Exhibit B - Section 2.1033 (c) Technical Report

1. Name and Address

The name and address of the manufacturer of the TTR-921 and TTR-4000 TCAS II Receiver-Transmitter and applicant for certification is Rockwell Collins, Inc., 1300 Wilson Boulevard, Suite 200, Arlington, Virginia 22209.

2. FCC Identifier

FCC ID	Description
AJK8221293	**TCAS II Receiver-Transmitter**

3. Installation and Operation Manuals

See Exhibit C.

4. Type(s) of Emission

The TCAS II emission type is V1D. Pulses emitted by the TTR-921 and TTR-4000 vary in width and amplitude, and contain angle modulation during the pulse. It is a single channel containing digital information without the use of a modulating subcarrier. The type of information transmitted by TCAS II systems is data only.

Due to the relatively complex nature of the signals transmitted by the TTR-921 and TTR-4000, there is no one single formula that can predict the necessary bandwidth. The modulation with the fastest temporal characteristic, and thus the greatest effect on frequency domain, is the binary phase shift keying which occurs during Mode S transmission.

Sam K. Shanmugam and John Wiley maintain that: "…the shapes of the psd of the binary PSK signal and the ASK signal are similar. The only difference is that the PSK spectrum does not have an impulse at the carrier frequency. The bandwidth requirement of the PSK signal is the same as that of the ASK signal."[1] Accordingly, we believe the formula from the procedures of Report 836 of the International Radio Consultative Committee, "Recommendations and Reports of the CCIR," 1982 accurately predicts the necessary bandwidth for a BPSK pulse as well as for an unmodulated pulse. Since the RTCA DO 185-A specifies no minimum switching time, the formula for a rectangular pulse will be used. Considering that the spectrum of a group of pulses falls within the envelope defined by the spectrum of a single pulse, the formula

$$Bn = 6.36 / t$$

is employed, where Bn is the necessary bandwidth, and t is the pulse width. The narrowest chip permitted by RTCA DO-185A has t = 230 nanoseconds. The necessary bandwidth then becomes Bn = 27.65 MHz. Thus the complete emission designation according to Section 2.201 and 2.202 is 27M7V1D.

5. Frequency Range

The transmission frequency is 1030 $\pm$ 0.01 MHz.

[1] Shanmugam, Sam K. Wiley, John, "Digital and Analog Communications Systems, " 1979, p. 403.

6. Range of Operating Power Values

Assuming full power operation, the total RF power at the TTR-921 and TTR-4000 ARINC RF power terminals is +55.25 dBm maximum and +51.25 dBm minimum.

The TTR-921 and TTR-4000 are used in conjunction with standard aircraft systems and with standard TCAS antennas. In a typical installation, the antenna gain is 3.25 dB and the cable loss is 2.5 dB.

The power-gain product or Effective Radiated Power (ERP) in the forward direction associated with each radiated transmission pulse shall be a maximum of +56 dBm (400 W), and a minimum of +52 dBm (160 W), assuming full power operation.

The power-gain product is related to Total Radiated Power (TRP), a variable used in the interference limiting algorithms, according to the following expression:

$$TRP = P*G(BW/360 \text{ deg})$$

where P is the net power delivered to the RF reference point; G is the peak azimuth antenna gain at 0 degrees elevation relative to a matched quarter wave stub (P*G is the power-gain product); and, BW is the 3 dB azimuth beam width in degrees. The specified limit on radiated power is intended to prevent excessive power transmission from causing premature interference limiting and, in turn, an unnecessary reduction in the dynamic range of the whisper-shout sequence.

The TCAS transmitter-receiver has a transmit/listen cycle of approximately 1 second. In each cycle, a series of increasing-power mode C interrogations is first transmitted. This is the whisper/shout (w/s) sequence. Either a listen period, or a mode S interrogation or reply followed by a listen period immediately follows. During the listen period, the transmitter-receiver listens for squitter signals and for interrogation replies from other aircraft transponders. If no signals are heard during this listen period, no interrogations or replies are transmitted. If signals are heard, a roll-call list of transmitting aircraft is compiled. (Mode S transponders transmit data that uniquely identifies the replying aircraft. This identification data is used by the TCAS to address only that aircraft when needed.) The transmitter-receiver will, at the beginning of the next interrogate/reply/listen portion of the cycle, transmit interrogations to aircraft in the roll-call list. After the transmission(s), the rest of the cycle is spent in the listen mode.

