White Paper

PIM Finding made easy with

Introducing the BPA-0707A filtered Band Pass Amplifier

With greater than 60dB of rejection to the test tones in front of the low noise amplifier, the BPA-0707A and the antenna probe combine to display PIM products right where they are generated.

"Helping Cellular, First Net and Public Safety networks in the 700 MHz band co-exist without interference"

Picture 1: Phone mounted on magnetic holder

The Problem

In the complex environment of interwoven broadband downlink transmissions, and complimentary low noise uplink receivers all in the 700MHz band, Intermodulation was always going to be a headache. Between 3 Cellular carriers, First Net and the Public Safety network, the intermodulation problem is complex.

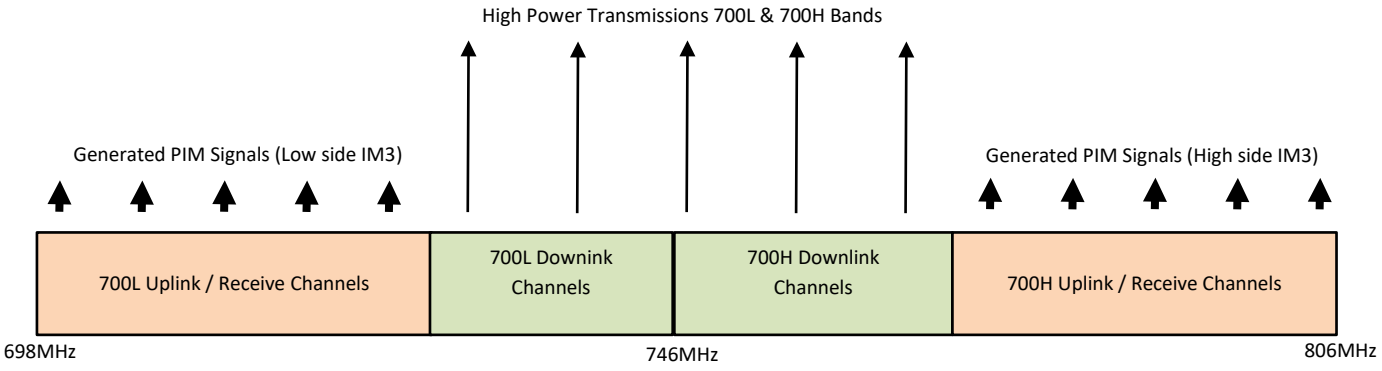


***Figure1**: Simplistic view of a complex problem. Most of the high power transmissions are in the middle of the band. In an unfriendly PIM environment, these will mix and create a forest of PIM signals in the receive bands.700L Band has mobile telephony carriers T-Mobile and AT&T. 700H Band has Verizon Wireless, Public Safety band and the 'First Net' Early responders emergency band. They can all mix with each other.*

Adding to the complexity, is that two broadband carriers mixing in a non-linearity produce a broadband PIM signal that is up to 3 times wider than the original signal bandwidths. This ensures nobody misses out on receiving an unwanted signal.

The Causes

Poor mechanical connections and dissimilar metals in close proximity to these high level signals will produce third order product tones that land in any of the multiple receive bands within the 700 MHz spectrum depending on the chosen carriers. These rogue signals can block the uplink or receive side of the channel, limiting the uplink working radius. Typical causes may be: Cable clamps, TMA and antenna mounting brackets as well as nearby metallic hardware.

The Solution

By combining the Kaelus iVA Cable and Antenna Analyser with the BPA-0707A filtered band pass amplifier, third order Passive Intermodulation (PIM) Products can now be easily found in a hostile RF multi tone test environment. IM3 tone levels are measured by the iVA and are transmitted via Bluetooth from the iVA back to a device running the Kaelus *Unify* application. With the result instantly visible, this makes dynamic PIM finding easy. The BPA is delivered with a magnetic phone mount. Both devices will run all day on their rechargeable Li-ion battery.

Under commissioning conditions, where all systems are not broadcasting, the set up begins with 2 x +46dBm CW tones radiated from the cellular antenna on the tower. Kaelus PIM testers iPA-0707D or iPA-0600D are both ideal for this.

The filtered band pass amplifier (BPA), a part of Kaelus PIM Finder solution, is immune to the large Tx tones present and will only respond to generated PIM signals. With a very low noise floor, large dynamic range and battery powered, the user can walk around with an antenna probe and find the offending PIM generating hardware.

