The VHF JOURNAL

March 1999 Volume 50 Number 5

Dedicated to the Radio Experimenters, Contesters and Operators above 50MHZ, along America's North Coast

In this Issue...

Membership in THE ROCHESTER VHF GROUP is by application. Dues are $10 (Ten Dollars U.S.$15 U.S. for Canadian Members) per year. Make Checks payable to "The Rochester VHF Group". Membership expires on May 31st.

The Club meets on the second Friday of each Month, September through June, at the Monroe County Social Services building at 111Westfall Road. Commercial advertising prices are $20 (twenty dollars U.S.) per year per space and must be arranged through The Advertising Manager. Non-commercial "For Sale" or "Wanted" ads are free.

Please address your Rochester VHF Group business to the P.O. Box listed on the reverse.

Since information is considered perishable (time sensitive), please be sure to send VHF JOURNAL correspondence to the above mentioned P.O. Box. or contact The VHF Journal's Editor, Curtis Braun via the internet: curtis.braun@digital .com orbraun@netacc.net.
http://vhfgroup@rochesterny.org

This Months Meeting...

Place:	*111 Westfall Road*
Time:	7:30 PM Friday Mar 12, 1999
Program:	VHF/UHF Experimenter
Presenter:	K2UA
Dead Line for Journal:	Mar 29,1999

President's Note:

By Steve, N2ULL

Please note our Web-site Address:
The URL is

http://vhfgroup.rochesterny.org

This Months Meeting:

By Dave,**K2DH**

For the March meeting, the speaker will be Rus Healy K2UA. His program will be: "Continuing Education for The VHF/UHF Experimenter". It should be interesting, as his talks always are.

THERE WILL BE A 50th ANNIVERSARY AWARDS BANQUET THIS YEAR!

READ ON....

Banquet News:

By RVHG Board via K2DH

Between Len Gessin (WA2ZNC) and my wife Diane, they have put together the following:

Date: Saturday April 10th.

Time: 6PM Cocktails,
7PM Dinner
(this may change slightly but probably not).

Place: Mario's Via Abruzzi,
(Pittsford. same place as last year)

Menu: Buffet
(details of selections to follow at the March meeting.)

Price: $23.00
(just a dollar more than last year)

Music: By Brad

Tickets: by AF2K, available at meeting.

Contest Corner:

By Mark, N2YB

I just got the word that there will be a banquet. This means that I have to work fast. First of all the award sponsors. If you plan to sponsor an award but have not turned in a check yet you should have your book out right now filling it in. The drop dead date for this is the meeting on 3/12/99. I am not going to beg any more for procrastinators. If I don't have the money in the hands of the treasurer on the evening of March 12, any award that is not covered will go un-sponsored. The following awards are currently un-sponsored. If your call appears after an award and you do not intend to maintain sponsorship, please call or e-mail me immediately.

ROVER

1st	Andros Mfg.
2nd	W2FU
4th	K2IV
5th	N2ULL

Unlimited Single

3rd	Andors Mfg.
4th	WA2MOP

Medium Single

1st	WA2TMC
2nd	WY2Z
3rd	AA2WV

QRP

1st	CATS Rotor Repair

Single Band

50MHz	KA2RDO
222Mhz	VE3IEY
2304/5760	K2DH

Most Improved W3OAB

There are a few awards that have been dropped by their last years sponsors and are now available to the membership.

Open Awards

Medium Single
4th place
5th place

Single Band

144 Mhz

I will be ordering the plaques the day after the March meeting hoping they will have a fast enough turn around to make the banquet date. If there was more time I would make it available to sponsors. The time will be very short even waiting until the meeting date. Please, if you have a sponsorship and wish to drop it, or want to sponsor one of the Open Awards, contact me. (Please send your sponsorship dollars to the club for the March Meeting or bring it with you – editor)

Spring VHF Thoughts:

By Tom Richmond, VE3IEY

The 144 MHz Sprint will be from 7 PM until 11 PM local time on Monday (April 12, 1999).

The 222 MHz Sprint will be from 7 PM until 11 PM local time on Tuesday (April 20, 1999).

The 432 MHz Sprint will be from 7 PM until 11 PM local time on Wednesday (April 28, 1999).

