Exhibit # 1

Modulating Signal

The 1030 MHz signal is pulse modulated for Secondary Surveillance Radar interrogations, both ATCRBS and Mode S types, in accordance with ICAO Aeronautical Telecommunications Annex 10. The Rockwell Collins TTR-920 used to transmit on this frequency is certified by the FAA to be compliant with this specification.

Exhibit # 2

Modulating Signal

The 1090 MHz signal is pulse modulated for Secondary Surveillance Radar replies, both ATCRBS and Mode S types, in accordance with ICAO Aeronautical Telecommunications Annex 10. Both the King Air KT-70 and the Rockwell Collins TPR-720 transponder units are certified by the FAA.

Exhibit # 3

Necessary Bandwidth

Complete signals in space are specified in ICAO Aeronautical Telecommunications Annex 10, section 3.8.2.2., which is reproduced here for convenience. The necessary bandwidth is not derived for this application, but taken from this document.

Exhibit # 4

Necessary Bandwidth

Complete signals in space are specified in ICAO Aeronautical Telecommunications Annex 10, section 3.8.2.1., which is reproduced here for convenience. The necessary bandwidth is not derived for this application, but taken from this document.

Exhibit # 5

Background

Sensis Corporation has won a NASA Langley Research Center contract for an evaluation installation of an Airport Target Identification System (ATIDS - contract L70528D) at Detroit Metropolitan Wayne County Airport. The ATIDS system is used to estimate position and velocity and provide identification for all aircraft on or near the airport surface and provide a suitable display to the operator. Aircraft will be observed during all phases of movement or stoppage including arriving, departing, landing, exiting, taxiing, stopping and parking.

Principle of Operation

All aircraft operating at major airports are required to carry a secondary radar transponder as part of their avionics suite. These transponders broadcast their aircraft ID or altitude in response to a general interrogation (ATCRBS), a specific interrogation (Mode S), or pseudo-randomly on their own (Mode S squitter). ATIDS will capitalize on these transmissions by employing an array of receivers placed at strategic points about the airport and measuring the time difference of arrival (TDOA) of the transmissions. Once the TDOA is known for three or mores receivers, a position can be calculated using a triangulation technique. Each receiver site also will have transmitter capability to allow it to interrogate transponders. The remote units are referred to as receiver/transmitter, or R/Ts.

Mode S short squitters and Mode A/C multilateration are used to locate and identify aircraft. Mode S squitters are pseudo-randomly transmitted at a nominal rate of 1 Hz by suitably equipped aircraft.

R/T units receive these messages, time stamp them with a fine resolution clock, and decode the message content. The messages are then sent via modem to a Central Processing Station computer where the aircraft position is calculated using multilateration. Discrete Mode S interrogations are used at a low rate to obtain aircraft altitude and mode 3 code. ATIDS does not use discrete Mode S interrogations for tracking, nor does it use the all-call formats.

In order to maintain a 1 second update rate on ATCRBS targets, ATIDS must interrogate the Mode A/C transponders to elicit a reply. The transponder responds to R/T generated whisper-shout interrogation sequences to control synchronous interference. A sequence consists of 26 interrogation steps at different power levels. Suppression transmissions are used in each step to limit each aircraft to only one or two of the interrogations in the sequence. Interrogations are performed once per second using a round robin technique for choosing the R/T.

System Description

In an operational configuration, ATIDS consists of several R/T units, along with several receive-only (RO) units, deployed around the perimeter of the airport coverage area, a central Processing Station (CPS), a reference transponder, and modems linking the R/T and RO units to the CPS. The reference transponder, R/T and RO units are placed at surveyed locations so that long squitters transmitted by the reference transponder can be used to calibrate the system. Transmissions from the reference transponder are processed the same as those from aircraft, and the calculated position is compared to the known surveyed location, allowing calibration adjustment.