The Product

Receiving these small signals with an independent broadband receiver in an environment where there are two high level tones, presents a major challenge for even the best receiver. The receiver itself can produce the same third order products, known as 'Active PIM', due to the high levels of the test tones present in the receiver front end, rendering the measurement useless.

Picture 2: BPA-0707A

The table below follows the losses from the downlink tone generation to the receiver front end.
The following discussion shows the excellent third order immunity of the BPA and iVA system.

Loss Budget	RF Power	Cumulative Power
Tone Powers	+43dBm	+43dBm
Antenna gain, away from the boresight	-10dB	+33dBm
Path loss (700MHz, 2meters)	-35dB	-2dBm
Probe gain	-10dB	-12dBm
Tones at BPA input connector		-12dBm
SAW filter Rejection	-60dB	-72dBm
Tones at BPA Amplifier Input (OIP3 30dBm, Gain 25dB)		-72dBm
Third order output from BPA Amplifier		-201dBm

Without filtering, even a very linear low noise amplifier with high third order performance, will produce major intermodulation. Consider a front end amplifier with +40dBm OIP3, and 20dB gain.
For the incident tones in the example above (-12dBm), the internally generated third order tones will be:

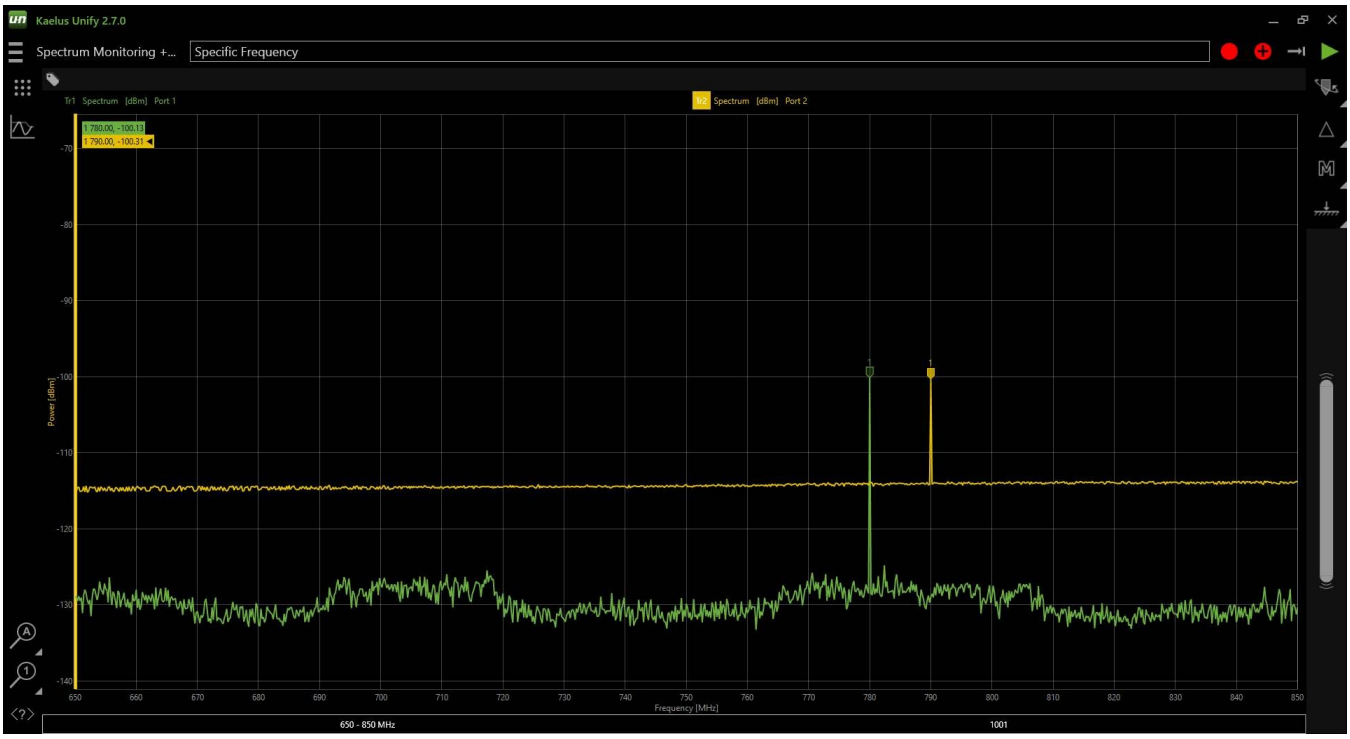
IM3 = 3*(Pin +Gain) – 2* OIP3
IM3 = 3*(-12+20) – 2*40
IM3 = -56dBm Anything below this level will be blocked.