The 902 MHz, 1296, and 2304 MHz Sprint will be on Saturday (May 8, 1999) from 6 AM until 1 PM local time.

The 50 MHz Sprint will be from 2300Z Saturday until 0300Z Sunday (May 15-16, 1999).

Sprints are ON with new sponsorship! See the following web-page:

http://www.arrl.org/contests/announcements/99/spring-sprints.html

For Sale
March 99

BELDEN 9913:100 ft. reel =50 $.
MIL RG–213: 0.30 $/ft; or precut with 2xN(M) conn. installed, 150 ft. =50$.
BIRD 8135 Load, NEW: 150 W rated to 4 kMcps =100 $ (247 $ in BIRD 97 Cat)
Shipping extra all.

Dean, WB2QCJ, (716) 385–1294.
(dkeyser@harris. corn)

From the Treasurer...

By Len WA2ZNC

No Receipts:	
Expenses:	$ 200.00
Balance on hand:	
Saving acct.	$ 1,780.08
Checking acct.	390.46
Total	$ 2,170.54

Treasurer
WA2ZNC, Len

QST,QST,QST Friends: CQ, CQ, CQ Contesters:

By RVHG Board

QST. QST,QST calling all RVHFG old-timers, Hear-ye Hear-ye, Read-all-about-it. QST. QST,QST calling all RVHFG old-timers...

The Rochester 50th Anniversary Banquet has been scheduled. Come one, come all, this is the one, we urge all of you to take some time from your busy schedule and come to *your Banquet.* This is a great opportunity to join some old friends and make some new ones, while celebrating the Club's 50 years of service.

Notes:

By Curtis. N2HKD

The VHF Forum at the Hamfest is booked.

CQ Spring Activity Weekends are, March 19-21 (FM), April 23-25 (Weak Signal) and May 2 1-23 (Specialty modes), 1999. For more information see the march issue of CQ VHF. See: http://www.cq-vhf.com

Six meter contests: Six Club sprints,
April 24-25, Sat.2300 UTC to Sun.0400 UTC
May 2 1-24, Fri.2300 UTC to Mon.0300 UTC
July 17-18 Sat.2300 UTC to Sun.0400 UTC
See: http://6mt.com/contest.htm

The following is an article from Dave Hallidy, previous presented during a RVHFG meeting.

Please come to the Banquet on Saturday April 10

LINEARIZING SOLID-STATE POWER AMPLIFIERS
OR
REDUCING SPLATTER ON THE VHF BANDS

by Dave Halildy K2DH March, 1998

INTRODUCTION

We've all heard it- the contest begins, and all you can hear around the calling frequencies is noise! Stations are piled on top of each other, all calling the guy in the rare grid that just fired up. So what? That's the way it is in contests. Generally, after the first few hours or so, most everybody starts to spread out and this relieves some of the noise problem. ***BUT NOT ALL OF IT!*** What's going on? You're listening to pops and crackles from another station, but there's nobody close by! So you tune around a bit, and sure enough, you find him- a guy who's loud (but not *that* loud) 10 or 20 kHz away from where you've been sitting, blasting away on SSB. You check, and your noise blanker is off. You tune up and down on either side of him and the "crud" is about the same. HMMMMM... it's him- but what's wrong with his signal?

What's wrong is, he's probably one of the zillions of stations that are running solid-state "brick" amplifiers after their transceiver or transverter to boost the output power up to the 150 to 200 Watt level (depending on the amp). And, to make matters worse, he's probably driving the snot out of it, so it will show its advertised power output on his wattmeter. If you ask him to turn down the drive, and he does, you notice something- his signal strength doesn't change much, but all of a sudden, the band around him is quieter. Well, it's a contest, and he's not about to leave the power down and possibly miss those extra multipliers all that "extra power" will bring in (and he probably secretly thinks it's your receiver anyway), so guess what- back up goes the drive and everything gets right back to the way it all started.

Now imagine what it's like if a whole bunch of stations are all similarly set up, and doing exactly the same thing- it's not a pretty picture! I've heard this noise, and heard the frustration of others on the bands when "the problem" rears its ugly head. The good news is, there is a fix. The rest of this article deals with an analysis of the problem and a practical, simple fix that takes about an hour to build and implement. After performing the minor modification to your brick amp, you'll be a much better neighbor on the band.