The R/T units are housed in weatherproof enclosures containing a TTR-920 TCAS unit, timing board, processor board, modem and cooling fans. The R/T enclosure measures 28 inches by 28 inches by 40 inches and is powered by 115 VAC. The RO units are similarly housed in weatherproof enclosures containing a receiver/decoder unit, timing board, processor board, modem and cooling fans. The RO enclosure measures 16 inches by 24 inches by 30 inches and is powered by 115 VAC

Demonstration Program

During operation of the ATIDS system, a reference transponder will squitter on 1090 MHz at a 1 Hz rate to provide timing information to the R/T and RO units. The ground bit will be set in the reference transponder so that it does not interfere with normal TCAS operation. The R/Ts interrogation rate will be limited such that the elicited fruit rate from air traffic will be less than 10 fruit per second per aircraft.

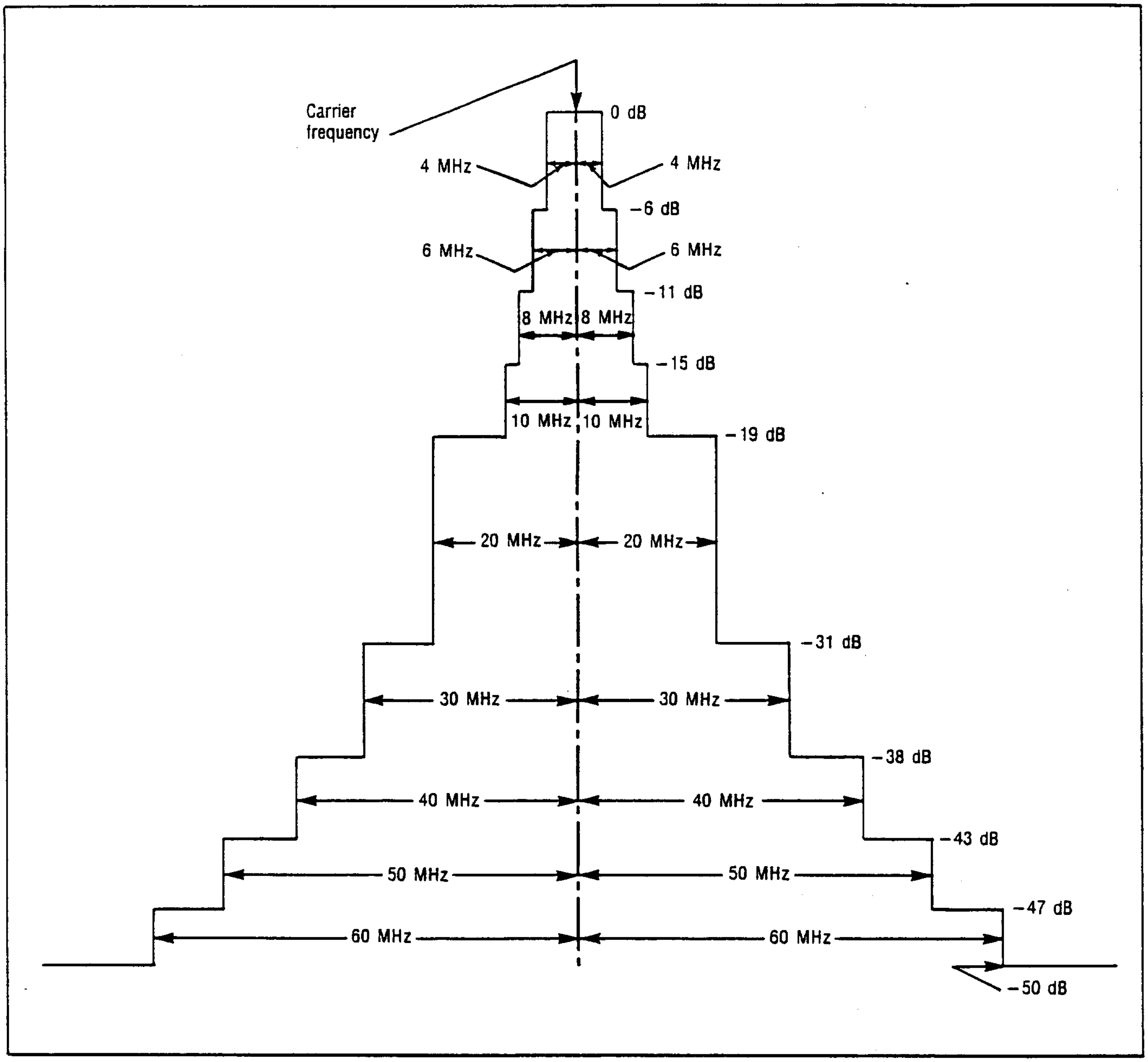


Figure 3-3.1. Required spectrum limits for interrogator transmitter

continuously the other critical parameters of the ground interrogator for any degradation of performance exceeding the allowable system tolerances and to provide an indication of any such occurrence.

3.8.1.11 *Spurious emissions and spurious responses*

3.8.1.11.1 *Spurious radiation*

Recommendation.— *CW radiation should not exceed 76 dB below 1 W for the interrogator and 70 dB below 1 W for the transponder.*

3.8.1.11.2 *Spurious responses*

Recommendation.— *The response of both airborne and ground equipment to signals not within the receiver pass band should be at least 60 dB below normal sensitivity.*

3.8.2 Systems having Mode S capabilities

3.8.2.1 *Interrogation signals-in-space characteristics.* The paragraphs herein describe the signals-in-space as they can be expected to appear at the antenna of the transponder.

