TDR-94/94D

RF Radiation Exposure Information

Antenna to the Spectrum Analyzer. This includes the cable (i.e., Coax #2 in Figure 3-1) and connectors and should be calibrated to 3 dB

P_rx_dBw = Power (in **dBw**) received at the Spectrum Analyzer

P_rx_dBm = P_rx_dBw + 30 = Power (in **dBm**) received at the Spectrum Analyzer

Then the expected power of the 1090 MHz signal received at the Spectrum Analyzer is given by the following equation.

EQUATION 1:

P_rx_dBw = 10*log(P_out) - Loss_TX + G_tx + Path_Loss + G_rx - Loss_RX

= 10*log(P_out) - Loss_TX + G_tx -33.1903022 -20*log(R) + G_rx - Loss_RX

Specifying a Range of 3 meters (i.e., the distance between the antennas along the reference line shown in Figure 3-1) to be used as the Range in the following procedure provides the following Equation 2.

P_rx_dBw = 10*log(P_out) - Loss_TX + G_tx - 33.1903022 - 9.54242509 + G_rx - Loss_RX

EQUATION 2:

P_rx_dBw = 10*log(P_out) - Loss_TX + G_tx - 42.73272729 + G_rx - Loss_RX

Note: *If the measurement distance, R, is different from 3 meters, then Equation 2 must be recomputed for the new R and the recomputation must be based on Equation 1. Equation 1 is based on the fact that there are 1852 meters in one nautical mile. Also, there are 6076.1 feet in one nautical mile. Therefore, for the purpose of these computations, there are 3.280831533 feet per meter.*

The Effective Radiated Power (ERP) emitted from the Transmitting Antenna is then given by Equation 3 as follows:

EQUATION 3:

ERP_dBw = P_rx_dBw + 42.73272729 - G_rx + Loss_RX

Note: *Whenever the need to measure radiated RF power is established, the question arises in regards to the permissible level of radiation that can be sustained by personnel making the measurements. This document addresses such concerns in the following paragraph of this note.*

Assume that the maximum Effective Radiated Power from the Transponder or ADS-B Transmitting Subsystem is 500 W (27 dBW) as specified in §2.2.2.1.2 of this document and §2.2.3.2.d of RTCA DO-181D. Then, using portions of equation 2 or 3 from above, the radiated power at 3 meters is given as follows:

P_3m_dBW = ERP - 42.73272729

= 26.98970004 dBW -42.73272729

P_3m_dBW = -15.74302725 dBW

then the power at 3 meters in watts is as follows:

$10*\log(P\_3m\_W) = -15.74302725$

$P\_3m\_W = (10^{-1.574302725}$

$= 0.02665\ W$

$= 26.65\ mW$

This would appear to be a minimum amount of power: however, it does not readily translate into Maximum Permissible Exposure (MPE) limits, which are typically used to determine hazard levels.

Consulting FCC OET Bulletin 65, Edition 97-01, August, 1997, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radio frequency Electromagnetic Fields," provides information as provided in the following paragraphs.

Section 2, equation 3, page 19 of the bulletin provides the following equation for the prediction of RF fields:

$$S = \frac{EIRP}{4\pi R^2}$$

where:

S = power density (in appropriate units, e.g., mW/cm^2)
EIRP = equivalent (or effective) isotropically radiated power (inappropriate units, e.g .mW)
R = distance to the center of radiation of the antenna (appropriate units, e.g., cm)

Applying this equation at 3 meters to the maximum radiated power (e.g., 500 W) allowed for transponders or ADS-B Transmitting Subsystems provides the following results:

$$S = \frac{(500\ W)(1000\ mW/W)}{4\pi(300\ cm)^2}$$

$= 0.44209706\ mW/cm^2$

Appendix A, Table 1(A) of the bulletin then provides MPE limits for Occupational/Controlled Exposure as follows:

Frequency Range (MHz)	=	*300 - 1500*
Electric Field Strength (E) (V/m)	=	*Not Applicable*
Magnetic Field Strength (H) (A/M)	=	*Not Applicable*
Power Density (S) (mW/cm^2)	=	*f/300*
Averaging Time, S (minutes)	=	*6*

Therefore, the MPE exposure for an average of 6 minutes at 1090 MHz is:

$S\_MPE\_1090 = (1090)/300 = 3.63333333...\ mW/cm^2$

Note that this limit value is 8.2184 times greater than the power density at 3 meters computed above as 0.44209706 mW/cm^2.

Next, the time of exposure must be considered. Page 11 of the bulletin addresses this concern with the equation:

$$\Sigma S_{exp} t_{exp} = S_{limit} t_{avg}$$

where:

S_{exp} = *power density of exposure* (mW/cm^2)
S_{limit} = *appropriate power density MPE limit* (mW/cm^2)
t_{exp} = *allowable time of exposure for* S_{exp}
t_{avg} = *appropriate MPE averaging time*

Taking into the consideration that the transponder or ADS-B Transmitting Subsystem will never exceed a transmitting duty cycle of 5%, the allowable time of exposure is computed from the above equation as follows:

$$(0.44209706\ mW/cm^2) * X * (0.05) = (1090/300\ mw/cm^2)(6\ minutes)$$

$$X = \frac{(1090/300\ mw/cm^2)(6\ minutes)}{(0.44209706\ mW/cm^2)(0.05)}$$

$$X = 986.209\ minutes$$

or

$$X = 16.4368\ hours$$

These calculations have demonstrated that the expected power density of the transponder or ADS-B Transmitting Subsystem at 3 meters is well within the allowable MPE. The calculations also demonstrate that the time of 16.44 hours of exposure to present a possible hazard is considerably longer than any time necessary to perform the test procedures address in this subparagraph.

The TDR-94/94D antennas are mounted along the fuselage of business regional aircraft. These locations are accessible to airport maintenance personnel only and are in general not accessible to the general population. In addition, airline maintenance and ramp operating procedures do not allow the system to utilize any of the bottom mounted radiating antennas when in the airport gate area where maintenance personnel have access to the aircraft. These limited access restrictions placed upon the TDR-94/94D falls under the definition of section (A) Controlled Exposures which requires a MPE power density limit of no more than 3.63mW/cm2 averaged over a 6 minute period.

Section 2.1091(b) defines a "mobile device" as "a transmitting device designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 3 meters is normally maintained between the transmitters radiating structures and the body of the user(s) or nearby persons."

Since the TDR-94/94D antenna mounting locations, along the top and bottom of the fuselage of business regional aircraft, are inaccessible in normal usage to any personnel and are located greater than 3 meters from any personnel, it falls under the definition mobile device in Section 2.1091(b).