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# Millions Saved With MDCL

## The International Broadcasting Bureau Goes Green in Its High-Power Transmission

**BY DANIEL MAXWELL**

*The author is an electronic engineer with the International Broadcasting Bureau/Broadcasting Board of Governors in Washington.*

In fiscal 2010, the International Broadcasting Bureau implemented Amplitude Modulation Companding in 19 high-power radio transmitters, contributing to annual energy savings of 17.7 million

**WHITEPAPER**

kilowatt-hours and a cost savings of ...nillion, despite a rising utility rate. ...r to converting, these transmit...ed energy savings methods such ...C, CCM, DCC or DAM. In this we compare the various MDCL ...ds, calculate theoretical consump...d discuss the exploitation of the ...r's automatic gain control, peak ...ltages and audio processor set...or optimum savings. Our experi...and observations are provided for those who wish to save energy using MDCL.

The IBB decided to use, where possible, the MDCL method called AMC, which was created by the British Broadcasting Corp. in 1984 and implemented with digital signal processors in 1994. By the end of fiscal 2010, the 19 transmitters had been converted to AMC. Energy savings data is shown on the transmitters in Thailand, the Commonwealth of Northern Mariana Islands and Sri Lanka. (See Figs. 1 and 2.)

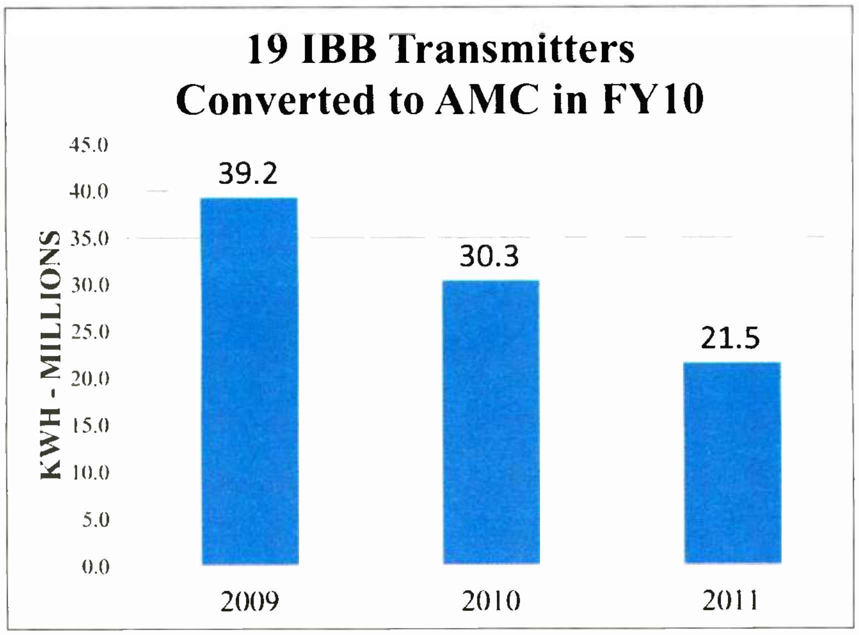


**Fig. 1: Energy usage surrounding conversion to AMC of transmitters in Thailand, the Commonwealth of Northern Marina Islands and Sri Lanka in FY10.**

**Fig. 2 (right): Consumption data for transmitters converted to AMC in FY10**

| Year | Cost | Hours | KWH | $/Hour | Cents/KHW |
|---|---|---|---|---|---|
| 2009 | 5,895,811 | 114,586 | 39,194,941 | $50.38 | $0.15 |
| 2010 | 5,102,379 | 120,922 | 31,970,959 | $43.01 | $0.16 |
| 2011 | 3,728,417 | 110,808 | 20,755,996 | $38.36 | $0.20 |

Predicting savings for the IBB is more than the simple detailing of consumption of electricity using a particular form of MDCL. Factors related to international broadcasting complicate matters, and must be mentioned to clarify the numbers. Aspects to consider include currency exchange rates, fluctuating program schedules, ionospheric propagation issues and maintenance-related subjects.

Electricity consumption of the 19 converted transmitters dropped from 39.2 million kWh to 20.8 million kWh from the end of fiscal 2009 to the end of fiscal year 2011. The conversions took place during fiscal 2010, so these numbers were in transition during FY 2010. If we normalize the drop in consumption by the drop in program hours, we arrive at an effective 21.5 million kWh.

### BACKGROUND OF IBB

The Broadcasting Board of Governors is the independent federal government agency that oversees U.S. civilian international broadcasting. BBG networks serve as indispensable sources of news for people who often lack access to independent information. The board is composed of nine experts in the fields of

*(continued on page 4)*

W H E A T N E T

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# MDCL: Popular But Controversial

## Power Saved at the Expense of Coverage?

BY MICHAEL LECLAIR

The use of various forms of carrier reduction, to save electricity in AM transmission, is known technically as MDCL, for modulation-dependent carrier level. It has taken off both internationally and now in the United States. We have tried to stay abreast of the technical aspects of the concept here at RW Engineering Extra because it offers some assistance to our oldest form of broadcasting. MDCL saves electric power, which helps to improve the competitiveness of AM by reducing the cost of operations.

The trend toward using MDCL began in the field of international broadcasting. With a goal of reaching populations in distant countries, such applications require high-power transmitters much larger than those permitted for commercial broadcasting in the U.S. and Europe. The prospect of even modest power savings in those circles was quite attractive.

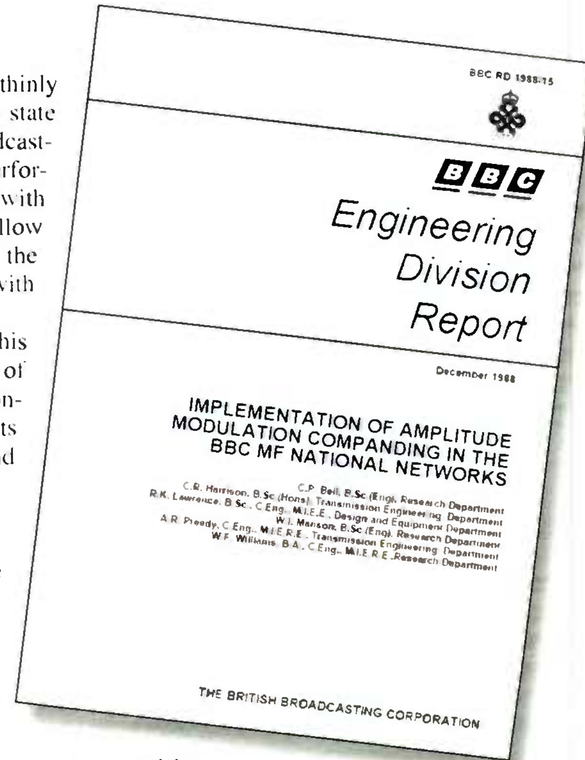
of Alaskan geography and its thinly spread population make this state a good place for AM broadcasting. The cost savings and performance demonstrated in Alaska with MDCL convinced the FCC to allow the use of this technology in the rest of the continental U.S. with written request for permission.

Cris Alexander writes in this issue about the experiences of Crawford Broadcasting with conversion to MDCL at two of its 50 kW stations in California and Colorado (see page 14).

### CONTROVERSIAL

While the benefits of some form of MDCL seem apparent, in this instance not all experts agree on the exact methods to use.

To help sort out the matter, and the alphabet soup that goes with it, we also present a white paper from Daniel Maxwell, an engineer at the International Broadcasting Bureau. Maxwell explains the benefits of MDCL and the various types of algorithms that can be employed.


BBC RD 1988/15
BBC
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December 1988
IMPLEMENTATION OF AMPLITUDE MODULATION COMPANDING IN THE BBC MF NATIONAL NETWORKS
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THE BRITISH BROADCASTING CORPORATION

**Visit our website for a link to this report on MDCL by the BBC.**

> **While the benefits** of some form of MDCL seem apparent, in this instance not all experts agree on the exact methods to use.

Medium-wave frequencies historically have been used for international transmissions due to their ability to reach areas well beyond the line of sight via sky wave propagation. Medium-wave tuners that can receive amplitude modulation are inexpensive and easy to build. Commercial AM stations in the U.S. operate on medium-wave frequencies to exploit these same advantages.

However, AM is a relatively inefficient transmission modulation technique because the carrier itself does not convey audio information. Audio is contained in the sidebands while the main function of the carrier is allowing the receiver to convey "silence." MDCL came about as a means to modestly reduce the carrier power without affecting the perceived "silence" level delivered to the listener.

### FCC NOW PERMITS MDCL IN AM

The first experiments with MDCL in U.S. commercial broadcasting took place in Alaska. The wide-open expanse

As reported in Radio World, J Fred Riley, formerly of Continental Electronics, has vehemently argued that use of the AMC algorithm for MDCL is a mistake. The core of his argument is that with AMC at peak modulation, the carrier power is reduced by half, along with the modulation sidebands. Riley suggests that stations that are using the AMC algorithm might as well just reduce their power by half and save even more power, at the cost of coverage area.

On the other hand, many international broadcasters have chosen AMC and reported no loss of coverage as would be expected with a 50 percent reduction in power. In particular, a BBC study from 1988 looked at this very aspect of AMC companding. They concluded coverage was equal to regular AM, as long as carrier power was not reduced more than a maximum of 3 dB. The study was conducted in Great Britain and used a variety of AM receivers as well as A/B blind listening panels to determine if the use of AMC resulted in audible degradation of the AM signal.

