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Federal Communications Commission
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August 4, 2011

Dear Ms. Gallagher:

Thank your for taking the time to speak with me recently regarding the efforts of the FCC to support Dynamic Carrier Control (DCC). At Nautel, we have been working with DCC technology in our transmitters since the mid 1990s. During the last few years we have been promoting this technology in the United States as a means for our customers to reduce their operating costs while reducing carbon emissions from the power utility. Reductions in electricity consumption of 25 to 50 percent are typical. Currently there is uncertainty with broadcasters regarding the legal status of DCC in the United States. Nautel would like to formally request that the Media Bureau issue guidance for broadcasters who wish to use DCC.

In the US broadcasting industry, the term DCC is used to refer to several similar technologies, including Dynamic Amplitude Modulation (DAM) and Amplitude Modulation Companding (AMC). These technologies emerged in the late 1970s and 1980s in the United Kingdom, Germany and Switzerland and refer to specific systems developed by both transmitter manufacturers and broadcast agencies. They all have a similar goal of reducing the average transmitted power in AM broadcasts and thus electrical energy use, while minimizing the negative effects on the received signal quality. A good example is AMC which reduces the entire signal power, but only while the audio is loud, so that the slight increase in background noise will be masked. A detailed explanation of all the systems and their variations is beyond the scope of this letter. However, in my opinion, they are similar enough to be governed by a single policy. To maintain a lack of technical bias, I would recommend the use of a more general descriptive term such as "Carrier Control Algorithms" in any communication to broadcasters. Presumably, if more

broadcasters begin to operate these systems, some version may win favor and perhaps a de facto standard will emerge.

A general, technical definition of a "Carrier Control Algorithm" might be: "A modified AM (Double Sideband Large Carrier) modulation technique where the carrier power is dynamically reduced from 100% of the licensed power by up to 6 dB depending on the peak audio level. Optionally, the sideband power may also be reduced. Any Carrier Control Algorithm must restore the 100% licensed carrier power for at least one specific audio input level." A definition such as this should differentiate between valid systems versus a simple reduction in transmitter power.

Currently the FCC rule which is incompatible with these algorithms is Section 73.1560(a). I can offer several observations that may be relevant when considering if an allowance could be made within the existing legal structure:

1. Any carrier control system should have the capability of being inhibited, so that the modulation will default back to standard AM with 100% licensed carrier power. Monitoring of directional radiation patterns, spectrum compliance and total power can be maintained if the carrier control algorithm is shut off while these measurements are made.

2. Any negative effects including loss of coverage, or distortion will be minimal provided the installation is done correctly. Since the majority of the implementations will be retrofit, it is important that the installation is verified to be correct. In particular, the 100% carrier condition (the currently licensed power) should be verified using a continuous audio tone. Also, the audio input sensitivity of the system must be matched to the audio source and the transmitter must be matched to the system. These steps will ensure the system will operate as intended.

3. Because all carrier control algorithms may be scaled, it is possible to set a limit on the maximum carrier compression allowed. Many versions allow up to 6 dB compression (1/2 carrier voltage) however a more restrictive 3 dB limit could be specified, perhaps for an initial period.

Over the years I have had experience with several customers who regularly use carrier control algorithms. The British Broadcasting Corporation consistently operates its transmitters with a 3dB AMC algorithm. The BBC reports that any loss of audio quality at the fringe is essentially imperceptible. Furthermore, the overall sound quality is unaffected. Other customers I have experience with routinely operate DCC and DAM algorithms with up to 6 dB compression, with minimal effect on coverage reported. Additionally, several controlled field studies were completed during the period that these algorithms were being developed. These studies were published in the IEEE Transactions on Broadcasting and other journals and confirm the minor or negligible effects on coverage and audio quality. I have attached a

copy of my presentation to the NAB Broadcast Engineering Conference which has a more detailed description of these systems together with references to some of the published articles.

I would be pleased to offer any further assistance required with this matter.

Best regards,

T. A. H.

Tim Hardy
Head of Engineering
Nautel Limited

Energy Conservation in AM Broadcast Transmitters Using Carrier Control Algorithms

Tim Hardy

April 21, 2009

Overview

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Historical Notes and References
Technical Description
Waveforms
Performance
Final Thoughts

Historical Perspective

Earliest References date to the 1930's to a system known as "HAPUG". This system was named after its inventors, Harbich, Pungs and Gerth. This system never made it beyond the experimental stage.