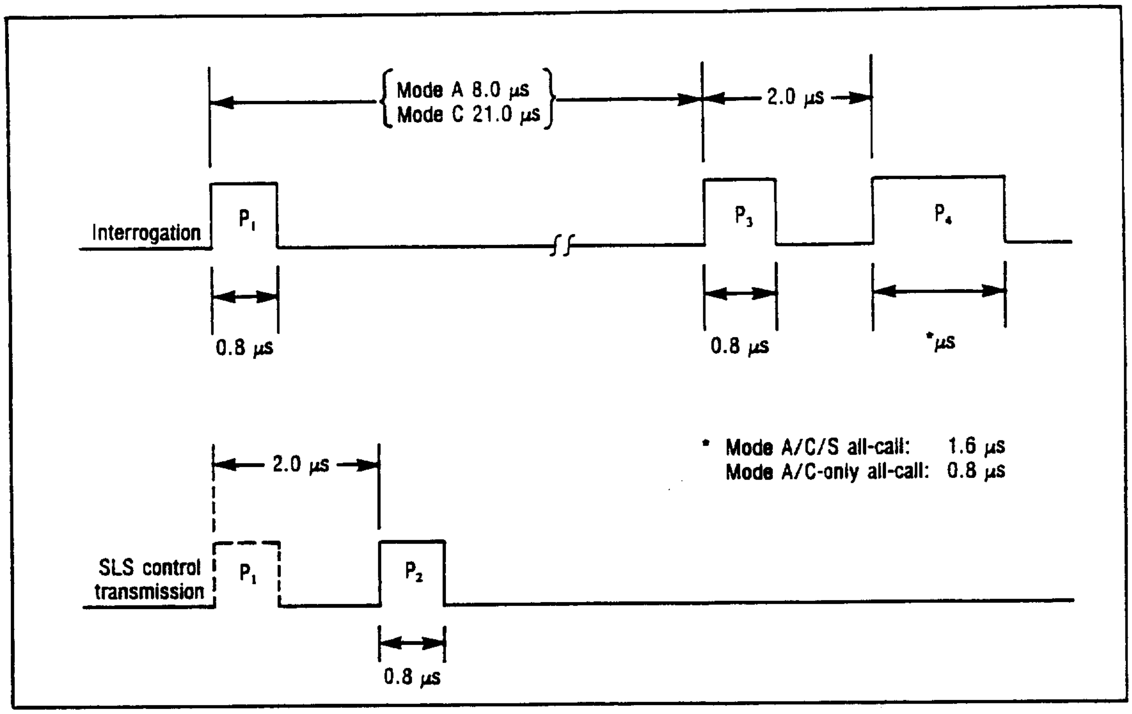


Figure 3-3.2. Intermode interrogation pulse sequence

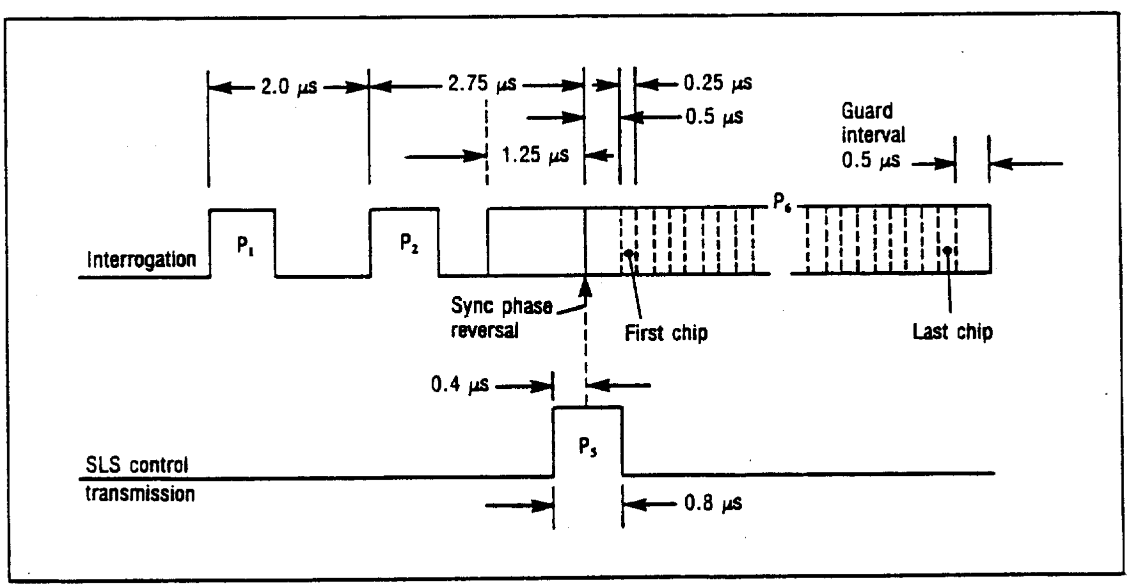


Figure 3-3.3. Mode S interrogation pulse sequence

Table 1. Pulse shapes — Mode S and intermode interrogations

Pulse	Duration	Duration tolerance	(Rise time) Min.	Max.	(Decay time) Min.	Max.
P_1, P_2, P_3, P_5	0.8	± 0.1	0.05	0.1	0.05	0.2
P_4 (short)	0.8	± 0.1	0.05	0.1	0.05	0.2
P_4 (long)	1.6	± 0.1	0.05	0.1	0.05	0.2
P_6 (short)	16.25	± 0.25	0.05	0.1	0.05	0.2
P_6 (long)	30.25	± 0.25	0.05	0.1	0.05	0.2

Note.— Because signals can be corrupted in propagation, certain interrogation pulse duration, pulse spacing and pulse amplitude tolerances are more stringent for interrogators as described in 3.8.2.11.4.

3.8.2.1.1 *Interrogation carrier frequency.* The carrier frequency of all interrogations (uplink transmissions) from ground facilities with Mode S capabilities shall be 1 030 plus or minus 0.01 MHz.

3.8.2.1.2 *Interrogation spectrum.* The spectrum of a Mode S interrogation about the carrier frequency shall not exceed the limits specified in Figure 3-3.1.

Note.— The Mode S interrogation spectrum is data dependent. The broadest spectrum is generated by an interrogation that contains all binary ONEs.

3.8.2.1.3 *Polarization.* Polarization of the interrogation and control transmissions shall be nominally vertical.

3.8.2.1.4 *Modulation.* For Mode S interrogations, the carrier frequency shall be pulse modulated. In addition, the data pulse, P_6, shall have internal phase modulation.