### SEE FOR YOURSELF

It is apparent that not everyone agrees on the best way to proceed. I would encourage anyone interested in deploying MDCL to read the studies from both sides. J Fred Riley's paper can be found at the links page for this issue, *http://radioworld.com/Apr-18-2012*. You'll also find the BBC study linked there.

If you want to join the debate, drop us a line at *rwee@nbmedia.com* and let us know your thoughts.

## THIS ISSUE

APRIL 18, 2012

# MDCL

(continued from page 1)

mass communications, broadcast media or international affairs, who are appointed by the president and confirmed by the Senate. The secretary of state serves ex officio. The International Broadcasting Bureau provides transmission, marketing and program placement services for all BBG broadcast organizations.

The organizations under the BBG are the Voice of America, Radio Free Europe/Radio Liberty, Office of Cuba Broadcasting/Radio and TV Martí, Radio Free Asia, the Middle East Broadcasting Networks and Alhurra TV and Radio Sawa.

The BBG broadcasters reach 187 million people each week with TV (satellite and terrestrial), Internet, mobile, social media and all radio bands in more than 100 countries. Radio remains important in places like Afghanistan, where IBB networks reach 75 percent of adults.

## MDCL DEFINITION

The International Broadcasting Bureau has chosen to use a four-letter term MDCL (Modulation-Dependent Carrier Level), to describe the existing three-letter methods of carrier compression for energy savings.

The term MDCL appears in a Continental Electronics article written by J.F. Riley in 1994:

> *"Terms used to identify differing algorithms (CCM, DCC, DAM and AMC) are either proprietary or closely identified with different manufacturers. A more general term is needed. Program-Dependent Carrier Level and Variable Carrier Power have been proposed. The most descriptive term might be Modulation-Dependent Carrier Level, MDCL."*

When a station uses MDCL, the transmitted RF carrier level is adjusted to save energy at key levels of modulation. The exact relationship between the amplitude modulation percentage and the carrier suppression is described further in the charts that follow. The circuitry used to suppress the carrier is typically located in the audio control stage with a DC control voltage that adjusts the amount of carrier power. The modulation percentage does not change and so the sideband levels are proportional to the suppressed carrier.

## MDCL THEORY

The first area to discuss when considering MDCL is the density of program audio, which may be explained in terms of how much of the time audio reaches the peak modulation percentage in a given unit of time. To calculate audio density, the waveform area under 100 percent peak modulation is integrated over time. Not all audio frequencies in the program may produce the same levels of modulation.

Therefore the subject of density is important when discussing MDCL. The program signal may be compared to a square wave with a duty cycle that describes density.

For example, a square wave of 75 percent duty cycle at 100 percent peak is equivalent to operating the transmitter with carrier only for 91 days out of the year, and with 100 percent tone modulation for the remaining 274 days. Likewise, a square wave at 50 percent duty cycle at 100 percent peak would represent operating the transmitter at carrier only for 182.5 days per year and with 100 percent modulation with tone for the other 182.5 days.

Large energy consumption occurs when broadcasting with amplitude modulation. All of the program audio information is in the sidebands, so the carrier itself contains what could be considered wasted energy. Periods of silence still cost money to transmit. Therefore, the chief aim of MDCL is to manage the energy in the carrier with a technique that matches the density level of program audio and satisfies audio quality standards in common receivers.

For example, if the aim is to save the most energy and the program audio is quite dense, AMC would be the clear choice.

## MDCL TYPES

There are several types of modulation-dependent carrier level designs as implemented by various transmitter manufacturers:

- ACC — Adaptive Carrier Control
- AMC — Amplitude Modulation Companding
- CCM — Controlled Carrier-Level Modulation
- DAM — Dynamic Amplitude Modulation
- DCC — Dynamic Carrier Control
- AM — None — Standard Amplitude Modulation

If the density is very low most of the time, most likely a method of MDCL will be chosen that reduces the carrier when the modulation index is low. If the density is very high most of the time, the best form of MDCL would be AMC. Therefore, the density of the program material must be understood at the beginning when implementing MDCL. The crossover point for energy savings depends on how much of the time the program audio remains at or near peak modulation levels.

## MDCL COMPARISONS

It is possible to group the various types of MDCL into two groups. The carrier suppression in group one is opposite that of group two.

(continued on page 6)

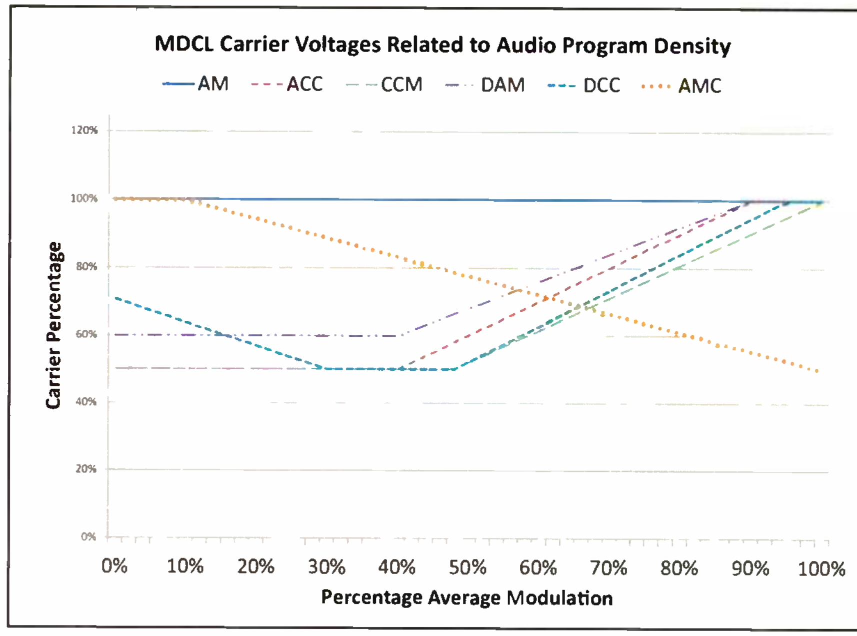


Fig. 3: MDCL carrier voltages related to program audio density

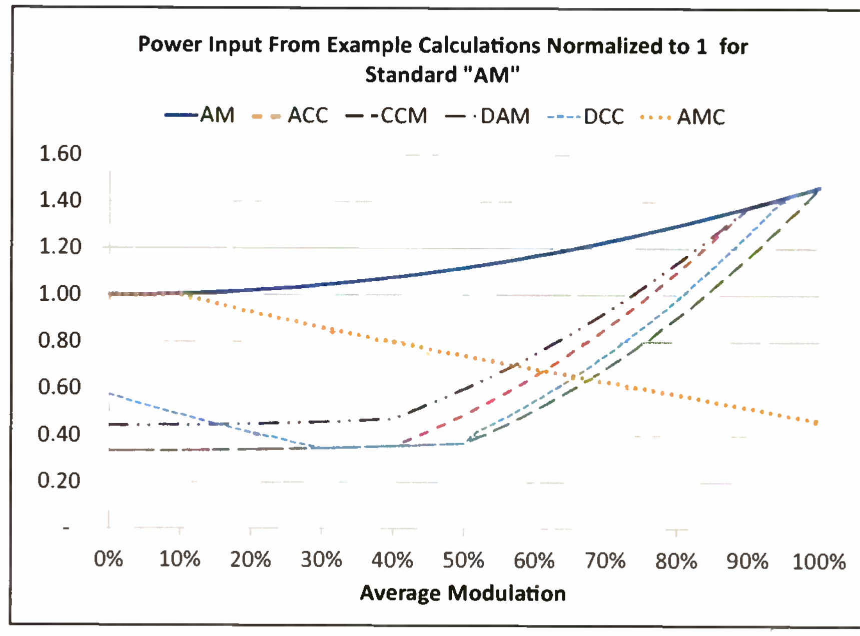


Fig. 4: Power consumed normalized to 1 as a ratio with standard "AM"

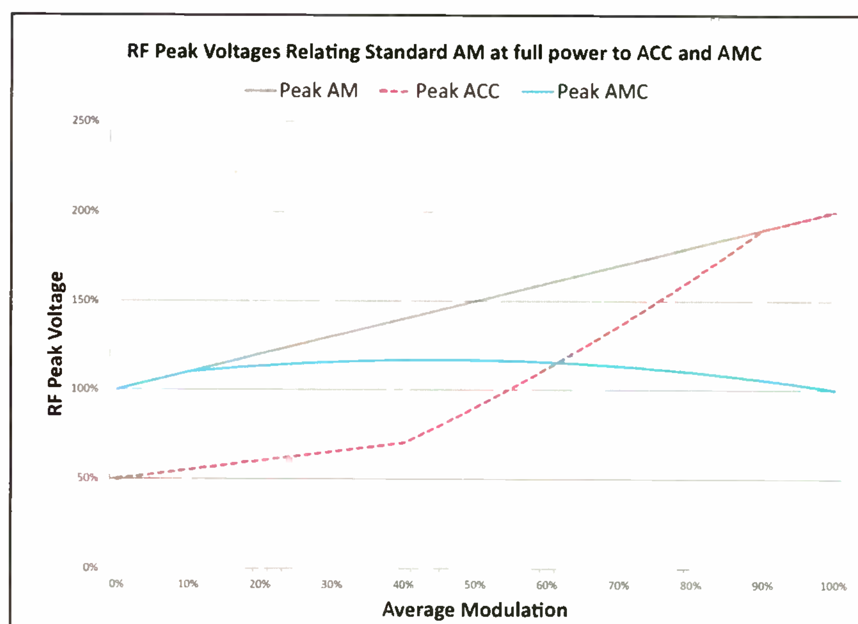


Fig. 5: RF peak voltages for MDCL with reference to AM

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# MDCL

(continued from page 4)

In group one, the MDCL techniques are ACC, CCM, DAM and DCC (in alphabetic order). This first group saves energy when no one is talking. A careful compromise between program loudness and energy savings is necessary. For example, the operator may desire to save so much energy that the audio processer settings result in a broadcast that is weak and lacking loudness.

