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Realtime Telemetry Wireless System Performance

Introduction

The Realtime Telemetry wireless system is specially design for radio-frequency-noisy, industrial environment. It tolerates strong interference in-band and out band by using the following techniques:

1. Tight controlled front end filter to block any out band interference.
2. High Transmit Power (20dbm) to over-power the interference signal.
3. Forward Error Correction/Channel coding to recover the bit error.
4. TCXO (Temperature Compensated Crystal Oscillator) equipped system to minimize the adjacent channel transmit power.
5. Narrow band IF filter to improve the adjacent channel selectivity.
6. Radio Range with Free Space Propagation: 1000 meters(min).
7. Inter-channel synchronization error is less than 1us to guarantee the overall system performance.

Detailed Specification and explanation.

1. Operating Frequency and Frequency Deviation

The Realtime Telemetry wireless system is using the 2.4Ghz ISM band (2400Ghz - 2.483Ghz), which is a international license free band.

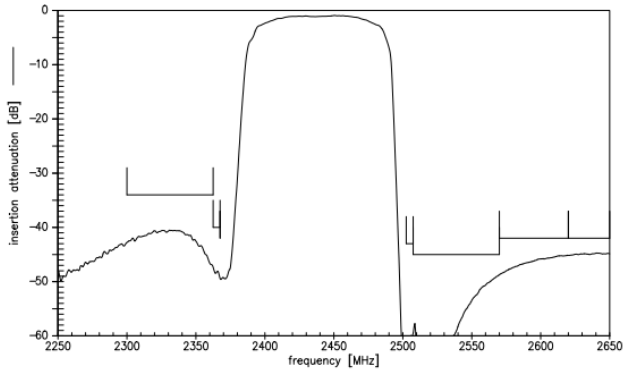
Frequency deviation defined how much the transmitted signal deviates from the designed frequency. The Realtime Telemetry wireless system equipped with a temperature compensated crystal oscillator with ±2.0ppm (±5Khz) accuracy. This is a very tight tolerance for 2.4Ghz RF system comparing with any WIFI or Bluetooth system, which is generally ±50ppm (±120Khz). A tight frequency deviation can effectively improve the adjacent channel interference on the receiver side.

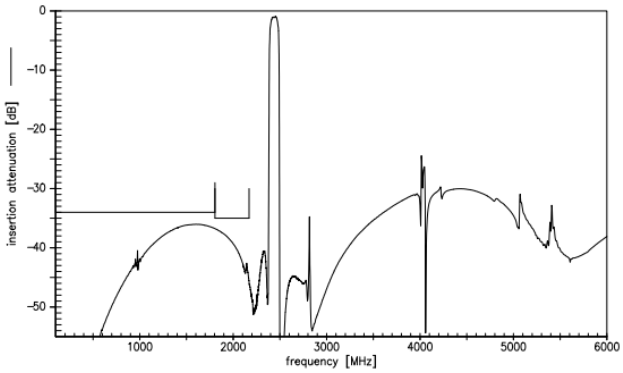
2. 2.4Ghz pass band filter

The 2.4Ghz pass band filter is implemented on both transmitter and receiver side to block any out-band noise from electrical sparks, engine electronics, etc. This is the first guard against interference from getting into the system. Figure 1 details the filter specification.

3. Non-overlapping Channel Spacing

The Realtime Telemetry wireless system uses 2Mhz as channel spacing.





