



MPE calculation

The M-Tec tracking device ME500 is a modular approved device that complies with FCC part 2.1091 (b) for mobile devices and RSS-102 Issue 5 for Industry Canada. The ME500 is certified and labeled "FCC ID: ZMF-ME500" and "IC-ID: 9746A-ME500". The antenna gain is measured in test report "ME501October2014Ver1.3signed.pdf" as the ME500-x tracking device family is mounted on the same PCB as for the ME501-x family. Thus both tracking device families contain identical antennas.

	Freespace		
Frequency	Antenna efficiency	Peak Gain [dBi]	
824 MHz	-2.9 dB ±1.9 dB	1.4 dBi ±1.9 dBi	
830 MHz	-2.8 dB ±1.9 dB	2.2 dBi ±1.9 dBi	
835 MHz	-2.5 dB ±1.9 dB	1.9 dBi ±1.9 dBi	
836 MHz	-2.4 dB ±1.9 dB	2.1 dBi ±1.9 dBi	
840 MHz	-2.3 dB ±1.9 dB	1.8 dBi ±1.9 dBi	
849 MHz	-3.0 dB ±1.9 dB	1.8 dBi ±1.9 dBi	
869 MHz	-2.1 dB ±1.9 dB	2.3 dBi ±1.9 dBi	
875 MHz	-2.0 dB ±1.9 dB	3.0 dBi ±1.9 dBi	
880 MHz	-2.1 dB ±1.9 dB	3.2 dBi ±1.9 dBi	
881 MHz	-2.1 dB ±1.9 dB	3.4 dBi ±1.9 dBi	
885 MHz	-2.2 dB ±1.9 dB	3.5 dBi ±1.9 dBi	
894 MHz	-2.7 dB ±1.9 dB	3.6 dBi ±1.9 dBi	
897 MHz	-3.4 dB ±1.9 dB	2.3 dBi ±1.9 dBi	
915 MHz	-4.0 dB ±1.9 dB	-0.5 dBi ±1.9 dBi	
925 MHz	-3.5 dB ±1.9 dB	2.2 dBi ±1.9 dBi	
942 MHz	-4.1 dB ±1.9 dB	1.5 dBi ±1.9 dBi	
960 MHz	-4.9 dB ±1.9 dB	-0.3 dBi ±1.9 dBi	
1710 MHz	-7.1 dB ±1.9 dB	-2.7 dBi ±1.9 dBi	
1747 MHz	-3.6 dB ±1.9 dB	0.2 dBi ±1.9 dBi	
1785 MHz	-2.0 dB ±1.9 dB	1.4 dBi ±1.9 dBi	
1805 MHz	-1.7 dB ±1.9 dB	1.5 dBi ±1.9 dBi	
1842 MHz	-1.8 dB ±1.9 dB	2.3 dBi ±1.9 dBi	
1850 MHz	-1.9 dB ±1.9 dB	2.2 dBi ±1.9 dBi	
1880 MHz	-1.6 dB ±1.9 dB	2.7 dBi ±1.9 dBi	
1910 MHz	-1.9 dB ±1.9 dB	2.6 dBi ±1.9 dBi	
1920 MHz	-1.8 dB ±1.9 dB	2.6 dBi ±1.9 dBi	
1930 MHz	-1.7 dB ±1.9 dB	2.8 dBi ±1.9 dBi	
1950 MHz	-1.7 dB ±1.9 dB	2.9 dBi ±1.9 dBi	
1960 MHz	-1.7 dB ±1.9 dB	3.3 dBi ±1.9 dBi	
1980 MHz	-1.7 dB ±1.9 dB	3.1 dBi ±1.9 dBi	
1990 MHz	-1.8 dB ±1.9 dB	3.2 dBi ±1.9 dBi	
2110 MHz	-2.0 dB ±1.9 dB	3.1 dBi ±1.9 dBi	
2140 MHz	-0.8 dB ±1.9 dB	4.6 dBi ±1.9 dBi	
2170 MHz	-0.3 dB ±1.9 dB	4.8 dBi ±1.9 dBi	

