A Crystal-Controlled SSTV Sync System

Beats QRM

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THOSE EXPERIENCED with SSTV operation in crowded ham bands are aware of the many interference problems caused by sideband splatter, heterodynes, cochannel habitation, and other forms of QRM. The purpose of the SSTV synchronization system described here is to provide a completely independent sync system, which, when utilized by two stations with similar sync generators, permits continuous SSTV synchronization without interruption due to any type of "on the air" interference. Then, even though some video portions of the picture may still be obliterated by interference, the relative positions of remaining picture elements are precise and the resultant video continuity is far superior to that obtained with "hold off" circuits, APC loops, or driven sync. As will be explained later, this condition will hold true for substantial time intervals, permitting greatly improved picture exchanges to be made in the presence of interference.

Principle of Operation

This sync system is independent of the power-line frequency and takes advantage of the comparatively low timing accuracy demanded by the amateur SSTV system. By using crystal-controlled sync generators and maintaining a modest frequency accuracy between the two stations in SSTV contact, excellent results may be obtained.

To elaborate a little more on the system, assume that two SSTV stations desire to use the crystal-controlled sync system. For convenience, each has chosen to use 1.966080-MHz crystals as outlined for the sync generators in this article. Then, even though the crystals used as the master oscillators may be operated in different environments, it is simple for the operators to adjust these oscillators, at least momentarily, to be within ±10 Hz of each other as contact is initially established. Once this is achieved, the only other requirement is to provide correct horizontal and vertical phasing. This is handled by a horizontal phasing control plus a momentary-action switch in the vertical sync circuit. After simple frequency and phase adjustments are made – bring on the QRM, it *will not* disturb the synchronizing performance of the SSTV at either station using the system.

Some may question how adequate timing accuracy is obtained when the master oscillators are not locked together. This is explained as follows: To produce sync pulses corresponding to the amateur SSTV standards from a 1.966-MHz crystal, a frequency division of 2^{17} or 131,072 times is required for the horizontal frequency of 15 Hz and a total of 2^{24} or 16,777,216 times for the vertical frequency of 0.117 Hz. (Such frequency divisions sound formidable, but are an easy task for some of the new counter ICs.) Because of the very large divisions involved, the initial good stability of the crystal-controlled master oscillator is translated to the very low frequencies, providing good timing accuracy for the SSTV sync. Master-oscillator frequency differences of 10 or 20 Hz show up as such miniscule differences in sync-pulse timing that they are almost imperceptible. Table I lists several possible MO frequencies and the divisions and/or multiplications required to produce usable SSTV horizontal frequencies. The field-rate frequencies shown are based on additional divisions of 128 times. Some of the line and field rates shown differ slightly from each other, but all are usable.

Several other frequencies, in addition to the 1.966080-MHz frequency mentioned earlier, are tabulated, since an extension of this system concept would be to phase lock to a standard frequency such as is available from WWV. Alternatively, one might lock to the 3.579545-MHz color reference oscillator of a color TV receiver. If the color receiver is in sync, the reference subcarrier would then be maintained at close tolerance by the broadcaster (in some cases by means of a rubidium