In group two, the MDCL techniques are AMC and E-AMC (Enhanced-AMC). This group saves energy when talking is the loudest. The carrier is compressed as the audio modulation percentage increases and so the word "Companding" is used to describe this style of MDCL. This technique saves the most energy (53 percent at full tone). However, the operator may inadvertently miss the mark when tuning and operate below the desired power level, reducing coverage area.

Common to all methods of MDCL is the saving of energy and the resulting lowering of the electric bill and cooling system requirements.

## SIGNIFICANCE OF RF PEAK VOLTAGES AND THE RECEIVER'S AGC

RF peak voltages are depicted in Fig. 5 (page 5) with the MDCL type ACC typifying all of those found in group one.

In group one (ACC, CCM, DAM, DCC), the RF voltage starts out as low as half that of standard AM and then rises to the same level as AM. The ratio is up to 4 to 1 or 12 dB (if compared to the fluctuation of AM, it would be a 2-to-1, or 6 dB, ratio). One member of this group (DCC) lessens the swing by using what is referred to as the "bathtub" curve, where carrier voltages are not reduced as much during quiet passages (see Fig. 3).

In group two (AMC), the RF voltage starts out at full carrier and rises until 10 percent modulation and then begins the Companding process. The peak RF voltages for group two is theoretically 1.16 to 1 or 1.1 dB (0.6 dB when contrasted to standard AM). This reduction in the fluctuation of RF peak voltages of AMC is what makes possible the exploitation of a receiver's AGC circuitry, which is able to lift the signal up and keep it up during all levels of modulation.

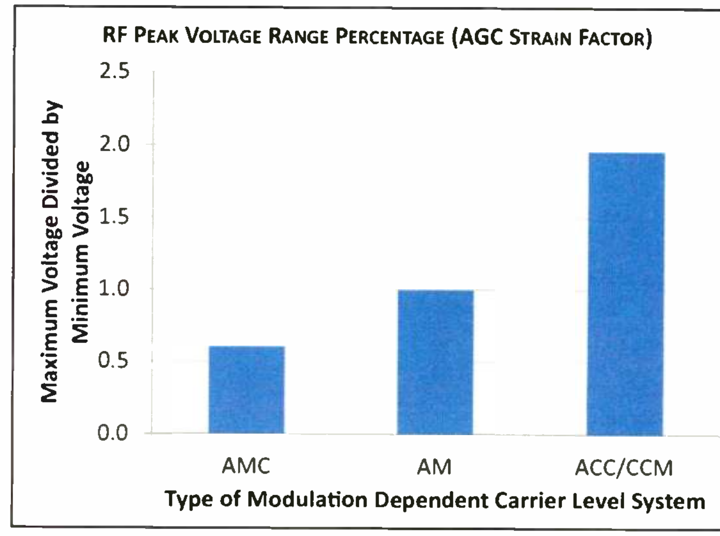


Fig. 6: AGC 'Strain Factor'

A phrase called the "AGC Strain Factor" is introduced to look into how the receiver influences the strength of the incoming signal along with audio loudness.

The AGC Strain Factor chart (Fig. 6) divides the maximum peak RF voltage by the minimum RF voltage to give an AGC stress factor. If the Automatic Gain Control in the receiver does not have a wide variation between peak audio and quiet passages, theoretically the receiver should be able to pick up a weak signal and keep it amplified.

In group two, the RF peak voltage for AMC is nearly constant. Therefore, with AMC, the receiver's AGC is exploited to compensate for a reduced RF overall signal during maximum modulation.

In group one, the AGC works "harder," or, it could be said, the AGC strains to keep up with a constantly changing RF peak voltage, which will result in a potential "pumping" of the audio in the fringe areas.

## NOISE CONSIDERATIONS AT THE FRINGE AREA

Listeners report not noticing any difference between standard AM and MDCL in all family groups when the signal is sufficiently strong that the receiver's AGC does not have to start amplifying the signal.

When considering signal-to-noise, whether it be jamming or environmental noise, there are compromises that are related to receiver quality and AGC (see "AGC Strain Factor" above).

If a tone is used at 100 percent modulation and a receiver is at the edge of the fringe area, the signal strength of a system using AMC will be

(continued on page 8)

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# MDCL

(continued from page 6)

1/2 (20*LOG(0.5) = −3dB) that of a system using the first group which is like standard AM. So, potential for jamming of an AMC system is highest when using a tone.

However, if using program material, the negative effects of jamming are worse for the first group during quiet passages. At strong passages, the receiver noises depend on how the AGC is behaving and whether or not the receiver is locked onto the carrier or has to hunt for the carrier due to the presence of a jamming carrier. The signal strength of the first group (ACC, CCM, DCC, DAM) is approximately 3 dB lower than the AMC system during very quiet passages of no audio. So, noise effects would be worse with group one MDCL when no one is talking; whereas with higher program level modulation, and if the AGC is not "strained" to fluctuate 4 dB, AMC sounds good.

As the receiver progresses further-away from the transmitter, noise levels increase and the AGC of the receiver is at maximum increasing potential, chances are best of still hearing some of the signal when using the first group (ACC, CCM, DAM, DCC). The region where this occurs may be a small piece of land, so marketing research and engineering should listen to see if the benefits of energy savings outweigh benefits of a of a louder signal.

For the IBB, in the past year or more of AMC operations, there have been no known complaints of AMC in the receiver areas (though maybe those who could complain do not know how to communicate that complaint back to headquarters because of their remote location).

### MODULATION MANAGEMENT

Once the genre of programming is chosen, optimal savings of power requires proper settings on the audio processor.

For maximum energy savings in group one (ACC, CCM, DAM, DCC), it is recommended to use an audio processing style resembling "classical" or "transparent" processing, which has the least amount of audio loudness (or compression) settings.

For maximum energy savings in group two (AMC), it is recommended to use an audio processor setting of "presence" or "loudness." So, if the modulation meter is always up at full scale, then more energy would be saved with AMC.

AM HD Radio or DRM systems require special consideration for MDCL. A recent study at WOR(AM), reported in Radio World, seems to indicate that AMC does the best for audio clarity and maintaining the HD Radio signal in the receiver. Go to *http://radioworld.com/Apr-18-2012* for the link to this story.

### CONSIDERATIONS FOR MAXIMUM BENEFIT

The genre of broadcast determines which MDCL style to use, and the charts in Figs. 3 and 4 help decide which method to choose. The crossover point for modulation density should be examined to determine which method to choose.

The transmitter and audio processor setup and operation become more complex when using MDCL. Care should be taken to set up proper processor settings and proper power levels after switching to an MDCL technique.

With AMC, the audio control circuitry can reduce power slightly more than necessary due to a shift in DC voltage when changing from AM to AMC.

### AMC MODULATION MONITOR ERROR

Due to the nature of "double AM" or amplitude modulation twice in the circuit (once with carrier compression related to MDCL, and the other with standard amplitude modulation), most modulation monitors struggle to report modulation accurately. The IBB recommends verification of modulation levels using an oscilloscope for AMC.

The rest of the MDCL types may be verified with standard modulation monitors and transmitter power meters.

### IBB HIGH-POWERED RADIO CONSUMPTION STATISTICS

There were 75 million kWh consumed in fiscal year 2011 compared to 98 million kWh consumed fiscal year 2009. This consumption is equivalent to eight hundred (800) U.S.-based transmitters (KFI, KGO, WOR, WLS, WGN, etc.) on the air at full power all year

(74.9M kWh / (8760H * 50kW * 1.45 Modulation / 77% Efficiency = approx. 800).