7. Maximum Power Rating as Defined in Part 87

Section 87.131, Power and emissions, does not specify maximum power for TCAS equipment. Instead, pursuant to table footnote no. 7, frequency, emission, and maximum power will be determined by appropriate standards during the certification process.

The appropriate standard for TCAS equipment is RTCA DO-185A. DO-185A calls for effective radiated power (ERP) of 56 dBm (400 watts). Accounting for standard TCAS antenna gain of 3.25 dB and cable loss of 2.5 dB, the maximum total transmitter output should be 55.25 dBm (298.5 watts).

8. Final Amplifier DC Voltages and Currents

The final stage consists of a 2-way power splitter, a pair of final transistors, and a 2-way power combiner. The dc voltage for each transistor is 48.0 VDC. The dc current under maximum pulse power conditions is 19.8 Amp DC.

9. Tune Up Procedures

See Exhibit D.

10. Schematics and Circuit Diagrams

See Exhibit E.

11. Nameplate Bearing the FCC ID and Placement

See Exhibit F.

12. Equipment Photographs (2.1033 (c) (12))

12.1 External Views

See Exhibit G.

12.2 Internal Views

See Exhibit H.

13. Description of Modulation System

Transmit Pulse Characteristics

Mode C Transmissions

Mode C interrogations from TCAS II equipment shall employ the "Mode-C-Only All-Call" format, which consists of three pulses P_1, P_3, and P_4. This shall normally be preceded by a Mode C "whisper-shout" suppression pulse designated S_1. Sidelobe suppression is accomplished by transmitting a P_2 pulse via a separate control pattern. These formats are illustrated in Figure 1. The pulses shall have shapes and spacings as tabulated below except that the rise and decay time may be less than shown in the table, providing the side-band radiation does not exceed the spectral limits tabulated in subparagraph 2.2.3.3 of DO-185A. The amplitude of P_3 shall be within 0.5 dB of the amplitude of P_1, and the amplitude of P_4 shall be within 0.5 dB of the amplitude of P_3. The amplitude of S_1 is specified in subparagraph 2.2.4.5.4.1 of DO-185A.

Mode C Pulse Shapes

(All values in microseconds)

Pulse Time Designator	Pulse Duration	Duration Tolerance	Rise Time Min.	Max.	Decay Min.
Max S_1, P_1, P_2, P_3, P_4 0.2	0.8	± 0.05	0.05	0.1	0.05

Figure 1 Mode C-Only All-Call Interrogation Pulse Sequence For TCAS

The pulse spacing tolerances shall be as follows:

S_1 to P_1	2 ± 0.10 microseconds;
P_1 to P_2	2 ± 0.10 microseconds;
P_1 to P_3	21 ± 0.10 microseconds;
P_3 to P_4	2 ± 0.04 microseconds.

Note: The tolerance values on these pulse widths, spacings, and amplitudes are smaller than the signal-in-space tolerance values defined in Ref. B in order to provide margin for waveform distortion due to multipath.