The first modern reference that I have found:

Reference 1: Energy Conservation and Reception Quality for Dynamic Amplitude Modulation, Institute of Radio Technology Report Number 22/80, G. Petke and J. Mielke, 7 August 1980.

Dynamic Amplitude Modulation (DAM) was then commercialized by Telefunken (then AEG Telefunken, today Transradio) during the 1980s.

Historical Perspective

ABB of Switzerland developed a very similar technology that they refer to as Dynamic Carrier Control (DCC). First on air tests were done on a 600kW transmitter in Vienna, Austria in 1983.

Reference 2: Dynamic Carrier Control, DCC, a Valuable Method to Save Input Power of Medium Wave Transmitters, Dr. Wolfram Schminke and Hans-Ulrich Boksberger, IEEE Transactions on Broadcasting, Vol. 35, No.2, June 1989

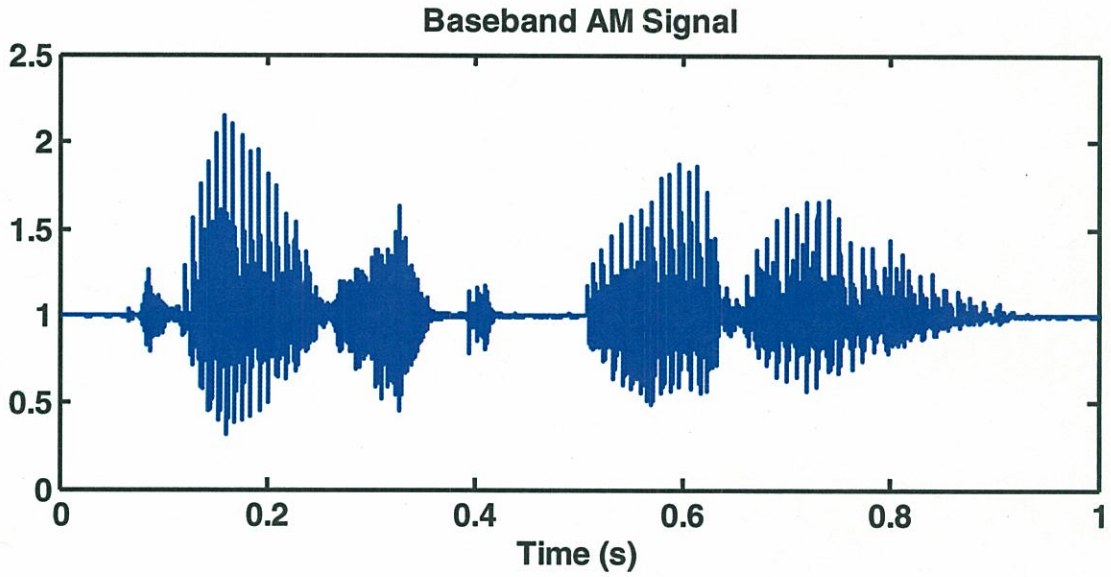
In the UK at the BBC Research and Development group, a different approach was developed referred to as Amplitude Modulation Companding (AMC).

Reference 3: Amplitude modulation radio broadcasting: application of companding techniques to the radiated signal. BBC Research Department Report No. BBC RD 1985/13. W.I. Manson, 1985

AM Carrier Power

The AM carrier does not carry any information yet contains more than 2/3 of the transmitted power.

How can the transmitted waveform be modified to reduce power without reducing received quality in simple AM receivers?