(continued on page 10)

## MDCL POWER CONSUMPTION FORMULAS

### Transmitter Consumption Equations

$\eta_D = Efficiency\ of\ PA\ Derating\ at\ lower\ power$

$$\eta_D = \eta_{PA} - K \times \left(1 - \frac{P_{CN}}{P_{CM}}\right) \text{ where } K = derating\ constant$$

$\eta_{PA} = Efficiency\ in\ the\ PA,$

$$\eta_{PA} = \frac{1}{\left(\frac{1}{\eta_T} - P_{IP}\right)}$$

$P_{IP} = Idling\ Percentage\ (TX\ ON, 0KW\ out)$

$$P_T = Power_{\text{Idling 0 KW}} + \frac{P_{PA}}{\eta_D}$$

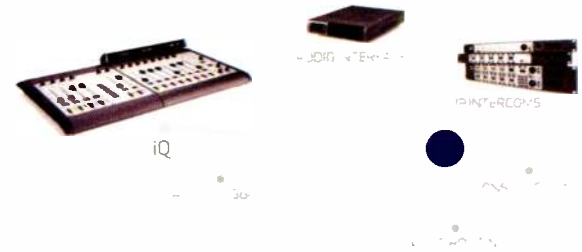
The modulation factor, $M_f$, is derived from the type of MDCL in use and the modulation percentage.

$$P_T = (P_{IP} \times P_{CM}) + \frac{\left(P_{CN} \times \left(1 + \frac{M^2}{2}\right)\right)}{\eta_D}$$

To write this in terms of what is given,

$$P_T = P_{IP} \times P_{CM} + \frac{\left(P_{CN} \times \left(1 + \frac{M^2}{2}\right)\right)}{\left(\frac{1}{\left(\frac{1}{\eta_T} - P_{IP}\right)}\right) - \left(K \times \left(1 - \frac{P_{CN}}{P_{CM}}\right)\right)}$$

$\eta_T$ = Overall Efficiency
$P_T$ = Power Total (Consumed Power)
$P_{CM}$ = Power of the Carrier Maximum (nameplate power)
$P_{CN}$ = Power of the Carrier Nominal (operating power)

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AxiaAudio.com/RAQ AxiaAudio.com/DESQ

AXIA

Available in the U.S. from BGS: (352) 622-7700

## MDCL POWER CONSUMPTION EXAMPLES

### Given:

*$P_{CM} = 500$ kW, $P_{CN} = 250$ kW, $\eta_T = 72\%$, $P_{IP} = 10\%$*
*$M = 90\% \times 88\%$ Average Density = 79.2%, K = 12%*
*Where M = Effective Modulation percentage (Program level multiplied by the apparent density of the program audio. See discussion on density under MDCL Theory on page 4).*

**MDCL Correction Factors:**

$$AM\ (Standard\ MF\ and\ HF): MDCL_f(M) = 1^2 = 1$$

$$ACC: MDCL_f = \begin{cases} 0.5^2 = 0.25 & 0 \le M < 40\% \\ (M+0.1)^2 & 40\% \le M \le 90\% \\ 1^2 = 1 & 90\% < M \le 100\% \end{cases}$$

$$AMC: MDCL_f = \begin{cases} 1 & 0 \le M < 10\% \\ \left(\frac{19}{18} - \frac{5}{9}M\right)^2 & 10\% \le M \le 100\% \end{cases}$$

**AM**

$$MDCL_f = (1)^2 = 1.0$$
$$\eta_D = 0.7759 - 0.12\left(1 - \frac{250 * 1.0}{500}\right) = 0.7159$$
$$P_T = 50.0 + \frac{1.0 \times 250 \times 1.3136}{.7159} = \mathbf{509\ kW}$$

**ACC**

$$MDCL_f = (0.792 + 0.1)^2 = 0.7957$$
$$\eta_D = 0.7759 - 0.12\left(1 - \frac{250 * 0.7957}{500}\right) = 0.7036$$
$$P_T = 50.0 + \frac{0.7957 \times 250 \times 1.3136}{.7036} = \mathbf{421\ kW}$$

**AMC**

$$MDCL_f = \left(\frac{19}{18} - \frac{5}{9} \times 0.792\right)^2 = 0.3789$$
$$\eta_D = 0.7759 - 0.12\left(1 - \frac{250 * 0.3789}{500}\right) = 0.6786$$
$$P_T = 50.0 + \frac{0.3789 \times 250 \times 1.3136}{0.6786} = \mathbf{233\ kW}$$

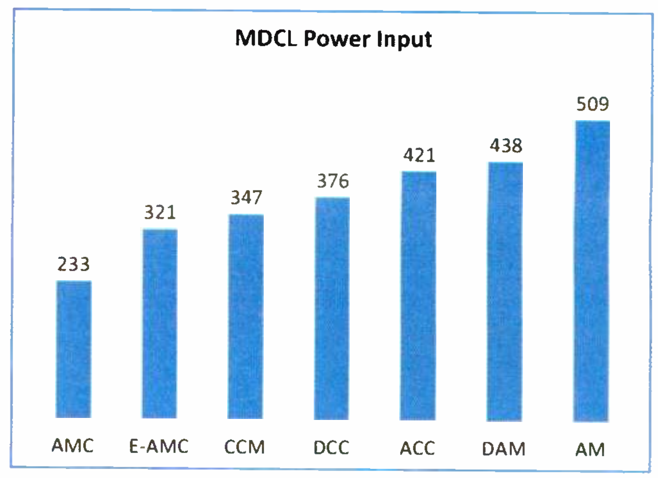
**MDCL Example Calculations**

The modulation level determines a new carrier level when using MDCL. The consumed power calculations take into account a reduced carrier level and a corresponding change in power amplifier efficiency at this new carrier level. A fairly typical derating line may be associated with a slope K above.

To further illustrate this point, if a transmitter is operating with a reduced power amplifier output power level during compression or Companding to 50 percent that of nominal power, PA efficiency would decrease by 6 percent as derived from a line with a decreasing slope of 12 percent. This is a "rule of thumb" from experience on various tube-type amplifiers down to about 50 percent. This number may be adjusted more accurately for each transmitter by observing and graphing the slope of degradation of PA efficiency as power is reduced.

The MDCL factor, $MDCL_f$, (see MDCL Correction Factors table) is used to calculate the new carrier power due to carrier compression. For this example, the modulation percentage is applied to the table in the three examples to find the corresponding $MDCL_f$. Then the new carrier power is multiplied by the modulation factor for power out, $(1+M/2)^2$, to find average output power out at the reduced carrier.

Secondly, the new carrier power is also used for calculating derated power amplifier efficiency because we cannot assume that the efficiency of the PA is constant across all power output levels.




**MDCL Sample Calculations Comparisons**

# MDCL

(continued from page 8)

The IBB has 85 transmitters with a potential simultaneous broadcast of combined 18,970 kW on a given day. Fig. 7 shows the comparison of electrical cost in dollars spent for various MDCL techniques within the IBB as of the end of FY 2011.

### OPERATIONAL ISSUES

One site appeared to have a large drop in consumption. The evidence was there to back this up. The water pipes were cooler; less money was spent on cooling, the power meters showed less power, etc. In actuality, the power drop was possibly a bit too much. When a 500 kW transmitter is set to operate at a nominal 250 kW and then AMC is utilized, when peaks of modulation occur, the power meter dips down into a region where tracking might not be reliable, in this case 62 kW.

When the transmitters are switched from AM to AMC, the carrier drops due to the manufacturer's circuitry. Compensation should normally occur to bring the power back to normal carrier power when there is no modulation. So the problem in this case would be saving more energy than necessary and potentially hurting the quality of the signal at the fringes area.

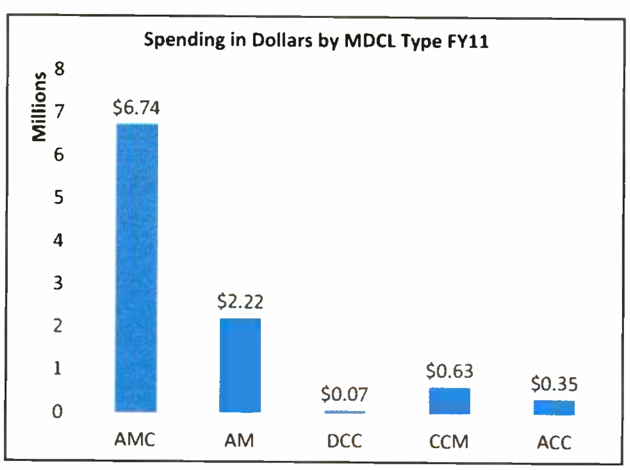



**Fig. 7: MDCL Costs by Type**

An operational benefit for AMC would be a reduction in peak voltage, which lengthens the life of tubes, capacitors or other components in the RF chain.

### CONCLUSION

In summary, significant energy savings occurred at the IBB after switching 19 transmitters to AMC in early fiscal year 2010 and an additional 28 in 2011. Further savings are expected through reduced high-voltage stress on components, cooling savings and possible tube and capacitor life extensions.

### REFERENCES

CCM: Riley, J.F., "Comparison of CCM Techniques", Continental Electronics Paper, 1994.
DAM: Wysocki, B. and Breitkopf, K., "Energy Savings With Modern PDM-Type High-power Transmitters", AEG-Telefunken and Rundfunk im amerikanischen Sektor, Germany, 1994.
DCC: Schminke, Dr. W. and Boksberger, H.U., "Dynamic Carrier Control, DCC, a Valuable Method to Save Input Power of Medium Wave Transmitters", ABB Infocom AG, Switzerland, 1989.
AMC: Bell, C.P. and Williams, W.F., "Implementation of Amplitude Modulation Companding in the BBC MF National Networks", IEEE Transactions on Broadcasting, Vol 35, No. 2, June 1989.
OVERVIEW: Hardy, T., "Energy Conservation in AM Broadcast Transmitters using Carrier Control Algorithms, NAB Paper, 2009

*This paper is based on a presentation prepared by Maxwell for the 2012 NAB Show.*

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# MDCL Operation Is a Winner for High-Power AM

## Power-Saving Technology Can Make Even Electricity-Hog 50 kW Stations Green

BY W.C. ALEXANDER

When my company began purchasing solid-state AM transmitters back in the late 1980s, we immediately began to see a considerable reduction in operating costs. Solid-state transmitters, even the early ones, were considerably more efficient than their tube-type predecessors. Not only were the power amplifiers more efficient, they didn't require kilowatts of power to heat filaments, and they didn't have big cooling blowers that likewise consume a lot of power.

In the summer months, the savings were even greater because the heat load was reduced and it didn't take as much air conditioning to maintain a safe operating temperature (although it might be argued that tube-type transmitters didn't require as cool an environment as solid-state designs).