Characteristics		min.	typ. @ 25 °C	max.	
Center frequency	f_C		2442.0		MHz
Maximum insertion attenuation - BT	α_{max}				
2401.5 ... 2480.5 MHz			1.3[2]	2.0[2]	dB
VSWR (Input and Output)					
2403.1 ... 2475.9 MHz			1.7	2.4	
2463.1 ... 2480.9 MHz			1.85		
Attenuation	α				
100.0...1805.0MHz		34	37		dB
1805.0...2170.0MHz		35	38		dB
2300.0...2360.0MHz[3]		34	41		dB
2360.0...2365.0MHz[3]		40	46		dB
2365.0...2370.0MHz[3]		40	48		dB
2500.0...2505.0MHz[3]		43[4]	62		dB
2505.0...2570.0MHz[3]		42	49		dB
2570.0...2620.0MHz[3]		40	45		dB
2620.0...2690.0MHz[3]		40	45		dB
4800.0...5805.0MHz		18	31		dB
2nd Harmonics					
CW tone at input, 2442 MHz, 22 dBm			-63		dBc

Figure1. The 2.4Ghz pass band filter performance

4. FEC (Forward Error Correction)

Forward Error Correction (FEC) or channel coding is a technique used for controlling errors in data transmission over unreliable or noisy communication channels. The central idea is the sender encodes the message in a redundant way by using an error-correcting code (ECC).

The redundancy allows the receiver to detect a limited number of errors that may occur anywhere in the message, and to correct these errors without retransmission. FEC gives

the receiver the ability to correct errors without requesting retransmission of data at a cost of transmitting extra data bits (FEC code). FEC is therefore applied in situations where retransmissions are costly or impossible.

Realtime Telemetry wireless system is a proprietary wireless interface, which is specially designed for industrial test and measurement. It transfers a group of analog signals in a real time manner with a constant latency. Retransmission is impossible in this situation. The FCC is implemented in the Realtime telemetry wireless system to improve the data integrity.

5. Transmitter Max Output Power

The Realtime telemetry wireless system use a power amplifier to boost the transmitter power output to 20dbm (100mW), which is generally permitted by international standard in the 2.4Ghz ISM (Industry, Science and Medical devices) band. This is about 10dB (10 times) higher than WIFI (wireless LAN) signal and 30dB (1000 times) higher than Bluetooth signal, which are the main interferers in this band.

6. Transmitter 20dB bandwidth

As illustrated in the Figure 2, 20 dB bandwidth is the signal occupied bandwidth, at which the signal strength falls to 20 dB below the total signal strength. The typical value in the Realtime Telemetry wireless system is 1800Khz, which leave 200Khz to 400Kz as guard band between channels. The TCXO effectively maintains the signal centered at the assigned frequency channel to reduce frequency spreading.

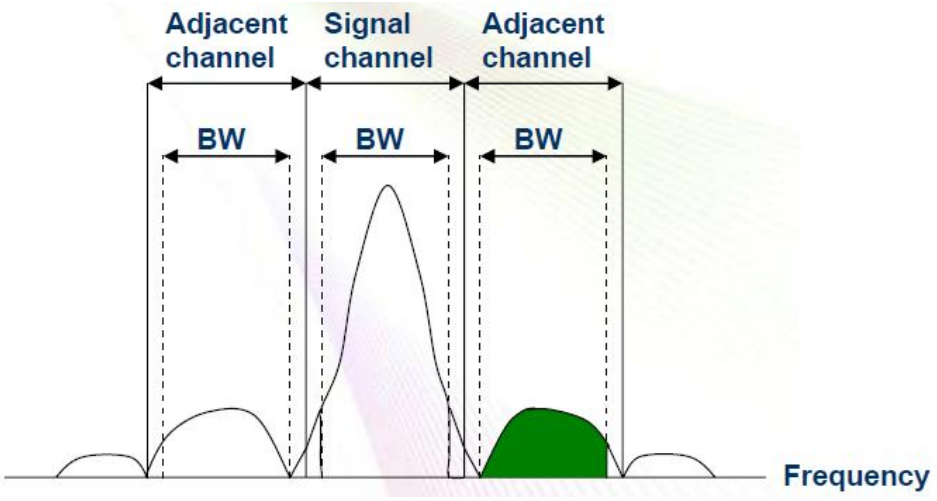


Figure 2. Signal bandwidth and adjacent channel transmit power

7. Transmitter Adjacent Channel Power Ratio (ACPR)

The ratio between the total power adjacent channel (inter-modulation signal) to the main channel's power (useful signal). ACPR is desired to be as low as possible. A high ACPR indicates that significant spectral spreading has occurred. The 1st ACPR in the Realtime Telemetry wireless system is -20dBc (0.01X) and 2nd ACPR is -50dBc (0.00001X)