ANALYSIS OF THE PROBLEM

The root of the problem is amplifier non-linearity and something called **Intermodulation Distortion (IMD).** We've all heard this term discussed, but what does it mean? We know that we expect our linear amplifier (with let's say, 10dB gain, for example) to faithfully copy the driving signal and increase its power by 10dB. So, with 1W in, we expect l0W out; with l0W in. 100W out, and so forth. An amplifier that behaves this way, right up to its output (or input) limit, exhibits a *linear* transfer function and is truly a ***linear amplifier.*** Most amplifiers, however, only exhibit this linearity over a limited range of operation. As they approach their operational limit, the output begins to compress- that is, for every unit of drive increase, the output doesn't correspondingly increase. Using the example of the 10dB amplifier above, we reach a point where, let's say at a drive level of 15W, we don't quite get 150W out. And at 20W in. we're only getting about 170W out. The amplifier is said to be "in compression" in this region. At some point, further increases in the drive will yield no further output increase- the amp is "in saturation" at this point. In order to have a clean transmitted SSB signal, we don't want to run heavily into compression, and we certainly don't want to run at saturation. (See Figure 1 for a graphic representation of this,) Why not? Because when the amplifier falls off the linear portion of its transfer characteristic, IMD products are generated. An SSB voice signal is a very complex waveform, varying rapidly in both frequency and amplitude due to the nature of human speech. Ideally, a transmitter will faithfully transmit these complex voice signals, without producing distortion. Realistically, these signals *do* intermix and produce IMD. How much IMD depends on the quality of the transmitter and its ability to deal with the rapidly varying characteristics of voice, and to remain linear through a fairly large dynamic range. Of course, even if the amplifier stage *was* perfect (generated no IMD of its own), its output could be no cleaner than the drive going into it, so there may still be sonic splatter. Figure 2 shows the spectral output of the driving source I used for this work- an ICOM IC-271A with its output at 25W PEP. It's not too clean, but representative of what can be found on the amateur market today.

While we're on the subject, a brief discussion of PEP vs. CW output power and the technique used to visualize IMD is worthwhile. A transmitter (or amplifier) can really never generate more PEP (Peak Envelope Power) output than it can single-tone CW output. This is because the stage is supplied with a certain amount of Collector voltage and will draw a certain amount of Collector current when driven to its maximum output. This is true whether the drive is SSB voice or a steady CW carrier. Thus, the measurements made of IMD start with an amplifier fed with a single tone and adjusted to provide maximum output. Then, a two-tone test is performed whereby two equal level tones which are non-harmonically related are applied and the RF output (with both tones applied) is adjusted to be 6dB below the single tone output on the display. The levels of the IMD products are then read directly off the analyzer display. The fundamental tones can be seen, as well as the IMD products (if any) that are generated. See Figure 3 for an example of a two-tone test output. I used a two-tone test for all of the IMD measurements made for this project.

The IMD generated in the exciter is a common problem of radios using hybrid PA output stages, and it will be reserved for another day (See Appendix A for a few examples of IMD levels specified by one manufacturer of hybrid amplifier modules such as are used in the ICOM IC-271A and other radios). My goal with this article is to help us reduce or eliminate the effects of PA distortion on the transmitted signal.

What I discovered when I got into this project was that the brick amps I tested were of marginal linearity. Consequently, they generated significant levels of IMD, and had a tough time making rated power output. I also discovered that the bias circuit commonly used in this type of amplifier is truly inadequate for the demands placed on it during periods of highpower SSB operation. The amplifiers I evaluated were both Mirage model B3016 amplifiers, rated at 160W output for 30W input across the two meter band. They typically draw about 20A when running at rated output with a 14V power source. Please refer to Figure 4 during the following discussion (note: This circuit or one very similar to it has been used in all of the amateur "brick" amplifiers I have seen). The bias circuit consists of a 50 ohm power resistor between the keyed 12V source and the anode of a silicon diode whose cathode is grounded. Bias is taken from the junction of the resistor and diode and connected, through a choke, to the bases of the PA transistors. This theoretically supplies about 0.7V positive bias to the transistors' Base-Emitter junctions, turning them on to a certain degree (I've determined that these amps typically draw about 10% of their rated current at idle, or about 2A, biasing them somewhere in Class AB). When driven with RF, the Base current increases and causes more Collector Current to be drawn. For the devices to stay linear, the Base must remain positively biased throughout the RF cycle (without bias, they revert to class C operation- that is, no Collector current drawn when there is no drive). But, the Base current required to stay positive at maximum Collector current is around 2A and the 50 ohm resistor in series with the bias circuit limits the available current to a few hundred milliamps. Therefore, the Base voltage drops farther and farther as drive increases, until it actually can go negative, forcing the PA devices further into Class C!