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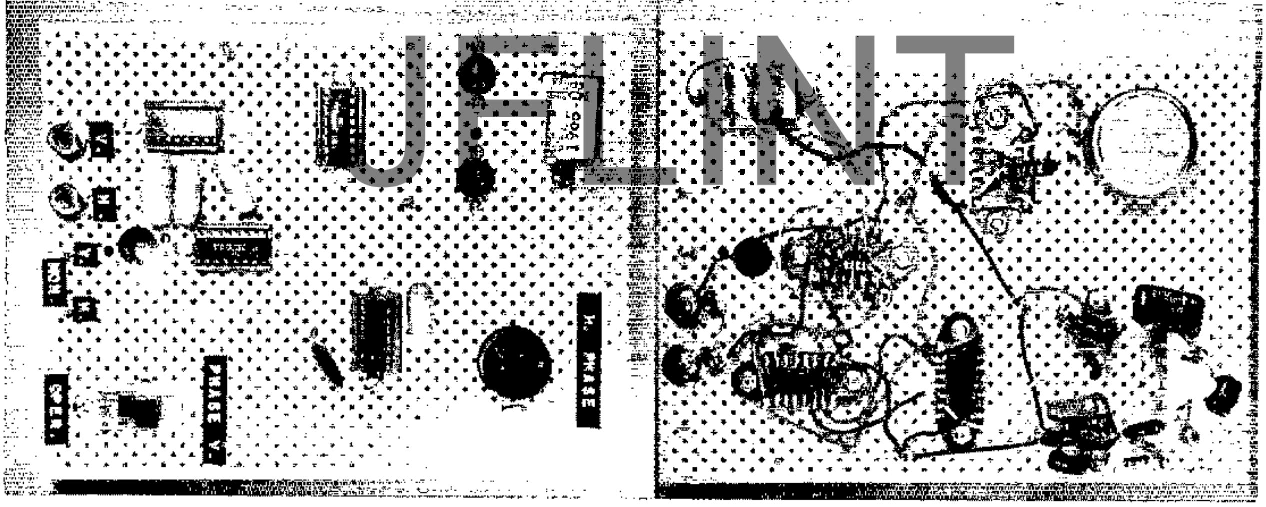


Top and bottom views of the sync generator with COS/MOS IC dividers. Perforated board, IC sockets, and point-to-point wiring were used in the construction. The crystal oscillator is positioned at the right on the board, with the vertical and horizontal sync outputs available at the left.

standard). Note that in all cases the calculated horizontal picture shift per minute is so small as to be imperceptible.

One might ask if the use of a 60-Hz reference frequency from the power line might not serve as well as the crystal-controlled source. If all stations involved in the SSTV exchanges were on a common phase-locked system, the answer would be yes. It is well known, however, that while the average timing accuracy of the public utilities service is very good, the nominal frequency increases or decreases by modest amounts over given time intervals. A horizontal shift of 10% of the picture width could be experienced if a 0.1-Hz shift of line frequency occurs during a one-minute time period. It is, therefore, considered more practical to utilize a stable local source such as a crystal oscillator, especially since a controllable amount of frequency shift can be obtained at will if it is required. A block diagram of the basic sync system using COS/MOS dividers is shown in Fig. 1.

It may be seen that the system is simple and straightforward. The dividers provide the frequency countdown. Wave-shaping circuits provide driving pulses of desired duration. A pair of monostable multivibrators is used to make up the horizontal phase shifter. Vertical phasing is produced manually with a momentary-action switch, S1. When the switch is depressed, the dividers are reset to zero.

Circuit Description

Two versions of the sync generator were developed. One version uses two COS/MOS 14-stage ripple counters, and the other version uses TTL dividers. The COS/MOS version is much more compact and easier to build. However, if the COS/MOS counters are difficult to purchase, some