3.8.2.1.4.1 *Pulse modulation.* Intermode and Mode S interrogations shall consist of a sequence of pulses. The pulses which may be used to form a specific interrogation are designated P_1, P_2, P_3, P_4, P_5 and P_6. Pulse shapes shall be as defined in Table 1. All values are in microseconds.

Note.— The 0.8 microsecond pulses used in intermode and Mode S interrogations are identical in shape to those used in Modes A and C as defined in 3.8.1.4.

3.8.2.1.4.2 *Phase modulation.* The short (16.25-microsecond) and long (30.25-microsecond) P_6 pulses of 3.8.2.1.4.1 shall have internal binary differential phase modulation consisting of 180-degree phase reversals of the carrier at a 4 megabit per second rate.

3.8.2.1.4.2.1 *Phase reversal duration.* The duration of the phase reversal shall be less than 0.08 microsecond and the phase shall advance (or retard) monotonically throughout the transition region. There shall be no amplitude modulation applied during the phase transition.

Note.— The minimum duration of the phase reversal is not specified. Nonetheless, the spectrum requirements of 3.8.2.1.2 must be met.

3.8.2.1.4.2.2 *Phase relationship.* The tolerance on the 0 and 180-degree phase relationship between successive chips and on the sync phase reversal (3.8.2.1.5.2.2) within the P_6 pulse shall be plus or minus 5 degrees.

Note.— In Mode S a "chip" is the 0.25 microsecond carrier interval between possible data phase reversals.

3.8.2.1.5 *Pulse and phase reversal sequences.* Specific sequences of the pulses or phase reversals described in 3.8.2.1.4 shall constitute interrogations.

3.8.2.1.5.1 *Intermode interrogation*

3.8.2.1.5.1.1 *Mode A/C/S all-call interrogation.* This interrogation shall consist of three pulses: P_1, P_3, and the long P_4 as shown in Figure 3-3.2. One or two control pulses (P_2 alone, or P_1 and P_2) shall be transmitted using a separate antenna pattern to suppress responses from aircraft in the sidelobes of the interrogator antenna.

Note.— The Mode A/C/S all-call interrogation elicits a Mode A or Mode C reply (depending on the P_1-P_3 pulse spacing) from a Mode A/C transponder because it does not recognize the P_4 pulse. A Mode S transponder recognizes the long P_4 pulse and responds with a Mode S reply. This interrogation may be used to acquire Mode S-equipped aircraft as well as for surveillance of Mode A/C-equipped aircraft.

3.8.2.1.5.1.2 *Mode A/C-only all-call interrogation.* This interrogation shall be identical to that of the Mode A/C/S all-call interrogation except that the short P_4 pulse shall be used.

Note.— The Mode A/C-only all-call interrogation elicits a Mode A or Mode C reply from a Mode A/C transponder. A Mode S transponder recognizes the short P_4 pulse and does not reply to this interrogation.

3.8.2.1.5.1.3 *Pulse intervals.* The pulse intervals between P_1, P_2 and P_3 shall be as defined in 3.8.1.4.3 and 3.8.1.4.4. The pulse interval between P_3 and P_4 shall be 2 plus or minus 0.05 microsecond.

3.8.2.1.5.1.4 *Pulse amplitudes.* Relative amplitudes between pulses P_1, P_2 and P_3 shall be in accordance with 3.8.1.5. The amplitude of P_4 shall be within 1 dB of the amplitude of P_3.

3.8.2.1.5.2 *Mode S interrogation.* The Mode S interrogation shall consist of three pulses: P_1, P_2 and P_6 as shown in Figure 3-3.3.

Note.— P_6 is preceded by a P_1-P_2 pair which suppresses replies from Mode A/C transponders to avoid synchronous garble due to random triggering by the Mode S interrogation. The sync phase reversal within P_6 is the timing mark for demodulation of a series of time intervals (chips) of 0.25 microsecond duration. This series of chips starts 0.5 microsecond after the sync phase reversal and ends 0.5 microsecond before the trailing edge of P_6. A phase reversal may or may not precede each chip to encode its binary information value.