THE SOLUTION

The solution is to provide a very low impedance bias source whose voltage is adjustable and regulated and which can easily provide the necessary Base bias current. In order to prevent thermal runaway of the PA transistors, thermal compensation is required so that the bias voltage will fold back somewhat as they heat up under periods of heavy use. The circuit shown in Figure 5 takes care of all of these requirements.

Please refer to Figure 5 for the following discussion. This is a very simple circuit, really. The 78L05 (or 08- it doesn't matter which you use) drops the keyed 12V down to a useable level. This voltage gets further dropped by the 1k ohm fixed resistor and the 1k pot. The wiper of the pot varies the voltage to the base of the TIP 142 Power Darlington (again- not a critical component- you could use a smaller Darlington, or connect two NPN power transistors in a Darlington configuration). The lower end of the pot is connected to the Anodes of two parallel-connected 1N4001 (or equiv.) silicon diodes. These diodes are placed on top of the PA transistor cases in such a way as to provide thermal contact with them. Some Heatsink compound around each and on the tops of the transistors will help the thermal conductivity. The purpose of the diodes is to provide compensation to the bias regulator with varying temperature. As the temperature of the PA transistor cases increases, so does the temperature of the diodes. This causes their forward bias voltage to decrease somewhat, lowering the base voltage to the Darlington, and thus lowering the bias voltage. The Collector of the TIP142 is connected to the keyed 12V source, so it can draw as much current from it as it requires. Connected as an Emitter Follower, the Darlington's Emitter is then connected to the Bases of the PA transistors, at the location indicated in Figure 4. Bias levels adjustable by varying the 1k pot in the circuit, to provide about 0.7V at the Bases of the PA transistors. If you can monitor supply current to the amplifier, you can easily set the bias for about 2A, or 10% of rated current, with no RF drive applied to the amplifier.

CONSTRUCTION / INSTALLATION

Construction is not critical, but remember that the Collector of the Darlington has 12V on it, so it must be insulated from ground. Also, some amount of heatsink is required on the transistor to keep it from overheating during heavy operating periods (it could be dissipating as much as 25W of power). Layout isn't critical, either- but try to make the assembly as small as possible, because there probably isn't a lot of empty space inside the amplifier housing. I stood mine off from the PC board with a piece of heavy gauge bus wire, soldering it to both the bias regulator and a large area of ground etch on the board. Try to keep the interconnecting leads (to the tap point in the old circuit, to the keyed 12V source, and to the thermal compensation diodes) as short as possible to minimize the possibility of stray RF pickup in the circuit.

It will be necessary to make a couple of breaks in the original circuit, but if you're careful, it can all be restored later if you decide to remove the new regulator. Refer to Figure 4 for the following modifications. I lifted the "hot" end of the RF Choke coming from the 50 ohm resistor, but left it in the amp, standing up on the PC board. I also lifted the Anode end of the original bias diode from the circuit, and similarly left it there to reinstall if necessary. The 12V source for the new regulator must come directly from the keyed 12V line, so as not to limit the current into the regulator. I connected the output of the regulator to the point where the Anode of the bias diode had been. The thermal compensation diodes must be in contact with the transistor cases, so I soldered the cathode leads directly to the PC board very close to the transistors. I then laid the bodies of the diodes on top of the transistors and put a little dab of thermal compound around the diode/transistor interface. The diode leads were then bent up so I could solder a wire to each Anode and run it over to the bias regulator circuit.

Photo 1 shows the bias regulator and how I placed the circuit into the amp, and Figure 4 shows where to break the original circuit to connect the new bias regulator.

Adjustment is simple. Power up the amp. If it has a manual keying circuit (most do), key the amplifier without any RF drive applied. Measure the DC voltage on the Base of one of the PA transistors and adjust the pot on the new regulator for 0.7V at this point. If you've started with the voltage too high, the amp may draw too much current, shutting down your power supply. If this happens just turn the pot down to decrease the bias voltage, and repeat the process.