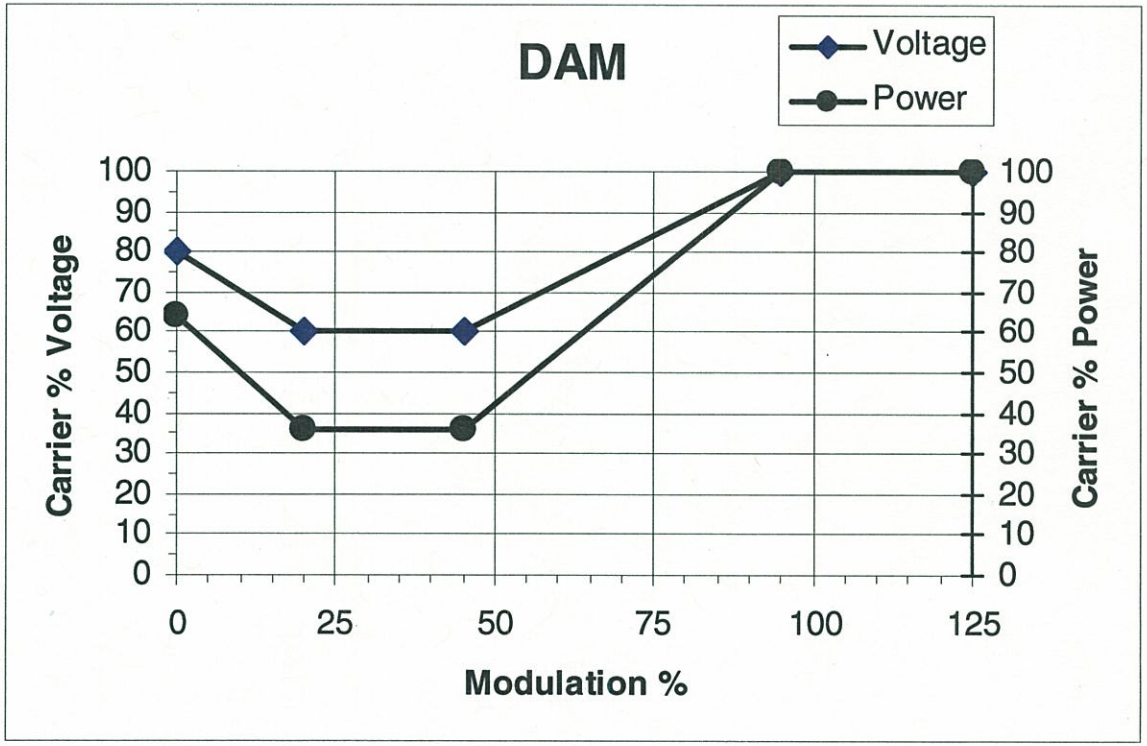


DAM Gain Function

Carrier (only) is decreased the most at moderate modulation levels.

Received loudness is increased when carrier is reduced.

The carrier is increased at higher modulation levels so that distortion does not occur.