3.8.2.1.5.2.1 *Mode S sidelobe suppression.* The P_5 pulse shall be used with the Mode S-only all-call interrogation (UF = 11, 3.8.2.5.2) to prevent replies from aircraft in the side and back lobes of the antenna (3.8.2.1.5.2.5). When used, P_5 shall be transmitted using a separate antenna pattern.

Note 1.— The action of P_5 is automatic. Its presence, if of sufficient amplitude at the receiving location, masks the sync phase reversal of P_6.

Note 2.— The P_5 pulse may be used with other Mode S interrogations.

3.8.2.1.5.2.2 *Sync phase reversal.* The first phase reversal in the P_6 pulse shall be the sync phase reversal. It shall be the timing reference for subsequent transponder operations related to the interrogation.

3.8.2.1.5.2.3 *Data phase reversals.* Each data phase reversal shall occur only at a time interval (N times 0.25) plus or minus 0.02 microsecond (N equal to, or greater than 2) after the sync phase reversal. The 16.25-microsecond P_6 pulse shall contain at most 56 data phase reversals. The 30.25-microsecond P_6 pulse shall contain at most 112 data phase reversals. The last chip, that is the 0.25-microsecond time interval following the last data phase reversal position, shall be followed by a 0.5-microsecond guard interval.

Note.— The 0.5-microsecond guard interval following the last chip prevents the trailing edge of P_6 from interfering with the demodulation process.

3.8.2.1.5.2.4 *Intervals.* The pulse interval between P_1 and P_2 shall be 2 plus or minus 0.05 microsecond. The interval between the leading edge of P_2 and the sync phase reversal of P_6 shall be 2.75 plus or minus 0.05 microsecond. The leading edge of P_6 shall occur 1.25 plus or minus 0.05 microsecond before the sync phase reversal. P_5, if transmitted, shall be centred over the sync phase reversal; the leading edge of P_5 shall occur 0.4 plus or minus 0.05 microsecond before the sync phase reversal.

3.8.2.1.5.2.5 *Pulse amplitudes.* The amplitude of P_2 and the amplitude of the first microsecond of P_6 shall be greater than the amplitude of P_1 minus 0.25 dB. Exclusive of the amplitude transients associated with phase reversals, the amplitude variation of P_6 shall be less than 1 dB and the amplitude variation between successive chips in P_6 shall be less than 0.25 dB. The radiated amplitude of P_5 at the antenna of the transponder shall be:

a) equal to or greater than the radiated amplitude of P_6 from the sidelobe transmissions of the antenna radiating P_6; and

b) at a level lower than 9 dB below the radiated amplitude of P_6 within the desired arc of interrogation.

3.8.2.2 *Reply signals-in-space characteristics*

3.8.2.2.1 *Reply carrier frequency.* The carrier frequency of all replies (downlink transmissions) from transponders with Mode S capabilities shall be 1 090 plus or minus 3 MHz for aircraft not capable of operating above 15 000 ft (4 572 m) and shall be 1 090 plus or minus 1 MHz for aircraft capable of operating above that level.

3.8.2.2.2 *Reply spectrum.* The spectrum of a Mode S reply about the carrier frequency shall not exceed the limits specified in Figure 3-3.4.

3.8.2.2.3 *Polarization.* Polarization of the reply transmissions shall be nominally vertical.

3.8.2.2.4 *Modulation.* The Mode S reply shall consist of a preamble and a data block. The preamble shall be a 4-pulse sequence and the data block shall be binary pulse-position modulated at a 1 megabit per second data rate.

3.8.2.2.4.1 *Pulse shapes.* Pulse shapes shall be as defined in Table 2. All values are in microseconds.