Succeeding generations of solid-state transmitters have become more efficient, using fewer devices and a smaller number of combiner stages to get the final power output. Later transmitters also employed higher voltages and lower currents, which often resulted in lower $I^2R$ losses in the DC wiring and connections.

Perhaps one of the biggest improvements we saw was the use of Litz wire in RF circuits, particularly in filter components, which not only reduced losses but also allowed for a much smaller footprint, since large copper tube coils were no longer required.

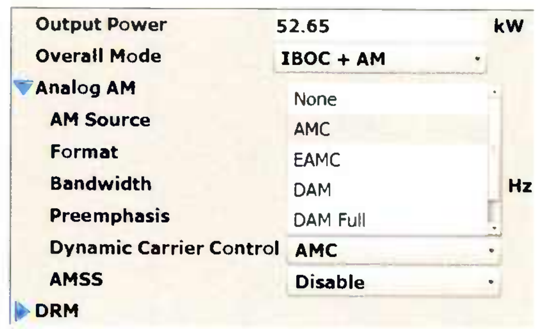
Current generation AM solid-state transmitters boast a range of 83 to 90 percent AC-to-RF efficiencies; impressive and very "green!"

### A BETTER MOUSETRAP

With the cooperation of the FCC, some transmitter manufacturers have gotten aboard with Modulation-Dependent Carrier Level (MDCL) technology, which has been a staple in European MW broadcasting for many years. In just the last few months, stations have begun to employ this technology and evaluate its power-saving benefits and effects on the signal.

As soon as the public notice came out, I filed the required paperwork with the FCC for one of our West Coast 50 kW stations, KCBC, which already had an MDCL transmitter in place. The Media Bureau issued a modified license within a few weeks and we were good to go … sort of.

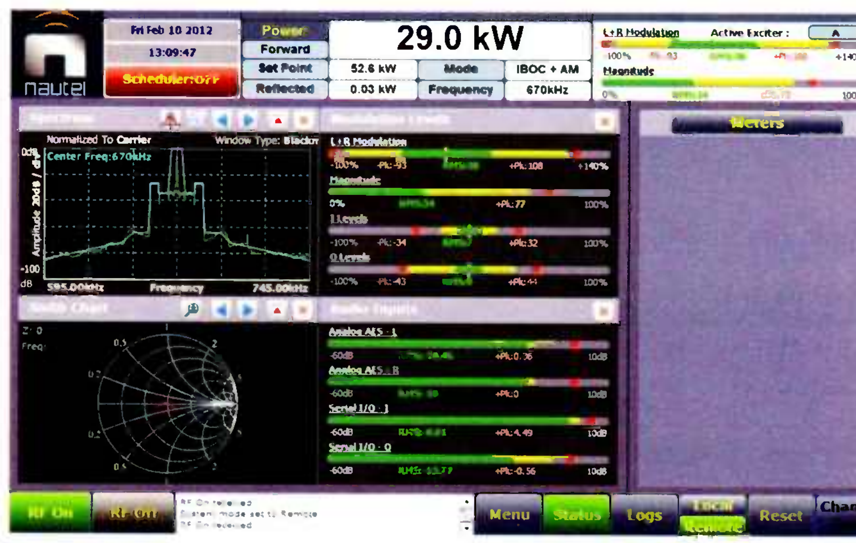
The issue for our digital AM station was that the firmware in the Nautel NX50 we were using would not permit simultaneous MDCL and HD Radio operation. We could have simply turned the digital carriers off for a while to test, but the good folks at Nautel got us a firmware update that would permit both.




The NX50 offers several MDCL algorithms to choose from.

Our staff at the station got the update installed and the MDCL turned on in short order.

After considering all the available algorithms, we opted for the Amplitude Modulation Companding (AMC) algorithm with 3 dB of carrier compression. Our station serves the Bay Area with a talk format from a site near Modesto. As a result, while most of the service area is within the 5 mV contour, it is also at a considerable distance from the site. My concern was that receiver AGCs in the distant coverage area would pump up the gain (and thus the noise) while the carrier was reduced, thus lowering the signal-to-noise ratio of the demodulated audio. That would be unacceptable.




AMC in action. Note that the instantaneous output power was 29.0 kW while the nominal TPO was 52.65 kW, about 2.6 dB of compression.

As it was explained to me, the British AMC algorithm takes care of that by restoring full carrier power during periods of low or no modulation, thus holding receiver AGC levels where they should be for the full-power signal. Further, with the sideband power unchanged, the loudness and reach of the station should not be changed.

That is exactly what we observed. In short, we have heard no discernible degradation of the signal, audio or coverage at all, analog or digital.

### SIGNIFICANT SAVINGS

What we have observed is a big reduction in our power bill.

We activated AMC operation at

(continued on page 16)

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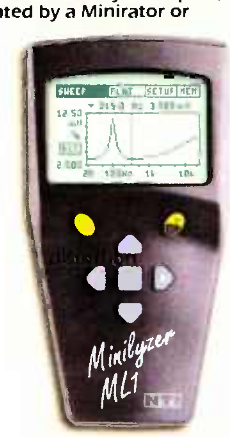


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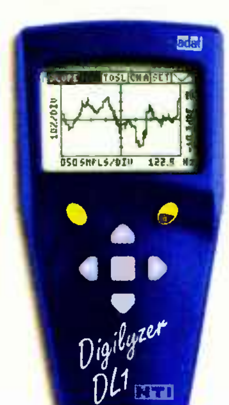


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# HIGH-POWER AM

(continued from page 14)

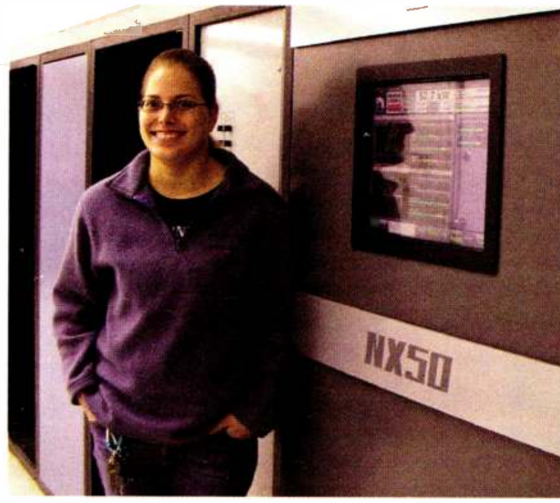
KCBC the first of November. When the November billing cycle closed at the end of that month, I was able to look at the electrical usage for that month and compare it to the same period for 2010. This showed a 21 percent decrease in electrical usage and an $800 decrease in the amount billed. That's significant.

I looked at the December usage in early January and found similar savings -- right at 21 percent -- for that month as well (compared to December of 2010). And as I prepared to write this, I checked the January usage: It showed 23,988 kWh compared to 30,306 kWh for January of last year, again, right at a 21 percent savings in power (and $882 less in energy costs).

In late December of last year, we replaced the 16-year-old Nautel ND50 at KLTT in Denver with a new NX50, the same model transmitter that we use at KCBC. Within a few days of installing it, we got the AMC working and I was personally able to observe the effects of this on the sound and coverage of the station.

As with KCBC, I could not detect any observable effects, even in the fringe area on the west side of the continental divide. What I could detect was a 21 percent decrease in energy usage at the site for the month of January compared to January of 2011. That is right in line with the KCBC savings.

Since those unqualified successes, we have added two more stations to the MDCL list. Our 50 kW station in Birmingham uses a 2000-vintage Nautel XL60, which by itself does not have MDCL capability. The good news is that Nautel offered us a firmware upgrade to the AM-IBOC HD Radio exciter that drives the




**KLTT Chief Engineer Amanda Alexander with her new MDCL-equipped NX50 and trusty ND50 aux (also capable of MDCL).**

transmitter with all the MDCL algorithms in it. So we jumped on that.

We applied for and got FCC authority, upgraded the exciter and turned on the AMC with 3 dB of carrier compression. As with the California and Colorado stations, we have observed no degradation in signal, coverage or audio in either the analog or digital domains. I don't yet have power savings numbers for that station, but my guess is that we will see something in line with what we have observed elsewhere.

We also activated MDCL on a 5 kW AM in Birmingham, Ala. Presumably the savings will scale. We'll be watching in the months to come.

## DEMAND WARNING

One anomaly that I noticed on the KLTT electric bill was that while total kWh was down 21 percent, the total cost was down only 11 percent.

It didn't take me long to figure out why. I noticed that the demand, which had been running right at 99 kW, dropped to only 90 kW for January. The reason was that during the early days of January, we had to operate both transmitters for testing. During this testing, I had limited the ND50 to 10 kW, but we had the new transmitter running into the dummy load at various power levels for awhile. It only takes 15 minutes to set the peak demand for the month, and that's just what I inadvertently did.

That brought to light an issue. If we have to use the auxiliary transmitter for more than a very short period of time, we're going to face a big jump in the electric bill if we run it at full power. At KLTT, we had a solution — that aux transmitter, like the XL60 in Birmingham, is driven by an AM-IBOC HD Radio exciter. We performed the same firmware upgrade and now the KLTT auxiliary is MDCL/AMC equipped. We are good to run it at full power if needed, without any peak demand penalty.

KCBC's aux, also an ND50, does not have an AM-IBOC exciter that we can upgrade, so the solution there is to simply limit its maximum output power to 25 kW. If our chief engineer needs to test it at full power for any reason, he can do it on the generator.

