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Tetra Radio Base Station Performance Analysis

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Abstract: This article presents the modulation accuracy analysis for the Tetra Base Station using the Aeroflex 3920 test equipment. The analysis shows that the modulation accuracy results are in compliance with the specifications of ETSI EN 300 392-2 Terrestrial Trunked Radio (TETRA) [1] Voice plus Data (V+D) Part 2 for Air Interface (AI) which is one of the industrial standards used as reference for mobile and fixed radio system.

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I. INTRODUCTION

Terrestrial Trunked Radio (TETRA) is a digital trunked mobile radio standard developed to meet the needs of traditional Professional Mobile Radio (PMR) user organizations such as Public Safety, Transportation, Utilities, Government, Military, Commercial & Industry, and Oil & Gas [2]. The TETRA standard has been specifically developed to meet the needs of a variety of traditional PMR user organizations. This means it has a scalable architecture allowing economic network deployments ranging from single site local area coverage to multiple site wide area national coverage. Having a low quality signal in terms of the modulation accuracy is not acceptable and will put the customer operations in high risk. Therefore, maintaining the standard modulation accuracy is a safety and operational requirement in order to have satisfactory Radio signal utilized by the customer to perform the plant field operations. In this paper, the Modulation accuracy common parameter called EVM (Error Vector Magnitude) [3] is analyzed and evaluated to see if the Tetra base station is meeting the Modulation accuracy comparing to the ETSI (European Telecommunication Standard Institute) [2] popular standards ETSI EN 300 394 (TETRA Conformance testing specification. The EVM is a common parameter to measure the quality of the modulated telecommunication signals; the Tetra Base station signal in this paper. The EVM parameter is valuable to the researchers and engineers for the reason that it contains information of both amplitude and phase errors in the signal. Before proceeding in analyzing the EVM, Table 1 shows general technical parameters of the Tetra Base Station under testing.

Table 1: General Technical Data for Tetra Base Station

Frequency Band	4 (400 MHz)
Duplex Space	10000 KHz
Modulation	π/4 DQPSK
Channel bandwidth	25 KHz
Access technology	TDMA
Symbol rate	18000 Symbols/s
Maximum data Rate	28.8 Kbit/s

II. ANALYSIS OF THE EVM

The modulation accuracy or the modulation quality is defined by the error vector between the vector representing the actual transmitted signal and the vector representing an ideal error-free modulated signal. The magnitude of this vector is called Error Vector Magnitude (EVM).

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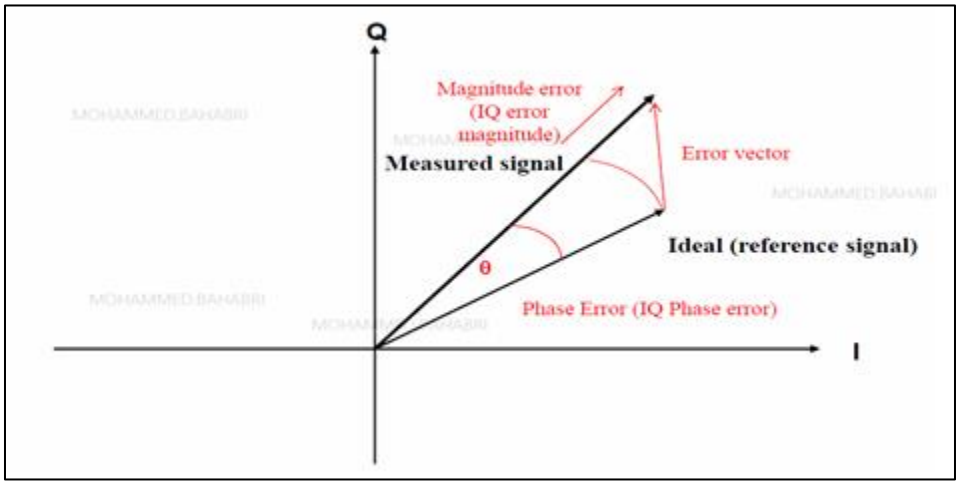

Fig 1. EVM Representation

The factors affecting the EVM include Carrier leakage, IQ skew, IQ gain difference, and Frequency response of both channels at all frequencies, added noise, phase noise.

III. ETSI STANDARDS LIMITATION FOR THE EVM MODULATION ACCURACY

Modulation accuracy is defined according to ETSI EN 300 392-2 [1] as a difference between the actual transmitted signal waveform and the ideal signal waveform. The difference is specified in terms of vector error magnitudes at a Symbol time. The parameters to be measured are RMS vector error, peak vector error, and residual carrier as defined in EN 300 392-2. Table 2 summarizes the EVM limits value as per ETSI EN 300 392-2

Table 2: EVM Limits Value as per ETSI EN 300 392 Standard

RMS vector error	Less than 10 %
Peak vector error	Less than 30 %
Residual carrier magnitude	Less than 5 %

