Regarding Fusion

Category: Fusion
October 22, 2022
Some thoughts about Fusion, digital modes, and the future.

Fusion uses the lower layers of the P-25 architecture. Modulation, transport, framing, etc. The primary differences revolve around what's in the packet. For example: The use of call signs instead of unit IDs. So Fusion shares most of P-25. FWIW, Fusion is also very similar to DMR. The primary difference is that it doesn't use TDMA – jamming two separate channels into the space of one.

P-25, DMR, NXDN(Kenwood), IDAS (Icom), and Fusion use the same vocoder. D* uses a much older and obsolete vocoder.

Fusion and D* have been optimized, although differently, for Amateur Radio. DMR, NXDN, and IDAS have been optimized for commercial services, like taxi cabs. P-25 has been optimized for government services, like police departments.

Fusion was actually designed by Motorola in that period of time that Motorola owned Yaesu. This benefits Fusion since the vocoder and the signal processing firmware are pretty much the same as what Motorola uses in their radios. (Believe me, not all signal processing firmware is designed the same!) Thus, the performance of Fusion is pretty darn good. Add to that an additional layer for FEC provided by Yaesu's modification to P-25, and the performance of Fusion is better than all the others. (D* is substantially worse than the other protocols.)

What we see from this is that most of the communication industry has evolved around the same technologies even though the systems are not directly compatible with one another. This is why it is

so easy for a hotspot to translate between DMR, P-25, NXDN, IDAS, and Fusion. But is this the best we can do?

No. Digital performance could be much better. C4FM already blows away FM with superior range and capability, but it was intentionally limited – to work with FM/PSK transmitters and receivers like those used with FM.

FM is a non-linear system thus it does not transmit all the information it could in the available bandwidth. Linear systems, such as OFDM, can provide higher bit rates lower error rates, better resistance to fading and multipath, amongst other things. The problem is OFDM requires linear amplifiers and thus is not compatible with all the FM/PSK transmitter and receiver designs.

Personally, I'd like to see OFDM as an option for digital's future.

But all digital systems could be made better by some enhancements at the repeater site. The use of multiple, diversity receivers incorporating very low-level discrimination could improve receiver sensitivity by as much as 10 dB. That means HT would perform almost as well as a mobile rig with no changes required of the user. Having multiple diversity receivers at various locations around a city could mean that a low power HT would work virtually anywhere in that city. Sadly, there doesn't seem to be a market for doing such things. (This technology is well understood and used by your cell phone.)

One last note. Several attempts have been made to build multi-protocol radios incorporating DMR, Fusion, D*, FM, and others into a single unit. Should be simple, right? But we have yet to see such radios on the market. If we did, they wouldn't do Fusion as well as Yaesu, or D* as well as Icom, or DMR as well as Motorola. Why? Protocols are damn hard to get right. They are even harder to get working really, really well where they take

into account all the things that can go wrong with data transmission. (Hotspots try to do the conversion, but never work as well as going “native”.)

I would argue that the amateur community should focus on those systems designed for Amateur Radio. Ultimately those will be easier to use and better suited for the job. (Police departments and taxi cabs should not use Fusion!) A good user experience is critical if digital, any digital, is to become generally accepted.

One last note: Nothing prevents Icom from building a Fusion radio. Every last little detail about Fusion is public information, particularly since most of it comes from P-25 – for which Icom builds radios. The only proprietary aspects of Yaesu’s system are WiRES-X and IMRS.

Purchasing amateur radios that do digital help support the future of digital by encouraging companies to develop more and better digital features. Buying commercial Chinese radios just helps the Chinese economy.

Understanding DGID and IMRS

Category: IMRS
October 22, 2022
DG-ID is like a CTCSS tone, but for digital. It filters out signals with different DGID’s as well as having the ability to do split DG-ID’s (like split CTCSS). DG-ID can be in a state of Rx & TX (DG-ID), Rx Only, Tx Only, and Split Rx & Tx (different DG-ID).

DG-ID servers as a means of selective signaling for access to a repeater or for a WiRES-X node. For the repeater it has a couple of different applications (IMRS and access purposes) while with WiRES-X it offers control of voice and control access.

DG-ID’s cannot be reused within the same configuration or network. For a repeater that means the DG-ID can only be in the LOCAL, RPT GROUP, or GROUP. There will be issues if in an IMRS network has anything with the same DG-ID.

DG-ID Repeater usage

LOCAL DG-ID: There are two factors:
1) The DG-ID it will not be sent down IMRS links and only allow access to the local repeater.
2) In an IMRS set-up, you will always hear the status beeps: One for end conversation; Two for link drop/end; and three for a repeater is not connecting with the DG-ID/IMRS group.