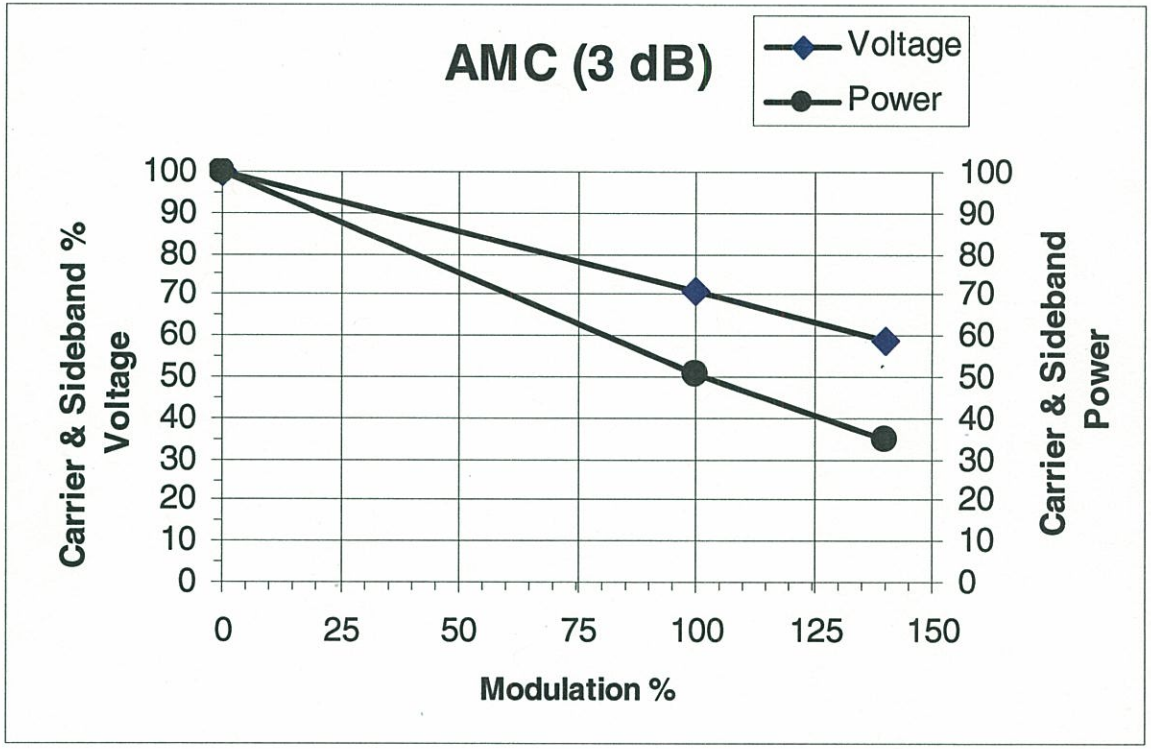


AMC Gain Function

Carrier and modulation together are decreased with increasing modulation index.

There is little impact on received loudness.

The carrier is increased to full power during quiet periods when noise is most easily perceived.



Time Domain Considerations

Typical settings for the audio peak detection of the audio are:

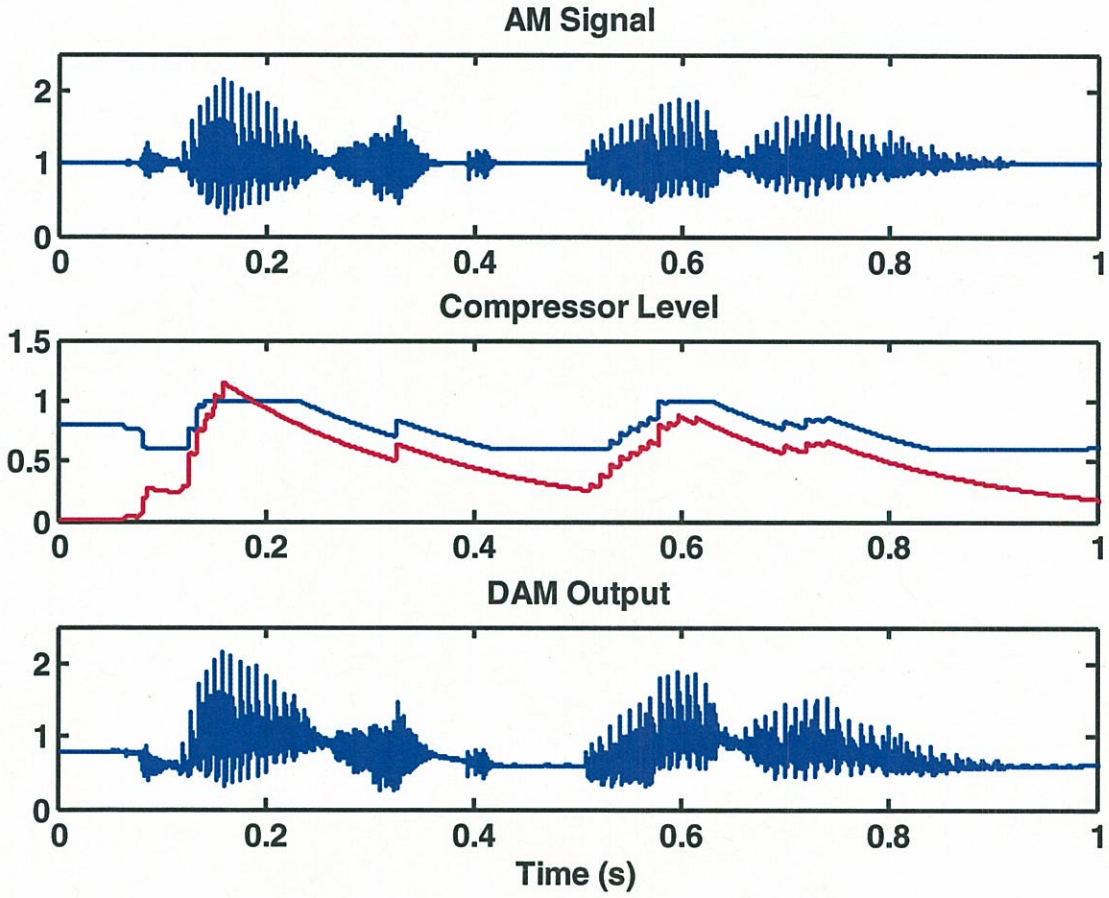
- Attack time: ~1 ms
- Decay time: ~200 ms