Table 2. Pulse shapes — Mode S replies

Pulse Duration	*Duration Tolerance*	*(Rise time) Min.*	*Max.*	*(Decay time) Min.*	*Max.*
0.5	±0.05	0.05	0.1	0.05	0.2
1.0	±0.05	0.05	0.1	0.05	0.2

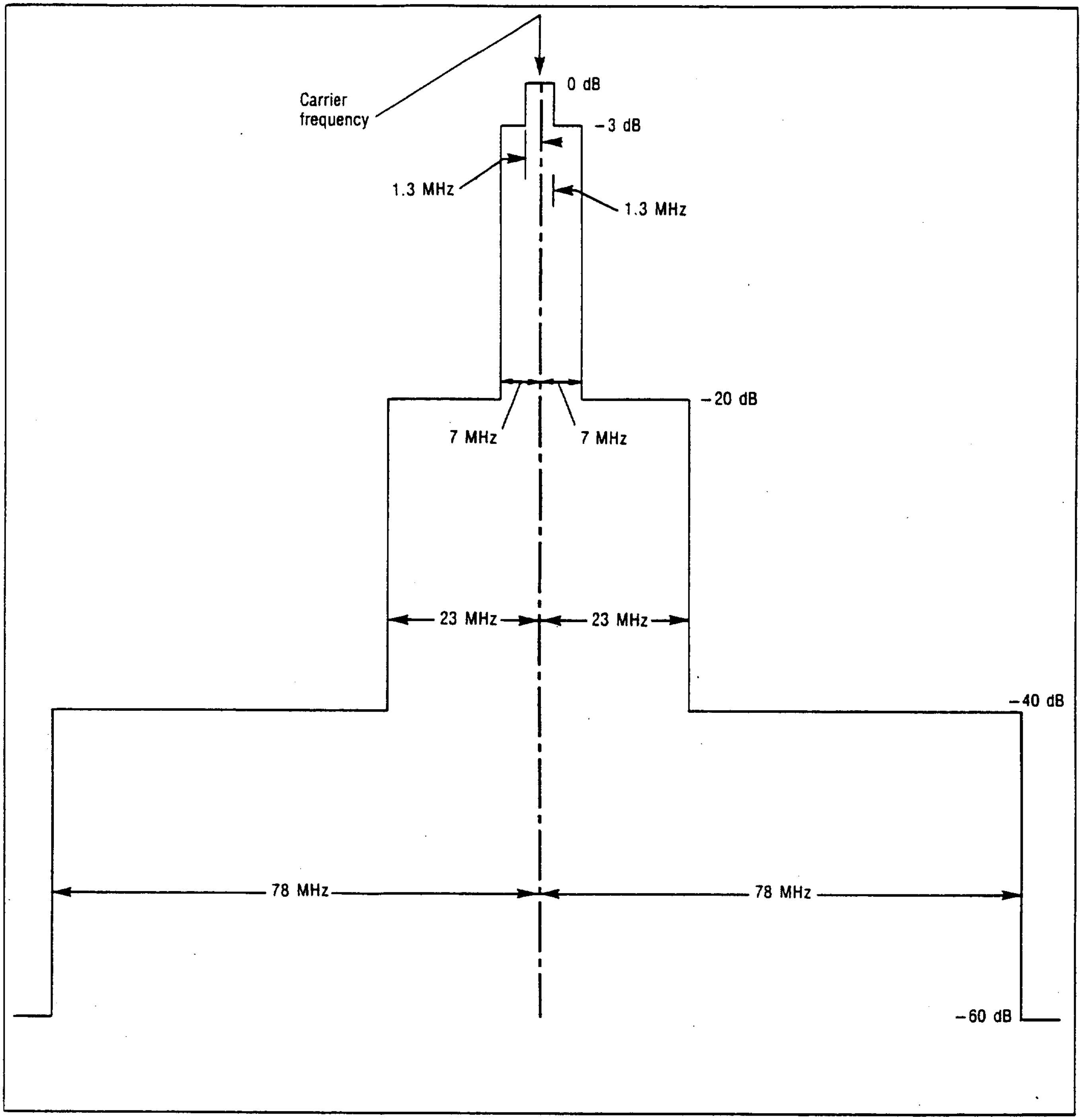
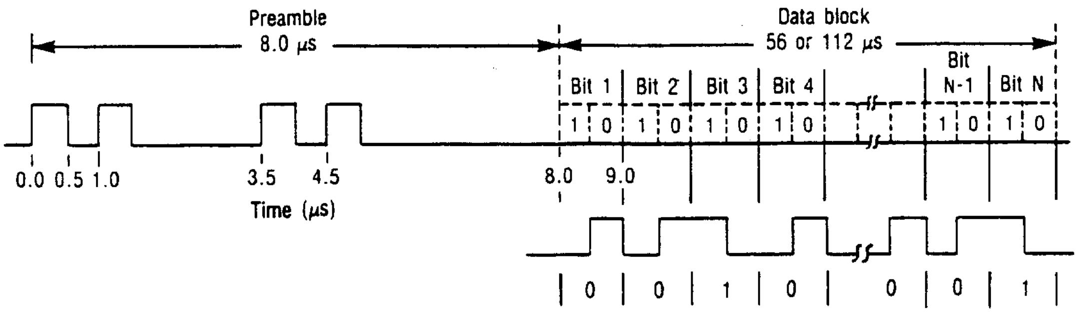