8. Receiver sensitivity

Receiver sensitivity is the minimum magnitude of input signal required to recover the signal with 0.1% error rate. The Realtime Telemetry wireless system use a low noise amplifier (LNA) to effectively reduce the total system noise level. The sensitivity of the system is below -93dBm.

9. Receiver Co-Channel Rejection

Refer to figure 3, the co-channel rejection is a measure of the capability of the receiver to receive a wanted modulated signal without exceeding a given degradation due to the presence of an unwanted in-channel interference (a modulated signal), both signals being at the nominal frequency of the receiver.

The Co-Channel Rejection in Realtime Telemetry wireless system is -6dB, which is much superior than WIFI and Bluetooth system (-10 to -12dB) operating in the same band. The Realtime Telemetry wireless system has more tolerance to the inference signal than WIFI/Bluetooth based system due to the narrow band characteristics and strong FCC (Forward Error Correction).

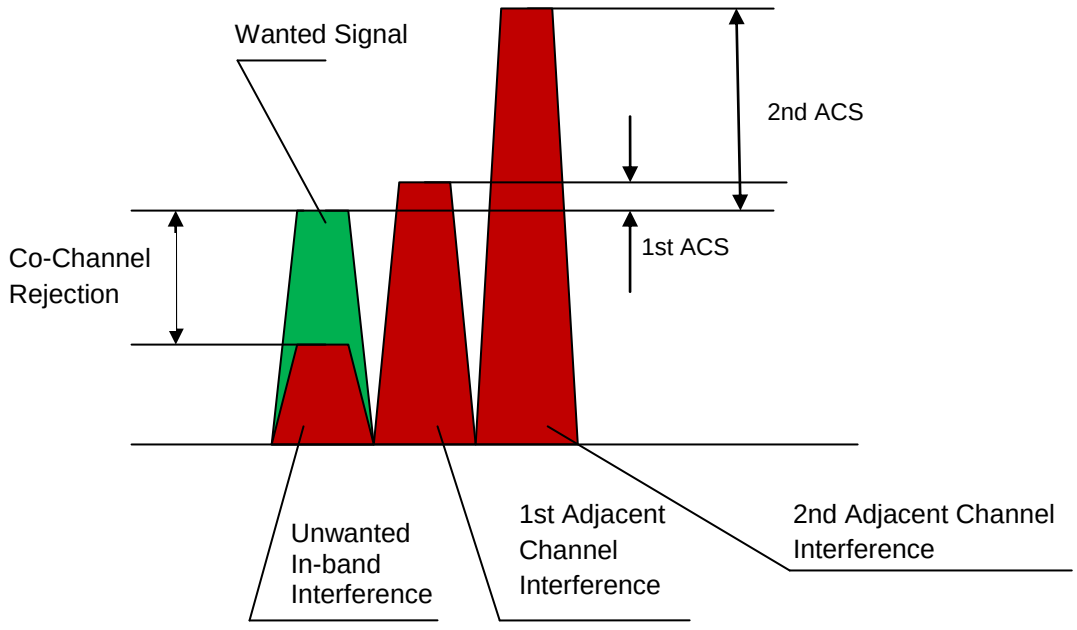


Figure 3. Co-Channel Rejection and Adjacent Channel Interference

10. Receiver Adjacent Channel Selectivity

Adjacent Channel Selectivity (ACS) is a measure of a receiver's ability to receive a signal at its assigned channel frequency in the presence of a strong signal in the adjacent channel. Refer to Figure 3, ACS is defined as the ratio of the receiver filter attenuation on the assigned channel frequency to the receiver filter attenuation on the adjacent channel frequency.