A Decay time of 200 ms is determined by the need for the receiver AGC to respond more quickly to closely track the changing carrier. Typical receiver AGC circuits are reported to be in the range of 20 to 60 ms.

With DAM the fast attack time is important so that the carrier may be recovered as quickly as the increase in audio levels so as to prevent pinch off distortion.

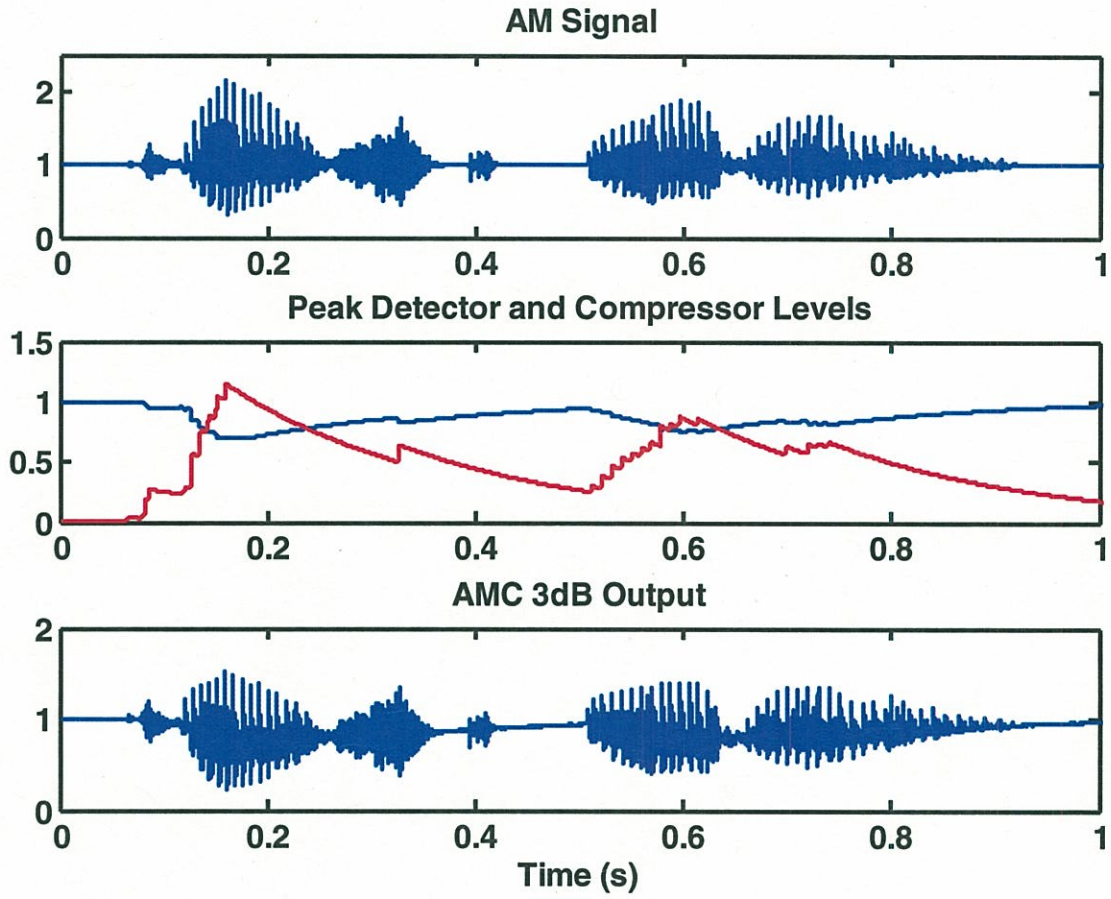
With AMC the action of the receiver AGC is to increase the audio gain when the carrier is reduced so that no net change is observed. However noise and interference is also boosted by the same amount. This increase in noise floor should be masked by the increased loudness during these stages.

