CTU 2019 Presents

Taking Digital Contesting to the Limit

Ed Muns, W0YK
Taking Digital Contesting ... to the Limit

1\textsuperscript{st} session: "Digital Contesting is Fun!"

- Receiver Configuration
- Call Sign Stacking
- Multiple Decoders
- SO2V, SO2R-SOnR
- AFSK vs. FSK
- FSK Bit Timing
- RTTY Transmit Bandwidth
- FT8 Future
Receiver Configuration

**AGC; headphone monitoring**

- Turn off AGC
  - or, at least minimize it, e.g., AGC=Slow
  - Fast AGC increases error rate in modern software decoders

- Minimize headphone monitoring fatigue
  - Use minimum discernible headphone volume
    - Only need to know start/stop of signal
  - Low Tones, e.g., 915/1085
    - Possible TX harmonics with AFSK
Receiver Configuration

IF filtering

- Narrow IF filters (Roofing & DSP)
  - 500 Hz - normal
  - 250 Hz - extreme QRM only
- Tone filters – don’t use!
  - Icom Twin Peak Filter
  - K3s Dual-Tone Filter
Receiver Configuration

Codec audio level

- Decoder audio level
  - Band noise 5% of full-scale
  - Maximum dynamic range
  - Weak signal decode
- Note 500 Hz IF filtering
  - Decoder optimum
Call Sign Stacking

“Slow Down to Win”

- Sailboat racing analogy:
  - Pinwheel effect at mark-rounding
- Let pile-up continue 1-3 seconds after getting first call sign
  - Increase chance for another call sign or two
  - Increase chance for QSO-phase-skip
- Apply same tactic for tail-enders … pause ½-second before sending TU/CQ message
Call Sign Stacking

The 4 Phases of a QSO

Normal Run mode flow:

1. CQ msg
   - repeat
   - AGN?

2. pile-up

3. Exchange msg
   - Send fill(s)

4. receive his Exchange
   - AGN? or NR? or QTH? or NAME?

1. TU/CQ msg (logs QSO)

Normal S&P mode flow:

1. CQ

2. <mycall> msg
   - repeat

3. receive his Exchange
   - AGN? or NR? or QTH? or NAME?

4. Exchange msg
   - send fill(s)

1. find next CQ
Call Sign Stacking

**Normal**
1. WPX P49X P49X CQ, or TU P49X CQ
2. K3LR K3LR K5ZD K5ZD
3. K3LR 599 2419 2419
4. TU 599 842 842

**Shortened**
1. (skip CQ)
2. (skip pile-up)
3. K3LR TU NW K5ZD 599 2420 2420
4. TU 599 1134 1134
Call Sign Stacking

**Normal**
1. WPX P49X P49X CQ, or TU P49X CQ
2. K3LR K3LR
3. K3LR 599 2419 2419 K5ZD
4. TU 599 842 842

**Shortened**
1. (skip CQ)
2. (skip pile-up)
3. K3LR TU NW K5ZD 599 2420 2420
4. TU 599 1134 1134
Call Sign Stacking

**summary**

- Efficiently work:
  - multiple callers in a pile-up, and
  - tail-enders to a completing QSO

- Calls **pushed** onto the stack as they arrive

- Message parameter **pops** call off of the stack into the Entry window

- Eliminates 2 of 4 QSO phases, which doubles short-term rate
Multiple Decoders

- Dominant SC MODEM
- Standalone, or ...
- Contest loggers:
  - N1MM Logger+
  - WriteLog
  - Win-Test
- Introduced June 2000
- Mako Mori, JE3HHT
Multiple Decoders

2Tone

- Outperforms MMTTY?
- Uses less CPU cycles
- Contest loggers:
  - N1MM Logger+
  - WriteLog
  - Win-Test
- Introduced late 2012
- David Wicks, G3YYD
Multiple Decoders

