TERRESTRIAL TRUNKED RADIO

Instruments

FREEDOM Communication Technologies
R8100 Communication System Analyzer

FREEDOM Communication Technologies
R8000C Communication System Analyzer

FREEDOM Communication Technologies
R9000 Communication System Analyzer

Frequencies & Channels

TETRA in Europe:
380 to 400 MHz
410 to 430 MHz
450 to 470 MHz

TETRA in Asia:
350 to 380 MHz
806 to 821 MHz, 851 to 866 MHz
870 to 876 MHz, 915 to 921 MHz

Typical duplex spacing:
5 MHz or 10 MHz (at 300 to 500 MHz) or 45 MHz (at 800 to 1000 MHz)

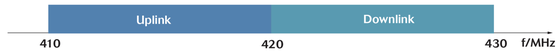
Calculation of RF parameters:

DL carrier frequency = frequency band · 100 MHz + radio carrier number · 25 kHz + frequency offset

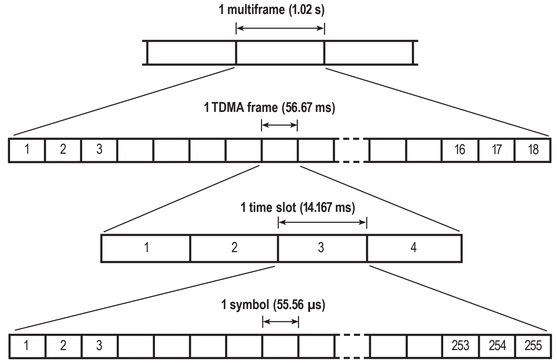
UL carrier frequency = DL carrier frequency – duplex offset

Example: TETRA band from 410 to 430 MHz, first UL channel = 410.0125 MHz, equivalent DL channel = 420.0125 MHz

Duplex spacing = 10 MHz
Duplex offset = 12.5 kHz
Frequency band = 4 (400 MHz)
Radio carrier number = 800



Bursts & Frames



Control uplink burst

Normal uplink burst

Normal continuous downlink burst

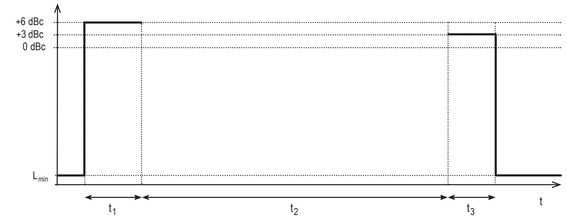
Synchronisation continuous downlink burst

Measurements & Limits

RF power

Maximum power, power control steps; see table in previous column

Burst power versus time



L_{min} = max (–70 dBc, –36 dBm)

Burst type	t_1	t_2	t_3
Control uplink burst	16 symbols	103 symbols	15 symbols
Normal uplink burst	16 symbols	231 symbols	15 symbols
Discontinuous downlink burst	7 symbols	246 symbols	7 symbols
Continuous downlink burst	Unspecified	Unspecified	Unspecified

Frame alignment

Burst timing error (deviation from the timing given by the base station)

Limit = ±¼ symbol

Frequency error limits for TETRA mobile stations

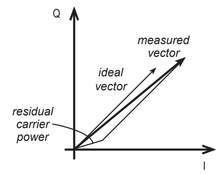
EN 300 392-2 (V+D) ed. 2: Limit = ±100 Hz

EN 300 396-2 (DMO): Limit = ±1 kHz (master), ±100 Hz (slave)

Residual carrier power

DC offset in the I-Q modulator

Limit = 5%

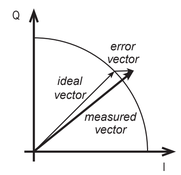


Vector error

Deviation of the measured vector from the ideal vector, relative to the magnitude of the ideal vector.

Peak vector error (within a burst) – limit: 30%

RMS vector error (averaged over a burst) – limit: 10%



Receiver measurements

Based on bit error rate (BER) measurements at a defined input power level

T1 signal: The test equipment transmits a pseudo-random bit sequence, the MS synchronises onto the signal and counts bit errors (measurement in the MS)

TT loopback: Receiver test mode initiated through a designated test protocol. The MS loops back the received bit sequence to the tester, the tester counts bit errors (measurement in the test equipment)

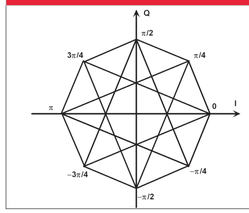
T1 loopback: Receiver test mode in which the MS loops back the received bit sequence to the tester without any protocol (no call being set up). The tester counts bit errors (measurement in the test equipment)

Limit: 0.01% at –112 dBm (receiver sensitivity, static conditions)

Advantages of TETRA Technology

Fast call setup time (group call: < 300 ms)
Individual and group calls
Direct mode communication between radios
Data services
Frequency-economic
Security features
Emergency and priority calls
High spectral efficiency
Infrastructure separate from public mobile networks (avoids congestion)
Fallback mode for base stations

Modulation



Format: π/4 DQPSK (differential quadrature phase shift keying, shifted by 45°)

The phase change determines the information transferred.