Consider the Kaelus combination (BPA+iVA) where there is 60dB of tone rejection:

IM3 = 3*(-72+25) – 2*30
IM3 = -201dBm Anything above this level will be visible.

Clearly, the iVA and BPA-0707A combination can easily deal with the high level tones present.

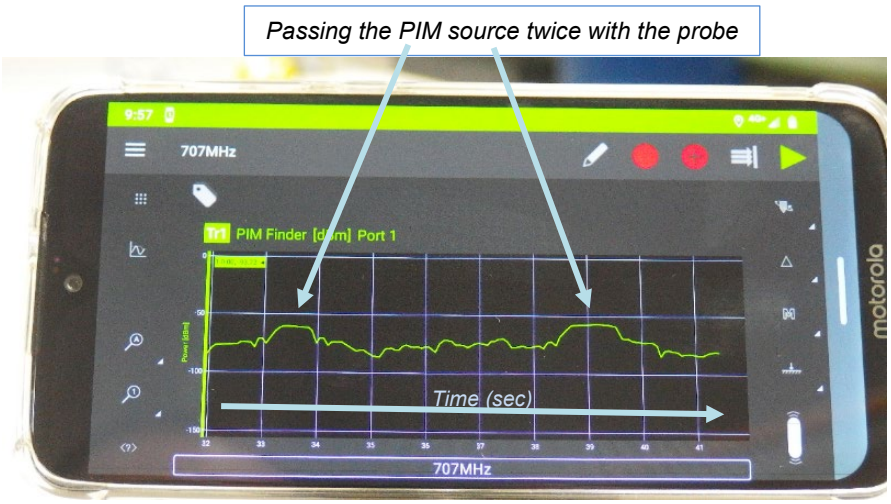
The screen shot below shows the noise floor of the iVA in spectrum monitor mode without the BPA (yellow trace) and with the BPA-0707A (green trace). The signal frequencies are offset slightly for the measurement and it can be seen there is a 15dB advantage with the BPA connected.



The Method

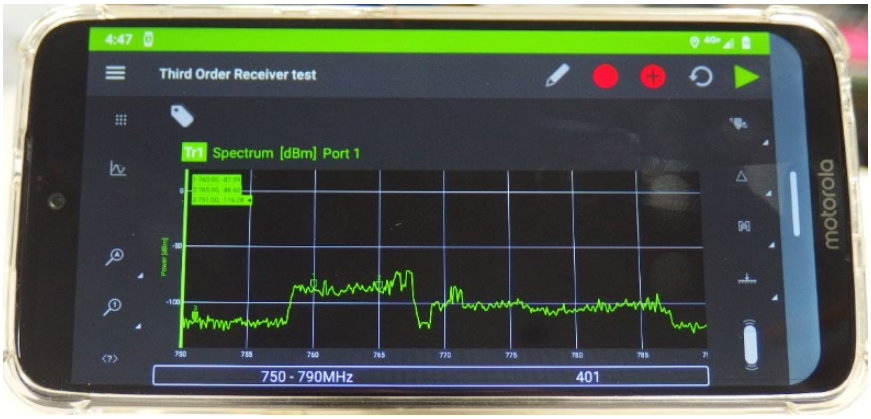
PIM Finder Mode

In the Kaelus Unify iVA app, use ‘PIM Finder’ mode when chasing down PIM caused by two CW tones. This mode responds to the maximum level and updates quickly leaving a time trace on the screen. As the probe is passed by a PIM source, the time trace will show its presence.



Spectrum Monitor Mode

Got a PIM problem and cannot turn off any of the systems?
Then use Spectrum Monitor mode. If the PIM is being generated by two broadband channels mixing somewhere, display the polluted receive band in Spectrum Monitor mode and go looking for its source.



In both cases, enter the amplifier gain offset in PIM Finder and Spectrum Monitor modes. This will lower the noise floor considerably. Add to that an extra 3dB of transmit power by increasing the tone power levels from 2x +43dBm to 2x +46dBm, and you have a versatile and sensitive instrument for the task at hand.

In both cases the system will receive nothing outside of the filter passbands.