DAM Waveforms



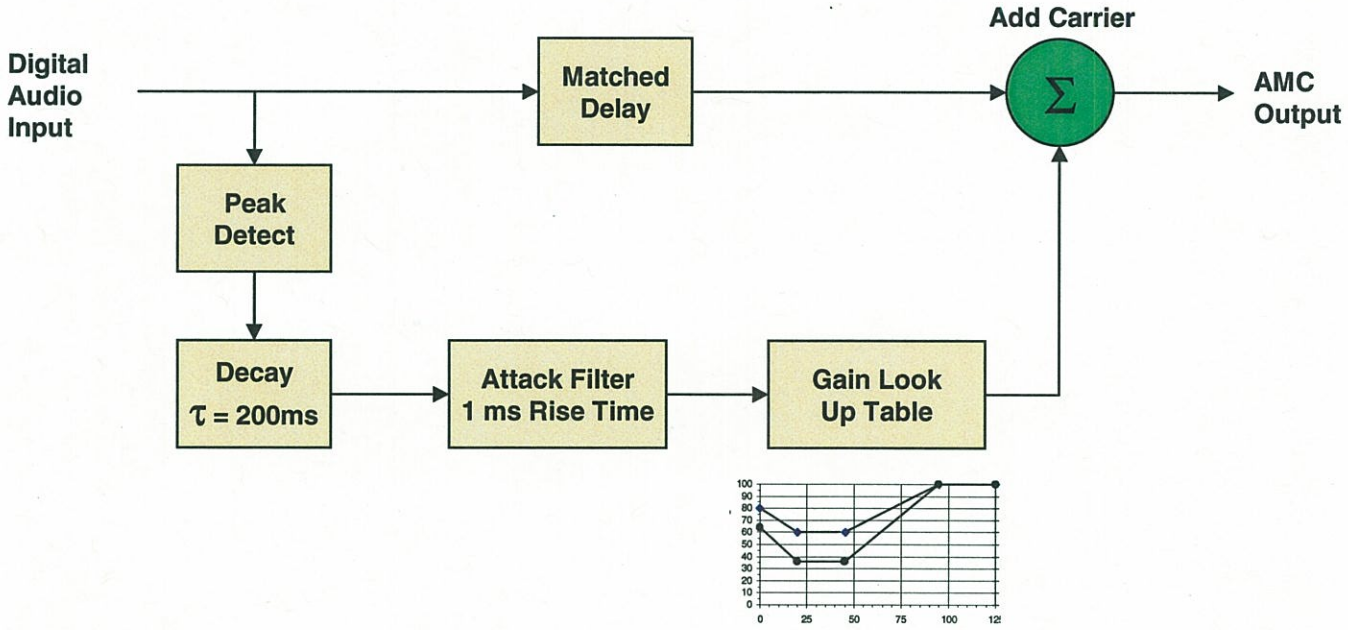
Average Power Reduction 40%

AMC (3 dB) Waveforms

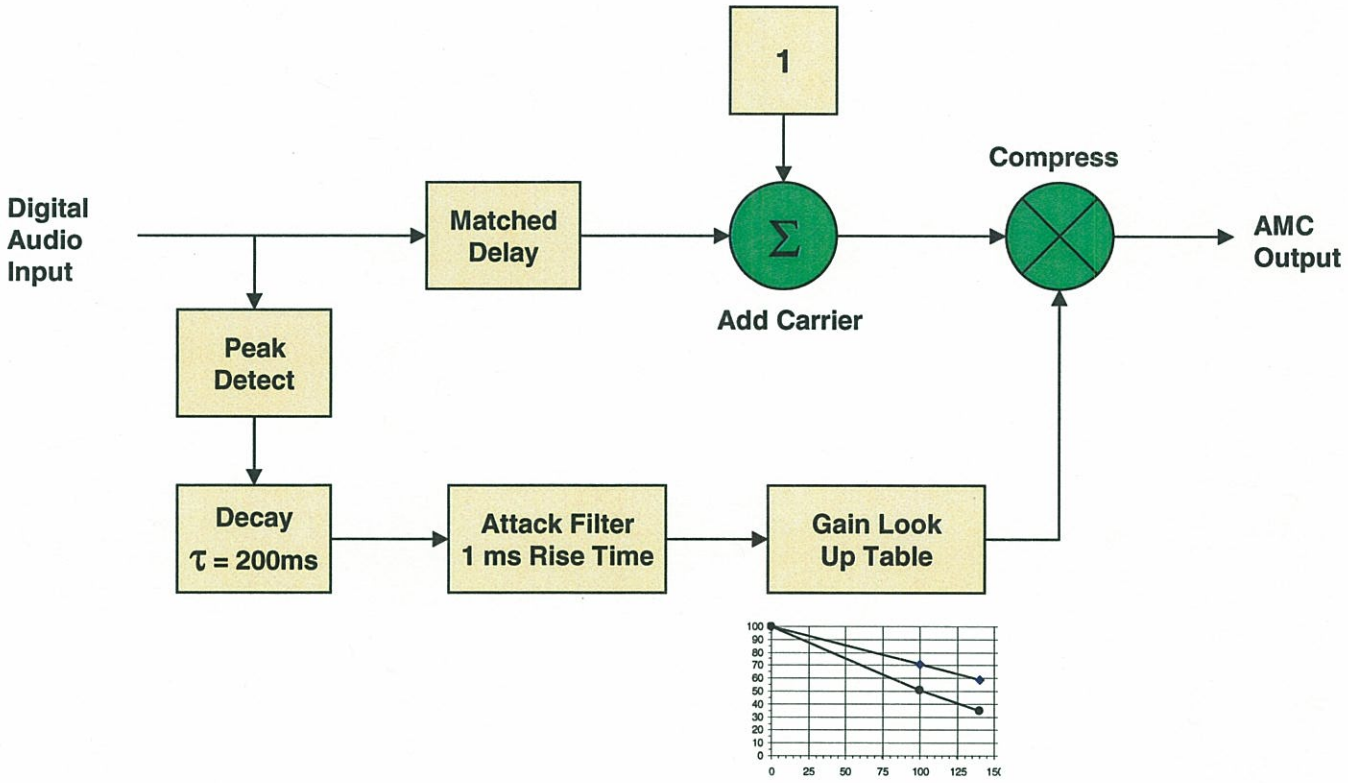


Average
Power
Reduction
23%

DAM Block Diagram



AMC Block Diagram



2008 Implementation