Phase change	Transferred bits
+ π/4	00
+3 π/4	01
–3 π/4	11
– π/4	10

General Technical Data

Channel bandwidth	25 kHz
Access technology	TDMA
Time slots (channels per carrier)	4
Modulation	π/4 DQPSK (2 bits per symbol)
Symbol rate	18 000 symbols/s (255 symbols/slot)
Maximum data rate	28.8 kbit/s
Call setup time	< 300 ms
Communication	Point to point (duplex, simplex) Point to multipoint
Encryption	Air interface End to end
Voice codec	ACELP (Algorithmic Code Excited Linear Prediction), 4.8 kbit/s

TEDS

TEDS (TETRA Release 2)	Extended air interface specification for higher data rates on traffic channels			
Channel bandwidth	25 kHz (8 sub-carriers) 50 kHz (16 sub-carriers) 100 kHz (32 sub-carriers) 150 kHz (64 sub-carriers)			
Access technology	TDMA/OFDMA			
Time slots	4			
Modulation	Quadrature Amplitude Modulation (QAM): 4-QAM, 16-QAM, 64-QAM			
Symbol rate on each sub-carrier	2400 symbols/s (34 symbols/slot)			
Downlink packet data throughput (kbit/s)	*25 kHz*	*50 kHz*	*100 kHz*	*150 kHz*
4-QAM	11	27	58	90
16-QAM	22	54	116	179
64-QAM	33	80	175	269
64-QAM	44	107	233	359
64-QAM	66	160	349	538

Power Levels, Power Control

Power class	Max. power level			Power class	Max. power level		
1	30.0 W	45.0 dBm	V+D only	3L	1.8 W	32.5 dBm	
1L	17.5 W	42.5 dBm		4	1.0 W	30.0 dBm	
2	10.0 W	40.0 dBm		4L	0.56 W	27.5 dBm	
2L	5.6 W	37.5 dBm		5	0.3 W	25.0 dBm	DMO
3	3.0 W	35.0 dBm					

Power step	Power class 1 (30 W)	Power class 2 (10 W)	Power class 3 (3 W)	Power class 4 (1 W)
1 (45 dBm)	45 dBm ±2 dB	40 dBm ±2 dB	35 dBm ±2 dB	30 dBm ±2 dB
2 (40 dBm)	40 dBm ±2.5 dB	40 dBm ±2 dB	35 dBm ±2 dB	30 dBm ±2 dB
3 (35 dBm)	35 dBm ±2.5 dB	35 dBm ±2.5 dB	35 dBm ±2 dB	30 dBm ±2 dB
4 (30 dBm)	30 dBm ±2.5 dB	30 dBm ±2.5 dB	30 dBm ±2.5 dB	30 dBm ±2 dB
5 (25 dBm)	25 dBm ±2.5 dB	25 dBm ±2.5 dB	25 dBm ±2.5 dB	25 dBm ±2.5 dB
6 (20 dBm)	20 dBm ±2.5 dB	20 dBm ±2.5 dB	20 dBm ±2.5 dB	20 dBm ±2.5 dB
7 (15 dBm)	15 dBm ±2.5 dB	15 dBm ±2.5 dB	15 dBm ±2.5 dB	15 dBm ±2.5 dB

Power step	Power class 1L (17.5 W)	Power class 2L (5.6 W)	Power class 3L (1.8 W)	Power class 4L (0.56 W)
1 (45 dBm)	42.5 dBm ±2 dB	37.5 dBm ±2 dB	32.5 dBm ±2 dB	27.5 dBm ±2 dB
2 (40 dBm)	40 dBm ±2.5 dB	37.5 dBm ±2 dB	32.5 dBm ±2 dB	27.5 dBm ±2 dB
3 (35 dBm)	35 dBm ±2.5 dB	35 dBm ±2.5 dB	32.5 dBm ±2 dB	27.5 dBm ±2 dB
4 (30 dBm)	30 dBm ±2.5 dB	30 dBm ±2.5 dB	30 dBm ±2.5 dB	27.5 dBm ±2 dB
5 (25 dBm)	25 dBm ±2.5 dB	25 dBm ±2.5 dB	25 dBm ±2.5 dB	25 dBm ±2.5 dB
6 (20 dBm)	20 dBm ±2.5 dB	20 dBm ±2.5 dB	20 dBm ±2.5 dB	20 dBm ±2.5 dB
7 (15 dBm)	15 dBm ±2.5 dB	15 dBm ±2.5 dB	15 dBm ±2.5 dB	15 dBm ±2.5 dB

Abbreviations

BER	Bit error rate
BS	Base station
DMO	Direct mode operation
DQPSK	Differential quadrature phase shift keying
ETSI	European Telecommunications Standards Institute
GSSI	Group short subscriber identity
GTSI	Group TETRA subscriber identity
ISI	Inter-system interface
ISSI	Individual short subscriber identity
ITSI	Individual TETRA subscriber identity
MCC	Mobile country code
MCCH	Main control channel
MER	Message erasure rate
MNC	Mobile network code
MS	Mobile station
PDO	Packet data optimised (standard not implemented)
PEI	Peripheral equipment interface
PTT	Push to talk
QoS	Quality of service
SCH/F	Signalling channel for mapping onto full bursts
SwMI	Switching and management infrastructure
T1	Test signal commonly used to test the TETRA receiver
T4	Test signal for TETRA II testing (QAM in Frames 1–17, DQPSK in Frame 18)
TCH	Traffic channel
TDMA	Time division multiple access
TEDS	TETRA Enhanced Data Service, supporting data transmission at rates from 50 to 250 kbit/s
TIP	TETRA interoperability profile (common TETRA standard subset defined by the TETRA Association)
TMO	Trunked mode operation
TS	Time slot
V+D	Voice plus data, also known as TMO