We will undoubtedly continue to learn more about MDCL. We may experiment with some of the other available algorithms to see what their advantages and liabilities are. But at this stage, I am prepared to call this experiment a success. I can't see ever going back.

*W.C. "Cris" Alexander is director of engineering at Crawford Broadcasting and a past recipient of SBE's Broadcast Engineer of the Year award.*

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# What's All This About DSOs?

## Rigol Delivers Powerful Measurement Capabilities at Modest Price

BY IRA WILNER

I own two analog scopes: a B+K Precision 100 MHz dual trace portable that I bought back in the 1980s and a Tektronix analog storage tube mainframe scope with high-performance plug-ins acquired at an electronics flea market in the early 1990s for pennies on the dollar. The Tektronix is a very heavy beast.

The other day, I got an email from a test equipment dealer about a line of Chinese-designed test equipment under the trade name Rigol. This company offers test equipment at drop-dead prices compared to the big players in the U.S. and Europe. Its product line runs from entry-level to mid-level equipment including DSOs (digital storage oscilloscopes).

When handheld DSOs not much larger than multi-meters were introduced, they became an instant must-have toy for some field service engineers. I was never impressed with them. Most had hard-to-see monochrome LCD displays, as well as poor resolution and frequency response due to insufficient memory and processing speed. Even the early bench DSOs suffered from dead-band issues and other digitization problems, making them less suitable than traditional analog scopes with CRTs for many measurement needs.

DSOs have matured, and it's rumored that Rigol is the OEM manufacturer for Tektronix's entry-level DSOs among other test equipment products. A 100 MHz dual channel DSO with a 1 Gigahertz sample rate, serious memory depth and lovely color LCD display selling for just short of $400 would be amazing if it really worked.

It does.

Fig. 1: Side View of Rigol DSO vs. Analog Scope With CRT

### DIGITAL VS. ANALOG

When it arrived, I put it through some paces that evening without even cracking the manual. It is outstanding. The on-screen measurement information, the automatic scaling for whatever signal you throw at it, the intuitive control layout and menus make it a winner. It effortlessly displays 2–3 cycles of a 100 MHz RF carrier while my so-called 100 MHz analog scopes struggle to paint viewable images.

Analog scopes have a fairly complex set of controls to set triggers, signal gain, position on the CRT screen and relative calibration to a scale bezel. Try something a bit more involved such as a measurement requiring dual time-base with delay so you can simultaneously view a large and a small portion of a wave form, and you have lots of controls to adjust to get it right: sweep start offset, sync level, trace delay, trace position, intensity, etc. Even the simple act of displaying two waveforms at once requires operator decisions on the analog scope. For low sweep rates, you need to choose chop, rather than alternate to share the one CRT with two or more input channels. For high sweep rates, you need to choose alternate else the waveforms will be chopped into broken dashes. And if you need to store a transient signal, your choices can be limited. With an analog storage scope, the image would blur and fade as the seconds went by unless you had a screen camera and film.

Or you might have had an analog scope with an expensive but shallow digital memory and limited speed digitizer. The top-of-the-line Tektronix analog scopes had measurement cursers and on-screen display of channel gain and sweep delay if you equipped them with the deluxe versions of their plug-ins.

DSOs do everything from the get-go. The signals are digitized and stored. Changing sweep rate is a memory record and readout issue. As a result, DSOs show lots of on-screen numerical measurements in the voltage and time domains, and they can do advanced math routines such as peak-to-average ratios, sums and differences between signals, multiplication of signals and fast Fourier transforms converting time domain to frequency domain displays. Press a button and in seconds a DSO will acquire a signal and adjust all of its parameters for best results. You can even view unrelated signals on both inputs by selecting alternate in the trigger source

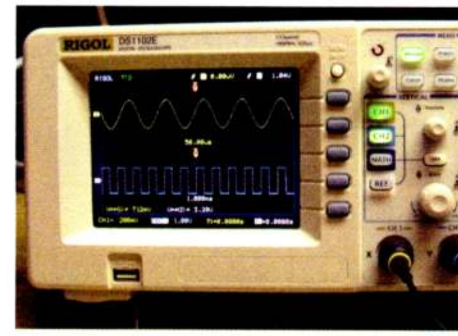

Fig. 2: Rigol Scope With Dual Waveform Dual Sweep

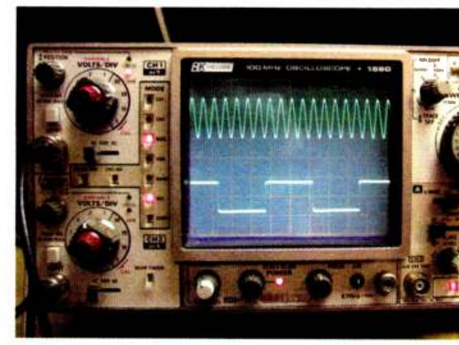

Fig. 3: B+K Scope With Two Waveforms

menu. Then each waveform will have its own sweep rate suited to its frequency.

If you are an old-school engineer who learned how to explore electrical signals with a conventional oscilloscope, a well-designed DSO will knock your socks off, but only after you forget what you know about analog scopes. After a half-hour of experimenting, I was able to put my new DSO through its paces without ever cracking the full manual, which is not delivered in print form. Controls and menus are quite intuitive.

### MEASUREMENT SHOOTOUT PART I

I experimented with setting up a simple dual time-base mode on my analog scopes. I'll admit to being a bit rusty. It took me 10 minutes to get a stable pair of displays. The same signals fed into the DSO took about five seconds to acquire including the time to press the correct button in the right menu screen. No contest!

The front panel of the Rigol DS1102E looks like a normal analog scope. It even has two groups of identical looking controls that would normally be two signal input channels of an analog instrument. One group controls horizontal activity, sweep rate or display magnification in the time domain while the other controls amplitude of the displayed signals. Waveform channel 1 or 2 amplitudes and positions are controlled one at a time by selecting the CH1 or CH2 button. Note other models give you two sets of vertical amplitude/scale knobs rather than sharing one, but at the cost of other controls or increased front panel size.

Press the horizontal scale knob and

the display instantly changes to dual sweep mode, where you can home in on a small portion of the waveform and magnify it and display it below the main trace. No need to reset vertical position as it happens automatically. There is hardly any need to fool with the trigger sync levels, unless you want to intentionally offset the trigger point. It locks to the waveform as stored in its buffer and the display parameters are calculated mathematically on the fly.

Physically the Rigol looks like my B+K scope but with 3/4ths of its rear body sawn off. See Fig. 1. The front panel has a similar size screen. See Figs. 2 and 3.

So, how does its signal capture compare to an analog scope? My 100 MHz test signal is full of AC hum due to some tired electrolytics in the generator's power supply. The B+K analog scope shows it as a fuzzy 100 MHz sine wave whose thickness varies as you change the lock-in position of the trigger circuit. The Rigol DSO shows it as a sharp 100 MHz sine wave that is drifting up and down at a leisurely rate as though it were beating slowly with a 60 Hz component. Trigger point does not change this

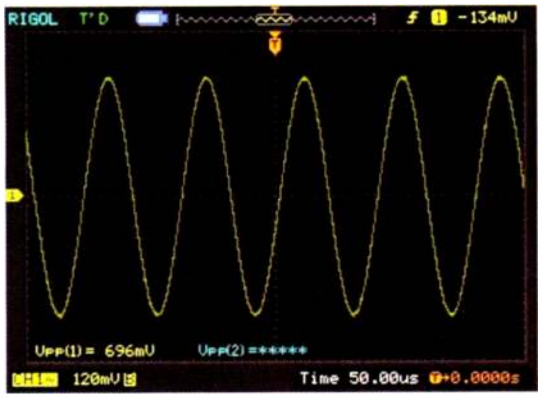


**Fig. 4: Rigol DSO exhibiting 'steps' in waveform.**

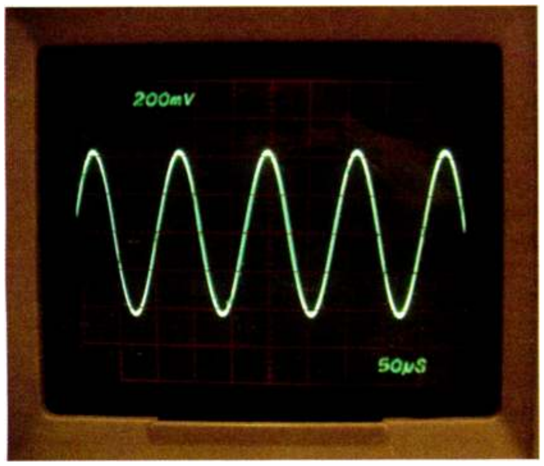


**Fig. 5: Even ancient analog scope shows smooth waveform trace — advantage analog.**

display. Force the sweep down to a low frequency and switch the sync to line frequency and *voilà*, you see a stable 60 Hz envelope on the RF. When you make an adjustment there might be a very slight screen lag; after all, the signal is being digitized and processed before it is converted into an image. Most of the time, there is no noticeable lag. The only glaring exception is when you remove a signal. The last sweep will remain on the screen for a couple of seconds as the scope goes into hold mode while it waits for the signal to come back. I suppose you could press the stop button and then save it before it vanishes forever.

## MSO PART II

There is one drawback with DSOs, at least the low-cost instruments. The LCD screen resolution cannot compete with an analog CRT. As a result, unless you display as large a waveform sample as possible with a single cycle showing, you will see stair steps in the trace, which could mask tiny glitches or make a clean smooth signal look a bit dirty. Should you continue to keep an analog scope around? Maybe. But the benefits of a DSO are so overwhelming it's worth making the jump.

