

VHF102: Digital WSJT Modes

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WB2FKO (DM65)

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Wide variety of digital modes in amateur radio

PSK31

RTTY

CLOVER

QPSK31

PACKET

MFSK16

AMTOR

THOR

OLIVIA

PACTOR

HELLSCHREIBER

WSJT

Choice depends strongly on what we are trying to do

Radio-teletype (RTTY): Keyboard-to-Keyboard Communication in Real-Time

Amateur use began post WW2

Five bit code (baudot). Equivalent to ~ 60 wpm cw

Primarily on HF

Teletype terminals replaced by PC + sound card



The computer sound card is key to modern digital communication modes

Sound card: Analog-Digital & Digital-Analog converter

Sound card-radio interfaces are inexpensive

A CAT cable is also recommended



PSK31: Keyboard-to-Keyboard Communication in Real-Time

Phase-shift keying at 31 baud (bits per second)

PC + sound card

Five bit code (baudot). Equivalent to ~ 60 wpm cw

Primarily on HF

The screenshot displays the fldigi software interface for a PSK31 QSO. The window title is "fldigi - AA6E". The interface includes a menu bar (File, Op Mode, Configure, View, Help), a status bar (RSID, TUNE), and a main display area. The frequency is set to 14070.000 MHz. The QSO table shows a contact with QSO Freq 14071.661, On/Off status 2017, and a call sign. The main display area shows the text of the QSO, including the call sign "IW2HUS DE N4TDO" and the message "Your signal is good copy Tnx QSO and good DX My report pls Best 73 to U and good DX 73 IW2HUS DE N4TDO SK". The interface also features a frequency display, a waterfall plot, and various control buttons (CQ, ANS, QSO, KN, SK, Me/QTH, QTH, Brag, Tx, Rx) and a status bar at the bottom showing "BPSK31", "s/n 20 dB", "imd -31 dB", and "AFC SQL".

Weak signal VHF/UHF

Often don't have the luxury of chatting

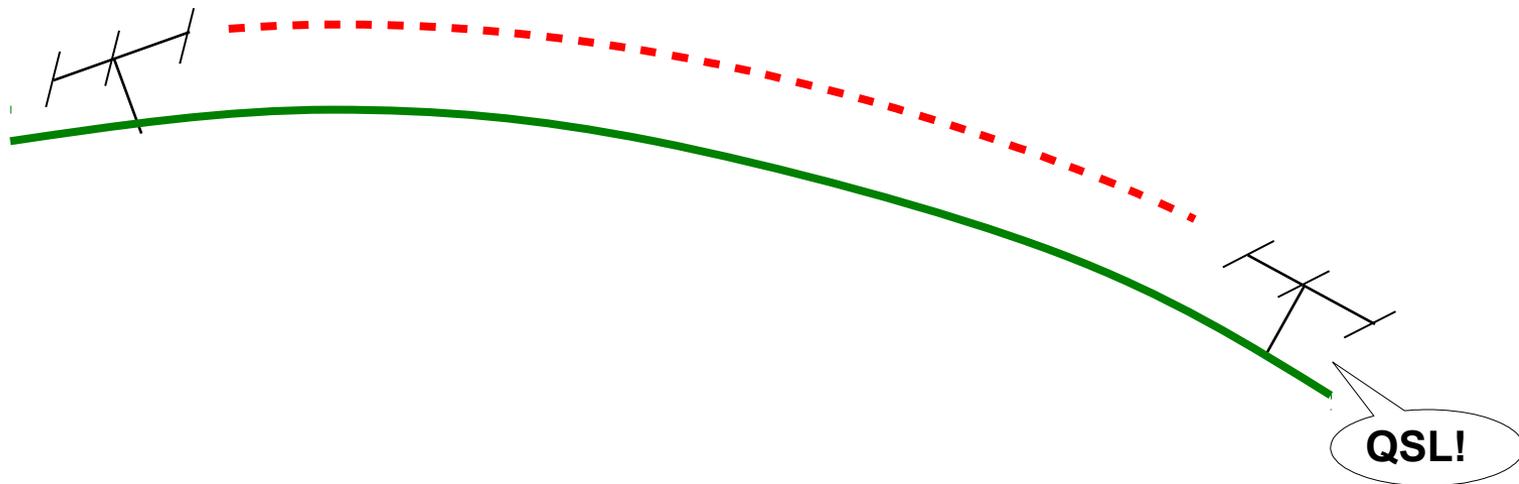
Can we even make a *minimum* QSO?!

Success if we just exchange callsigns and a report



WSJT: Digital protocol for minimum communication on marginal paths

The mode to use when all else fails!



WSJT: A software package for digital radio communication

Weak **S**ignal communication by Professor **J**oe **T**aylor (K1JT)

Uses computer soundcard via a computer-radio interface

Upper sideband

Introduced in 2001

Development is still going strong in 2017



A free open-source download!

Two general use scenarios:

- 1) Slow modes: Sustained paths on VHF and HF**
Signals may be ultra-weak and fluctuating
Can work when voice and cw fail
- 2) Fast modes: Meteor scatter on VHF**
Ionization in the E-layer by random meteors
Propagation path exists for < 1 second

Foundational work for WSJT: Compact messages

Messages can be very efficiently coded

CALLSIGN1 CALLSIGN2 GRID



Tom Clark, K3IO



Phil Karn, KA9Q

WSJT messages are generally not free-form
Greatly reduces the amount of data required
Defines a 72 bit protocol

KG5FHU WB2FKO DM65

This message can be coded into 71 digital bits
Takes 209 bits in CW (1 dit = 1 bit)

Why are compact messages useful?

1) Make data packets very small

– *OR* –

2) **Add other, very useful data to message**

FORWARD ERROR CORRECTION:

The crucial enhancement CW does not have

Modern electronics:

Modems

Hard drives

CDs

DVDs

Blue-Ray

Digital TV

Satellites

Deep-space probes

QR codes for phones

Amateur radio:

D-Star

DMR

Fusion

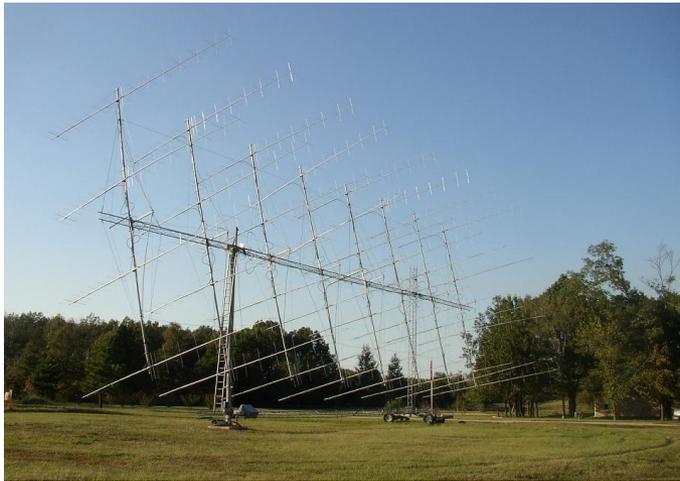
QPSK31

MFSK16

Olivia

WSJT

FORWARD ERROR CORRECTION IN JT65



FORWARD ERROR CORRECTION IN JT65

JT65: Sub-mode of WSJT

Ultra-weak but sustained propagation

Developed for Earth-Moon-Earth

**Now widely used for terrestrial
on HF, VHF, UHF, and microwave**

FORWARD ERROR CORRECTION IN JT65

Each **72 bit** message is augmented with **306 Forward Error Correction bits**

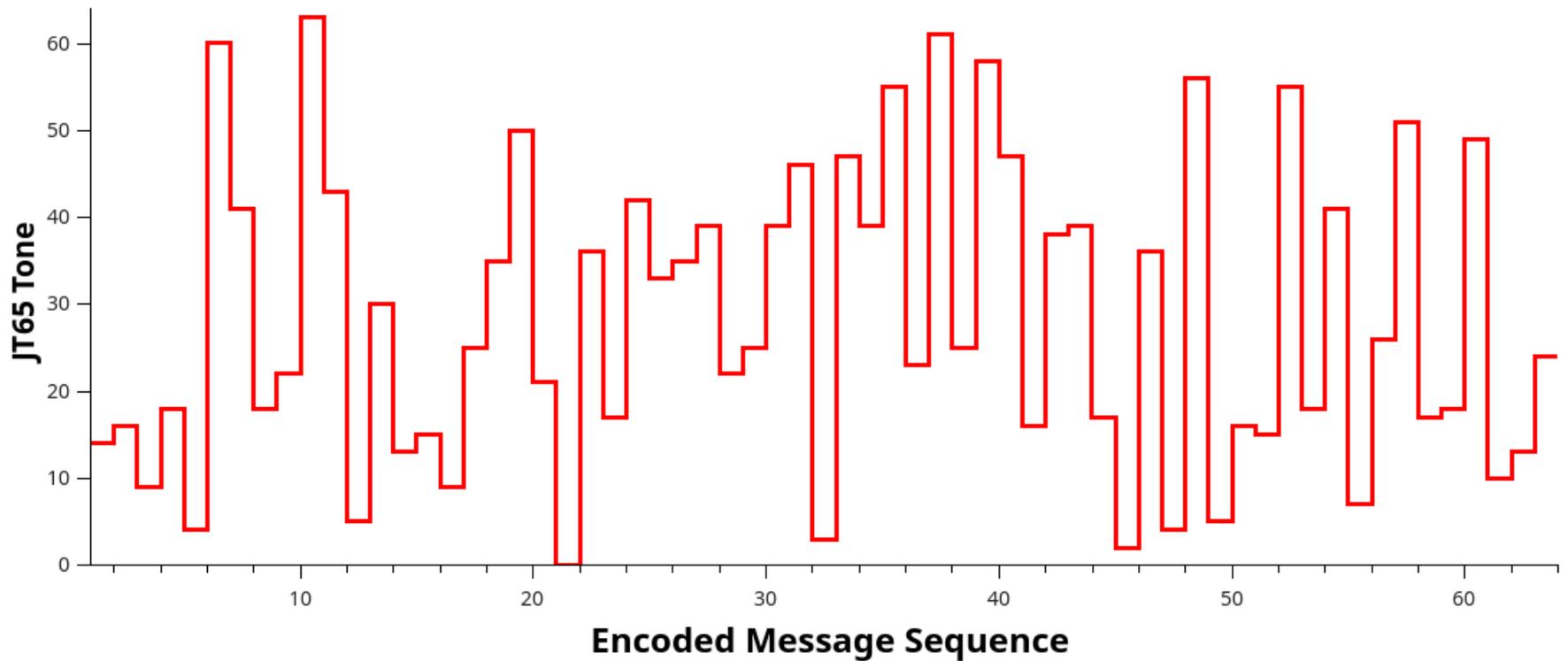
81% of the message length is FEC bits

378 bits then mathematically encoded into a unique **63 character string** represented by sequence of tones

Tones produced by PC sound card using Frequency Shift Keying (FSK)

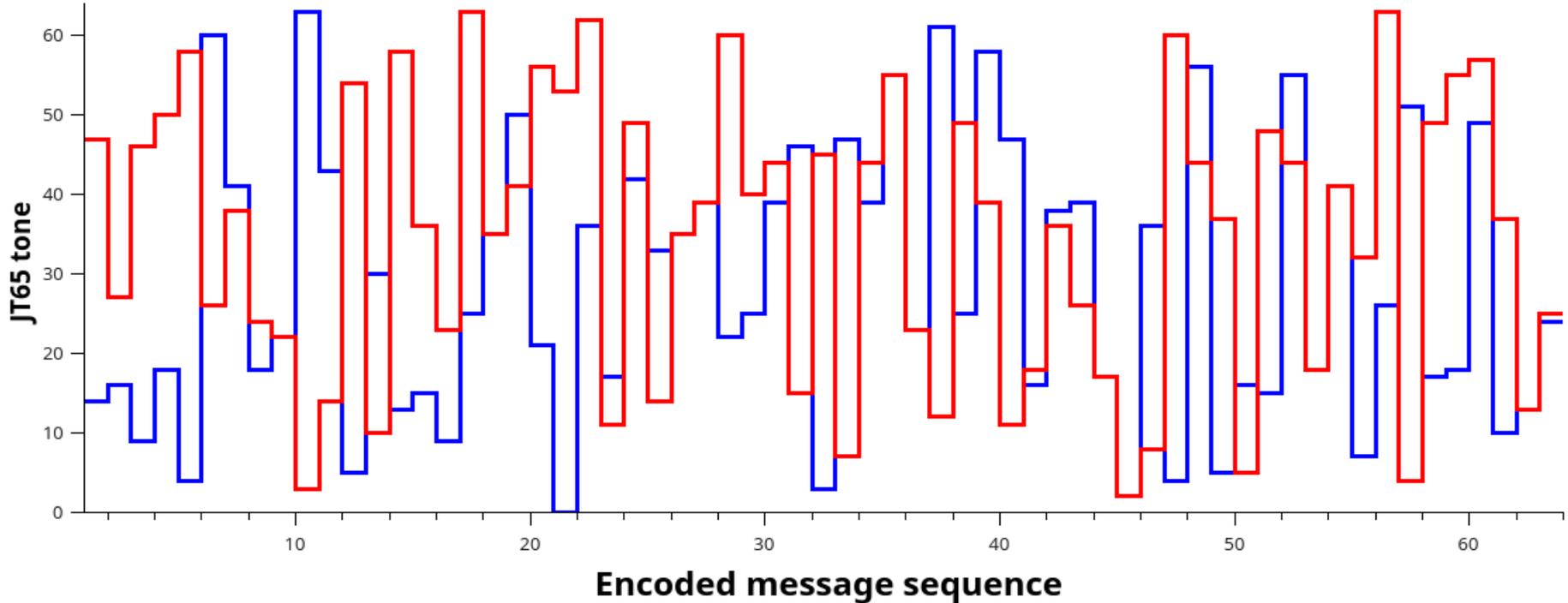
Sequence of JT65 Tones in 63 time intervals define a message:

G3LTF DL9KR JO40



Just one character difference *radically* changes the encoded message tone sequence

G3LTF DL9KR JO40
G3LTF DL9KR JO41



TIME SYNCHRONIZATION

PSK31 and other modes can be sent and decoded randomly

WSJT modes gain additional sensitivity by requiring tight time-synch of the stations

