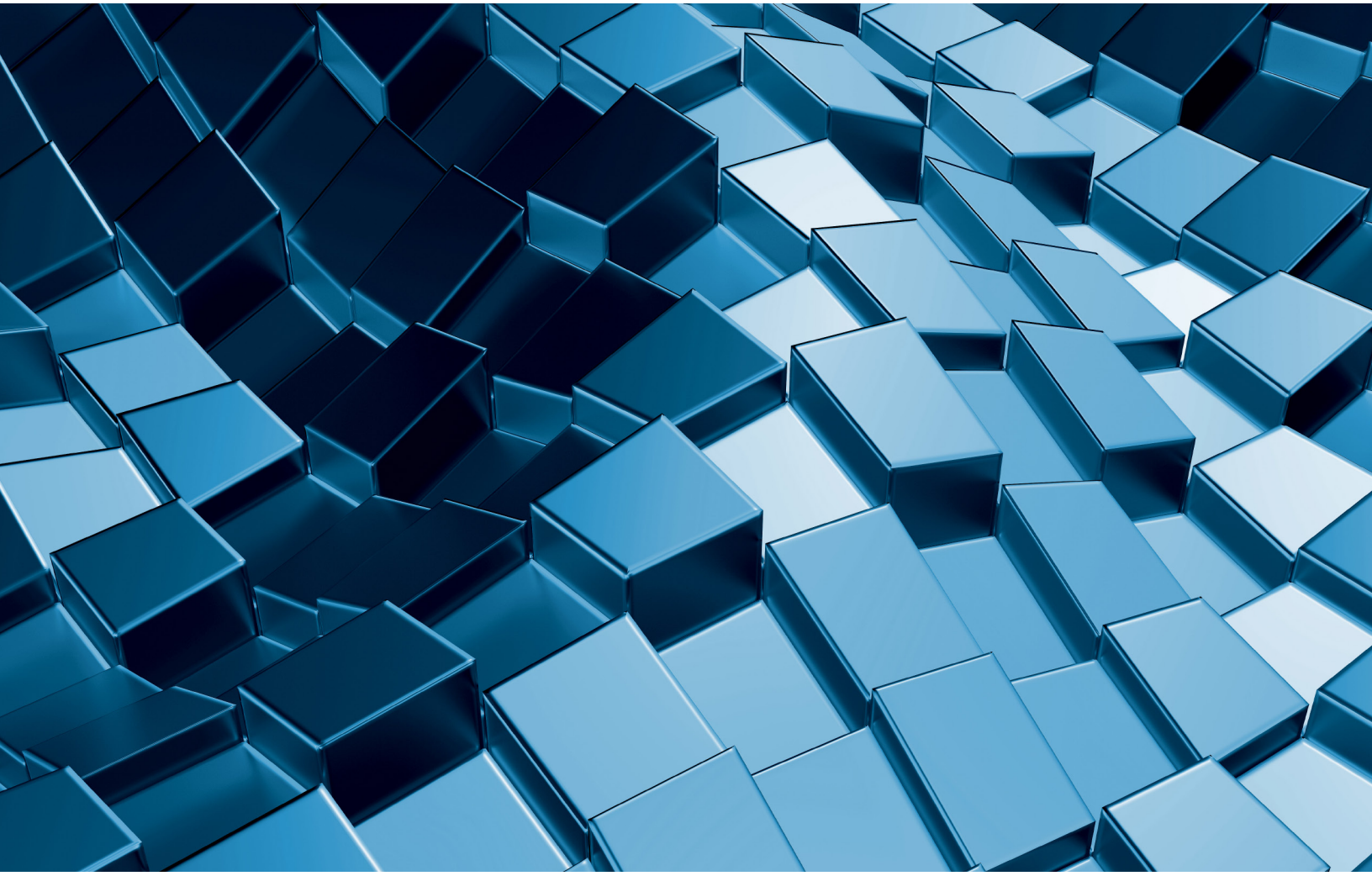

SOLUTION PAPER:

Ensuring IMD and PIM Performance with AWS-3 Spectrum

JMA WIRELESS

Introduction: Advanced Wireless Service

(AWS) is a collective term for radio frequencies mostly used for 3G and 4G mobile services, which support advanced technologies such as LTE. This spectrum easily enables a variety of applications from voice to full-motion video. In March 2014 the FCC (Federal Communications Commission) issued a report regarding the allocation, and technical and licensing rules for commercial use of the 1695-1710 MHz, 1755-1780 MHz and 2155-2180 MHz bands, collectively coined AWS-3. At the conclusion of the AWS-3 auction in January 2015 a record $45 billion in revenue had been generated for the U.S. federal government, making it the largest wireless auction in the history of the FCC and the most significant auction since the 700 MHz one in 2008.