**GRITTY**

- Best accuracy?
- Bayesian statistics
- Standalone, or …
- Contest loggers:
  - N1MM Logger+ only
- Introduced late 2015
- Alex Shovkoplyas, VE3NEA
Multiple Decoders

hardware MODEM
Multiple Decoders

**MMTTY & DXP38**

- Parallel decoding
  - Software, e.g., MMTTY
  - Hardware, e.g., DXP38
- Diverse conditions
  - Flutter
  - Multi-path
  - QRM, QRN
  - Weak signals
  - Off-frequency stations
Multiple RTTY Decoders

multiple MMTTY profiles

- Parallel decoding
  - same audio stream
  - switching takes too long
- Multiple profile windows
  - Standard
  - Fluttered signals
  - Fluttered signals (FIR)
  - Multi-path
  - hyper sensitive
  - EU1SA
  - AA6YQ-FIR-512
    - weak signals in QRN
Multiple Decoders

two IF bandwidths

- Narrow IF filtering (main RX)
  - Hardware modem, i.e. DXP38
  - MMTTY profiles:
    - Standard
    - Fluttered signals
    - Fluttered signals (FIR)
    - Multi-path
    - hyper sensitive
    - EU1SA

- Wide IF filtering (sub RX)
  - MMTTY profile:
    - AA6YQ-FIR-512
      - Dual Peak Filter
      - “Matched filter”
Multiple Decoders

- VFO-A (main RX)
  - MMTTY Standard profile
  - 2Tone Flutter profile
  - 2Tone Selective profile
  - DXP38

- VFO-B (sub RX)
  - MMTTY Standard profile
  - 2Tone Flutter profile

- 6 decoders
  - A → B

SO2V
Multiple Decoders

*Tone choices for monitoring*

- Low tones are less fatiguing
  - Use high tones for secondary audio stream(s)
- Low/High tones can be mixed to put two audio streams in one ear:
  - SO2R plus SO2V per radio (4 streams)
  - SOnR (3+ streams)
1. [single rcvr] If Assisted and running on VFO-A, then
   - A<>B, click spot, tune, ID station, work station
   - A<>B, resume running
2. [dual rcvr] Set up decoder windows on VFO-A and VFO-B
   - Radio must have two true receivers
   - Monitor both frequencies simultaneously with right/left channels of sound card
     - Left-click call from 2\textsuperscript{nd} RTTY window into VFO-B Entry Window
   - Two ways to transmit on VFO-B:
     I. A<>B, work the mult, A<>B
     II. SPLIT, work the mult, un-SPLIT, resume running
       - Requires “wire-OR’d” FSK or AFSK and two transmit RTTY windows
         - WriteLog Shared Com Port obviates the wire-OR
         - K3/WriteLog invokes SPLIT when VFO-B call is clicked
SO2V

Wire-OR FSK/PTT

Radio Interface
(microHAM, RGblaster...
or at least two transistors)

- RS232 cable & Comm port
- PC serial ports, db9 connectors
- PTT = DTR = Pin 4
- FSK = Data = Pin 2

Rosewill (or other) 2 or 4 port serial card

FSK Comm config
MMTTY Instance #1

FSK Comm config
MMTTY Instance #2

Serial Signals (K8UT)

FSK/PTT Signals (W0YK)
SO2V

Wire-OR FSK/PTT

Serial Signals (K8UT)

FSK/PTT Signals (W0YK)

Circuitry built into DE9 hood
SO2R

- Eliminates SO1R RTTY boredom
- Think beyond run and S&P:
  - Dueling CQs; run on two bands simultaneously
  - S&P on two bands simultaneously, esp. w/Packet
  - SO2V on one or both radios (SO4V!)
- Two networked computers:
  - Eliminates swapping radio-focus
  - Display room for more decoder windows per radio
  - RTTY doesn’t require much typing; mini-keyboards
  - 2 x SO2V=SO4V for picking up mults on both run bands
  - Easily extendible to SOnR

*No time to watch TV or read spy novels!*
SO2R

“M2” configuration

Left-hand Trackball

Right-hand Trackball

Right-sized Keyboards
SO2R in the NA Sprint

*maximize TX duty cycle*

- Set VFOs at least 10 kHz apart on both radios
- Find a clear spot on one radio and CQ while you tune the other radio for a station to work
- If you don’t find a station to work before the CQ finishes, find a clear frequency and duel CQ
- After a QSO, swap VFOs on that radio, search during other transmission, then resume dueling CQ
- Don’t waste time trying to work the “couplet” … CQing is OK in Sprint!
SOnR

> 2 radios

- Simplify antenna/filter band-decoding:
  - Dedicate a band/antenna to the 3rd (or 4th) radio
- Networked PC/radio simplifies configuration
- RTTY (vs. CW or SSB) easier for operator
  - PC decodes for operator
  - Low tones & high tones allows two radios per ear
    - Classic audio headphone mixer (per ear) provides radio A, radio B or both
SO\textsuperscript{o}nR

Multi-Multi configuration

dedicated to 10 meters
AFSK vs. FSK

which is better?