Fig. 4 shows a bitmap capture from the DSO. Notice the raster image jaggies compared to the continuous vector beam drawings of the analog instrument in Fig. 5. Notice the DSO's improved screen draw when selecting a faster time-base, which results in a larger waveform and reduced screen aliasing. Fig. 6.

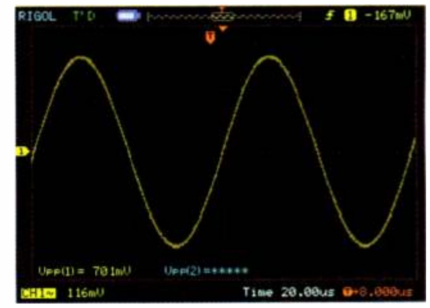


**Fig. 6: Expanding the waveform trace to show fewer cycles improves the image on the DSO.**

Let's try a more complex setup, two unrelated waveforms being measured and viewed at the same time on our dual trace scopes. We'd like to use different sweep time-bases so we can acquire sufficient wave-shape detail for both images even though one is a much higher frequency than the other. I chose a 1 kHz square wave from a scope calibrator and a 9.6 kHz sine wave from an audio generator.

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# OSCILLOSCOPES

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Here's how the scopes fared. The DSO images (Figs. 2 and 7) made the process look easy. Setting the trigger menu to alternate and dialing in the desired time-base rate for the second channel is all that it took. Notice all the detailed measurement data on the display, instrument is in stop mode to hold the image for storage, both waveform triggers are set for zero crossing 0.00 uV. Peak-to-peak voltages of both

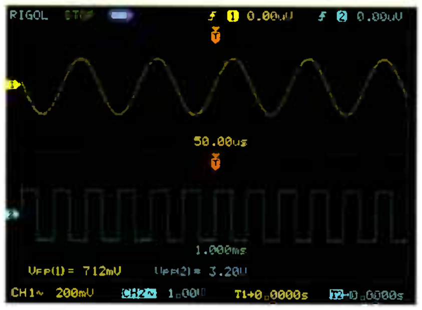


Fig. 7: Effortless display of dual timebase traces referenced accurately to 0 volts — advantage digital.

waveforms are shown along with each channels amplitude value per grid line and sweep times per grid line.

The Tektronix analog mainframe was able to do much the same, but only by showing duplicates of both channels, first at one time-base and then at the second time-base. Careful reduction of waveform height and screen position was required to be able to capture a similar but much more cluttered display. See Fig. 8. Note the on-screen readouts of both time-bases and the vertical scale of the first channel.

In comparison, the B+K analog scope failed to duplicate the screen on my first attempt as the dual time-bases are linked such that the B time-base cannot be slower than the A. See Fig. 9. As you can see, Time-base B would be too fast for the square wave on channel 2 if we sped up time-base A to permit only a few cycles of the sine wave on channel 1 to display. You cannot randomly select any time-base rate. You have to assign the lower frequency waveform to the first input channel. Thus, when I reversed the scope probes, we get the results depicted in Fig. 10, which more closely matches the DSOs display.

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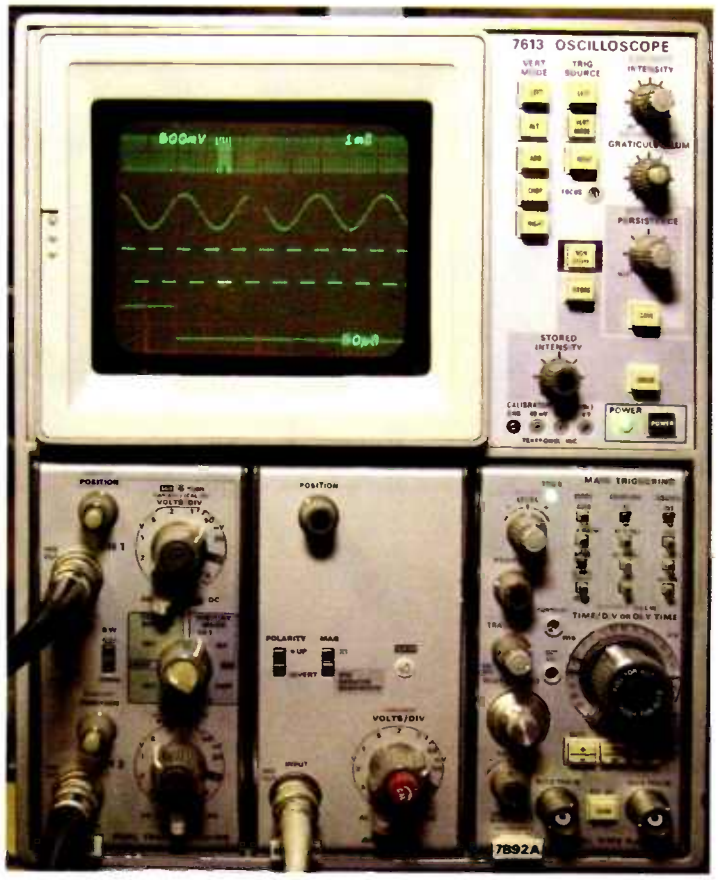


Fig. 8: Same signals on the analog storage scope — not easy to read this.

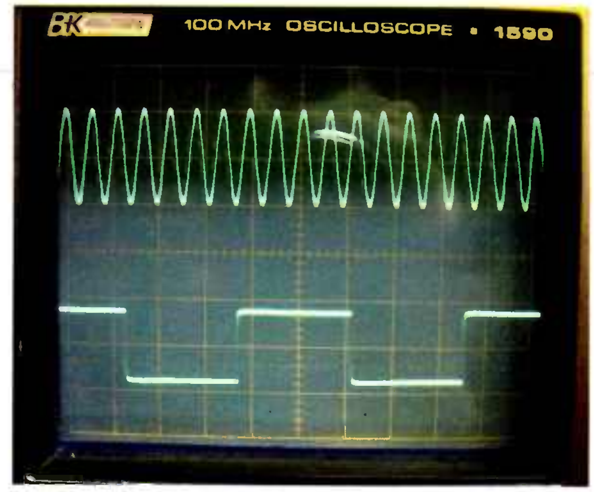


Fig. 9: Upper trace unable to show higher resolution due to time base limitations.

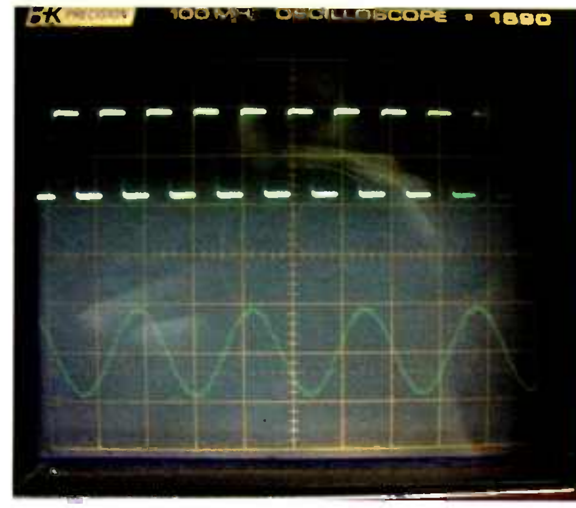


Fig. 10: The display now shows what the DSO does but the high frequency sine waves are dimmed — advantage digital.

## PRODUCT CAPSULE

**RIGOL DS1102E**
Digital Storage Oscilloscope

Thumbs Up
+ Quick automatic waveform acquisition
+ Multiple on screen measurements negate the need for a multi-meter
+ Measurement and setup storage to internal or external memory
+ Easy-to-read accurate color LCD display
+ Compact and lightweight
+ Very inexpensive; price/performance ratio is amazing

Thumbs Down
– Input channels share one set of controls
– Waveform display can be a bit choppy due to segmentation
– Fan is a little noisy
– No storage pouch for probes or other accessories
– No hard-copy manual

Price: $399

CONTACT: Rigol USA at (440) 232-4488 or (877) 4-RIGOL-1 or visit www.rigolna.com

# IPv6

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entirely). Some years ago, when it became clear that IPv4 numbers would eventually run out, some workarounds were implemented as a stopgap measure.

IPv4 has 32-bit addresses, permitting 4.3 billion different values, from 0.0.0.0 to 255.255.255.255. Certain blocks are reserved for private networks; the familiar group from 192.168.0.0 to 192.168.255.255 is just one example. These addresses cannot be routed on the Internet. In fact, if a data packet makes it onto the Internet with one of these IP numbers as the source or destination, it's called a "martian" and is slaughtered. Who says geeks don't have a sense of humor?

Your network could have a printer at 192.168.1.200 and mine could have a video camera at the same address. Since our networks are isolated from one another, we can both use the same block of numbers without a conflict.

Here's the key. Since these networks are isolated, continuing to use IPv4 on a private network is going to work fine; the biggest thing is to ensure is that your connection to the Internet will work OK. Now, your ISP may assign your Internet connection an IPv6 number in the near future. But again, it's your choice in-house. Don't let anyone tell you otherwise.

## THE ADVANTAGES OF IPV6

Everyone focuses on the much larger IPv6 numbers, so let's get that out of the way first. The addresses are 128 bits in size, allowing up to 340 *undecillion(!)* different address numbers. How's that for killing a shortage?