With AWS-3, major U.S. mobile operators can offer new capabilities such as increased LTE bandwidth for data, Voice over LTE (VoLTE), and real-time video services that are increasingly in demand. In order to use AWS-3 mobile carriers must first review and upgrade equipment within their network.

In order to meet the demands of operators involved with the AWS-3 change, JMA Wireless provides a full suite of solutions dedicated to the AWS band, and in particular for the extended version (AWS-3). JMA is the first supplier in the market to design its equipment in support of AWS-3, enabling mobile operators to easily take full advantage of this new spectrum. The company's primary focus is to provide solutions, which can operate with all forms of LTE-enabling technology while coexisting with current systems.

By maintaining full control of its core technology JMA Wireless is able to deliver critical features in its products, which enable excellent Error Vector Magnitude (EVM) and robust Intermodulation Distortion (IMD) and Passive Intermodulation (PIM) performance, ensuring optimum results are achieved when deploying AWS-3 with existing services. The end result is a smooth migration to new services and performance that provides high value for mobile subscribers who have come to expect the fastest speeds from their wireless devices.

This solution paper will explain intermodulation distortion (IMD), passive intermodulation (PIM), and JMA Wireless' approach to these issues in regards to AWS-3.

Spectrum Background

AWS-3 is the last band activated in the Advanced Wireless Service bands (see Figure 1). Below is a list of the AWS spectrum bands the Commission has designated over the years:

- **AWS-1:** In 2002, the FCC released an Order that allocated 90 MHz of spectrum for AWS at the 1710-1755 MHz and 2110-2155 MHz spectrum ranges.
- **AWS-2:** In 2012 at 1915-1920 MHz and 1995-2000 MHz ("H Block").

The market areas for AWS licenses (see Figure 2) are:

- Cellular Market Area (CMA) – There are 734 CMAs.
- Economic Area (EA) – There are 176 EAs.
- Regional Economic Area Grouping (REAG) – There are 12 REAGs.

Figure 1: The preferred spectrum pairing for AWS-3:

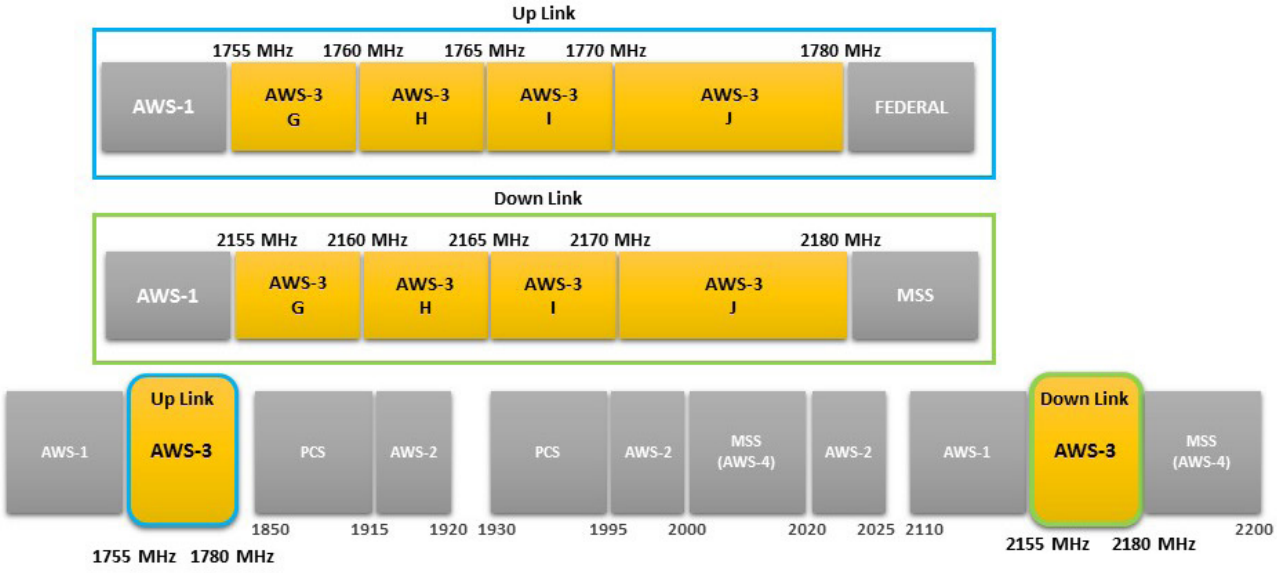

Figure 2: Channel blocks are groups of frequencies. The specific channel blocks associated with a particular AWS band are included in the chart below.

Block	Frequencies	Bandwidth	Pairing	Graphic Area Type	Number of Licenses
G	1755-1760 / 2155-2160 MHz	10 MHz	2 X 5 MHz	CMA	734
H	1760-1765 / 2160-2165 MHz	10 MHz	2 X 5 MHz	EA	176
I	1765-1770 / 2165-2170 MHz	10 MHz	2 X 5 MHz	EA	176
J	1770-1780 / 2170-2180 MHz	20 MHz	2 X 10 MHz	EA	176

Defining Intermodulation Distortion and Passive Intermodulation

Intermodulation distortion (IMD) arises when two (or more signals) coexist in the same transmission system with nonlinear performance, generating unwanted signals, which negatively impact the high-speed system data rates as a result of LTE. Basically, IMD describes the ratio between the power of fundamental tones and third-order distortion products.

Passive Intermodulation is generated by the non-linear components present in passive devices, which results in distortion of the fundamental frequencies. PIM occurs when non-linear passive components produce two or more signals, which combine or multiply to create intermodulation distortion; thereby affecting the transmission of the radio frequency. Coexistence is challenging between LTE networks and other existing communication services such as PCS. This type of intermodulation distortion can occur even when active components are absent. The performance of desired services can be impacted adversely by PIM.

The JMA Wireless Approach to PIM and IMD

JMA Wireless has improved and optimized the design of all active and passive equipment in order to limit and control PIM and IMD within a distributed antenna system (DAS), especially with the new bands extended with 25 MHz. By producing all active amplifiers, especially power amplifiers with high isolation, as well as the filters and combiners, it is possible to optimize the overall performance, ensure system excellence and limit the impact of IMD and PIM. Strong isolation of the output combiner in the Remote Unit ensures that negligible IMD levels fall into the UL bands in multi-operator scenarios (see Figure 3).

This approach ensures:

- High linearity and wide operating bandwidth by the power amplifiers.
- Coexistence of multiple carriers offering different technologies in the same band.
- No changes are needed even if a new operator joins the system, frequency re-farming occurs, or new technology is inserted.