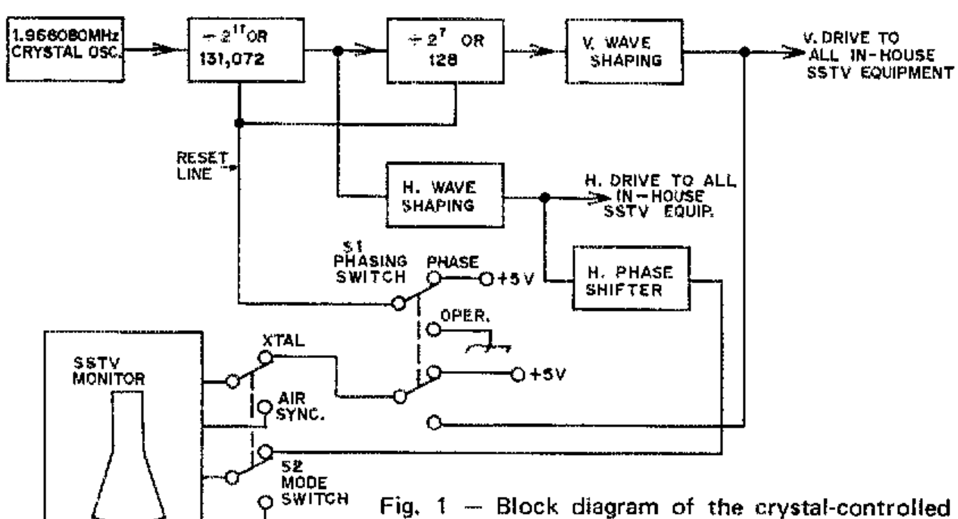


Fig. 1 — Block diagram of the crystal-controlled sync generator for SSTV with COS/MOS frequency dividers.

TABLE I

MO Freq.,	**Mult.*	**Division*	*Nominal Hor. Freq., Hz*	***Max. Hor. Pic. Shift/Minute*	****Field Rate,Hz*
1.000,000	–	2^{16} or 65,536	15.259	0.12%	0.11921
1.966,080	–	2^{17} or 131,072	15.000	0.06%	0.11719
3.579,545	4	955,500	14.985	0.034%	0.11707
5.000,000	9	3,000,000	15.000	0.024%	0.11719

*Total multiplication and/or division required to obtain nominal hor. frequency.
**Based on 20-Hz MO frequency difference between stations.
***Based on 2^7 division of specified horizontal frequency.

of the more readily available TTL ICs can be used. It ends up that the comparative cost between the two versions is not greatly different. Fig. 2 is the schematic diagram for the COS/MOS unit; Fig. 3 is that of the TTL unit. The CA3096 transistor array used in the COS/MOS version could also be used with the TTL unit, or individual discrete transistors substituted for the output system of the COS/MOS unit. Physical comparisons of the two units are seen in the photographs.

Connecting the System into a Station

Some elementary knowledge of the operation of the SSTV monitor, camera, and/or flying-spot scanner systems is desired if the system is to be

