Recommended Procedures for Random Digital EME

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Around the year 2000 a growing number of VHF enthusiasts began experimenting with digital coding and modulation techniques that show great promise for enhanced weak signal communications. Early efforts included the computer-aided high-speed CW mode of 9A4GL, designed for meteor scatter, and a multi-tone frequency-shift keying mode called PUA43, developed by W7PUA and intended for EME. At about the same time, modes like PSK31 (by G3PLX) and MFSK16 (ZL1BPU and IZ8BLY) were becoming popular on the HF bands. My own software program WSJT was based in part on the pioneering work of these and other amateurs; my goal was to make the advantages of digital communications conveniently and widely available to VHF/UHF weak signal enthusiasts. WSJT began seeing worldwide use for VHF meteor scatter QSOs in mid-2001, and for EME some nine months later. The presently popular EME mode called JT65 was incorporated into the program in late 2003.

Not surprisingly, the new weak-signal modes first gained popularity among a subset of amateurs who were familiar with computers and digital electronics, as well as being skilled in VHF/UHF weak signal techniques. The new developments came at a time of rapidly increasing use of the internet for general communication. As a consequence, technical development and popularity of the new weak-signal protocols benefited enormously from suggestions, advice, feedback, and other information exchanged via email reflectors and internet chat rooms. Special purpose loggers like *Ping Jockey Central,* the *JT65 EME Link,* and the *ON4KST EME Chat* sprang up to help experimenters coordinate their early efforts with the new software. These "loggers" made it very easy to find willing QSO partners and to make real-time schedules.

I think all of these developments have been good for Amateur Radio, and for the VHF/UHF weak-signal community in particular. However, in this brief note I wish to suggest that there is more to amateur EME operation than simply making pre-arranged QSOs. *Any* contact with a fellow amateur using signals reflected from the moon is exciting, a significant achievement, and something to be proud of; but it is *especially* rewarding when a QSO begins with the pleasant surprise of someone answering your CQ without pre-arrangement through another medium. My goal here is to suggest operating procedures that should help to facilitate more widespread access to those very pleasant moments of surprise.

Protocols like JT65—and others that will surely succeed it—can enable amateur radio contacts with signals too weak to be audible. Such signals can't be found by the traditional method of slowly tuning the band with the headphones on, listening for weak carriers. Even worse, for many of us such procedures serve mainly to locate the ubiquitous "birdies" that plague us in this increasingly electronic age. We are fortunate, however, that digital

technology has brought us the capabilities of spectroscopic visual aids that make it easy to find weak JT65 signals in a specified region of a VHF/UHF band. The JT65 synchronizing tone, which carries half of the energy of every transmission, is readily distinguishable from birdies because JT65 transmissions start on a UTC minute and end about 47 seconds later, alternating with somewhat longer "off" periods. Operators who make the effort to install a software package like Linrad (by SM5BSZ) or Winrad (I2PHD), and the hardware to support it, can have a panoramic view of all the signals in a 90 kHz band segment and can watch the behavior of those signals over time. With such a system it is easy to pick out the potentially workable JT65 signals on one's favorite band.

Most operators use WSJT with a standard SSB transceiver providing a bandwidth of little more than 2 kHz, and the waterfall spectral display built into WSJT was configured with this limitation in mind. It follows that until many operators upgrade their stations to include the capabilities of a wide bandwidth Linrad-like display, digital EME operation will be greatly facilitated if we can designate relatively narrow sub-bands where such activity can be concentrated—standardized "meeting places" where QRV operators can find one another without relying on information from another source. To make my proposal specific, Table 1 contains suggested sub-bands to be used for random digital EME activity on our worldwide VHF and UHF bands.

Table 1. Suggested sub-bands for concentration of random digital EME.

Frequency Range (MHz)
50.185 – 50.195
144.115 – 144.135
432.060 – 432.070
1296.060 – 1296.070

As far as I am aware, these suggested frequency ranges conform reasonably well with existing band plans and operating practices. The center frequencies of 50.190, 144.125, 432.065, and 1296.065 MHz are close to the activity centers already being used for JT65 EME on these bands. The choices of 432.065 and 1296.065 MHz have useful mnemonic advantages, so I have placed them at the centers of suggested 10 kHz ranges that seem sufficient for present levels of activity. On 2 meters, where JT65 EME activity is much higher, I suggest a 20 kHz range. In North America 144.140 is used as a calling frequency for the FSK441 meteor-scatter mode, so I have avoided that frequency. To accommodate operators in Japan, who are required to transmit JT65 below 144.100, I suggest a secondary sub-band 40 kHz below the one listed in Table 1, centered at 144.085 MHz. If an operator

who must transmit above 144.100 finds a JA station calling CQ on 144.082, I suggest that a reply should be made on 144.122, exactly 40 kHz higher—and vice-versa. Of course, one should be aware of other (possibly regional) uses of these band segments, and always operate accordingly. If split-frequency operation is required, such as when working between Japan and the United States on 2 meters, care must be taken not to cause QRM on the transmitting frequency. Remember that EME Doppler shifts can be substantial on the higher bands—as much as 3 kHz at 1296 MHz.

