Single Sideband Modification for The AN/ARC-38

Single sideband methods have been in use in wire carrier telephones for approximately 40 years, and in low-frequency transoceanic telephone systems for about 30 years. Developments in frequency stability standards and filters since 1936 have made possible the single sideband method of transmission for point to point fixed ground station and shipboard stations with such success that it has been suggested that single sideband methods be utilized for all point-to-point radio telephone applications below 30 megacycles.

Although single sideband will not solve all the problems associated with long-range voice communication, it does offer many benefits. These include spectrum conservation, elimination of the high power carrier resulting in better power efficiency of the intelligence bearing sidebands, more durable signals in the presence of difficult propagation conditions, and reduced equipment size for a given speech power. Single sideband does have some inherent problems. To mention the most difficult, extremely stable circuits are required in the transmitter, and complex automatic frequency control circuits are required in the receiver, and demodulation difficulties result when no carrier is transmitted. The Coast Guard has made limited use of single sideband for ground and shipboard use, which lead to a study of the advantages and disadvantages of single sideband equipment for aircraft. Examination of the conventional AN/ARC–38 indicated that it could be modified to include a single sideband mode of operation. A modification program included several advantages over procurement of new equipment.

The modified AN/ARC–38 would require no "debugging" period, as it would be composed of some unchanged and some electrically changed modules using existing and evaluated parts, in circuits which have already proved to be reliable.

Logistic support for the AN/ARC–38 is already available. The additional spare stocks could be made available concurrently with production.

Maintenance personnel have already been trained on AN/ARC–38, so little additional training would be required.

No aircraft rewiring would be required.

New power supplies and antenna couplers would not be required.

The converted set would permit communications on AM or CW with existing stations not possessing single sideband capability.

Production sets could be made available in roughly half the time required to produce all new equipment.

Sets now located in spares stock could be used for the initial production pool.

Single sideband capability would be available with little compromise in original performance.

These factors all leaned heavily on modification of the AN/ARC–38 over procurement of new equipment. Private industry was approached, and the Radio Corporation of America was the successful bidder on a request for quotation to modify three equipments for evaluation. RCA had just completed a contract for the Air Force modifying the AN/ARC–21 high-frequency transceiver for single sideband operation and were well experienced in such a program. Three standard AN/ARC–38's were shipped to RCA and a project was established at NADC Johnsville for qualification testing and evaluation. Full qualification testing was carried out concurrently with a flight evaluation by a Navy Barrier Squadron. After some minor modifications, the equipment passed all tests. The AN/ARC–38 is at this time the only qualified airborne single sideband equipment.

Modification Required

The modifications required to existing AN/ARC–38's to give them single sideband capability are not overly extensive. No change is required in the dynamotor power supply DY–118/ARC–38 nor in the antenna coupler CU–351/AR. The remaining units are to be canged as follows:

No mechanical changes are made in the radio set control C–1398/ARC–38 (master control). However, to add the single sideband mode, slight electrical changes are required.

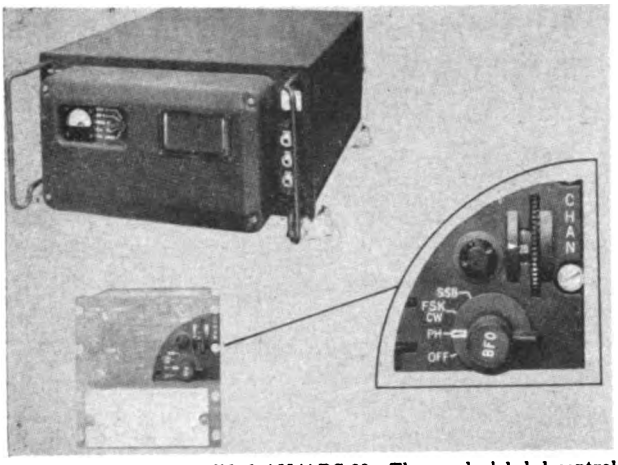

Figure 1. An RCA modified AN/ARC-38. The newly labeled control panel function switch is the only change visible to the operator.