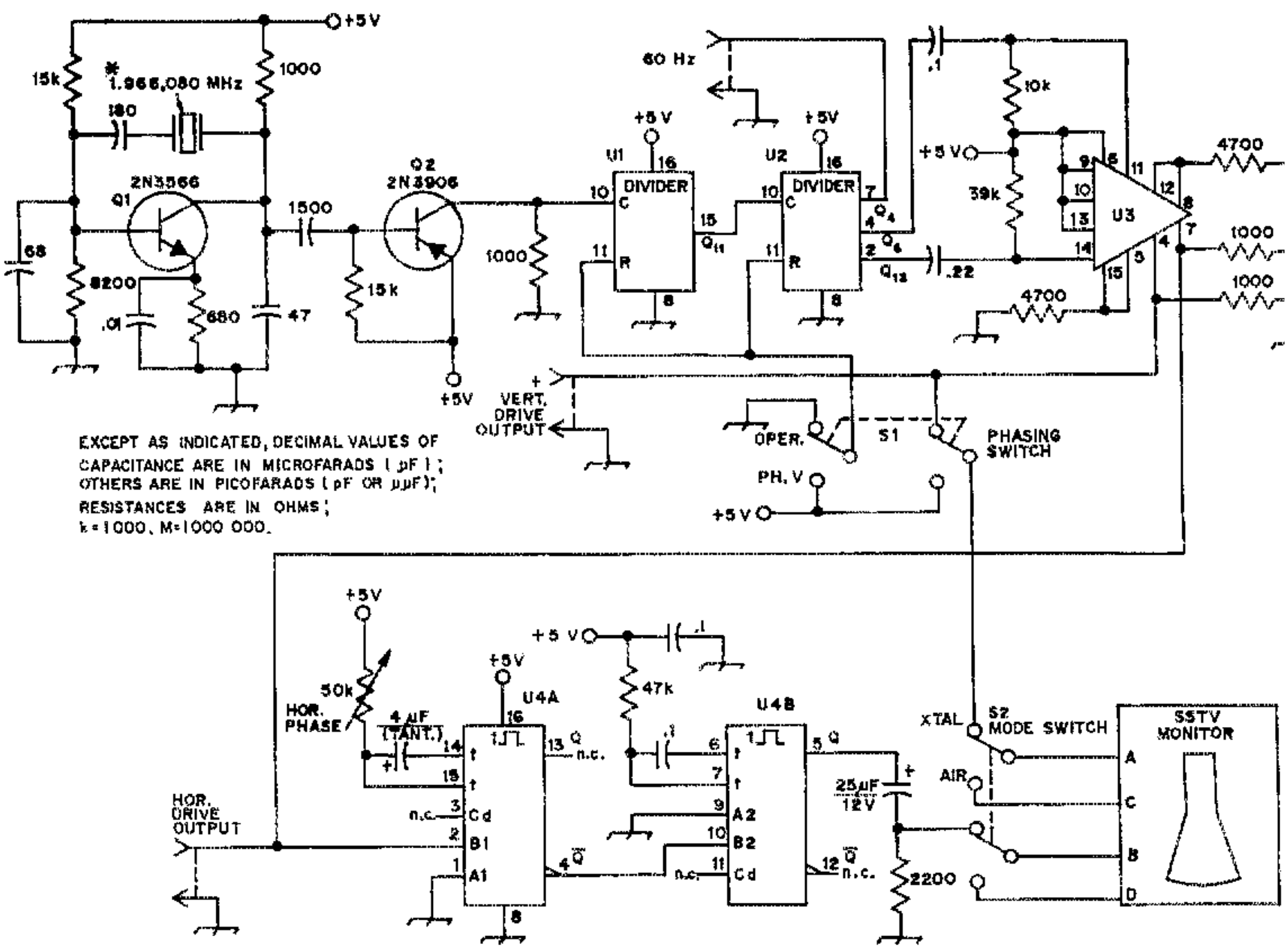


Fig. 2 — Circuit diagram of sync generator with COS/MOS IC dividers. A 7-45 pF trimmer connected in shunt with the crystal will provide for about 100 Hz of frequency-adjustment range, if desired.
U1, U2 — RCA CD4020 or Motorola MM5620 or equiv.
U3 — Transistor array, RCA CA3096 or equiv.
U4 — TTL monostable multivibrator, type 74123.

properly implemented. Horizontal and vertical drive signals from the sync generator are used to drive all cameras or flying-spot scanners in the station. The SSTV monitor is driven by the horizontal and vertical drive signals supplied via the horizontal phase shifter and the vertical phasing switch.

Representative connections to several different monitors and a typical camera are as follows:

W9LUO, Mark I Monitor

1) Open base leads to Q10 and Q16.

2) Connect terminal A of mode switch to base of Q10. Connect terminal B of mode switch to base of Q16.

3) Connect pin 6 of vert. monostable MV to terminal C of the mode switch. Connect pin 6 of hor. monostable MV to terminal D of the mode switch.

