier of antenna solutions (active and passive) for industrial, commercial, automotive, and medical applications. AVX antennas provide enhanced throughput/speed, spectral efficiency, reliability, and performance. For more details, visit AVX's website or check out the EC686-3 datasheet.

NORTH AMERICA
Tel: +1 864-967-2150

ASIA
Tel: +65 6286-7555

CENTRAL AMERICA
Tel: +55 11-46881960

EUROPE
Tel: +44 1276-697000

JAPAN
Tel: +81 740-321250