Figure 3-3.4. Required spectrum limits for transponder transmitter



Example.— Reply data block corresponding to bit sequence 0010 001

Figure 3-3.5. Mode S reply

3.8.2.2.5 *Mode S reply.* The Mode S reply shall be as shown in Figure 3-3.5. The data block in Mode S replies shall consist of either 56 or 112 information bits.

3.8.2.2.5.1 *Pulse intervals.* All reply pulses shall start at a defined multiple of 0.5 microsecond from the first transmitted pulse. The tolerance in all cases shall be plus or minus 0.05 microsecond.

3.8.2.2.5.1.1 *Reply preamble.* The preamble shall consist of four pulses, each with a duration of 0.5 microsecond. The pulse intervals from the first transmitted pulse to the second, third and fourth transmitted pulses shall be 1, 3.5 and 4.5 microseconds respectively.

3.8.2.2.5.1.2 *Reply data pulses.* The reply data block shall begin 8 microseconds after the leading edge of the first transmitted pulse. Either 56 or 112 one-microsecond bit intervals shall be assigned to each transmission. A 0.5-microsecond pulse shall be transmitted either in the first or in the second half of each interval. When a pulse transmitted in the second half of one interval is followed by another pulse transmitted in the first half of the next interval, the two pulses merge and a one-microsecond pulse shall be transmitted.

3.8.2.2.5.2 *Pulse amplitudes.* The pulse amplitude variation between one pulse and any other pulse in a Mode S reply shall not exceed 2 dB.

3.8.2.3 *Mode S data structure*

3.8.2.3.1 *Data encoding*

3.8.2.3.1.1 *Interrogation data.* The interrogation data block shall consist of the sequence of 56 or 112 data chips positioned after the data phase reversals within P_6 (3.8.2.1.5.2.3). A 180-degree carrier phase reversal preceding a chip shall characterize that chip as a binary ONE. The absence of a preceding phase reversal shall denote a binary ZERO.

3.8.2.3.1.2 *Reply data.* The reply data block shall consist of 56 or 112 data bits formed by binary pulse position modulation encoding of the reply data as described in 3.8.2.2.5.1.2. A pulse transmitted in the first half of the interval shall represent a binary ONE whereas a pulse transmitted in the second half shall represent a binary ZERO.

3.8.2.3.1.3 *Bit numbering.* The bits shall be numbered in the order of their transmission, beginning with bit 1. Unless otherwise stated, numerical values encoded by groups (fields) of bits shall be encoded using positive binary notation and the first bit transmitted shall be the most significant bit (MSB). Information shall be coded in fields which consist of at least one bit.

Note.— In the description of Mode S formats the decimal equivalent of the binary code formed by the bit sequence within a field is used as the designator of the field function or command.