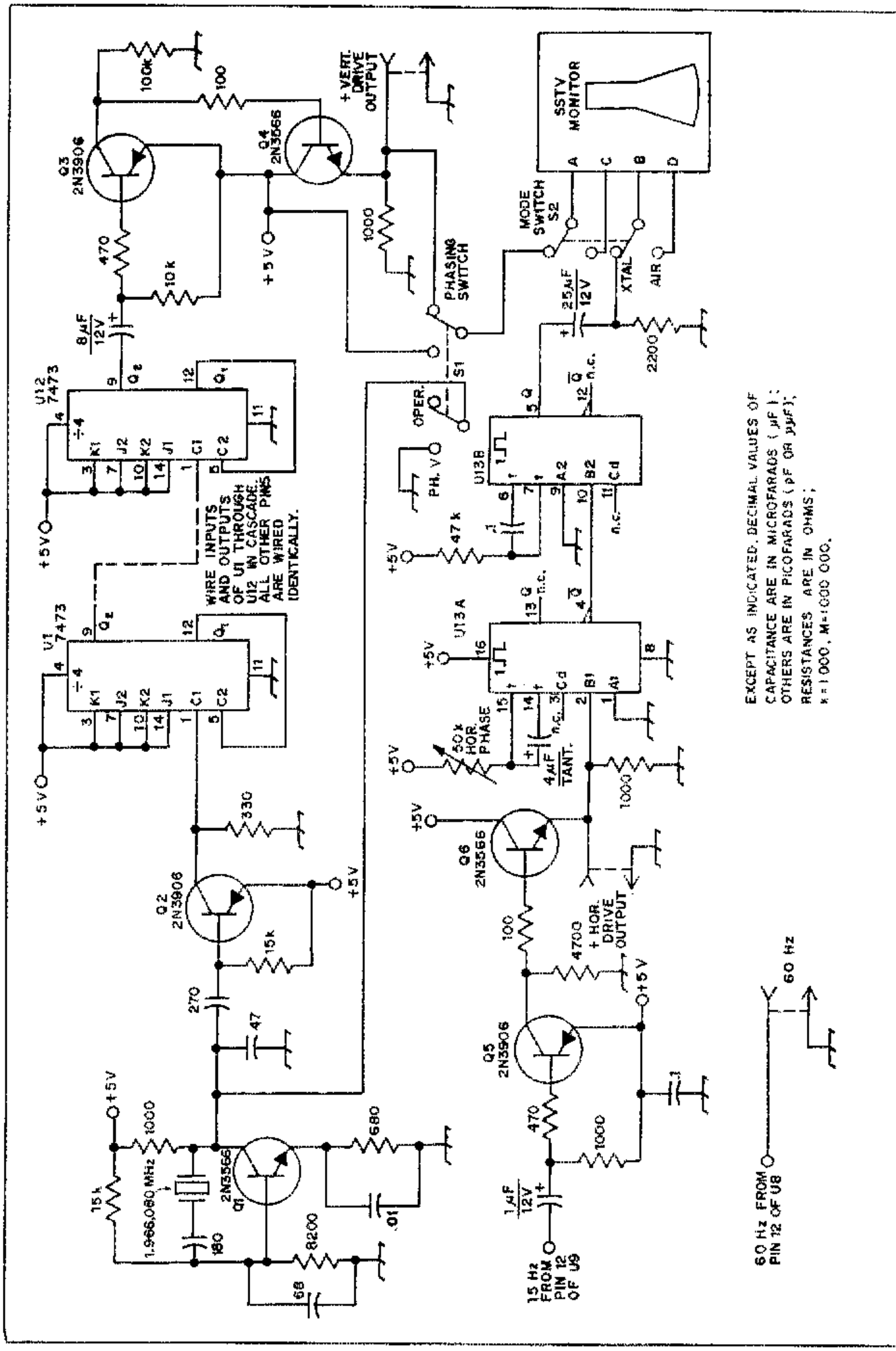
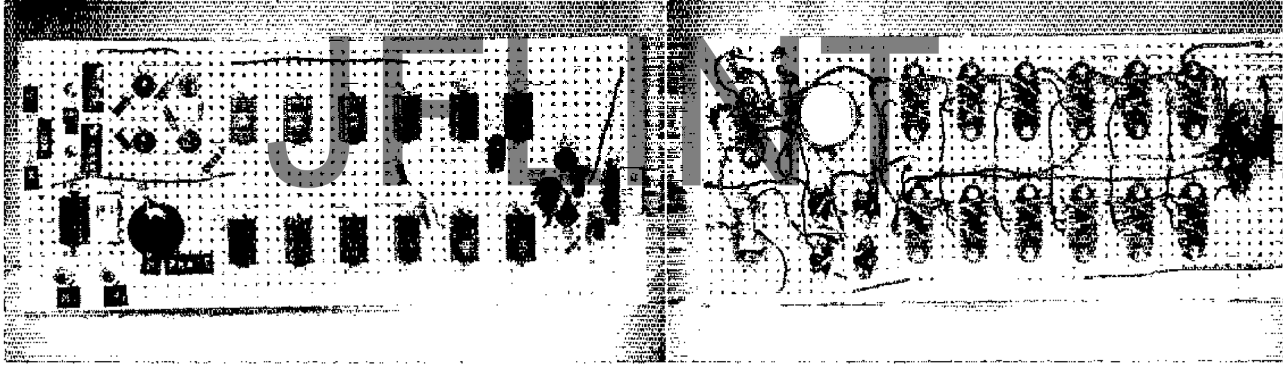