- First and foremost, a “religious belief”
  - Personal preference, enthusiastically advocated!
- Both are equally high quality on the air, if …
  - They are configured and adjusted properly
- Telegram:
  - AFSK can achieve high quality with any radio
  - FSK minimizes unintended consequences
    - Only K3 has acceptably narrow TX bandwidth
AFSK vs. FSK

**AFSK**
- Indirect (tones → Mic input)
- Any SSB radio (esp. legacy)
- SSB (wide) filtering (legacy)
- Dial = sup. car. frequency
- VOX or PTT
- Audio cable (a’la FT8, JT65/9, PSK31)
- Must use high tones

**FSK**
- Direct (like CW keying)
- “Modern” radios
- RTTY (narrow) filtering
- Dial = Mark frequency
- PTT
- Com port FSK/PTT keying cable
- Can use low tones

*Eliminates:*
- audio level adjust
- disabling speech proc.
- erroneous sound keying

*Less bandwidth* (depends on setup)

Easier cabling; NET

Less pitfalls
FSK Bit Timing Issues

- Issues
  1. Bit jitter (variation of bit length)
  2. 45 instead of 45.45 baud (22.22 vs. 22.00 msec/bit)

- Caused by Windows OS:
  1. Task Scheduler injects delays between bits
  2. API interface limited to sending integer parameters

- Increased receive error rate
  - Adequately loud, but incorrectly printed characters
  - Wasted time on fills
FSK Bit Timing Issues

**bit generation**

- **Software FSK**
  - Bit transitions generated in a *Windows* program:
    - MMTTY EXTFSK/EXTFSK64
    - 2Tone FSK
    - WriteLog Rittyrite Software FSK

- **Hardware FSK**
  - Bit transitions generated outside of *Windows*:
    - Hardware modem
    - UART on Serial I/O card or USB-Serial adapter
    - Micro-controller: FSKit, TinyFSK, RpiFSK
    - Pseudo-FSK via AFSK
FSK Bit Timing Issues

- Bit transitions generated in a *Windows* program
- Com port signal toggled: TxD, DTR or RTS
- Windows Task Scheduler interrupts bit stream
  - Other programs which need CPU cycles
  - User operations, e.g.:
    - Mouse movements
    - Starting a program
    - Interacting with a program
  - Average deviation close to zero
  - Some instantaneous deviations of a few msec.
FSK Fit Timing Issues

software FSK solutions

- High performance PC
  - Reduces, doesn’t eliminate, bit jitter
    - Extent of timing variation
    - Frequency of timing variation
  - Minimize the number of other running programs
- Use hardware FSK
  - May have another timing problem
    - 45 instead of 45.45 baud (22.22 vs. 22.00 msec.)
FSK Bit Timing Issues

- Bit transitions generated outside of Windows:
  - 5-bit words sent to hardware bit generator
  - Some UARTs don’t go below 110-600 baud
    - Modern Serial cards and USB-Serial adapters
    - Clock divider optimized for a higher speed range
- UARTs that handle 45.45 baud
  - Windows API integerizes 45.45 baud to 45
    - Bits are 22.22 msec instead of 22.00
    - Minor impact on receive error rate
FSK Bit Timing Issues

**hardware FSK solutions**

- Use another hardware FSK alternative:
  - Hardware MODEM (ST-8000, DXP38, PK232, Kam ..)
  - FSKit by K4DSP (PCBs no longer available)
  - TinyFSK (Mortty kit for $18)
  - Pseudo-FSK
    - FSK keying circuits driven by AFSK
      - Jitter-free AFSK\(^1\) without the adjustment issues
      - DIY solutions: FLdigi, 2Tone

- Use AFSK 😊

\(^{1}\) **AFSK tone timing uses soundcard clock, independent of windows**
RTTY Transmit Bandwidth
unnecessary QRM

- Wasted power
  - Outside receiving decoder bandwidth
  - Suitably narrow TX BW effectively amplifies signal