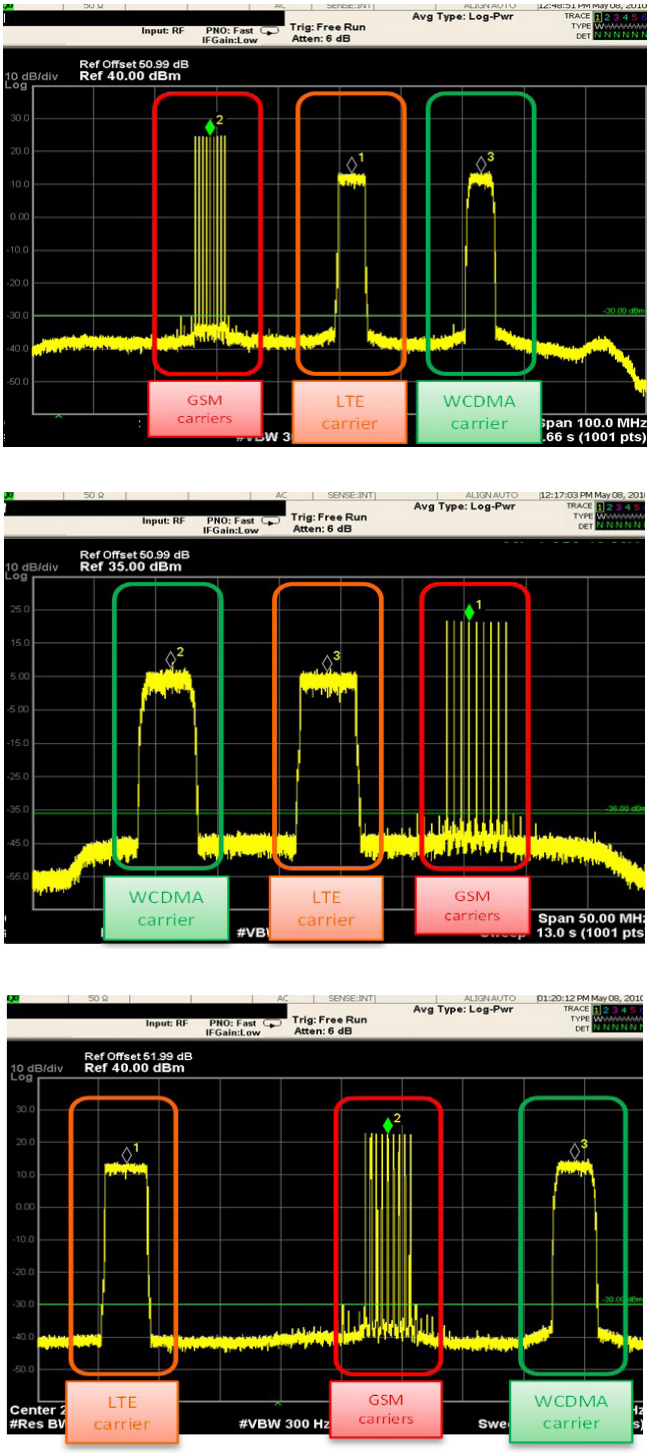

Figure 3: Perfect coexistence of multiple carriers and different technologies occurs.