BPA-0707A Response

The plot below shows the BPA frequency response with dual passbands. Attenuation is typically 70dB in the band 728 to 757MHz and 60dB in the band 757 to 764MHz.

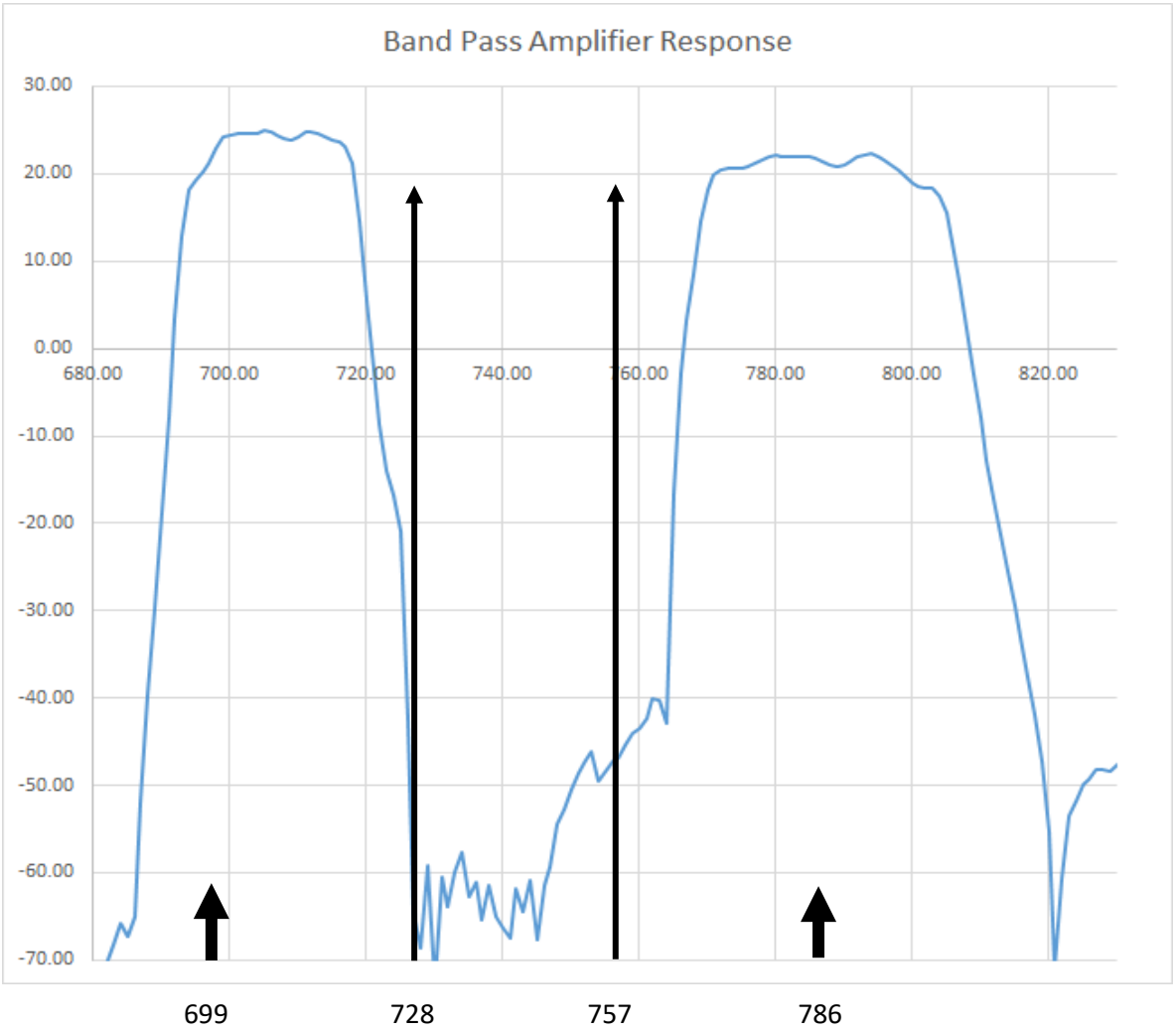
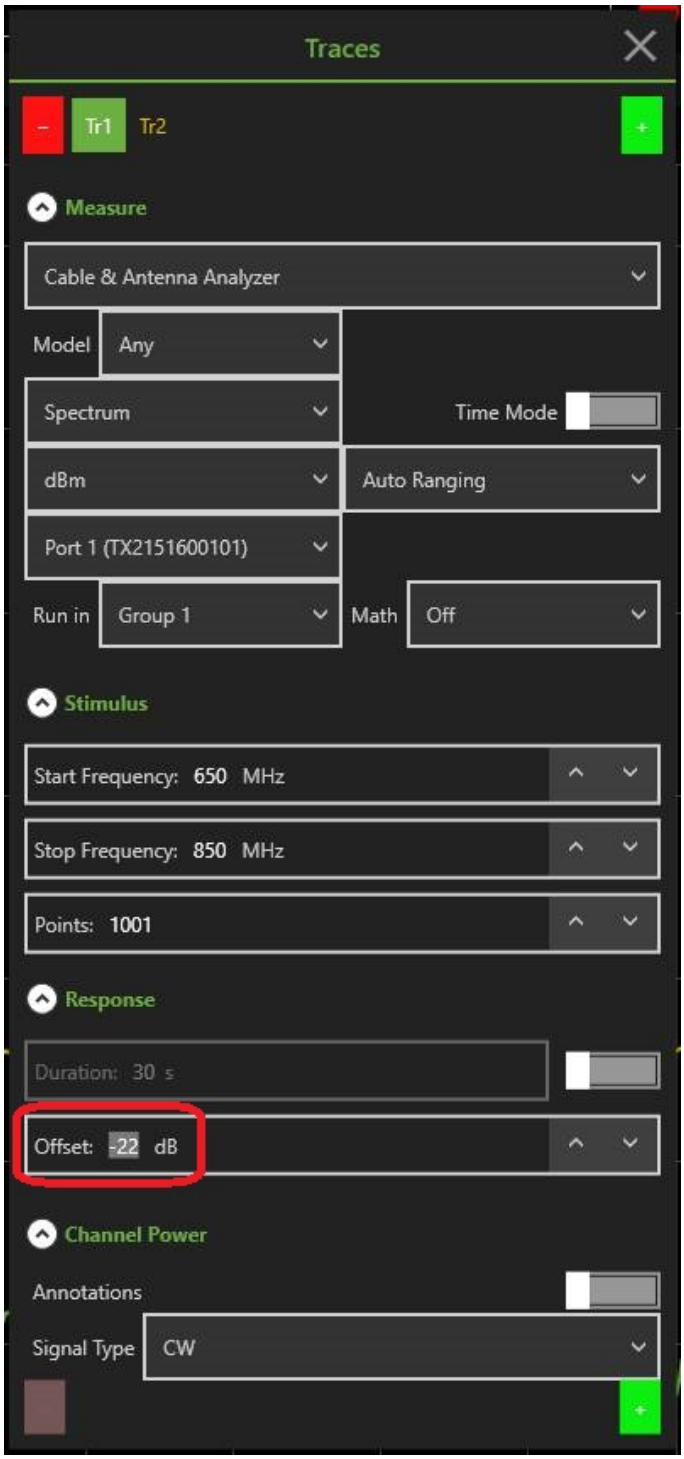