Lock the 2 computers to a reference clock



TIME SYNCHRONIZATION

Computer synch only gets in the ballpark

JT65 decoder requires an accuracy ≤ 0.03 seconds

The message must supply its own synch signal

JT65: TIME SYNCHRONIZATION

A JT65 message has 126 time intervals

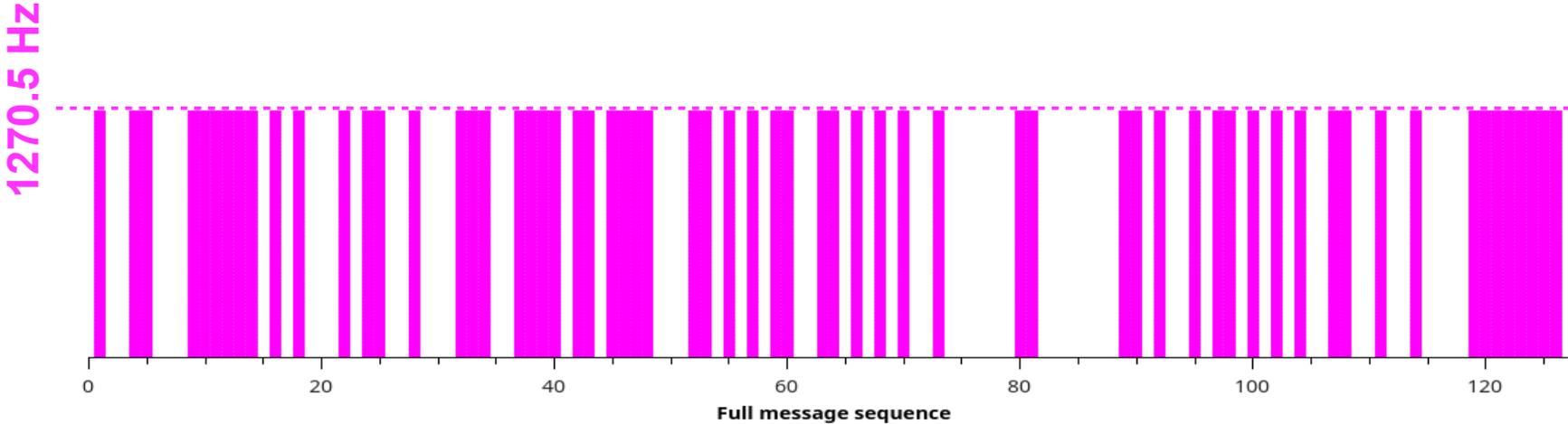
Each interval is 0.372 seconds

Total message duration: 47.8 seconds

63 intervals allotted for the message + FEC

63 intervals allotted for synch

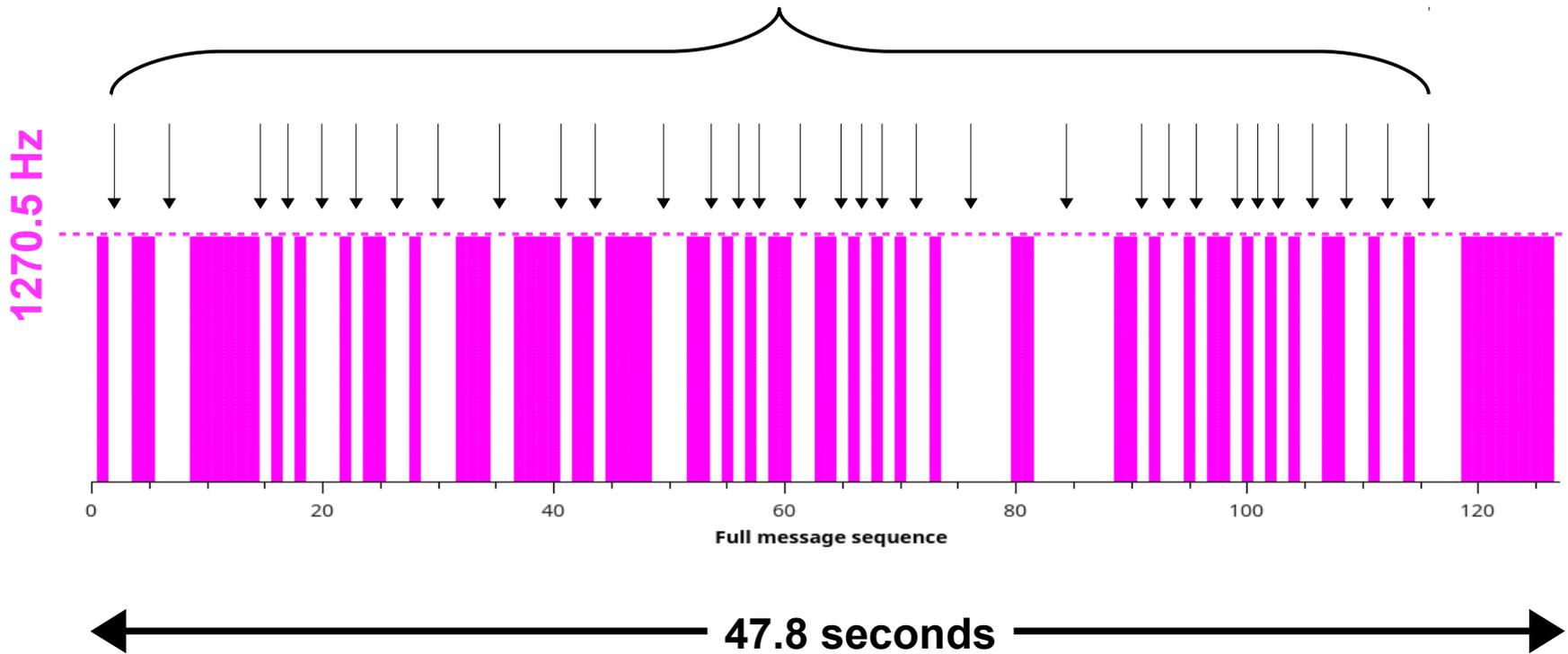
Half of each message is used for synchronization
Synch tone at 1270.5 Hz



← 47.8 seconds →

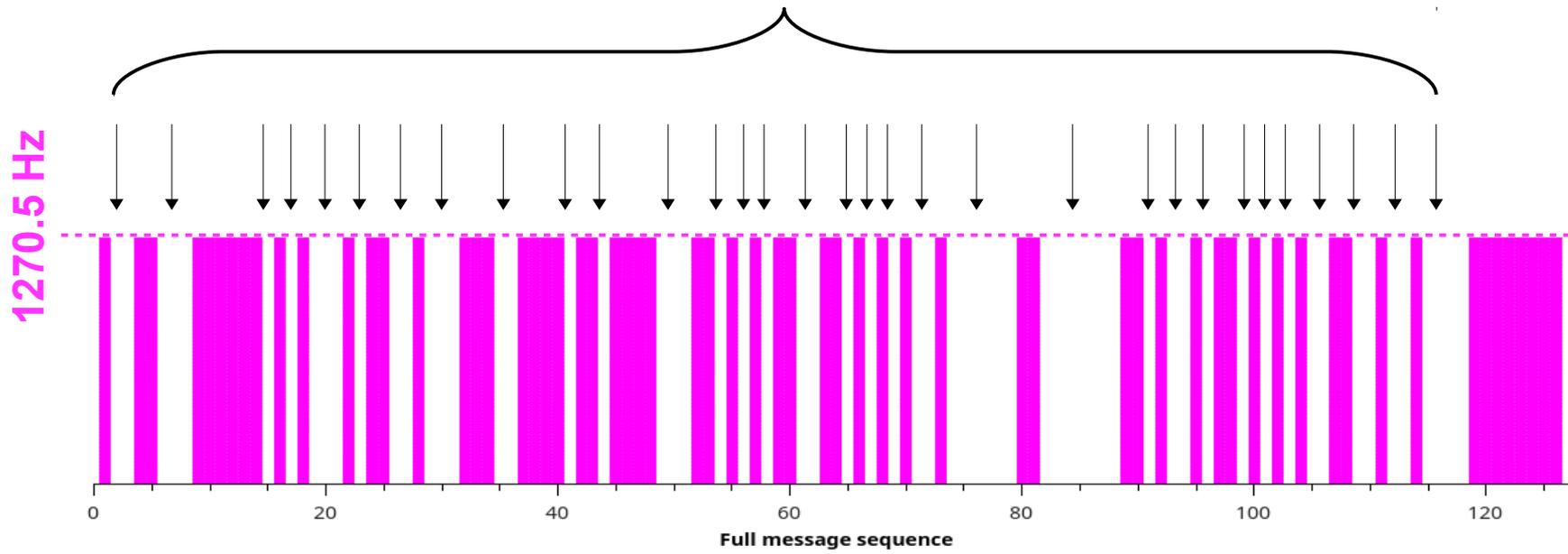
**Half of each message is used for synchronization
Synch tone at 1270.5 Hz**

Encoded message is in the remaining 63 time intervals



Half of each message is used for synchronization
Synch tone at 1270.5 Hz

KG5FHU WB2FKO DM65



47.8 seconds

WSJT Procedure

WB2FKO answering CQ from **KG5FHU**

60 second sequences

CQ KG5FHU DM78

KG5FHU WB2FKO DM65

WB2FKO KG5FHU -03

KG5FHU WB2FKO R-07

WB2FKO KG5FHU RRR

KG5FHU WB2FKO 73

TOTAL TIME: 6 minutes

The price paid for
extreme sensitivity of JT65:

TIME!