The switch position marked "CWS" (CW sharp) becomes "SSB". Certain connections on the volume control switch wafer S2402 were moved to insert the audio "T" pad attenuator in this position. A jumper was added to switch S2405G so that rotation of the "Local-Remote" switch does not throw the set into AM only. A small overlay, covering the original switch function markings shows the following: "OFF, PH, FSK, CW, SSB", Figure 1.

Since the original radio set contained only voice mode, no function selection knob exists on the remote control panel C–1399/ARC–38. At this location, therefore, it was considered uneconomical to provide optional single sideband or AM selection because new leads would be required in the aircraft.

Instead, it has been proposed that the procedure for mode selection be accomplished in the following manner: Assuming that C–1399/ARC–38 is installed at the pilot's position, procedures now require that the pilot request the operator to switch the C–1398/ARC–38 to "Remote" in order to give him control of the AN/ARC–38. As presently wired, C–1398/ARC–38 performs this transfer but at the same time selects "Phone" mode. As modified, the pilot would not only request control, but at the same time, request either SSB or AM mode to be selected on the master control unit. If this procedure is used, no changes to the C–1399/ARC–38 are required.

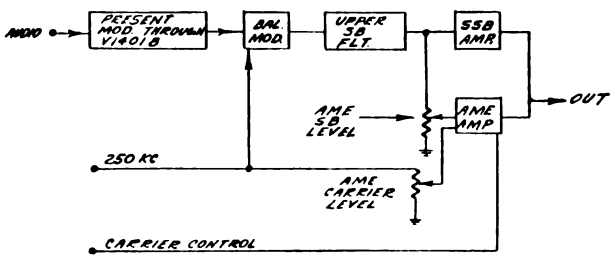

Figure 2. A block diagram of a SSB modified AN/ARC-38 modulator.

The following changes will be made to the modules in the RT–311/ARC–38 radio receiver;

Main chassis. The chassis base will not be altered. However, the modulation transformer is removed, and in its place is mounted an octal socket to hold the master crystal assembly. Also, certain wiring is rerouted to accommodate the new mode. Where tight cabling does not permit easy removal, new wires are run and tied outside the bundle.

Tuner subassembly. No mechanical changes of any sort are required. Very minor wiring changes are made to adjust the biasing for SSB operation.

Audio amplifier subassembly. No changes are required on this module.

Servo amplifier subassemblies. These modules are also unaffected by the conversion. No changes are required.

Relay subassembly. Minor wiring changes of some relay contacts are required to permit switching of the SSB mode.

Power Amplifier Subassembly. No mechanical changes are necessary on this module. However, the sidetone diode is disconnected, as voice sidetone is derived from the modulator. Bias for the amplifier tubes is reset for optimum class AB_1 operation, and a sampling diode is added to monitor the signal level at the power amplifier grids.

I-F amplifier subassembly. Some minor mechanical changes are made here. The narrow mechanical filter is removed and replaced with a filter approximately 3-kilocycles wide. A mixer tube is added for use as a SSB demodulator. The 250-kilocycle heterodyne voltage is connected to the SSB demodulator, and the time constant of the AVC (automatic volume control) circuit is lengthened to accommodate the suppressed carrier SSB signal.