RPT GROUP DG-ID: This offers the ability for an IMRS link to be established in a one-way direction. The DG-ID used is the LOCAL DG-ID of the other repeater that you are calling. If users are using DG-ID Tx AND RX they will not hear beeps the confirmation beeps (see above).

Example of RPT GROUP usage:

San Diego Repeater – Local 1 Los Angeles Repeater – Local 2, RPT GROUP 1

San Diego users using DG-ID 1 stay on San Diego for usage; Los Angeles users use DG-ID 2 stay on Los Angeles for usage. Los Angeles users who use DG-ID 1 will establish a one-way link to San Diego and will communicate with one another until the IMRS TOT is reached. Once the link drops it is reestablished by

someone using DG-ID 1 on the Los Angeles repeater group as San Diego cannot establish the link as it is not a RPT GROUP.

GROUP DG-ID: offers the ability for an IMRS link to be established in either direction by any of the repeaters that have it programmed into IMRS. If users are using DG-ID Tx AND Rx they will NOT hear the confirmation beeps.

Example of GROUP usage:

San Diego – Local 1, GROUP 10 Los Angeles Repeater – Local 2, GROUP 10

San Diego users use DG-ID 1 only stay on San Diego for usage. Los Angeles users use DG-ID 2 only stay on Los Angeles for usage. San Diego or Los Angeles users that use DG-ID 10 will connect to one another via IMRS and stay connected till the IMRS TOT times out.

Overall example with LOCAL, RPT GROUP, and GROUP:

San Diego – LOCAL 1 – RPT GROUP (blank), GROUP 10

Los Angeles – LOCAL 2 – RPT GROUP 1 – GROUP 10

San Diego: DG-ID 1 talks locally, using DG-ID 10 talks between San Diego and Los Angeles

Los Angeles: DG-ID 2 talks locally, using DG-ID 10 talks between San Diego and Los Angeles. DG-ID 1 establishes a link between San Diego and Los Angeles.

WiRES-X & DG-ID Local

Using WiRES-X with a DG-ID, it is not recommended to use the

LOCAL DG-ID if you have an IMRS setup with a DG-ID. Here's why: WiRES-X will hear all the confirmation beeps from IMRS (argh!). Also WiRES-X will hear everyone but only talk locally since a LOCAL DG-ID is being used.

Example of WiRES-X and IMRS (with three repeaters in an IMRS Network)

- San Diego – LOCAL 1 – RPT GROUP (blank) – GROUP 10, 20, 99
- Los Angeles – LOCAL 2 – RPT GROUP 1, 3 – GROUP 10, 30, 99
- Chicago – LOCAL 3 – RPT GROUP (blank) – GROUP 20, 30, 99
- WiRES-X – DG-ID 99
- DG-ID 10 connects San Diego to Los Angeles
- DG-ID 20 connects San Diego to Chicago
- DG-ID 30 connects Los Angeles to Chicago
- DG-ID 99 connects all together along with WiRES-X

In this setting the users can do the following, per repeater, with the DG-ID's.

San Diego:

- DG-ID 1 is local.
- DG-ID 10 establishes a link between San Diego and Los Angeles.
- DG-ID 20 establishes a link between Los Angeles and Chicago.
- DG-ID 99 establishes a link between San Diego, Los Angeles, Chicago and WiRES-X.

Los Angeles:

- DG-ID 2 is local.
- DG-ID 1 establishes a one-way link between Los Angeles and San Diego.
- DG-ID 3 establishes a one-way link between Los Angeles and

Chicago.
- DG-ID 10 establishes a link between San Diego and Los Angeles.
- DG-ID 30 establishes a link between Los Angeles and Chicago.
- DG-ID 99 establishes a link between San Diego, Los Angeles, Chicago and WiRES-X.

Chicago:

- DG-ID 3 is local.
- DG-ID 20 establishes a link between San Diego and Chicago.
- DG-ID 30 establishes a link between Los Angeles and Chicago.
- DG-ID 99 establishes a link between San Diego, Los Angeles, Chicago, and WiRES-X

Once an IMRS link is established ALL the DG-ID's in the repeater can be used to keep the link active. If in the San Diego example a link is established, then DG-ID's 1, 10, 20, and 99 can all be used to keep the link alive. DG-ID that established the link is the only one that will be transmitted by San Diego.