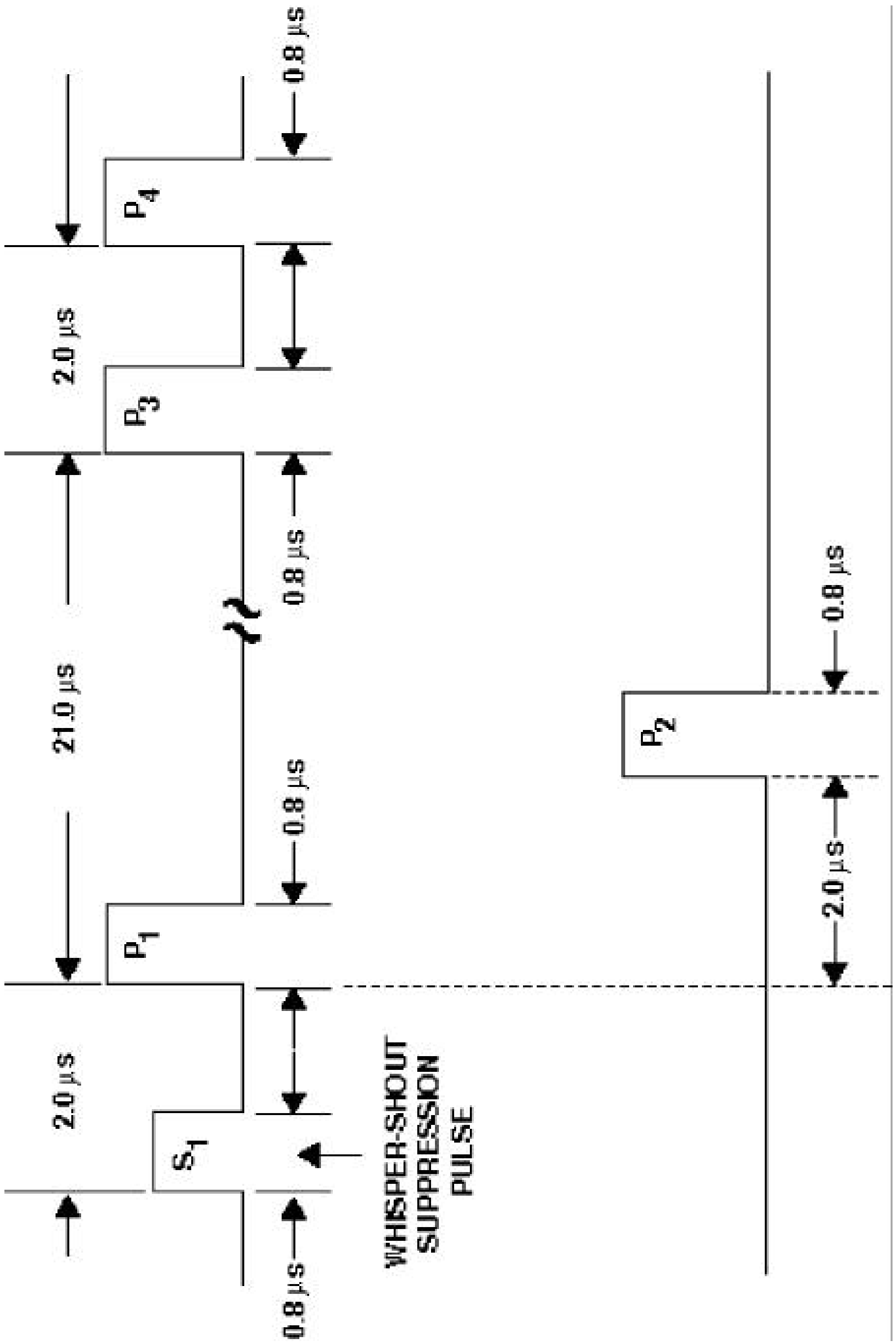


Figure 1 Mode C-Only All-Call Interrogation Pulse Sequence For TCAS

Mode S Transmissions

Mode S transmissions shall consist of P_1, P_2, and P_6 pulses as shown in Figure 2. The pulses shall have shapes and spacings as tabulated below except that the rise and decay time may be less than shown in the table, providing the side-band radiation does not exceed the spectral limits tabulated in subparagraph 2.2.3.3.