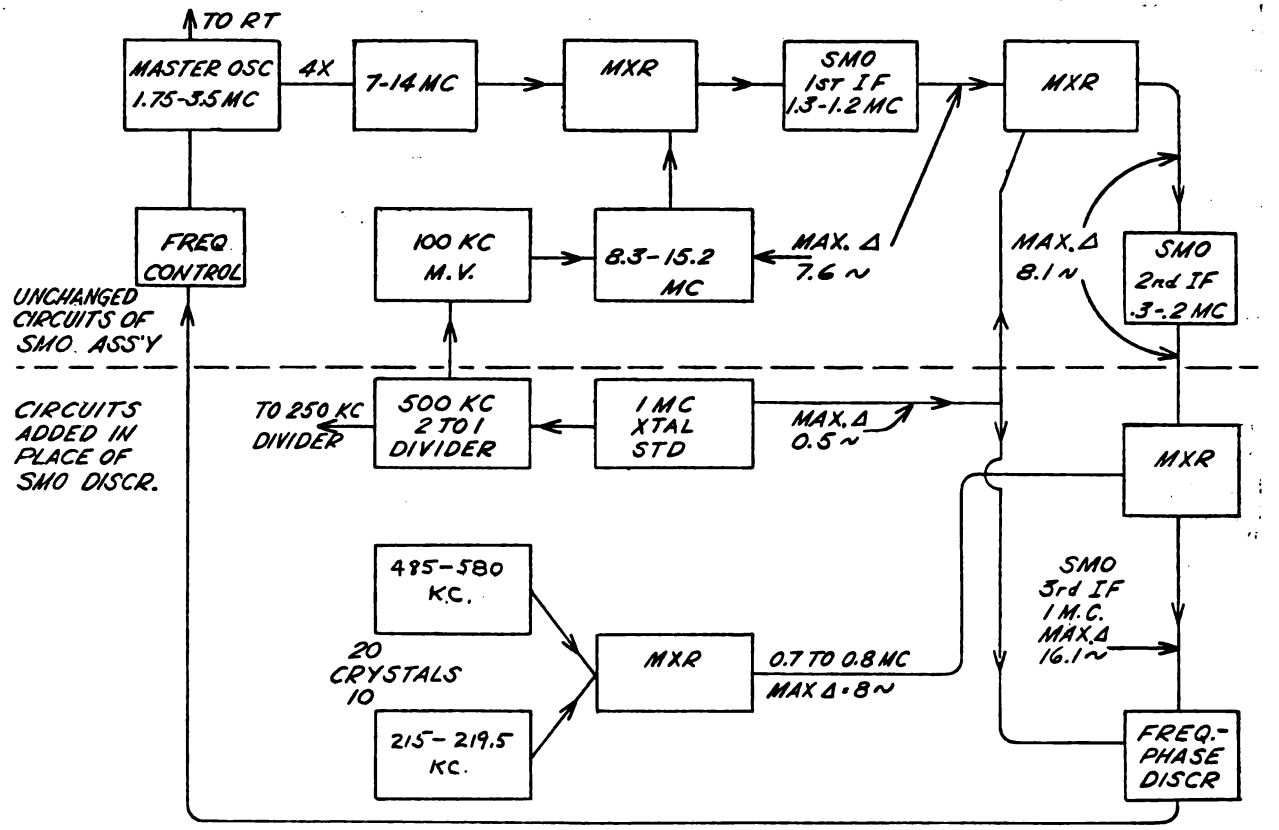

Figure 3. A block diagram of a stabilized master oscillator modified for crystal interpolation.

Modulator subassembly. The two 6159 power pentodes, their sockets, components, and the tube shelf are removed, as are the resistor and capacitor components formerly used by V1403. The vacated space is then used for installation of a new bracket to hold new components for a 250-kilocycle balanced modulator and components. As shown in Figure 2, an upper-sideband mechanical filter, level adjustment potentiometers, carrier gating tube, 250-kilocycle output circuit, and sidetone circuit are added.

250-kilocycle oscillator and BFO subassembly. No mechanical changes required. The 250-kilocycle crystal assembly is removed, and the stage reconnected as a two-to-one frequency divider (500 kc to 250 kc).

SMO servo amplifier subassembly. This unit is deleted, as the circuit which was used to position the stabilized master oscillator required no amplifier.

SMO 500 kilocycle oscillator subassembly. The crystal unit installed on the unmodified AN/ARC–38 is not capable of furnishing adequate stability for SSB operation. Crystal Y2001 is therefore removed and the stage reconnected as a 500- to 100-kilocycle frequency divider, Figure 3.