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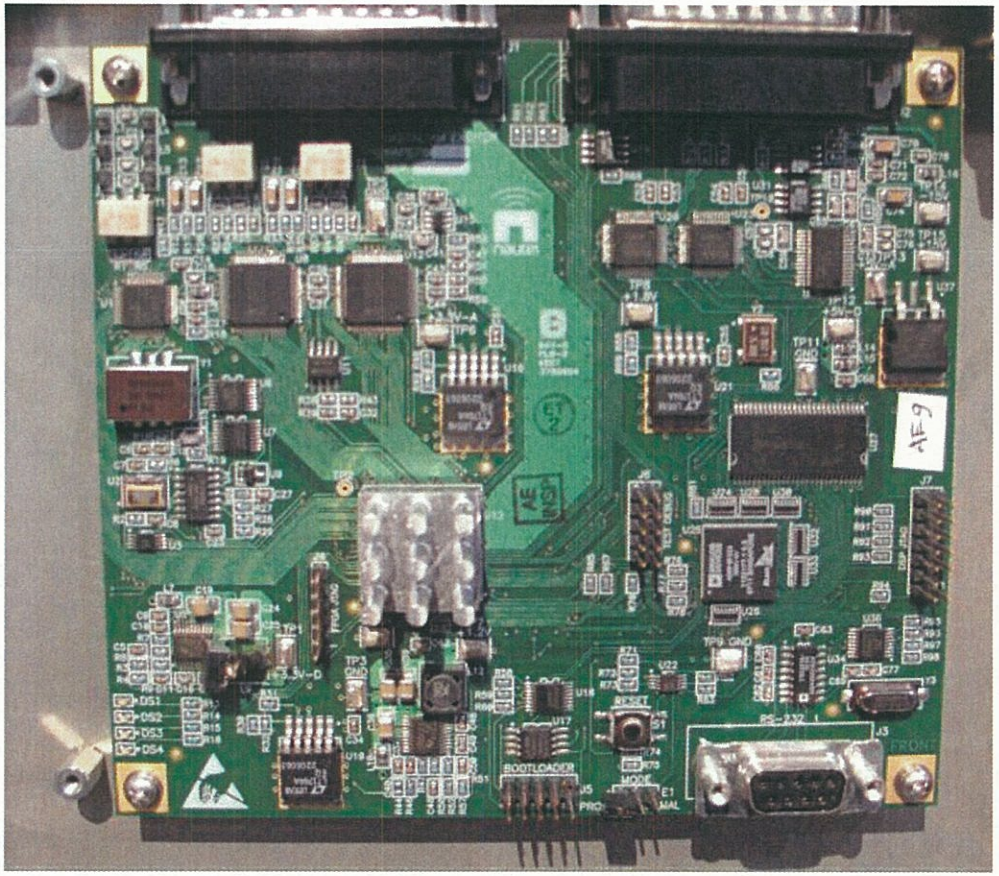
These algorithms are quickly and efficiently implemented on a modern transmitter. The code is written in C and in this case compiled for the Analog Devices fixed point DSP.