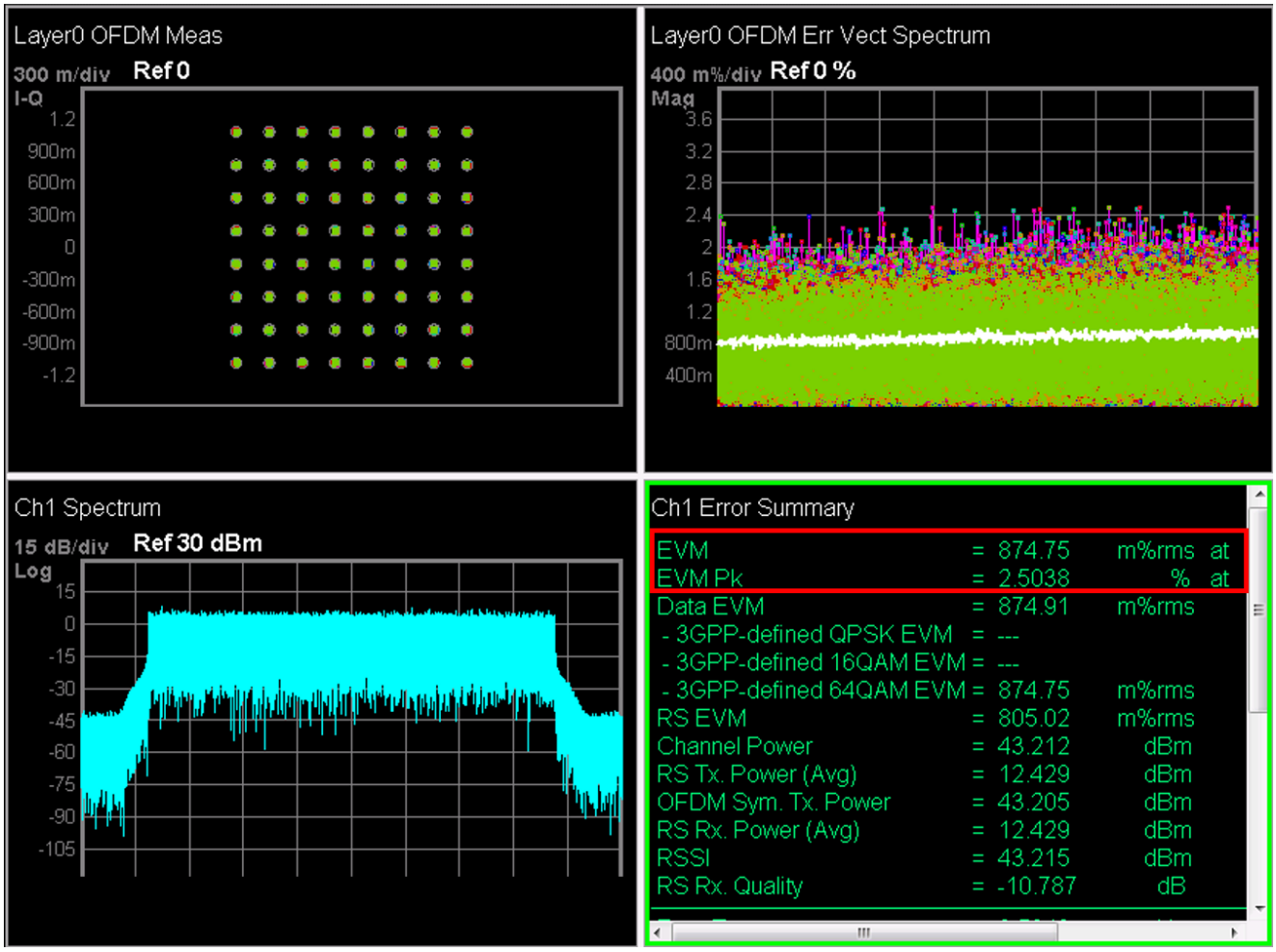

Figure 4: Optimized Error Vector Magnitude (LTE EVM < 1%) for high capacity modulations.

Thanks to the high quality passive components and highly linear active elements, all JMA Wireless DAS solutions support the extended bandwidth of AWS-3 while maintaining superior IMD performance, which is in compliance with the mobile operators' strict requirements. For high capacity modulations an optimized Error Vector Magnitude is necessay, as shown in Figure 4 (LTE EVM < 1%). The recently launched high power, low PIM 4.3-10 connector is easy to install, provides efficient RF connectivity on the Remote Units and ensures low PIM performance. The concentration of high power and wider bands is an increasing challenge for traditional N-connectors. This, combined with our low power PIM connectors and tools, ensures best in class performance. With the 4.3-10 connector interface, the installation companies will experience easy handling as well as low and reliable PIM independent of torque.

Testing Intermodulation with the Teko Multi-Band Spectrum Analyzer

To verify robustness of the DAS against IMD and PIM (see Figure 5), JMA Wireless offers the Multi-band Spectrum Analyzer (MSA). The MSA is a system designed to monitor and analyze RF waveforms or elements within the Teko DAS platform. It has the capability to display real time spectrum waveforms and track interference sources of uplink/downlink frequencies. With a frequency range of 700 MHz to 2.7 GHz and 24 input ports, the Multiband Spectrum Analyzer is a fundamental component in the network. It not only monitors and analyzes spectrum waveforms, and creates appropriate SNMP alarm notifications to a designated SNMP IP address, but it also emails the recipients.

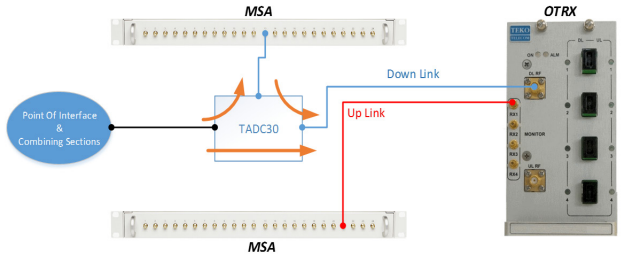

Figure 5: High level scheme for an IMD test with the Multi-band Spectrum Analyzer (MSA)

The MSA includes the 2 Continuous Wave (CW) tone generation function that measures intermodulation products in the uplink path by injecting 2 CW tones in the downlink path (see Figure 6). Only the administrator can access and control this function due to the fact that an unintended CW tone would be injected to the DAS head-end unit (see Figure 7). This function is used for testing purposes only.