IPv6 addresses are written as eight 16-bit blocks separated by colons, in hexadecimal (base 16, or "hex" if you're a geek). One, and only one, string of consecutive zeros can be replaced by doubled colons. For example, all of these IP addresses might point to the same host:

IPV4: 192.168.1.200
IPV6: fe80:0:0:0:0:0:c0a8:1c8
IPV6: (abbreviated, leading zeroes replaced with doubled colons) ::ffff:0:c0a8:01c8.

(By the way, this is just an illustration. Don't just assume that you can use Windows' Calculator program to convert "192.168.1.200" to hex, add the "fe80:0:0:0:0:0" prefix and call it a day!)

The complete IPv6 specification has several other advantages. I'll briefly mention a few.

First, IPv6 supports more efficient routing. The upper portion of the IP address is a "prefix" that tells an IPv6-aware router, on the fly, where to send the data. Rich, complex and layered routing schemes can be implemented easily with IPv6.

Second, it's more secure. IPSec, or Internet Protocol Security, is mandatory and no longer optional as it was with IPv4. Everything on an IPv6 wire is encrypted and validated.

Third, you no longer need Network Address Translation (NAT). At present, the usual setup is for your IPv4 internal network to access the Internet with a router/modem that does this for you (see "The Mysteries of Network Masquerading," *RWEE*, Aug. 31, 2010). Once everything is IPv6, NAT will no longer be required. Smaller facilities (and remember, that's who I'm targeting here) would probably never notice the difference, but someone with hundreds of computers accessing the Internet might see a dramatic increase in performance.

Those network admins who've already converted to all-IPv6 claim that it's actually easier once you get used to it, because of other advantages such as auto configuration. If you have a huge internal network, the security and efficiency alone might make it worth the expense.

## SUMMARY

Remember: think, "Internet, IPv6; but in-house, stick with what we've got."

Now, when buying new equipment, you should opt for hardware that can do both IPv6 and IPv4. You may have to disable the IPv6 for now. But that way you'll be ready (or readier, anyway) when you finally make your in-house transition to IPv6.

The key point that you need to take away from this is that there is no need to panic. For the Internet, yes, you should become familiar with IPv6. Talk to your ISP and hosting provider(s). For your internal networks, though, it's up to you. IPv6 offers some real advantages over IPv4, but if you have a lot of IPv4-only equipment — as we do — you'll probably decide just to "let it ride" for now.

And do read up on IPv6. I've only scratched the surface here. Good luck!

# OSCILLOSCOPES

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Unfortunately the B+K scope when alternating sweep time-bases does so at less than the lower sweep rate. This is why a camera shot of the screen shows the faster sine wave as being much dimmer as it is blanked much longer than its writing speed and it repeats less often. So it appears darker to the photographic camera, which is not integrating the image over as long a time as the human eye. To the naked eye, both waveforms are alternately flashing on and off.

## LEARN ANALOG, BUY DIGITAL

So which scope would you prefer most of the time? Analog or DSO?

The digital age tends to remove us from the touch and feel of the real world that we learned to understand with our own senses and analog tool extensions. For that reason, I firmly believe analog scopes should continue to be used in education to acquaint students with the concepts they are measuring and the functions used to acquire those waveform measurements. After students get a physical understanding of the process, they can graduate to DSO tools with all of their hidden processes and measurement advantages.

Like all modern digital devices, the Rigol can output measurement files and screen shots to a host computer or even directly to a "Pict-Bridge" capable color printer. It can also be used on an assembly line where it'll provide a go/no go contact closure to automatic test equipment. Physically the unit has little depth. No need for it as there is no long-necked CRT in the cabinet. The case is made of sturdy plastic, but the innards are housed within a shielded metal chassis. It has a good heft to it for something as small as a table radio. Even so, it weighs a tiny fraction of a traditional oscilloscope.

It comes with two switchable 1X/10X probes, amazing when you consider that a pair of name brand probes would set you back almost half the price of the DSO itself.

*Ira Wilner is director of engineering at Monadnock Radio Group, Saga Communications in Keene, N.H.*

## ADVERTISER INDEX



# PRODUCTS & SERVICES SHOWCASE

# Let's Demystify This IPv6 Thing

## Is it Time to Convert Everything on Your Network?

**BY STEPHEN M. POOLE**

Welcome to the future!

A great deal has been written about Internet Protocol Version 6. You've no doubt heard that we're running out of IPv4 addresses (the familiar "xxx.xxx.xxx.xxx" numbers) and that IPv6 is the answer. IPv6 also has many enhancements and improvements over the older v4.

But if you're like me, maintaining one or more small-to-mid-sized IPv4 networks, you might wonder: What's the bottom line? What do I need to do to get ready?

First, I disclaim: If you have a huge, continent-spanning network, what I say here may not apply to you. (Then again, you've probably got a full-time IT staff to worry about it for you.) I'll gloss over a lot of detail too. My purpose here is not to explain the actual IPv6 specification; it's to help you make an informed decision about how and when you begin your own upgrade. As usual, you should do a Web search for more information.

But if you want the quick, dirty bottom line, go stand at the Internet gateway for your building. For most of you, it'll be the router/modem supplied by your ISP.

Look out onto the Internet and think, "IPv6 Land."

Now turn around and look at your in-house network. Think, "MY land. I decide."

Yep, it's that simple. If everything in your facility is chugging along fine with IPv4, *there's no hurry*. If you really wanted to, you could elect not to use TCP/IP at all. I'll admit that's not likely, but keep that in mind when an "IPv6 Consultant" calls and insists that you need to pay big money to convert everything right away.

I just angered some IPv6 fanbois by saying that, so I'll compensate by covering some of IPv6's advantages later.

### CONFLICTING INFORMATION

There's no way to predict the future. IPv6 proponents insist that it'll be ubiquitous and worldwide within a few years at most. But there are many people — including yours truly — who wonder about that. Ironically, *third-world* nations may be the first to reach 100 percent on IPv6, because they're still building their Internet infrastructure. They don't have tons of existing IPv4 equipment that will need replacement.

Many of us do. Our stations have installed IPv4-only microwave data links for use as STLs. Our Wheatstone Generation 6 system is IPv4-only. We will not even consider upgrading these for some time. No doubt you can provide your own examples.

There are ways to make IPv4 and IPv6 coexist on the same network, but the folks who've actually done this warn that it isn't perfect. You will have problems with it. For smaller networks, it's probably not worth the expense, time and bother.

You need to have a serious talk with your Internet service provider about their IPv6 migration. If you host your websites elsewhere, talk to your hosting provider as well. If they're rolling out IPv6 soon, you obviously need to ask them for an IPv6 address and the required dual DNS (i.e., both IPv4 and IPv6) entries right away.

**The Tieline Genie codec is IPv6-enabled.**

But do have that serious talk. Yes, the last block of available IPv4 addresses was assigned in February 2011. When those numbers run out, it'll either be IPv6 or (as I suspect) a hot market will develop for available IPv4 values!

For the record, I haven't found a single ISP or hosting provider who requires IPv6 at present. There are still plenty of IPv4 numbers available here in Birmingham. Your mileage will vary and your city may be different.

There's one other thing you need to consider (and talk about with your ISP). If you are given an IPv6-only Web presence and DNS entry, people who are on IPv4-networks may not be able to get to your website. For the record, I have talked to several ISPs about this and *none of them* was able to give me a satisfactory answer about how this will actually be handled during the transition.

The fact that so much of this is still up in the air alone should be enough to give us pause. Yes, IPv6 is coming … but let's do this on *our* terms and according to our own timetable.

Broadcast equipment vendors give mixed responses on the subject of IPv6 as well. At the urging of our editor, I sent several requests for information: Where are you at? Are you planning to roll out IPv6 and if so, when?

I only got two responses, from Comrex and Tieline. They were markedly different.

Tieline has been IPv6-ready for some time now. If you get to a remote site with IPv6-only Internet access, you can plug and play. You're ready to go.

Comrex, on the other hand, is where I suspect most vendors are. They're ready at the hardware level, needing only a "flash" update or firmware upgrade to make it fly. Tom Harnett of Comrex provided this gem of a quote when I asked for further information:

"Comrex products all utilize software stacks that are fully IPv6-capable, and support will require some changes to the user interface firmware of our devices (e.g., to enable fields for longer static IP addresses). All our products are field-upgradable, so these user interface changes will be easy to apply when required. We actually haven't released any IPv6-capable firmware to date for one reason — *it hasn't yet been requested by a single customer* [emphasis mine]. We are readying major firmware releases including these changes this summer, and will have firmware ready on request for customers needing IPv6 compatibility before then."

### HOW INTERNET ADDRESSSES ARE ASSIGNED

My "bottom line" rule is possible because of a very important distinction. The "shortage of IPv4 addresses" is primarily *on the Internet*.

Internet addressing is overseen globally by IANA, the Internet Assigned Numbers Authority. They decide which blocks of addresses will be used for which purposes. Some are assigned to each region, where a subordinate authority takes over. In North America, it's ARIN: the American Registry for Internet Numbers. If you're curious, the assignment data is online. For example, you can go to *www.dnsstuff.com* and enter any IP address to find out who "owns" it.

ARIN has granted to our ISP, Hiwaay Information Services, all IPv4 addresses from 216.180.0.0 to 216.181.255.255. Hiwaay, in turn, has leased 216.180.115.25 to us for a mail server. We "own" this address; no one else can use it on the Internet.

### PRIVATE NETWORK VS. THE INTERNET

Each host or device on any network must have a unique address (whether IPv4, IPv6 or something else

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