Table-1

ME500/ME501 antenna gain from ME501October2014Ver1.3signed.pdf test report

With reference to "KDB 447498 D01 General RF Exposure Guidance v06" and the "Health Canada's RF exposure guideline, Safety Code 6" the ME500 is classified as a mobile device. The ME500 is subject for further evaluation according the FCC part 2.1093/RSS-102 for exposures levels defined in FCC part 1.1310/RSS-102 for the general population/uncontrolled environment.

ME500 maximum output power in single GMSK/GPRS transmitting mode:



GSM 850 conducted power (Max): 1.730 W (1 slot) PCS 1900 conducted power (Max): 0.975 W (1 slot)

5

4

ME500 operates as a data only device designed for GPRS multislot class 10 operation.

- Maximum number of active timeslots (TS):
- Maximum number of downlink TS:
- Maximum number of uplink TS: 2

The worst case operations of the ME500 that will create the maximum output power density of the device occur when using two uplink timeslots for GPRS.

Prediction of MPE limit

Equation from page 18 of OET 65, Edition 97-01

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

Where:

S = Power density

P = Power input to the antenna.

- G = Power gain of the antenna in the direction of interest relative to an isotropic radiator.
- R = Distance to the center of radiation of the antenna.

The calculation is performed for each frequency band at the worst case conditions:

Reference table values

The conductivity of the human head and body at various frequencies are listed in the table below:



Target Frequency	He	ad	Bo	ody
(MHz)	٤r	σ (S/m)	εr	σ (S/m)
150	52.3	0.76	61.9	0.80
300	45.3	0.87	58.2	0.92
450	43.5	0.87	56.7	0.94
835	41.5	0.90	55.2	0.97
900	41.5	0.97	55.0	1.05
915	41.5	0.98	55.0	1.06
1450	40.5	1.20	54.0	1.30
1610	40.3	1.29	53.8	1.40
1800 - 2000	40.0	1.40	53.3	1.52
2450	39.2	1.80	52.7	1.95
3000	38.5	2.40	52.0	2.73
5800	35.3	5.27	48.2	6.00

(ϵ_r = relative permittivity, σ = conductivity and ρ = 1000 kg/m³)

FCC rules

The limits for uncontrolled RF exposure (W/cm²) over the frequency range 0.3 MHz to 100 GHz are defined as:



Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm ²)	Averaging Time $ \mathbf{E} ^2$, $ \mathbf{H} ^2$ or S (minutes)
0 3-1 34	614	1.63	(100)*	30
1.34-30	824/f	2.19/f	$(180/f^2)^*$	30
30-300	27.5	0.073	0.2	30
300-1500			f/1500	30
1500-100,000			1.0	30

(B) Limits for General Population/Uncontrolled Exposure

f = frequency in MHz *Plane-wave equivalent power density

The human body limits are also defined in (W/kg) for uncontrolled exposure in relation to the body mass as:

(B) Limits for General Population/Uncontrolled Exposure (W/kg)

Whole-Body	Partial-Body	Hands, Wrists, Feet and Ankles
0.08	1.6	4.0

IC rules

The limits for uncontrolled RF exposure (W/cm²) over the frequency range 0.003 MHz to 300 GHz are defined as:



Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m ²)	Reference Period (minutes)
0.003-10 ²¹	83	90	10 (SIL)	Instantaneous*
0.1-10		0.73/ f	-	6**
1.1-10	$87/f^{0.5}$		1.	6**
10-20	27.46	0.0728	2	6
20-48	$58.07/f^{0.25}$	$0.1540/f^{0.25}$	$8.944/f^{0.5}$	6
48-300	22.06	0.05852	1.291	6
300-6000	$3.142 f^{0.3417}$	$0.008335 f^{0.3417}$	$0.02619 f^{0.6834}$	6
6000-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	$616000/f^{1.2}$
150000-300000	$0.158 f^{0.5}$	$4.21 \ge 10^{-4} f^{0.5}$	$6.67 \ge 10^{-5} f$	$616000/f^{1.2}$
Note: f is frequency	in MHz.	de de de		da de co
*Based on nerve stin	nulation (NS).			
** Based on specific	absorption rate (SAR).		