Figure 6: CW Tone Generator

The Administrator can set the CW tone, assigning frequency and target amplitude levels. While 2 CW tone generations are in progress, the Administrator can move to the uplink port and measure the intermodulation in the spectrum analyzer mode.

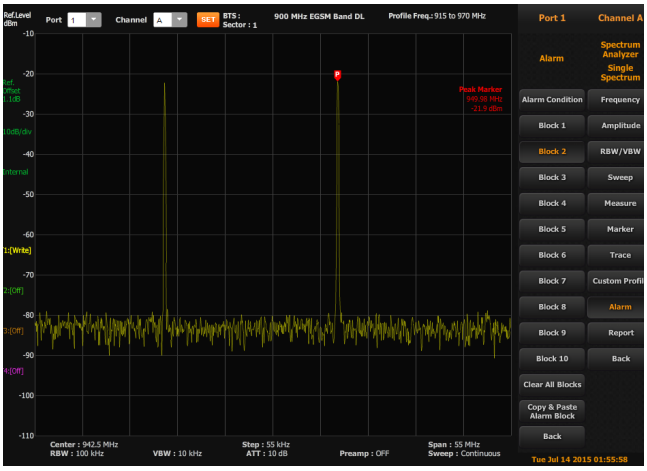

Figure 7: CW tone generation injected into the system to measure intermodulation

The JMA Wireless Approach to Supporting AWS-3 and Multiple Operators

Unlike the competition, JMA now offers Remote Units with AWS-3 integrated. This product is known as the 6 Band Enhanced Low Power Remote Unit, which offers a truly compact design for ease of installation and flexible deployment (see Figure 8). It can be used for a single system supporting multi-bands and shared multi-operator deployments as well as for single operator applications with WCS and PCS bands integrated in the same unit. Furthermore, JMA soon will be introducing this same capability in very high and ultra-high power Remote Units.

Unlike the competition, one of the main features of this Remote Unit is the ability to have only one common antenna connector for all of the six supported frequency bands (LTE700, SMR800 commercial, Cell850, Extended PCS, Extended AWS, and WCS2300). This capability results in, high performance, limited PIM and guaranteed 31 dBm output power per band without adding external combiners.

Figure 8: 6 Band Enhanced Low Power Remote Unit with a 31dBm enhanced power output per band supports the following bands: LTE700, SMR800 commercial, Cell850, Extended PCS, Extended AWS, and WCS2300

With this future proofed solution each operator can use the bands that best fit its needs. Furthermore, modulation transparency is provided to support multiple technologies in each band. Power amplifiers can be enabled/disabled independently.

For the first time in the market, Remote Units permit the coexistence between Extended AWS and WCS2300, the Wireless Communications Service (WCS) that operates in the 2.3 GHz portion of the RF (radio frequency) spectrum (see Figure 9). A frequency of 2.3 GHz represents a wavelength of approximately 130 mm in free space. The WCS includes frequency allocations for fixed, mobile computing, cellular telephone, radiolocation, and satellite communications within two discrete spectrum blocks, and in designated geographical regions.

Figure 9: Allocations for WCS bands

Conclusion

The wireless industry is constantly evolving. New spectrums such as AWS-3 are welcomed by the market, but they also may create issues for it too. However, JMA Wireless is at the forefront of technology innovation, and designs solutions with the future in mind. Concerns such as intermodulation distortion and passive intermodulation are managed readily. Remote Units of varying power levels are developed to easily support future bands. When looking for future ready, cost-effective and efficient solutions turn to JMA Wireless.

References:

Federal Communications Commission Website

"AWS-3 Spectrum Auction Primer: What you Need to Know before the Bidding Starts", Phil Goldstein, FierceWireless, November 12, 2014

Wireless Communications Service – WhatIs.Com Website

"Understanding Intermodulation Distortion Measurements", David Hall, Electronic Design, October 9, 2013

Radio Electronics Website

AWS - PhoneScoop Website

JMA WIRELESS

JMA Corporate Headquarters

7645 Henry Clay Boulevard

Liverpool, New York 1308

+1 315.431.7100

+1 888.201.6073

customerservice@jmawireless.com

www.jmawireless.com