RESULTS

The results of this work are gratifying. See the graphs and spectral plots in Figures 6-17. I found that the power gain of the amplifiers increased, their maximum output capability increased, and most important of all, the 3rd, 5th, and 7th order IMD levels decreased significantly. IMD *is* the most important improvement, because it is this distortion that is observed as splatter on the frequencies around the offending transmitter. Reducing the

IMD levels has the effect of reducing the apparent occupied bandwidth of your signal, making it easier for stations to operate close to your frequency.

The bias regulator circuit described can be installed in just about any of the popular brick amps for 50, 144, 222, or 432MHz. I've shown how easy it is to construct and install, and how much of an improvement it can make in the IMD performance of solid-state linear amplifiers.

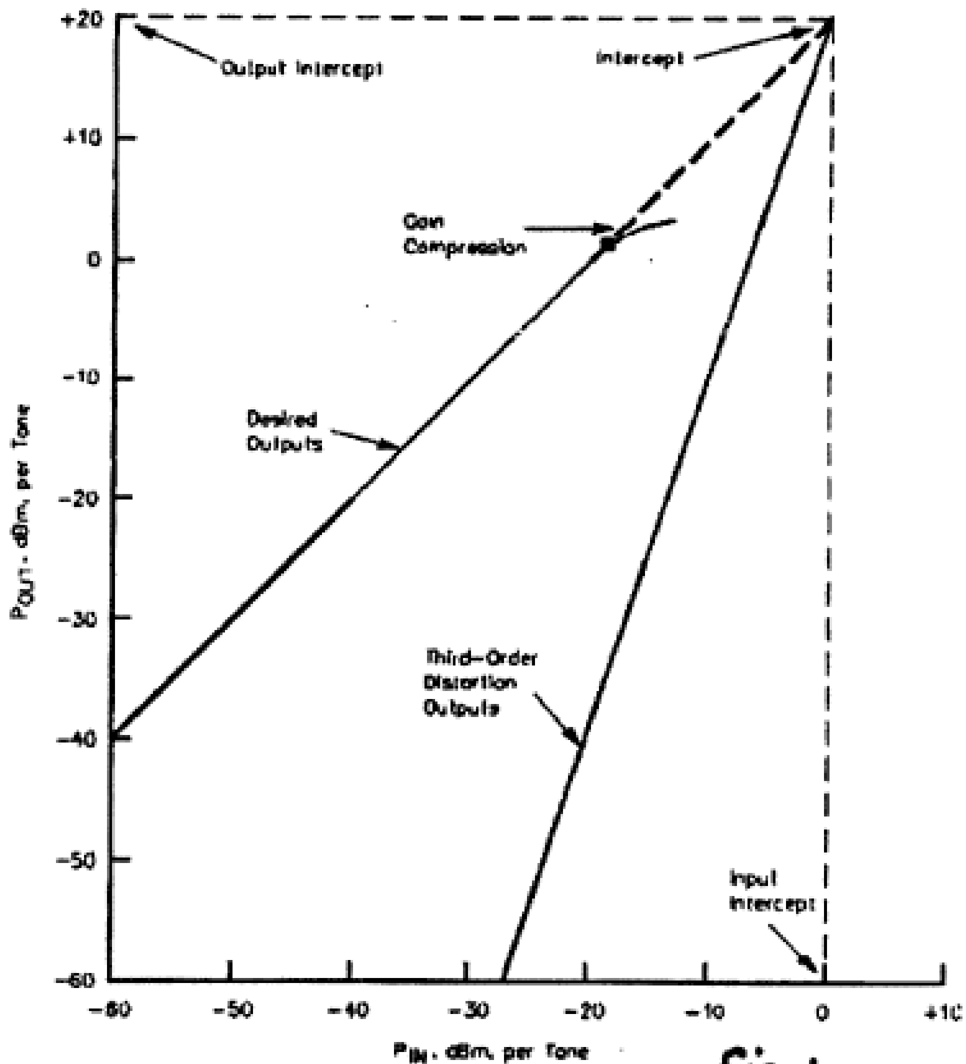

Fig 1