Even with perfect decodes a
WSJT QSO requires several minutes

E-layer propagation path on VHF
may exist for 1 minute or less

Rarely need JT65 sensitivity in 6m Es openings



FT8: Franke-Taylor Design, 8-tone FSK

Introduced for alpha-testing 30 June 2017

Short duration, weak but steady openings

15 second sequences \Rightarrow 4x faster QSOs

4–6 dB less sensitive than JT65

Narrower channels: 47 Hz (FT8) compared to 178 Hz (JT65)



Steve Franke, K9AN



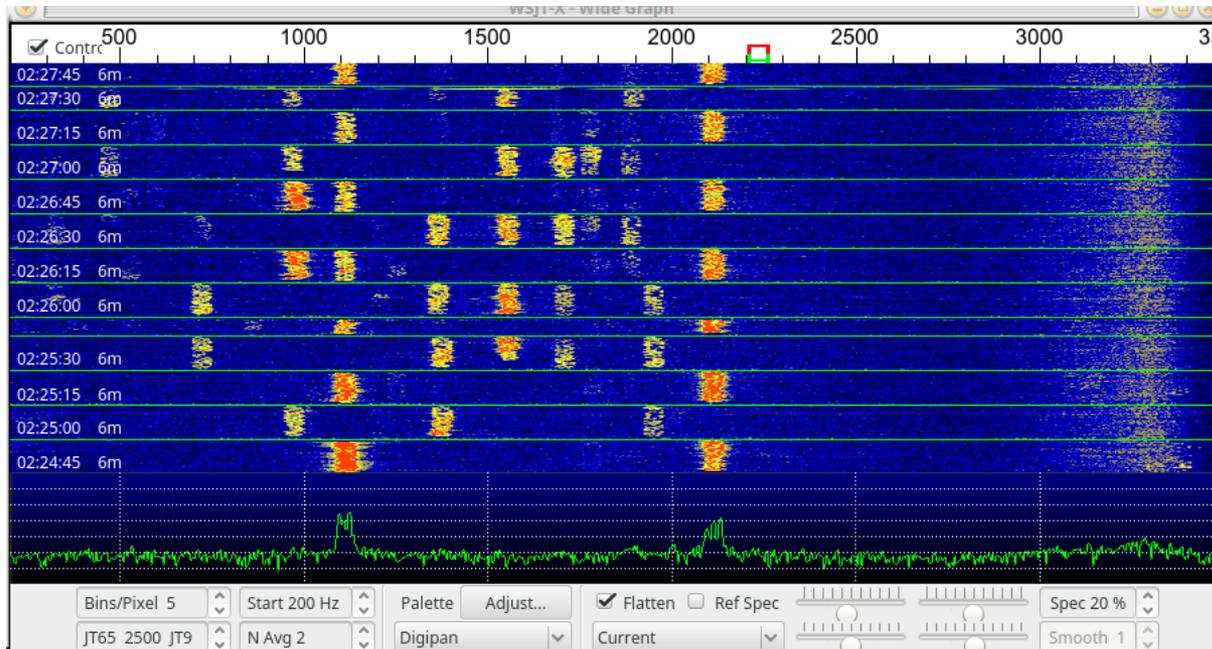
Joe Taylor, K1JT

Real-time decodes of *multiple* signals in waterfall display



2017 CQ World Wide
VHF Contest

FT8 available in
WSJT-X beta



WSJT-X V1.8.0-rc1 BY K1J1

File Configurations View Mode Decode Save Tools Help

Band Activity					Rx Frequency				
UTC	dB	DT	Freq	Message	UTC	dB	DT	Freq	Message
022700	1	0.5	1530	AAZUR WJW EN82	022315	3	0.1	1092	WB2FKO KC3OL 73
022700	-3	-0.0	1685	CQ K8OM EN42	022345	-2	0.1	1092	CQ KC3OL EM28
022700	-4	0.6	1756	K1KA WU9Q EN41	022415	0	0.1	1092	CQ KC3OL EM28
022700	-11	0.6	1865	CQ K6EU CM97	022445	-9	0.2	1091	XE2CQ W9FF RRR
022715	-1	0.1	1089	N7IR KC3OL 73	022530	-7	0.0	1686	CQ K8OM EN42
022715	-15	0.6	1756	WU9Q K1KA -08	022600	-10	-0.0	1685	CQ K8OM EN42
022715	3	0.5	2088	CQ W7GJ DN27	022630	0	0.5	1685	CQ K8OM EN42

Log QSO Stop Monitor Erase Decode Enable Tx Halt Tx Tune Menu

6m **50.313 200**

DX Call: K8OM DX Grid: EN42
Az: 54 982 mi
Report -7
Auto Seq Call 1st

Generate Std Msgs Next Now Pwr

K8OM WB2FKO DM65	Tx 1
K8OM WB2FKO -07	Tx 2
K8OM WB2FKO R-07	Tx 3
K8OM WB2FKO RRR	Tx 4
K8OM WB2FKO 73	Tx 5
CQ WB2FKO DM65	Tx 6

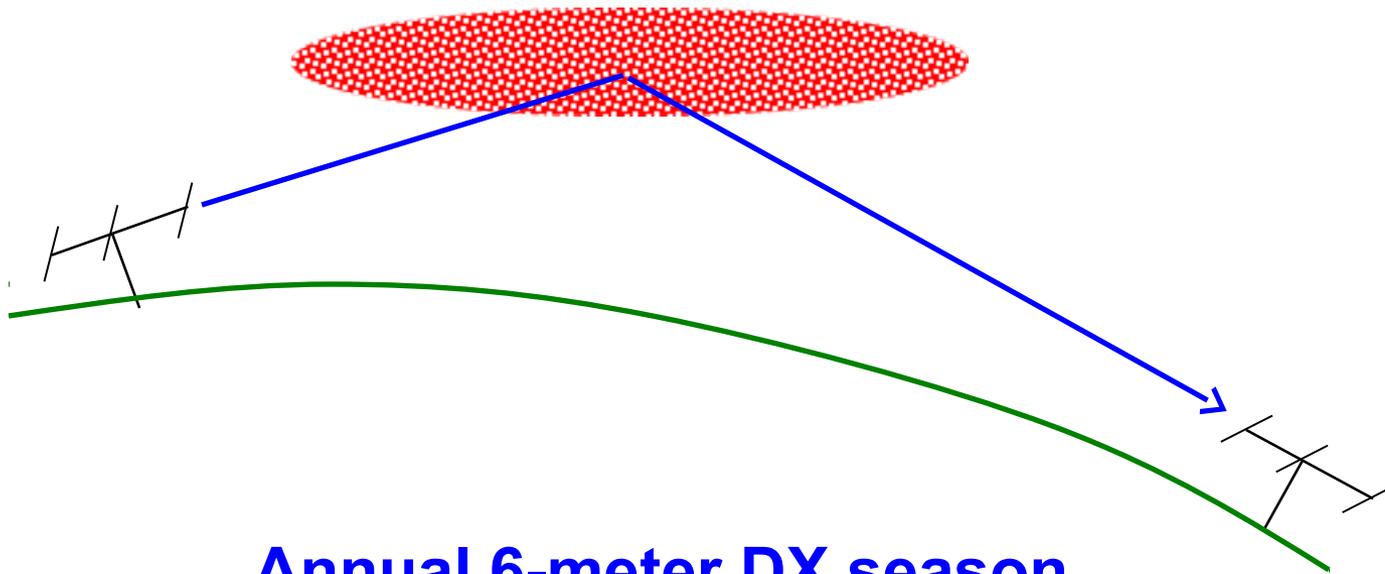
Receiving FT8 Last Tx: CQ WB2FKO DM65 10/15 WD:15m