The Realtime Telemetry wireless system has 0dB, -20dB, -24dB for the 1st, 2nd and 3rd adjacent channel selectivity. These parameter is determined by the bandwidth of the IF filter and the FCC algorithm.

11. Radio Range with Free Space Propagation

Free-space path loss (FSPL) is the attenuation of radio energy between the feed-points of two antennas that results from the combination of the receiving antenna's capture area plus the obstacle free, line-of-sight path through free space.

The Radio Range with Free Space Propagation for the Realtime Telemetry wireless system is 1000 meters minimum. Due to the interference and multipath effect, the radio range will reduce dramatically in the real world. On the other hand, it yields a very high margin to prevent the interference signal from over-powering the Realtime Telemetry wireless system.

12. Inter-channel synchronization error

The inter-channel synchronization error is defined as the time difference between channels (from same or difference transmitters) for the same analog signal arriving at the sampling terminals. Realtime Telemetry wireless system is a Polygon Technologies' proprietary wireless technology, which is specially designed for test and measurement. The inter-channel synchronization error is maintained at less than 1us, which contribute less than -70dB system error.

Summery

Overall, the Realtime Telemetry wireless system is specially designed for industrial test and measurement in noisy industrial environment. It is equipped with latest RF technologies, such as the high-selectivity analog filters, temperature compensated crystal oscillator, high power transmitter, FEC channel coding etc. to minimize all the interference from electric motor, high voltage/high current sparks, etc. Realtime Telemetry wireless system is the first in class to extend the RF technologies into the test and measurement domain.

The following table listed a comparison between the Realtime Telemetry, WIFI and Bluetooth technologies.

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Table 1: Wireless Technologies Comparison

Property	Realtime Telemetry	WIFI	Bluetooth
Digital Technology	Yes	Yes	Yes
Communication Error Detection (CRC)	Yes	Yes	Yes
Communication Error Correction (FEC)	Yes	No	No
Typical Power in 2Mhz bandwidth[(1)]	20dBm (0.1W)	10dBm(0.01W)	0dBm(0.001W)
Clock Stability (-40°C to +80°C)	±2.0ppm	±50ppm	±50ppm
Nominal Bandwidth	2Mhz	22Mhz	1Mhz
Wireless link budget (typical)	100 dB	90dB	80dB
Radio Range with Free Space Propagation (typical)	1000 meter	300 meter	100 meter
Signal Latency	Constant	Variable	Variable
Embedded Sampling Clock	Yes	No	No
Designed for testing and measurement	Yes	No	No

Note 1: WIFI 802.11b is used for comparison. The total bandwidth for 802.11b is 22Mhz with 20dBm power output. So the power in the 2Mhz band is about 10dBm

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Appendix: Realtime Telemetry Wireless System Performance

Transmitter Operation

Parameter	Min	Typical	Max	Units
Operating Frequency	2400		2483	Mhz
Frequency Deviation (-40°C ~ +80°C)			±2.0	ppm
Max Output Power	18	20	22	dBm
20dB bandwidth for modulated Carrier		1800	2000	Khz
1st Adjacent Channel Transmit Power			-20	dBc
2nd Adjacent Channel Transmit Power			-50	dBc
Non-overlapping Channel Spacing			2	Mhz
Data Rate			2000	Kbps

Receiver Operation

Parameter	Min	Typical	Max	Units
Sensitivity (0.1%BER)		-93		dbm
Carrier over Interference (Co Channel Rejection)		6		dBc
1st Adjacent Channel Selectivity		0		dBc
2nd Adjacent Channel Selectivity		-20		dBc
3nd Adjacent Channel Selectivity		-24		dBc
Nth Adjacent Channel Selectivity (>12Mhz)		-42		dBc
Nth Adjacent Channel Selectivity (>36Mhz)		-50		dBc