- Unnecessary QRM
  - Wide 1.5 KW RTTY can QRM 5-10 channels
  - Similar to CW key click problem of the past

Why hurt yourself AND QRM close-by stations?
RTTY Transmit Bandwidth

MMTTY - AFSK
- No filtering
- Flex 6000 @ 60 W

Thanks K9CT
RTTY Transmit Bandwidth

**AFSK**

**MMTTY - AFSK**
- Default 48-tap TX BPF
- Flex 6000 @ 60 W

**MMTTY - AFSK**
- 512-tap TX BPF
- Flex 6000 @ 60 W

Thanks K9CT
RTTY Transmit Bandwidth

MMTTY - AFSK
- 512-tap TX BPF
- Flex 6000 @ 60 W

2Tone - AFSK
- Default “AM” setting
- Flex 6000 @ 60 W

Thanks K9CT
RTTY Transmit Bandwidth

MMTTY - AFSK
- Unfiltered
- Flex 6000 @ 60 W

2Tone - DOOK
- Default “AM” setting
- Flex 6000 @ 60 W

Thanks K9CT
RTTY Transmit Bandwidth

AFSK

2Tone - AFSK
- 512-tap TX BPF
- Flex 6000 @ 60 W

2Tone - DOOK
- Default “AM” setting
- Flex 6000 @ 60 W

Thanks K9CT
RTTY Transmit Bandwidth

PA IMD impact on AFSK bandwidth

MMTTY - AFSK
- 512 Tap TX BPF
- K3 @ 1 mW

MMTTY - AFSK
- 512 Tap TX BPF
- K3 @ 100 watts

Thanks K0SM (http://www.frontiernet.net/~aflowers/k3rtty/k3rtty.html)

**CTU**
**CONTEST UNIVERSITY**

42/56
RTTY Transmit Bandwidth

**MMTTY AFSK filter vs. K3 AFSK filter**

- **MMTTY - AFSK**
  - 512 Tap TX BPF
  - K3 @ 100 watts

- **MMTTY - AFSK**
  - No MMTTY filter
  - K3 AFSK filter
  - K3 @ 100 watts

Thanks K0SM (http://www.frontiernet.net/~aflowers/k3rtty/k3rtty.html)
RTTY Transmit Bandwidth

- Old K3 FSK bandwidth
  - No waveshaping
  - < DSP281 firmware
  - Typical of all radios
  - 50 watts

- New K3 FSK bandwidth
  - Optimal DSP filter
  - DSP281 firmware, March 2013
  - Lobby other mfrs

Thanks K0SM (http://www.frontiernet.net/~aflowers/k3beta/)
**RTTY Transmit Bandwidth**

*recommendation for minimum QRM*

**FSK**

1) K3, or
2) QRP with other radios
3) Otherwise, use AFSK

**AFSK**

1) K3 or Flex
   a) Enable K3 AFSK filter
   b) 2Tone DOOK or AFSK
   c) MMTTY 512-Tap

2) Other radios
   a) 2Tone DOOK or AFSK
   b) MMTTY 512-Tap
Resources

- [www.rttycontesting.com](http://www.rttycontesting.com) premier website
  - Tutorials and resources (beginner to expert)
  - WriteLog, N1MM Logger+ and MMTTY
- [rtty@groups.io](mailto:rtty@groups.io) Email reflector
  - RTTY contester networking
  - Q&A
- Software web sites
  - [hamsoft.ca](http://hamsoft.ca) (MMTTY)
  - [n1mm.hamdocs.com/tiki-index.php](http://n1mm.hamdocs.com/tiki-index.php) (N1MM Logger+)
  - [www.writelog.com](http://www.writelog.com) (WriteLog)
  - [www.win-test.com](http://www.win-test.com) (Win-Test)
- Software Email reflectors
  - [mmtty@yahoogroups.com](mailto:mmtty@yahoogroups.com) (MMTTY)
  - [N1MMLoggerplus@groups.io](mailto:N1MMLoggerplus@groups.io) (N1MM Logger+)
  - [Writelog@contesting.com](mailto:Writelog@contesting.com) (WriteLog)
  - [support@win-test.com](mailto:support@win-test.com) (Win-Test)
Clublog QSOs by Mode