FT8 in operation at WB2FKO

6m frequency: 50.313 MHz

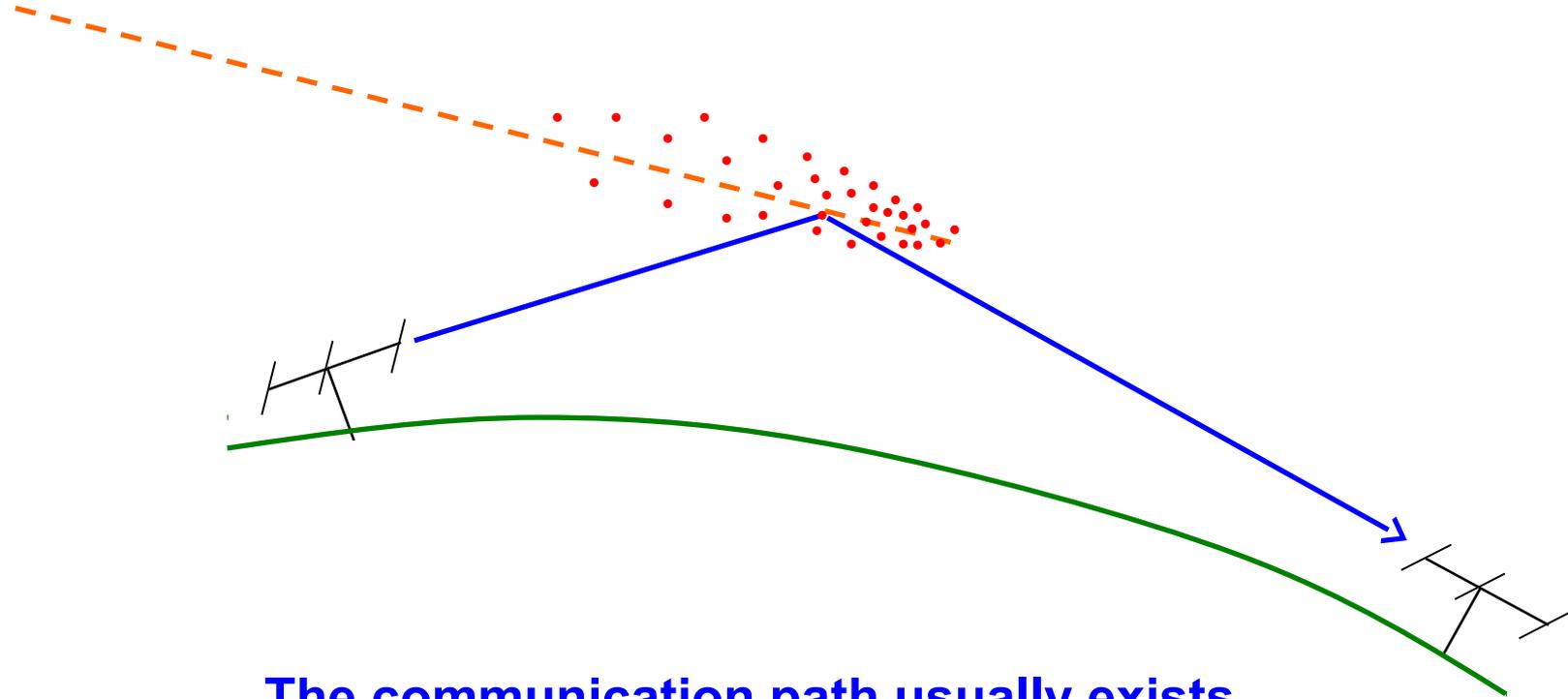
VHF meteor scatter: Fast-modes of WSJT

Es: sporadic ionization of the E-layer
Height above ground: ~ 60 miles



Annual 6-meter DX season
Openings last for hours

Meteor scatter: Momentary ionization of the E-layer



**The communication path usually exists
for a fraction of a second**

Meteors:

Size of sand grains or dust specks

Speed is in the range 10 – 70 km/s

Cause ionization trails in E-layer

Ionization trails reflect radio waves

VHF DX is possible at 500 – 1300 miles



PROBLEM: Except in major meteor showers, ionization trail disappears very quickly!

Short-lived ionization trails are called *PINGS*

Typical *PING* lifetime:

< 1 second at 50 MHz

< 0.3 seconds at 144 MHz

< 0.1 seconds at 432 MHz

Meteor pings are too short to support an ssb QSO

Pings are present in the E-layer 24/7

High speed communication is possible

High-speed meteor scatter

1990s: **High-speed CW** (W8WN and others)

2001: **FSK441** sub-mode of WSJT (K1JT)

Computer sound card

Use 4 audio tones

Equivalent to 1765 wpm cw

2016: **MSK144** sub-mode of WSJT-X (K1JT and K9AN)

Error detection

Real-time decoding

MSK144: Minimum Shift Keying

Similar to PSK

Modulation scheme invented 50 years ago

Message Format:

72 information bits (same as JT65)