With modern tools and equipment engineering time is only a few days.



Energy Savings

- This technology is most relevant to high power stations ie. 50kW
- State of the art AM transmitters are 90% efficient
- Average power consumption is perhaps 73 kW. (70% average modulation)
- 8760 hours per year (24 hr station)
- 640,000 kWhr per year
- Electrical rates range from 5 cents to 20 cents depending on the region

Assuming a 30% power reduction:

- Savings are $19,200 per year at a 10 cent/kWhr rate
- Savings are $28,800 per year at a 15 cent/kWhr rate

If converting an older 70% efficient transmitter:

- Savings are $37,600 per year at a 10 cent/kWhr rate
- Savings are $56,400 per year at a 15 cent/kWhr rate

AMC Perceived Quality

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Reference 4: Implementation of Amplitude Modulation Companding in the BBC MF National Networks, C.P. Bell and W.F. Williams, IEEE Transactions on Broadcasting, Vol. 35, No. 2, June 1989

Key Notes:

- Laboratory tests on subjective listening quality suggested the degradation was not significant.
- Subjective testing with interference (co-channel) did not indicate a significant change in quality.
- Comparisons with simple power reductions were done. A 1dB power decrease was imperceptible (with noise or interference) to 90% of listeners. This corresponded to 3 dB AMC with noise tests and 7dB AMC with interference.
- In a field trial from Brookman's Park, a 100kW site near London, Engineers made assessments at 29 locations in the daytime and a further ten locations at night. No impairments were observed.

Other Considerations

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Processing: These systems do not perform as well with heavily compressed audio levels. This is because high level peaks occur very regularly and quickly so that the detected peak level always stays at nearly 100%. Voice program tends to work well due to the pauses between words.

AM IBOC:

No work has been done to consider if the AM IBOC system could be modified to operate with carrier control algorithms. It is not known if this system would interfere with the normal operation of the IBOC receiver, although it seems unlikely. Implementation with IBOC would also be more challenging.

Legal Status:

Due to restrictions in the FCC rules this system may not be legal. However due to the extensive body of knowledge and the experience internationally, operation with a Special Temporary Authority or a change in the rules could be possible.

Final Summary

Carrier control algorithms were developed and tested in the 1980s and continue to be deployed in high power AM transmitters around the world. These systems are a specified requirement in most high power AM bids.

Research conducted in the 1980s revealed that significant reductions in transmitted and consumed electrical power are possible with very minor impairments in subjective quality measurements on the received signal.

With modern transmitters, the cost of implementation is very small or no cost in the case of new systems. However the electrical energy savings are very significant especially on high power transmitters. These energy savings are complementary to the savings from modern high efficiency transmitters.

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Thank You.

Questions?