Table 4: RF Field Strength Limits for Devices Used by the General Public (Uncontrolled Environment)

The human body limits are also defined in (W/kg) for uncontrolled exposure in relation to the body mass as:

Table 3: SAR Limits for Devices Used by the General	l Public (Uncontrolled Environment)
-----------------------------------------------------	-------------------------------------

Body Region	Average SAR (W/kg)	Averaging Time (minutes) ²⁰	Mass Average (g)
Whole Body	0.08	6	Whole Body
Localized Head, Neck and			
Trunk	1.6	6	1
Localized Limbs	4	6	10

MPE calculation

For devices operating close to or in relation to the human body the uncontrolled exposure are measured as SAR in (W/kg) and for devices that does not operate in close relation to the human body a MPE calculation determines the uncontrolled exposure level (mW/cm^2) .

The ME500 is intended to be fixed mounted in vehicles, construction and moving machinery, lifts, cranes, tractors etc. in a minimum distance of 20 cm from the human body that is equal to a MPE calculation in order to comply with the approval requirements for high power devices.



Prediction of MPE limit at a given distance for the 850 MHz band

Measured parameter	Measured Value GPRS	Units
Conducted peak power - 1 slot	32.38	dBm
Conducted peak power - 1 slot	1729,82	mW
Duty cycle (12.5% per. Timeslot)	25,0	%
Maximum antenna gain*	+2.2	dBi
Maximum antenna gain	1.660	numeric
PAR for GMSK modulation	0	dB
EIRP (mW) - Averaged	717,70	mW
EIRP (mW) - Time-averaged in active slots only	2870.78	mW
Prediction distance (R)	20	cm
Prediction frequency (Pf)	847.8	MHz
FCC: MPE limit for uncontrolled exposure at P_f ($f_{MHz}/1500$)	0.565	mW/cm ²
IC: MPE limit for uncontrolled exposure at $P_f (0.02619*f_{MHz}^{0.6834})$	0.263	mW/cm ²
Calculated power density for ME500 at P _f (Average)	0.143	mW/cm ²
Calculated power density for ME500 at P _f (Time-Average)**	0.571	mW/cm ²
* Antenna gain report ME501October2014Ver1.3signed.pdf		
** Gated average over TX slots only.		

Prediction of MPE limit at a given distance for the 1900 MHz band

Measured parameter	Measured Value GPRS	Units
Maximum peak output power (conducted)	29.89	dBm
Maximum peak output power (conducted)	975,00	mW
Duty cycle (12.5% per. Timeslot)	25.0	%
Maximum antenna gain*	+2.7	dBi
Maximum antenna gain	1.862	numeric
PAR for GMSK modulation	0	dB
EIRP (mW) - Averaged	453.88	mW
EIRP (mW) - Time-averaged in active slots only	1815.52	mW
Prediction distance (R)	20	cm
Prediction frequency (Pf)	1909.8	MHz
FCC: MPE limit for uncontrolled exposure at Pf	1.0	mW/cm ²
IC: MPE limit for uncontrolled exposure at $P_f (0.02619*f_{MHz}^{0.6834})$	0.458	mW/cm ²
Calculated power density for ME500 at Pf (Average)	0.090	mW/cm ²
Calculated power density for ME500 at Pf (Time-Average)**	0.361	mW/cm ²
* Antenna gain report ME501October2014Ver1.3signed.pdf		
** Gated average over TX slots only.		