+ 8 bits: cyclical redundancy check

80 bits mapped into 128-bit codeword

+ 16 bits for time synch

= 144 bits total

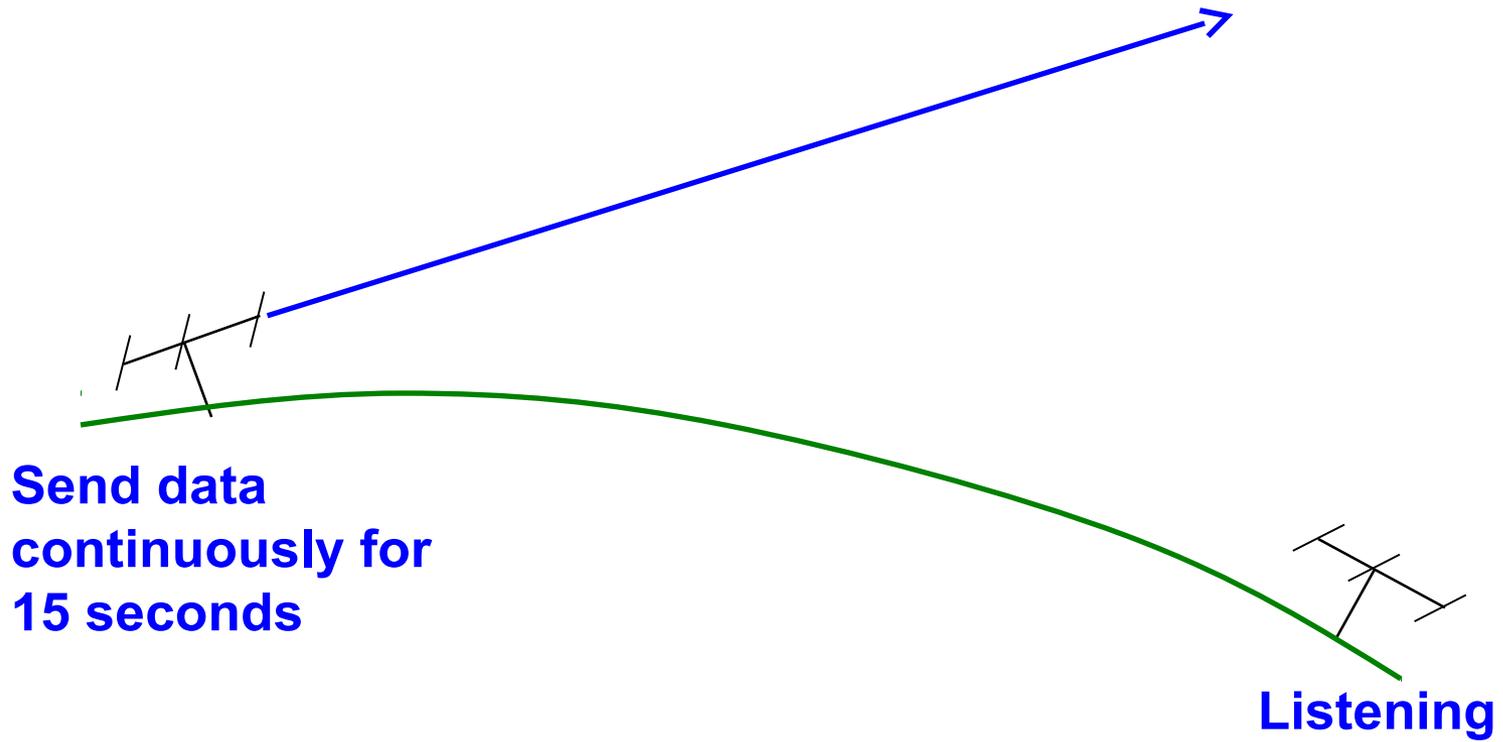
MSK144: Minimum Shift Keying

70% faster data rate than FSK441
***including* time-synch and**
error detection

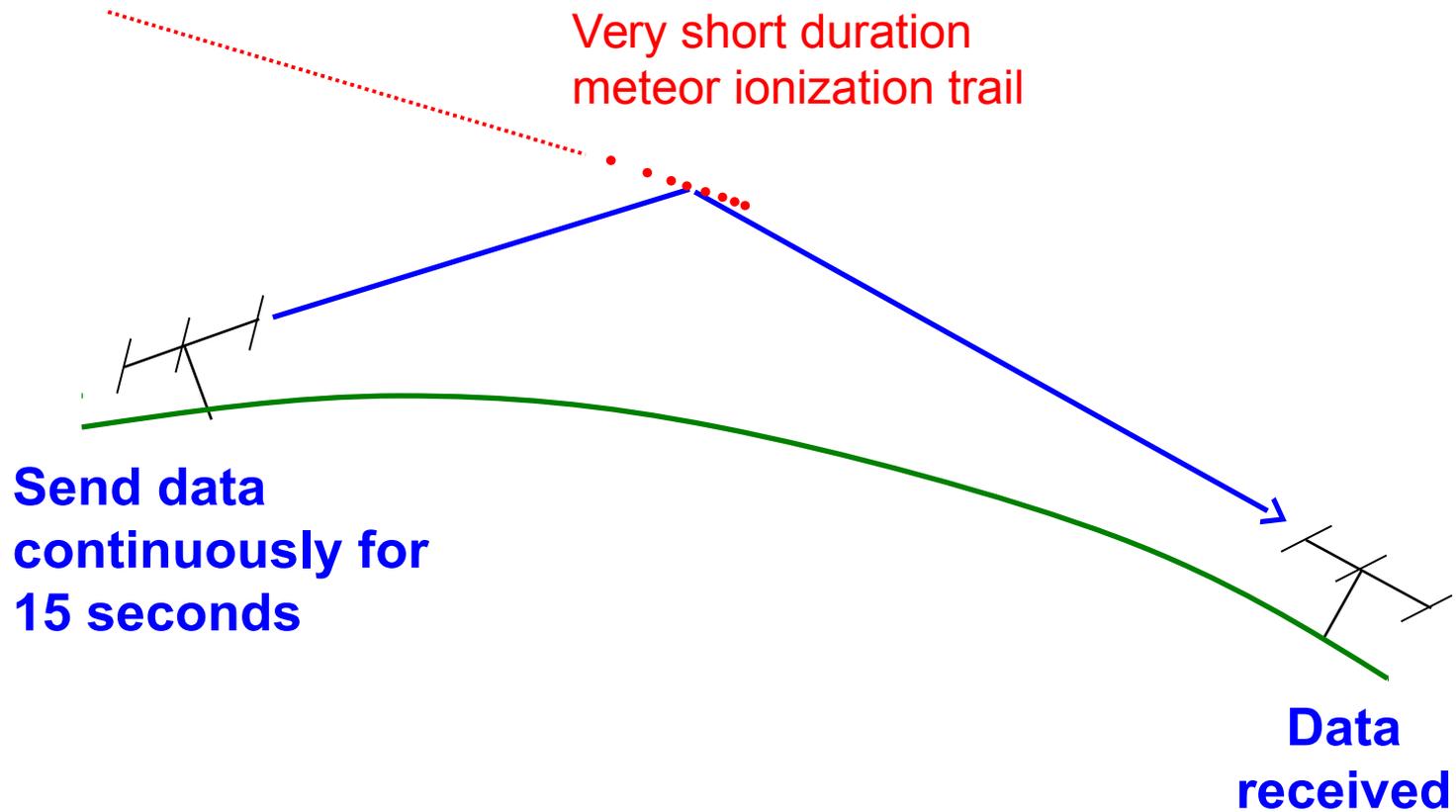
Stable, accurate VFOs required
Stations must be within 200 Hz