% Share of Modes Stored in Club Log from 2017 to 2019

- FT8
- CW
- Phone
- RTTY
- Other
- PSK
FT8 Contest Technology Future

- TU, NW
- Multi-streaming transmission (Fox-Hound DXped.)
- RTTY replacement, or additional mode?
- Synchronous vs. asynchronous Tx/Rx cycles?
FT8 Contest Technology Future

- **TU, NW**
  - CQ RU K1ABC FN42
    - K1ABC W9XYZ 579 WI
  - W9XYZ K1ABC R 589 MA
    - K1ABC W9XYZ RR73
    - K1ABC G3AAA 559 0013
  - TU; G3AAA K1ABC R 569 MA
    - K1ABC G3AAA RR73
    - K1ABC P43A 599 2145
  - TU; P43A K1ABC R 599 MA
    - K1ABC P43A RR73
    - K1ABC K9CT 579 IL

\[\text{2 cycles; 120 Q/hr} \]
\[\text{2 cycles; 120 Q/hr} \]
FT8 Contest Technology Future

- TU, NW

- **Multi-streaming transmission (Fox-Hound DXped.)**
  - Many Foxes, many Hounds (DXped: 1 Fox, many Hounds)
  - Moderate incoming rate (DXped: very high incoming rate)
  - Split freq. problematic (DXped: split freq. feasible)
  - Therefore:
    - **Multi-signal or single-signal multi-partner?**
      - Multi-signal: Signal voltage/n $\rightarrow$ Signal power/n$^2$
    - **Limit to 2 or 3 or n streams?**
    - **Run or S&P per stream?**
      - Run vs. S&P could be dynamic per QSO partner
      - Run & S&P mixed within stream
FT8 Contest Technology
Future

- TU, NW
- Multi-streaming transmission (Fox-Hound DXpeditioning)

- Additional mode or RTTY replacement?
  - **Choice:**
    - Exploit inherent multi-channel strengths, or
    - Reduce Tx cycle time by widening BW and lowering sensitivity
  - How much QSO rate is needed?
    - Service rate >> incoming rate
FT8 Contest Technology
Future

- TU, NW
- Multi-streaming transmission (Fox-Hound DXpeditioning)
- Additional mode or RTTY replacement?
- Synchronous vs. asynchronous Tx/Rx cycles?
  - 0, 15, 30 and 45 seconds vs. operator initiated like RTTY
Synchronous vs. Asynchronous

**Synchronous**
- multi-streaming
- SO2R “lockout”
- signal density
- better decoding
- auto sequencing
- QRM immunity
- even/odd cycle usage
- no “doubling”

**Asynchronous**
- higher rate?
- no clock sync
- no time lost for unsync’d clocks
- no decoding time lost each Tx cycle
- high CPU demand at end of each Rx cycle
- easier integration with contest loggers
FT8 Contest Rules Future

- Multi-channel \(\rightarrow\) Assisted/Unlimited?
- How much automation?
  - Operator initiate each QSO?
  - Or, allow maximum automation and allow SO to run a MM?
- Multi-mode digital contests?
  - CW/SSB/“Digital” or CW/SSB/RTTY/FT8 modes?
- 100 watt limit?
- Participation determines which mode(s) prevail
Conclusions

- FT8 is controversial
  - Explosive adoption threatens RTTY
  - Fear of robotic, unattended operation
  - Threatening to many “legacy” hams, but more appealing than CW/SSB/RTTY to new hams

- FT8 has instantly entrenched itself as:
  - A primary amateur mode
  - The pre-eminent digital DXing mode

- Will contest rules let FT8 be all it can be?
- Will FT8 subsume RTTY in digital contesting or become an additional mode? (Contest participation will determine)

- Multiple digital modes in a single contest:
  + Increases overall participation
  - Dilutes per-mode participation
  = Net?
Resources

- WSJT-X 2.0 web site with download link: 
  https://physics.princeton.edu/pulsar/k1jt/wsjtx.html

- WSJT-X 2.0 Quick-Start Guide: 
  https://physics.princeton.edu/pulsar/k1jt/Quick_Start_WSJT-X_2.0.pdf

- MSHV web site: 
  http://lz2hv.org/mshv

- FT8 Roundup web site with tutorial: 
  https://www.rttycontesting.com/ft8-roundup

- ARRL FT8 Press Release: 