Mode S Pulse Shapes

(All values in microseconds)

Pulse Designator	Pulse Duration	Duration Tolerance	Rise Min.	Time Max.	Decay Min.	Time Max.
P_1, P_2	0.8	± 0.05	0.05	0.1	0.05	0.2
P_6 (Short)	16.25	± 0.125	0.05	0.1	0.05	0.2
P_6 (Long)	30.25	± 0.125	0.05	0.1	0.05	0.2

The short (16.25-microsecond) and long (30.25-microsecond) P_6 pulses shall have internal modulation consisting of possible 180-degree phase reversals of the carrier at designated times. The first phase reversal in the P_6 pulse is the sync phase reversal and is always present. The presence or absence of a subsequent phase reversal indicates a one or zero in the transmitted code respectively.

Note 1: The sync phase reversal is the timing reference provided to identify chip positions to Mode S interrogation decoders.

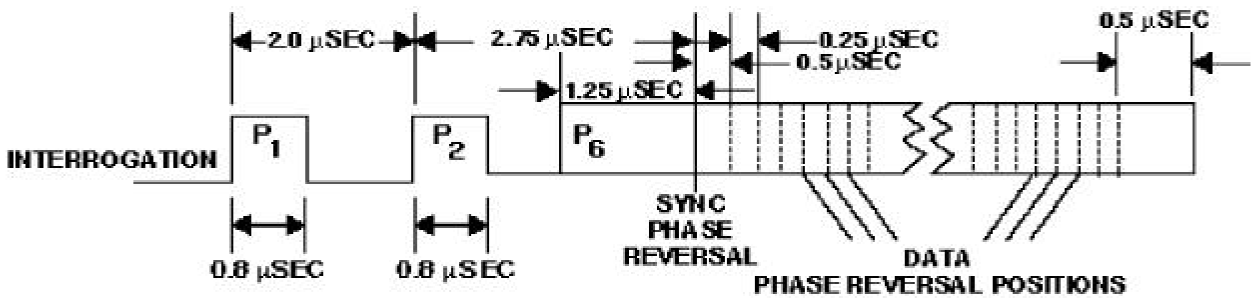
The duration of a phase reversal in P_6 shall be less than 0.08 microsecond as measured between the 10-degree and 170-degree points of the phase transition. The interval between the 80-percent points of the amplitude transient associated with the phase reversal shall be less than 0.08 microsecond.

The tolerance on the 0- and 180-degree phase relationships in P_6 shall be ±5 degrees.

The 90-degree point of each data phase reversal in P_6 shall occur only at a time (N x 0.25) ± 0.02 microsecond (N .GE. 2) after the 90-degree point of the sync phase reversal.

Note 2: 56 or 112 data phase reversals can occur in the 16.25 and 30.25-microsecond P_6 pulses respectively. This results in a 4 Mbit/sec data rate within the P_6 pulses.

The spacing from P_1 to P_2 shall be 2 ± 0.04 microseconds between leading edges. The spacing from the leading edge of P_2 to the 90-degree point of the sync phase reversal of P_6 shall be 2.75 ± 0.04 microseconds. The leading edge of P_6 shall occur 1.25 ± 0.04 microseconds before the sync phase reversal.



<u>Figure 2</u> Mode-S Interrogation Pulse Sequence For TCAS

Note 3: *The P_1-P_2 pair preceding P_6 suppresses replies from ATCRBS transponders to avoid synchronous garble due to random triggering of ATCRBS transponders by Mode S interrogations. A series of "chips" containing the information within P_6 starts 0.5 microsecond after the sync phase reversal. Each chip is of 0.25 microsecond duration and is preceded by a possible phase reversal. If preceded by a phase reversal, a chip represents a logic "1". There are either 56 or 112 chips. The last chip is followed by a 0.5 microsecond guard interval which prevents the trailing edge of P_6 from interfering with the demodulation process.*

The radiated amplitudes of P_2 and the initial first microsecond of P_6 shall be greater than the radiated amplitude of P_1 minus 0.25 dB. The maximum envelope amplitude variation between successive phase modulation chips in P_6 shall be less than 0.25 dB.

Note 4: *The tolerance values on these pulse widths and spacings and the location of the sync phase reversal are smaller than the signal-in-space tolerance values defined in Ref. B in order to provide margin for waveform distortion due to multipath reflections.*

14. Required Measurements

See Exhibit I.