15 second sequences

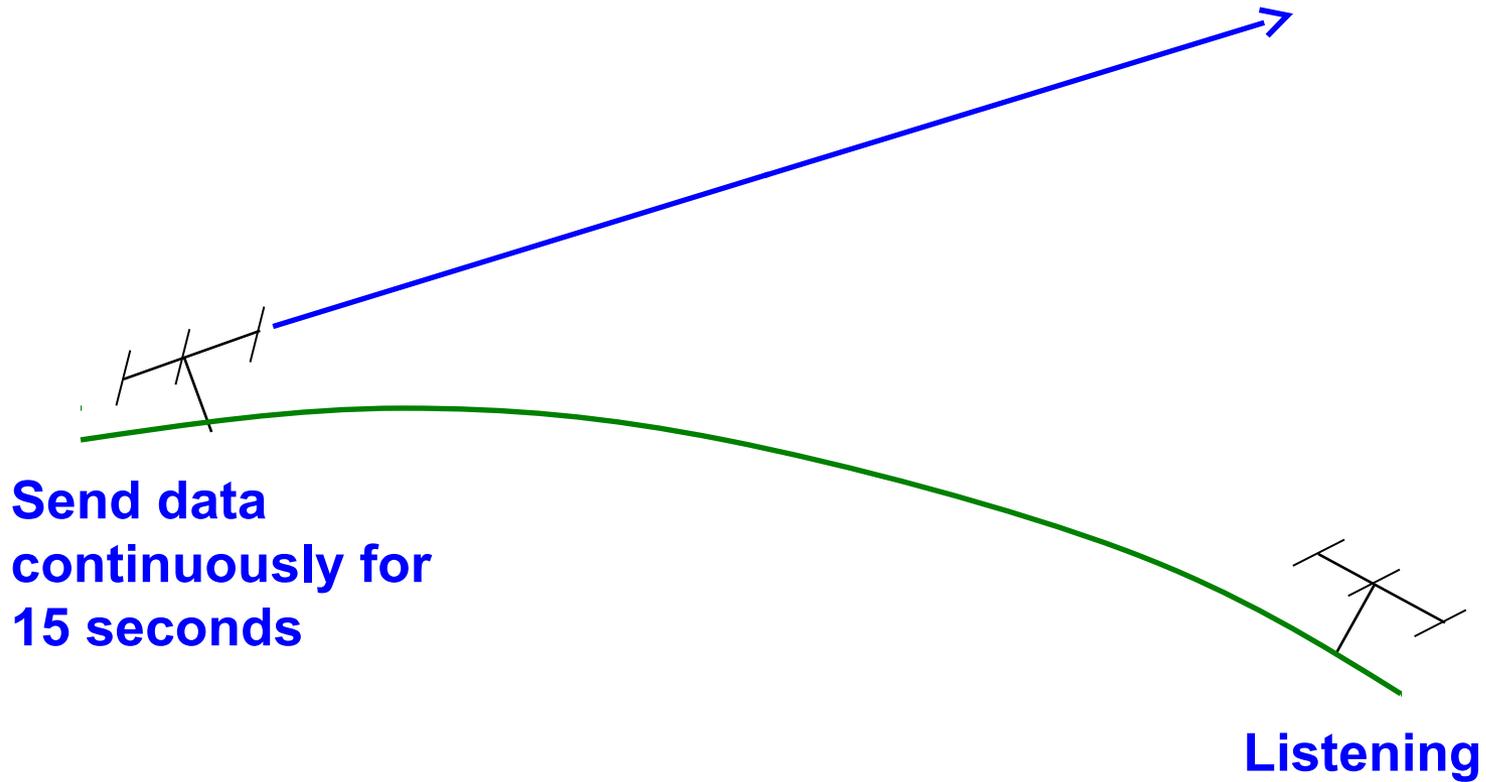
What happens



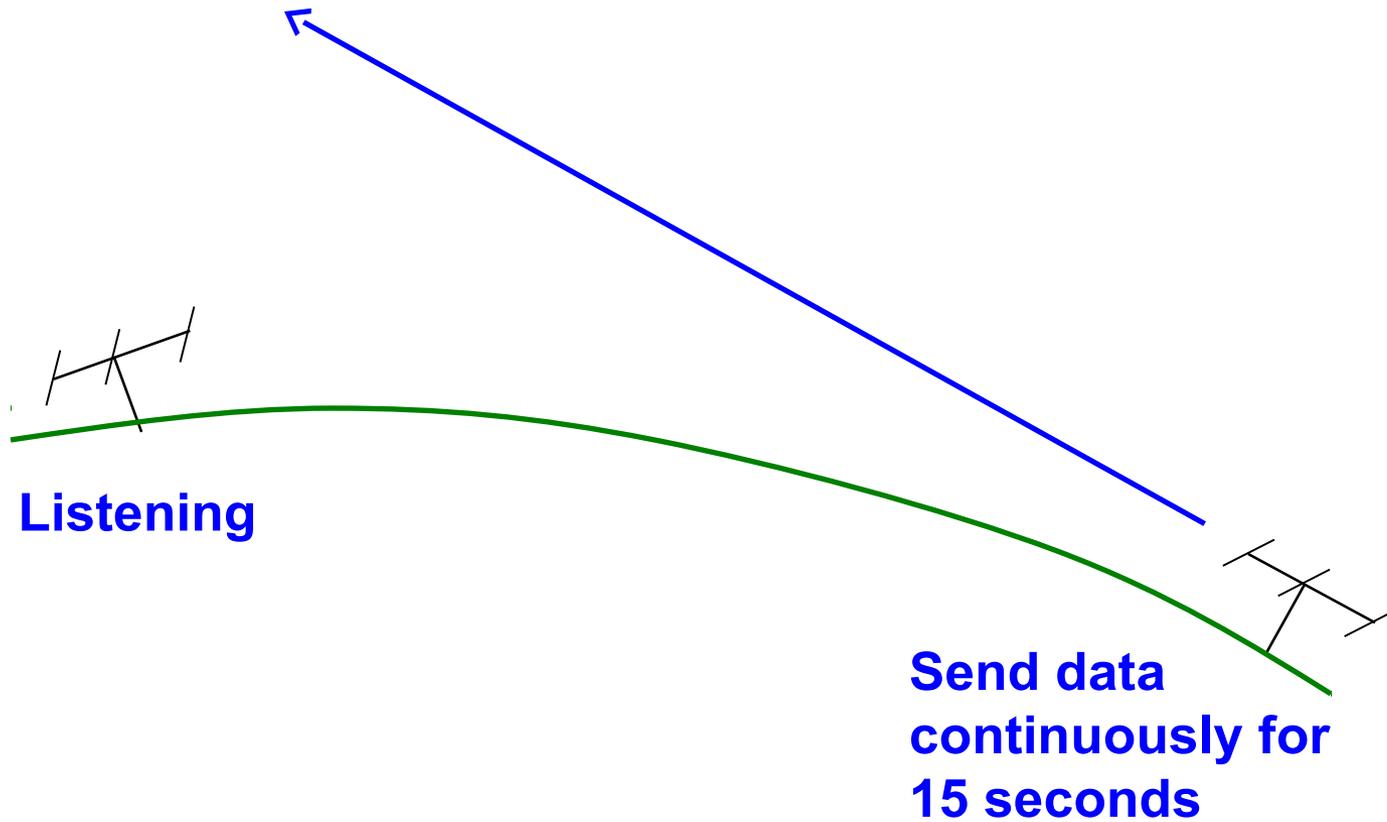
What happens

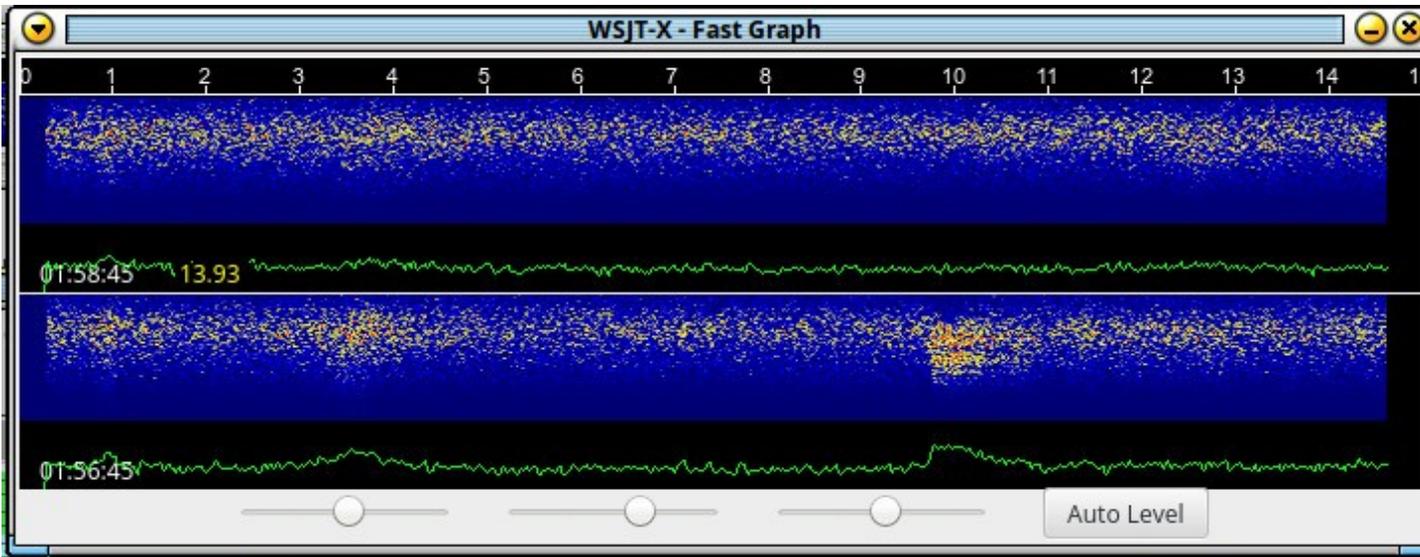


What happens



What happens





WSJT-X v1.7.0 by K1JT

File Configurations View Mode Decode Save Help

Band Activity					Tx Messages				
UTC	dB	T	Freq	Message	UTC	dB	T	Freq	Message
015645	2	9.8	1536	& CQ K5DOG EM00	015845	-5	12.7	1538	& WB2FKO K5DOG R EM00
015645	3	9.8	1537	& CQ K5DOG EM00					
015845	-5	12.7	1538	& WB2FKO K5DOG R EM00					

Log QSO Stop Monitor Erase Decode Enable Tx Halt Tx Tune

6m **50.000 000** Tx even/1st

Rx 1500 Hz F Tol 200 Report -5 T/R 15 s Tx CQ 280 Sh Auto Seq

DX Call: K5DOG DX Grid: EM00 Az: 123 B: 109 El: 10 542 mi

Lookup Add

2017 Feb 12 18:04:49

Generate Std Msgs	Next	Now	Pwr
K5DOG WB2FKO DM65	<input type="radio"/>	Tx 1	Pwr
K5DOG WB2FKO DM65	<input type="radio"/>	Tx 2	
K5DOG WB2FKO R DM65	<input type="radio"/>	Tx 3	
K5DOG WB2FKO RRR	<input checked="" type="radio"/>	Tx 4	
K5DOG WB2FKO 73	<input type="radio"/>	Tx 5	
CQ WB2FKO DM65	<input type="radio"/>	Tx 6	

MSK144 0/15 WD:14m

What about bandwidth?

FT8: 47 Hz/channel

JT65: 178 Hz/channel

MSK144: full receiver bandwidth ~ 2 kHz

Meteor scatter requires high data rates

**MSK144 supports simultaneous
QSOs on the same frequency**

Calling frequency: 50.260 MHz

**When it's really busy, can call CQ
and indicate where listening**

Example: CQ K5QE 265

Pingjockey.net Online real-time scheduling of meteor scatter contacts

Ping Jockey Central.



Relief page	Skeds in-progress	CQ Announcements	JT65 Link
Refresh	Look back	Distance/Bearing Locator	Who's Earwiggling?
Update User details	AA1YN Callsign database	Mike, WB2FKO NM DM65rc	Refreshed 30Sep 15:03

This page is to be used only for the purposes of discussing matters related to amateur radio meteor scatter communications. **Any** non-meteor scatter use is strictly prohibited.

That means **DO NOT USE THIS PAGE TO WORK JT65 or for General chit-chat.**

Remember, in North America, 50.260MHz and 144.140MHz are calling not operating frequencies.

Exchanging any contact details on here before you're complete, invalidates the contact, and, if it's not HIGH-SPEED METEOR SCATTER, it doesn't belong here!

Enter your message here

Go!

DDMMM UTC

30Sep 15:03 Test anyone on 6M? ([W0VB/6M/2M/QRO](#) Terry MN EN34qb 162.255.232.22)

30Sep 15:03 i like how these computer run when you get all the crap off them ([K0TPP/2/6/222/](#) Larry MO EM48rj 71.10.182.149)

30Sep 15:02 K0TPP, Larry, V7123 is now history here,,,,, on v7111 now. Test? ([W0VB/6M/2M/QRO](#) Terry MN EN34qb 162.255.232.22)