If a link established by DG-ID 10 on the San Diego repeater, the repeater will Rx DG-ID's 1, 10, 20, and 99 but will only transmit back DG-ID 10. Therefore, if you have DG-ID 99 set-up in your radio for Tx & Rx you will be able to talk down the link but you will not hear anything because the repeater is Tx DG-ID 10.

Information from N9UPC.

AT-180 Tuner Not Matching on 60 Meters

Category: HF Operation
October 22, 2022
An internal tuner is limited in what it can do.

Online CW QSO’s

Category: HF Operation,Online HF Tools
October 22, 2022
Conduct CW QSOs from your computer, tablet or smart phone! HamRadio.Solutions offers a Virtual Band with several bands where you can hold CW QSOs. The sit lets you set all your CW parameters. You can even hook up your keyer and use that. Or just listen to the QSOs. You can select audio, text or both, so you can compare what you copy with that which was sent. Give it a try! This service is provided courtesy of David, W6DS.

YSF Global Monitor

Category: Radio Operation Hotspots
October 22, 2022
W6DS operates a network monitor which simultaneously displays activity on a number of YSF reflectors including MNWis, SoCalHam

(K9EQ), US-MVARC (Idaho), US-KENTUCKY, US-SADRC, plus others. In addition, you can listen to the conversations or go back in the transmission history to hear past conversations by clicking on the reflector. It also shows technical data so you can see how well you are getting in. What you want is the minimum number of sequence errors. Check out the Network Digital Radio Monitor.

Repeaters Inputs with Bursty Noise

Category: Repeaters
October 22, 2022
Always test repeaters in FM! Your ear can determine a lot of things. On digital, the range goes down and people that get into the repeater fine don't notice it.

About 90% of the time when people complain about bursty noise, it's the antenna system. If you're running a duplexer and there IS ANY kind of bad connection, that bad connection will act like a diode. You get the diode effect whenever two dissimilar metals are in contact! What often happens is that as antennas are blown about they develop bad connections between sections. Really good repeater antennas have everything welded, don't use a bunch of different metals (like solder, brass, and copper), and pretty much don't bend in the wind. (And they cost $600 – $1,200.)

So see if you still have the problem into a dummy load. This is basic troubleshooting. If not, it's your antenna system.

Keep in mind these bad connections can be anywhere. It can be caused by coax, coax connectors, or you may have a bad

filter/duplexer. In this last case, the dummy load comes in handy again by testing with it placed at the output of the duplexer instead of the output of the transmitter.

More power makes this worse. Sometimes you'll have some arcing at 100 watts and none at 25.

When I last had this problem, it took me months to solve it. I had gone through everything in the rack. Bonded all the metal together. Checked and verified all coax cables, duplexer, etc. Tried different antennas. It was still there.

I finally ended up figuring out how to DF the source of the noise. The antenna was on the roof of this big building that was full of bolts holding things together. I fixed a Verizon antenna that had a loose N connector and aming bolts (really Verizon?). That wasn't it. I went around tightning down everything I could. About 100 bolts later, the noise went away.

So the point is this can also be caused by a nearby antenna, the tower, etc. Had this problem on one repeater that was on its own tower. We moved the antenna to the broadcast tower (and much closer to the broadcast antennas) and the problem went away.

You will also find that the problems at 2 meters are much, much worse than at UHF. Because of the proliferation of computers and networks, two meters has just plain gotten real noisy. In the incident on the roof of the building, we couldn't even operate a 2 meter repeater because of all the interactions with the hundreds of miles of CAT cable and thousands of computers and network devices. Unless you are truely miles away from civilization, my preference is to run a repeater on UHF.

This is from Martin, GW3XJQ

"I must have spent years tracking down the 'rusty bolt effect'

causing intermittent ‘crackling audio’, so annoying and would disappear for weeks and then return for no apparent reason. But of course, there is always a reason and always a solution to a problem.

“I bonded everything in sight and to ground with copper tape and rods, heavy conductor and thought it was fixed, until one day it came back! This was on a UHF FM repeater and the effect can be demonstrated by simply scratching a screwdriver blade against any metal associated with the repeater, even when I resolved the problem. As you say Chris, electrical and RF connections must be perfect and using only top quality connectors, cables and testing for continuity and insulation resistance using professional test equipment.

“The only effective solution in the end, was to opt for separate aerials for transmit and receive frequencies and with vertical separation on the tower. With a duplex system and one aerial, the noise would always return. It was all down to the fact that the building housing the repeater was constructed using steel reinforced concrete and which was deteriorating with the effects of time and weather and ‘blowing’ of some concrete panels. It was impossible to electrically bond all the structural steel.