Stabilized master oscillator assembly. Minor modifications were required. The SMO discriminator subassembly is removed at its shaft drive coupling, and in its place a unit which connected to the same drive coupling is mounted. In this manner, the added switches can be positioned in a manner identical to the discriminator in the original equipments.

Master crystal assembly. A separate stable frequency source is added. This unit is the same crystal oscillator assembly now in production for use by the AN/ARC–65 (Air Force). It consists of a plug-in assembly which houses a precision crystal, transistor oscillator, and transistor buffer stage in a single oven. Two thermostats control separate booster and cycling heaters and maintain the oven at 75 C in any ambient temperature. The unit generates a frequency of 1 megacycle and

maintains a stability of ±0.5 cycles. Although this "package" is hermetically sealed, it contains a soldered plug bottom which may be opened if necessary for resetting the crystal after long use.

Table 1 summarizes the characteristics of the modified AN/ARC–38.

Table 1. A summary of the characteristics of the SSB-modified AN/ARC–38.

Frequency range	No change
Number of channels	No change
Frequency change method	No change
Frequency stability	1.13 cycles per megacycle
Voltage requirements	No change
Curent requirements	No change
R-F power output	100 watts PEP (SSB)
R-F output impendence	No change
Types of emission	SSB, AME, CW
Audio characteristics	No change
Channeling time	3-second increase (approximate)
Spurious radiation	No change
Environment performance	No change
Sidetone	Keyed 400 cps in CW: Direct audio in SSB or AME
Sensitivity	No change
Sensitivity control	No change
AVC	6 db; 10 to 100,000 μv
Selectivity	SSB: 2.85 kc at 6 db; 6 kc at 60 db. CW and AM: 6 kc at 6 db; 12 kc at 60 db
I-F rejection	No change
Image rejection	No change
Audio output	No change
Noise limiting (AM only)	No change
CW reception	No change

Test Equipment

Some of the test equipment listed on page 13 of the recent AN/ARC–38 Handbook of Service Instruction NAVAER 16–30ARC–38–502 will be modified for alignment and test of the SSB transceiver. This modification will be carried out in such a manner that the test equipment will accommodate the standard AN/ARC–38 in addition to the SSB unit. For frequency measurement, the AN/USM–26 or an equivalent commercial counter will provide measurements with adequate accuracy for good quality voice communications. Precise frequency measurement can be achieved using this equipment, if a short-time calibration is made using WWV as a standard. Directions for doing this are included in the instruction books of the AN/USM–26 and its commercial equivalent.

It is expected that an initial quantity of modified AN/ARC–38's will be delivered early this year. Present plans call for use of this equipment both in the aircraft and at selected aero radio stations as an interim measure pending procurement and installation of ground station SSB equipment. Ultimate plans include single sideband capability in most Coast Guard aircraft.

Mercury Dry Cell Batteries[1]

Under certain conditions, mercury dry-cell batteries will explode. Although cases and caps have been blown about storerooms by batteries which exploded while standing idle, the possibility of explosion exists mostly in the misuse of this type of battery. Explosion hazards are not usually present during ordinary usage.

Military mercury dry batteries can be identified by the letters BA followed by a four-digit number starting with the numeral 1, for example, BA–1328.

An explosion may be caused by overheating or ignition of hydrogen gas. Merely heating a mercury dry battery to 400 F will cause it to explode. Such heating may result from shorting a battery or a cell.

Hydrogen-gas evolution from individual cells within a multicell battery usually occurs when such cells are forced to pass current after the end of their useful life. This dangerous condition may occur when one or more individual cells are weaker than the rest. These weak cells tend to reach the end of their life sooner than other cells.

When passing current, the weak cells act as resistors and electrolyze the water in the cell. The electrolysis forms oxygen and hydrogen gasses. The oxygen is absorbed in the cell by combining with the zinc anode, but the released hydrogen may build up pressure in the unvented cell. An explosion occurs if this compressed hydrogen gas is subjected to sufficient heat or to a spark.

Reports on explosions of mercury dry-cell batteries are rare, but the possibility exists. To

[1] Reprinted from Bureau of Ships Journal.