Figure2: *Fixed Tone Testing, Major tones 728 & 757MHz are rejected by the BPA-0707A. Third order products 699 & 786MHz are now visible with the low noise, high rejection amplifier.*

Setting the Gain Offset in Unify

When the BPA is attached to the iVA, the iVA needs to be offset with the value of the gain which is marked on the underside of the BPA. The following image is a screen shot example from Unify where the BPA has a gain of 22dB and that has been included as a -22dB offset.

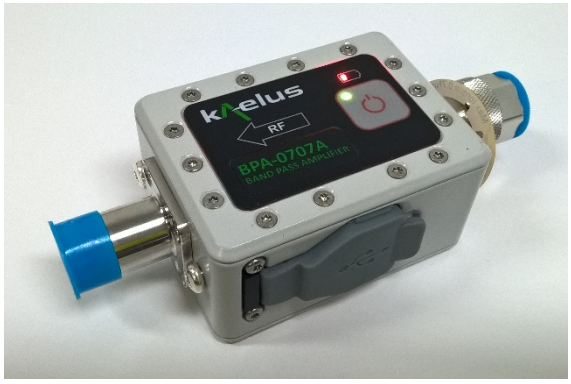


Front panel LED indication

The following images provide an indication of the various states of the BPA based on the colours of the two front panel LEDs.

BPA in the OFF state

BPA in the ON state without need to charge



BPA in the low battery state needing a charge

BPA in the ON state and charging

BPA in the OFF State and charging