“The repeater is now Yaesu Fusion AMS, plus WiRES X and all is well. Hopefully, this discussion will help others with similar problems.”

Repeater Lock-Ups

Category: Hotspots,Repeaters,WiRES-X
October 22, 2022

Many people have reported Fusion repeater lock-ups that required the repeater to be shut down (power removed) and rebooted. I've had repeater lock happen as well with an HRI-200 directly connected to the DR2X. In this particular case I believe the event was triggered by sending a number of commands from the radio (such as the GM mode) which resulted in a race condition within the firmware.

I have previously observed that invalid data (I.e., with a lot of bit errors or badly formed packets from a hotspot) can also cause the lock-up. My assumption is that this is a problem of not validating inputs to a function prior to executing the function. The invalid data is not handled correctly and causes one of the lock-up faults I mention below to occur.

I have observed that data is more likely to be invalid if there is a lot of noise on the signal. Also a major source of problems are badly behaving hot spots that inject all sorts of crap into the data stream. There's no control over these devices and it just gets worse as there is more work being done converting from one thing to another thing, etc.

Communications software is EXTREMELY HARD to write and much of what I see out there is poorly documented (which leads to bad code) and poorly tested.

Reflectors such as YSF or FCS are pretty dumb when they relay signals. They look for an incoming packet from one of the connected hotspots and just send that same packet out to all the other hotspots (including bridges to WiRES-X). Garbage in, garbage out. To address this I have modified the YSF reflector

software to be very aggressive at dropping packets with CRC errors, invalid data in fields, and most importantly invalid FICH headers. The FICH header is extremely important for everything to work right. (You can look up FICH headers in the System Fusion documentation published by Yaesu.) This modified software is running on MNWis, Princeton Kentucky, MVARC (Idaho) and America Link. It has dramatically reduced the number of problems with WiRES-X problems.

So what is a “lock-up”. A lock-up occurs when the processor looses track of what it was doing and either halts or ends up executing invalid code. In either case it is no longer processing the code it was intended to run. Events that cause the processor to, using a technical term, go out to out to lunch can result of errors in the software that cause it to happen, corrupted memory, invalid states in a state machine, incorrectly handled race conditions, or a really nasty thing called priority inversion (where a high priority task which is pre-empting use of the CPU is waiting for a low priority task to complete, which can’t complete because, well, it’s not high priority.)

How to solve the problem?
First of all, the repeater firmware should never crash. Since it is very hard (but not impossible) to write code with no bugs, most continuously operating real-time systems will incorporate a “watch dog timer”. It is the purpose of this timer to detect when the “wheels have fallen off the processor” and perform a reset.

Since we can’t modify the repeater’s software, there are some actions we can take.

First would be to prevent bad data from getting into the system. A careful examination of the logs possibly combined with audio recordings could be helpful.

A quick fix might be to install a timer on the power supply such that the repeater's power is removed for a short time once or several times a day.

I have a technical concept for a generic lock-up detector that would reboot the repeater in the event of a lock-up without the need to make any modifications. Not sure if I'll work on this because I don't know how much interest there would be. This solution would also work with non-Yaesu repeaters.

One further note. I made an observation that this problem was more likely to occur on 2 meters than on 440. Why? My theory is that there is a lot more interaction with the environment on 2 meters. Computer networks, small power supplies, computers, almost everything digital generally creates a lot more noise on 2 meters than it does on 440 MHz. I observed a situation where mixing products were occurring on a 2 meter repeater in a noisy environment. This repeater would lock up regularly. My theory was that the mixing products contained a lot of noise along with the C4FM signal causing a high number of bit errors and thus crashing the repeater. This was observed on a DR1X.

If you are struggling with this problem, I suggest you contact Juan at Yaesu Customer Service with your details. Provide Juan with as much information as you can.

Running two HRI-200's on one

IP Address

Category: WiRES-X
October 22, 2022
I use VyprVPN from GoldenFrog. It is necessary to turn of NAT for your account. That means that each VPN connection is a raw connection straight to the Internet. YOU HAVE NO PROTECTION OTHER THAN WHAT YOU PROVIDE!!! (The same company will rent you a VPN that you can host on your own cloud provider where you can control port forwarding – but I suspect this is well beyond most folks.)

I've been using this solution for over a year. If you've ever seen me demonstrate WiRES-X, I'm either using AT&T/cell or the local Wifi along with the VPN to get access to the incoming ports.

Good news! My fully patched and maintained Win7 boxes have not yet been hacked. One of which has been online via VPN for over a year.

