High Performance Radio Systems for 47 & 78 GHz

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High Performance Radio Systems for 47 & 78 GHz

Need for High Performance Systems

New Technologies Available Now

 Building High Performance Systems for 47 & 78 GHz

Work Still Needing to be Done

Need for High Performance Systems

- Modern System Designs facilitate Long Haul communications Using:
 - Low Phase Noise Local Oscillators
 - Very Stable & Low Cost Reference Oscillators
 - Low Noise Figure Receivers
 - Good Transmit Powers
 - Image Rejection Techniques

Need for High Performance Systems

Good Hardware Allows Long Haul QSOs
New Digital Modulation Techniques Give additional Dynamic Range
Extra "System Performance" Allows Distance and Propagation Mode Attempts Beyond "Line of Sight' Paths New Technologies - Low Phase Noise Local Oscillators

- We Have Seen Phase Locked Oscillators (PLOs) Become the Norm
- Phase Noise Performance was Poor Initially at Upper Microwave Bands
- Now Greatly Improved
 - Near Level of "Frequency West Bricks"
 - Easy Multiple Frequency Programmability
 - Relatively Low Cost & Small Size & Power

New Technologies - Low Phase Noise Local Oscillators

Typical Units Available Today

- Kuhne MKU LO 8-13 PLL
- ZL2BKC ZL-PLL 14 G
- Q5 Signal digiLO
- Various Surplus Verticom Units

New Technologies - Low Phase Noise Local Oscillators



New Technologies - Very Stable & Low Cost Reference Oscillators

- New PLO Synthesizers Use 10 MHz References
- Cheap & Plentiful Supply of "Used" 10 MHz Units on Ebay, etc.
- Quick Warmup and Much Better Stability than International Xtals in FW Bricks !
- Phase Noise Not Always Good on Low Cost Units

New Technologies - Very Stable & Low Cost Reference Oscillators

- Typical Surplus Units on Ebay:
 - OSCILLOQUARTZ 8663-XS 10 MHz Double
 Oven OCXO Double sinewave output
 - Trimble 49422 10MHz 12V Sine Wave OCXO Crystal Oscillator
 - 10Mhz sinewave +12V Trimble high precision Oscillator OCXO 65256
 - Etc.....

New Technologies - Very Stable & Low Cost Reference Oscillators



Modern Technologies Low Noise Figure Receivers

- Early 2000's Explosion in Deployment of 26-40 GHz Microwave Radio Systems Spurred Chip Development
- US Military Use of 45 GHz and Now Commercial Microwave at 64 & 80 GHz
- Now 5 G Cellular use of mm Wave Frequencies
- All Need Mixers, LNAs, Amplifiers

Modern Technologies Low Noise Figure Receivers

- Most of the Amplifier Chips Require Surface Mounting as a minimum, Wire bonding in the extreme.
- Kuhne Electronic has been Selling Assembled Amplifiers for 24 and 47 GHz since the Early 2000s.
- Now Even 78 GHz Amplifiers are Available at "Reasonable" Cost

Modern Technologies Low Noise Figure Receivers



Modern Technologies Higher Transmit Powers

- Early Low Noise Amplifiers Used for Low Power Transmitters
- Terrestrial and Satellite Systems Need More Power to Support Wider Bandwidth Transmissions

 Stimulated Development of High Power Amplifier Chips Using Improved Technologies and Materials for Chips Modern Technologies Image Rejection Techniques

- Radio Systems Need Ease of Frequency Changes Without Hardware Changes
- Traditional Band Pass Filters Not Flexible Enough
- Image Reject Technique Not New, But Much Easier to Implement on a Chip
- Image and LO Rejection Relaxes Other Filtering Requirements

Modern Technologies Image Rejection Techniques Implemented on New Kuhne Transverters



Modern Technologies Image Rejection Techniques Implemented on New Kuhne Transverters



• Kuhne has all the Pieces - Transverter, PLL LO, Power Amp, BPF's The Transverter is only 30 mW so the **1 W PA is desirable (Only 0.5 W typical)** • A Driver Amp Required to get 1 W out Image Rejection Spec is ~17 dB But LO Leak-thru not specified & IS a concern !

- A BPF <u>IS Required</u> to Reduce LO leakage
- RX Noise Figure is 6-7 dB, so Much Better than Old Mixers
- Wanted to do Better, so Surplus EME preamp with ~3.5 dB NF added with BPF to improve Image Rejection
- Added 4 State Sequencer & IF Interface
- WR-22 WG Used But WR-28 in Antenna







• Kuhne <u>NOW</u> has All the Pieces

- Transverter, PLL LO, Power Amp Built In!

- 200 mW Out, 8.5 dB NF, 20 dB Image Reject

I Did Not use Kuhne Solution !

I had a lot of 78 GHz Stuff to Fall back on.

 WR-15 WG Used But WR-12 in Antenna/ Preamp/ Power Amplifier

- Wanted to do Better, so WA1MBA EME preamp with ~4 dB NF added with BPF for Image Rejection with Fund. Mixer
- Separate TX Mixer, BPF, WA1MBA Driver Amplifier
- Using SAGE mm 1 W PA with 35 dB Gain

- Trouble with TX Mixer (DB6NT PCB Type)
 High LSB and LO Output.
- Adjusted BPF and Nulled Carrier, USB/ LSB about the same now ⁽²⁾
- Will look at Better Mixer/ Image Reject
- Used MTS2000 PLL with Very Low PN
- 4 Step Sequencer and DEMI IF Interface









Areas for Further Work

- Antenna Return Loss measurement on Both Bands and Possible Improvement
- Improve TX image rejection with addition of better filters or Replace with Better Mixer?
- Replacement of High Conversion loss 78 GHz TX mixer may allow removal of driver amplifier
- Resolve problem with Insufficient Output Indication on 78 GHz TX

High Performance Radio Systems for 47 & 78 GHz Summary

- Need for High Performance Systems
- New Technologies Available Now
- Building High Performance Systems for 47 & 78 GHz
- Work Still Needing to be Done
- Questions?