I believe that the frequency ranges suggested in Table 1 are consistent with present practices for digital EME. If I have overlooked some important constraint, I trust that a suitable modification to Table 1 can be found and agreed upon.

Let us suppose that the worldwide EME community agrees to the suggestions outlined above. (The basic ideas have been discussed on the Moon-Net email reflector already, with positive responses.) What other operating procedures could be adopted to help us find one another on the bands and optimize our available time for making digital EME QSOs? I suggest that in general we should listen first near the center of the relevant sub-band. If this frequency seems unused and is free of local problems, it should be a good place to call CQ. If the center frequency is busy, or perhaps you have a strong local birdie there, move up or down in small steps, say 1 kHz. During contests or special activity weekends the whole sub-band may become busy; in such cases one can move farther outward from the nominal center frequencies.

The bandwidth of a JT65 transmission in the A, B, and C submodes is about 178, 355, and 711 Hz, respectively. More than 25 JT65B signals can be squeezed into a 10 kHz window without interference. Moreover, the JT65 decoders cope surprisingly well even when two signals overlap in frequency. Local interference from another EME-class station can be a problem; in such cases, the best recourse is usually to transmit in the same sequence (first or second) as that used by other stations in your area. When contending with signals reflected from the moon, a bit of QRM can be almost welcome. WSJT can easily decode several different signals received simultaneously, and it's fun to keep track of who else is active while you are on the air.

Our operating procedures should be friendly to SWLs and third-party listeners. After a QSO is finished, stay where you are for at least a few minutes, listening for possible tail-enders. If you originated a QSO by calling CQ, another station may call when you finish; if you answered someone else's CQ, a third station may want to work you afterward. Common courtesy dictates that he will probably not call right on the frequency you have been using. Considering the bandwidths of JT65 signals, I suggest calling "up" by something like 0.5 to 1 kHz in such situations. By the same token, I recommend listening carefully after your QSOs, both on your own frequency and slightly higher. A future version of WSJT may

increase the available bandwidth by a factor of two or more, if your receiving hardware can support it. This would make such procedures significantly easier.

Special circumstances sometimes apply to DXpeditions, rare DX stations, and "big guns" in contest situations—in other words, whenever many stations are simultaneously calling a single desired station. Under normal activity conditions, minimal JT65 EME QSOs generally proceed something like the example shown at the left in Table 2. When there is a significant chance of confusion about who has transmitted a message or who it may be intended for, callsign-tagged formats should be used for messages 4 and 5, as shown on the right in Table 2. JT65 provides for other message formats, as well, including ones with numerical signal reports. If you are unsure of the available message formats and capabilities, refer to the WSJT User's Guide for details and instructions on their use.

Table 2. Recommended message formats for minimal EME QSOs using JT65.

Normal activity	Pileup situations
1. CQ RN6BN KN95	1. CQ 3Y0X EC41
2. RN6BN K1JT FN20	2. 3Y0X K2TXB FM29
3. K1JT RN6BN KN95 OOO	3. K2TXB 3Y0X EC41 OOO
4. RO	4. 3Y0X K2TXB RO
5. RRR	5. K2TXB 3Y0X RRR
6. 73	6. 73

When designing the standard JT65 message formats, I imagined that the mode might be used in terrestrial VHF/UHF contests where grid locators are part of the required exchange. In EME QSOs the locators are largely superfluous and could well be eliminated. A future version of WSJT may provide enhanced performance for messages that contain a callsign but no locator, as well as for callsign-tagged messages with reports or acknowledgments.

If you agree with the sentiments I have expressed here, please help to spread the word—and lead others by your own example! When you are QRV on the moon, call CQ somewhere in the sub-bands listed in Table 1, starting near the center and working outward as QRM requires. Post a CQ notice on the logger, if you wish, encouraging others to come and find you ... and then wait for the special pleasant surprise when a new "initial" or an old friend unexpectedly responds to your call. Better still, when activity levels are sufficient, forget the logger and just call CQ! Practice random operating so that you can do it easily during contests, without external aids. Self-spotting and other real-time liaison are forbidden in many contests, including the European EME Contest sponsored by DUBUS and REF.