Most VPNs won't work because they don't give users their own IP. The VPN host shares IPs between multiple users which means they can support more users with fewer IPs (and better obscures your traffic). I'm only aware of two VPN providers that allow you to specify incoming ports.

The previous post of using the Ham's IP space is a good one. I plan on giving that a try when I have time. But VyprVPN is very much plug-and-play.

Note: You will need to PAY for VyprVPN (~$70/yr). The free service does not allow you to disable NAT.

On Repairing PA’s of Repeaters and Radios

Category: FAQ
October 22, 2022
If you are experiencing low or no power output…..

1. Replacing a blown final does not necessarily fix the problem that caused the blown final. Never replace a blown final in anything where you haven’t gone through and figured out if there was a reason the final blew. These are very rugged transistors that should last a very long time.

2. Some failures are related to heat, most are not. The DR repeaters have excellent cooling. Unless the fans have died, temperature should not be a problem.

3. There have been, er, problems in the past. Being that I’ve been in Fusion since the very beginning, I have had a few radios where finals blew. The root cause many failures in the repeaters has been resolved a long while ago. DR2s never had any issues. Later DR1s were fine.

Suggestion: Add a 10 amp fuse between the power supply and the Tx. This can prevent burning of the PCB should the final end up in a “high current” mode. Not a likely event, but good insurance against a potentially much more expensive repair. (If the transistor is biased on with no RF input, the current draw will go to about 15.5A. All of that power is used to heat up the transistor and the PCB.)

4. The official Yaesu replacement transistor is not available on the open market. You must purchase it from Yaesu. I have

successfully replaced PA’s, but be advised your specific non-Yaesu replacement transistor might have characteristics that won’t play well with the other components on the board.

My suggestion: Unless you’re really set up to do this stuff and are willing to match a replacement transistor to the circuit, let Yaesu do the repair. If Yaesu did not do the repair, we shouldn’t get concerned when someone reports multiple PA failures.

From another post:
First, replacing the transistor may not fix the problem. One has to wonder why it failed. These transistors should not fail under normal use (i.e., no lighting). High bias voltage can easily kill a PA.

I had a similar problem with an FTM-400. Blown PA, no bias. Forget what I did, but I could have kicked myself for not checking the bias and working on that problem before I put the new transistor in. As I recall I just worked my way through the bias circuitry and fixed what was wrong. My recollection is that the bias was bad on both the driver and the PA so I ended up looking at the common circuitry.

Note that the PA transistors you can buy from places like RF Parts are different transistors from those that Yaesu uses. For a number of years now they have been purchasing Mitsubishi transistors with a custom part number. My guess is that they have been selected for consistent parameters in the 430-450 range whereas the standard part is specified for 450-470. This means variation in the standard part may require fine tuning of the input/output circuitry.

I had a DR-1X who’s power output went to zero. Fortunately I had placed a 10 amp fuse in series with the Tx which blew and protected the PA transistor. (Otherwise it sits at 16 amps and melts itself.) The problem was a failing solder joint on an inductor that was used to provide RF isolation to the transistor that engaged the Tx low pass filter network band switch relay.

It really helps if the Tx frequency is on the same band that the output filter is on! This is an example of a non-PA failure that could have killed the PA. These transistors should not fail and if they do there’s probably a reason.

Aside: In the above I ended up bypassing the relay so it always used the 440 MHz low pass since I only use the repeater on UHF. Figured one less failure point. Funny thing is that it worked fine on VHF (of course) but that the spurious emissions were still pretty low. It would easily meet FCC spec with a duplexer on the output.

Repeater Power Output

Category: Repeaters
October 22, 2022
The DR repeaters are calibrated in the middle of the band. For UHF that is 440.000 MHz. You may want to check the power output at that frequency as you are operating right at the band edge. While you’re at it, measure the Tx current. At the lower power output the current should be lower, otherwise it could indicate a problem.

Under no circumstances should the Tx current be above 10 amps (I recommend a 10 amp fuse in the Tx power supply line) and will more typically be around 7 amps. At 30 watts it should be less.

There are differences in the DR-1X depending on when it was produced and/or which updates it has received. Early units should only be run on medium power, especially on UHF.

The DR-1 does not sense SWR. It simply looks at voltages in the output filter that should be represent a higher SWR as an

apparent higher output power thus causing input power to be slightly reduced. Variations in the frequency response characteristics of the filters and amplifier gain will cause the output to vary over the 430-450 MHz range. You can always recalibrate the output at your frequency of interest but be careful. It has been my experience that the output can also be greater than 50 watts on certain frequencies.