Fig. 3 — Circuit diagram of sync generator with TTL IC dividers. U1-U12, incl. — TTL dual *J-K* master-slave flip-flop, type 7473. U13 — TTL monostable multivibrator, type 74123.



Top and bottom views of the sync generator with TTL IC dividers. With 7473 dividers, twelve are required to obtain division by 2^{24}. With necessary wiring changes, the same division may be obtained with six 4-bit binary counter ICs, TTL type 7493. The dividers occupy the central section of the board, with the oscillator at the right and the outputs at the left.

W9LUO, Mark II Monitor

1) Open base leads of Q2 and Q5. (Do not disconnect 2200-Ω resistor at Q2.)

2) Connect terminal A of mode switch to base of Q5. Connect terminal B of mode switch to base of Q2.

3) Connect output from pin 8 of U5 to terminal C of the mode switch. Connect output from pin 14 of U2 through 0.1-μF capacitor to terminal D of mode switch.

Robot Model 70 Monitor

1) Open base lead to Q28. Connect this base to pin A of the mode switch.

2) Connect collector of Q15 to terminal C of mode switch.

3) Use negative hor. drive output from horizontal phase shifter of the sync gen. (This is obtained by moving the 25-μF output coupling capacitor from pin 5 to pin 12 of the 74123.)

4) Lift the end of C28 going to the sync source in the Model 70 and connect this lead to terminal B of the mode switch.

5) Connect the collector of Q2 in the Model 70 to terminal D of the mode switch.

Robot Model 80 Camera

1) Disconnect 60-Hz source end of R110.

2) Connect this lead to the 60-Hz output terminal of the crystal sync generator.

General Information on Connections

In cases where conventional discharge transistors are used to supply sawtooth driving waveforms to deflection output circuits, such stages may be driven from the 15-Hz and 1/8-Hz outputs of the sync generator. If the camera or flying-spot scanner contains a sync generator that is normally driven by a 60-Hz source, the 60-Hz output from the crystal sync generator can be used to drive at this point.

Operating the System

While full advantage of interference-free performance is achieved only between stations using similar crystal-control systems, either one of the two generators described is an excellent sync source for any ham SSTV station. When operating with crystal-controlled sync, it is necessary to establish correct vertical and horizontal phasing. A couple of frames are transmitted by one station as the other station closes his vertical phase switch and waits until he hears the vertical sync pulse, at which time he releases the switch or push button. The horizontal phase is then adjusted to properly position the picture with respect to retrace. The second station then sets the horizontal phase on his monitor. After this, operation may be carried on for extended periods without further adjustment.

If, during operation, a blanking bar were to appear near the left of the received picture and show a slow drift to the right, this is an indication that the local master oscillator frequency is substantially greater than that of the transmitting station; conversely, if a blanking bar appears near the right and shows a slow drift to the left, the local master oscillator frequency is lower than that of the transmitting station. (If the two master oscillators are within 100 Hz of each other, it will be difficult to see any shift during a several minute transmission.)

Conclusion

The independent crystal-controlled SSTV sync system described above offers synchronizing performance to the SSTV enthusiast that is totally immune to "on the air" interference. It is reasonable to visualize an extension of this concept to ham SSTV networks phase locked to precision standards, thereby offering a new dimension in SSTV synchronizing performance. QST

Strays

Join the fun on Straight Key Night, a six-hour stretch starting at 0100Z July 4. Remember this is the evening of July 3, local time. Check page 95, June *QST*, for details.

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