30Sep 15:01 I'm just messing around some while waiting to go to an appointment. ([AG0N/6](#) Gary NE DN81fv 65.161.181.76)

30Sep 15:01 Tried CW too ([AG0N/6](#) Gary NE DN81fv 65.161.181.76)

30Sep 15:00 nobody home mabe i reload win onm one of the shack computer clean it up give me some to do ([K0TPP/2/6/222/](#) Larry MO EM48rj 71.10.182.149)

30Sep 15:00 SSB old fashioned mouth noises..... ([W3XS](#) Bill OR CN86ce 107.77.97.50)

30Sep 15:00 I'm hearing bits and pieces.. ([KC5WX/6/2/432](#) Gene TX EM13rs 24.119.48.110)

30Sep 15:00 RR Gary,,think i heard you faintly.. ([W5LDA](#) Larry OK EM15xu 72.169.80.204)

30Sep 14:59 Hear you now and then Larry. ([AG0N/6](#) Gary NE DN81fv 65.161.181.76)

30Sep 14:57 SSB? Watsat? What tab is that under, Larry? ([AG0N/6](#) Gary NE DN81fv 65.161.181.76)

30Sep 14:54 rr ([W5LDA](#) Larry OK EM15xu 72.169.80.204)

30Sep 14:54 ssb? ([W5LDA](#) Larry OK EM15xu 72.169.80.204)

30Sep 14:54 ssb ([WQ0P](#) Greg KS EM19wf 216.147.226.27)

30Sep 14:53 W5LDA want to try 50.130? ([WQ0P](#) Greg KS EM19wf 216.147.226.27)

30Sep 14:53 WQ0P Greg,,Can you call me?? 918-292-9030 ([W5LDA](#) Larry OK EM15xu 72.169.80.204)

30Sep 14:52 I've got almost every old version for the last few months. ([AG0N/6](#) Gary NE DN81fv 65.161.181.76)

30Sep 14:50 I saved it from previous install. ([AG0N/6](#) Gary NE DN81fv 65.161.181.76)

30Sep 14:49 where do I get 7115? ([WQ0P](#) Greg KS EM19wf 216.147.226.27)

30Sep 14:48 Yep, tx ok now ([AG0N/6](#) Gary NE DN81fv 65.161.181.76)

30Sep 14:48 7115 is good, Greg. ([AG0N/6](#) Gary NE DN81fv 65.161.181.76)

30Sep 14:47 trying to get 7111 working... no CAT, no audio in, no PTT out... WSJT version 10 worked great... I am about to give it up.. ([WQ0P](#) Greg KS EM19wf 216.147.226.27)

30Sep 14:46 Couldn't find any new error files,so will just roll back. He had a routine to save a spl file in the version I tested while looking for the QRA problem

30Sep 14:44 7115 working good ([K0TPP/2/6/222/](#) Larry MO EM48rj 71.10.182.149)

30Sep 14:43 yes same problem here ([K0TPP/2/6/222/](#) Larry MO EM48rj 71.10.182.149)

30Sep 14:43 yep. I'm looking for the error file before reloading older version. Will send to Joe if it is in this vers. ([AG0N/6](#) Gary NE DN81fv 65.161.181.76)

30Sep 14:42 garv i had it loaded early on both mach was crashing on both went back to 7115 ([K0TPP/2/6/222/](#) Larry MO EM48ri 71.10.182.149)

What radio hardware do I need?

Better equipment yields better results

QRP + Omni antenna + 144 MHz = **Frustration**

Online Resources

WSJT Yahoo Users Group

WSJT Developers Mailing List

Pingjockey.net

Online Resources

WSJT Yahoo Users Group

WSJT Developers Mailing List

Pingjockey.net

THANK YOU!