➢ *Testing Procedure*

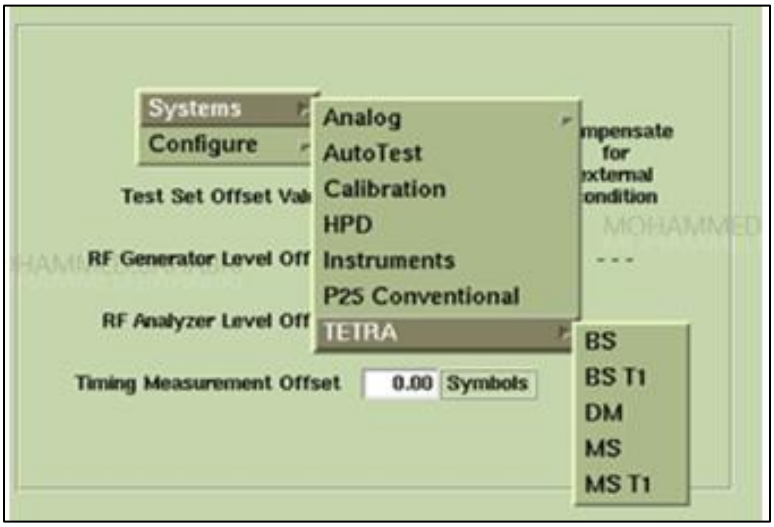

Fig 2 Adjusting the Aeroflex test Equipment

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The Aeroflex test equipment is adjusted for Tetra BS (Base Station) mode testing as shown in Fig.2. The 3900 TETRA BS System provides features for testing TETRA Base Station Transmitters in their normal operating mode. It provides the following test capabilities:

- Base station identification for MCC (Mobile Country Code), MNC (Mobile Network Code), and LA (Location Area)
- Frequency setting via Channel Plan, Channel Number or manually.
- Conversion of frequency to nearest equivalent Channel Number.
- Transmitter measurements (power, **Modulation Accuracy**, frequency error).
- Graphical displays of modulation.
- Direct RF connection to BS transmitter via T/R Connector.
- Off-air monitoring of BS transmitter via ANT (Antenna) Connector.
- Capture, demodulation and channel decoding of base station transmissions (5000 Bursts).

IV. ANALYSIS RESULTS

After the test equipment has been adjusted to provide the transmitter measurements for required tetra base station channel number and frequency over 20 transmitted pulses, Figure 3 shows the constellation diagram of the modulated signal transmitted from the tetra base station.

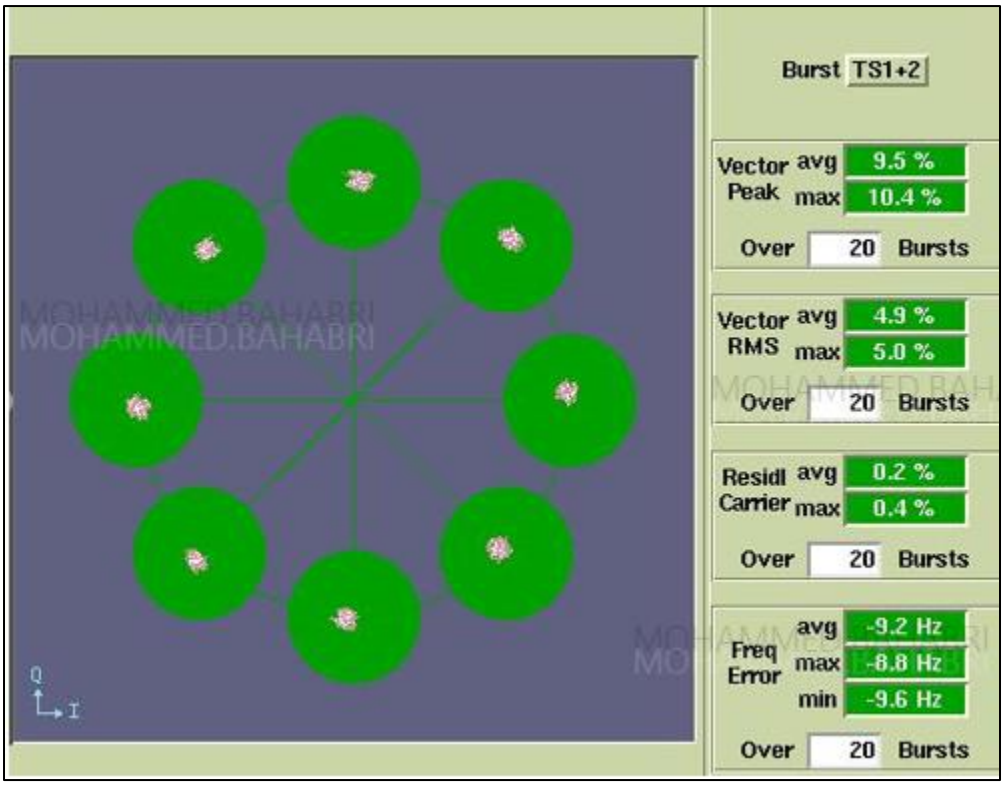

Fig 3 Constellation Diagram of the Modulated Signal Transmitted from Tetra Base Station.

The analysis results, captured from the Aeroflex Tetra Test equipment, are summarized in table 3 including whether is pass the ETSI EN 300 392 page 102 standard defined criterial mentioned in table 2 or not.

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Table 3: Summery of Aeroflex Tetra Test Equipment for EVM Analysis Results

ETSI EVM Limits		Analysis Result	Standard Criteria	Pass
Vector Peak	Avg	0.095	< 0.3	Yes
	Max	0.104	< 0.3	Yes
Vector RMS	Avg	0.049	< 0.1	Yes
	Max	0.05	< 0.1	Yes
Residual carrier	Avg	0.02	< 0.05	Yes
	Max	0.04	< 0.05	Yes

V. CONCLUSION

After evaluating the analysis results obtained from the Aeroflex test equipment model 3920 measuring base station Tetra Signal on the Air, it was found that the results are in compliance with ETSI EN 300 394 (Terrestrial Trunked Radio (TETRA); Conformance testing specification which is one of the industrial standard used as reference for Digital Trunked Radio System. This conclusion is very significant in terms of Safety, Security, and Operational prospective since the Tetra Radio services are utilized by several vital organizations such as Operations, Security, Fire, Medical**,** etc**.**

REFERENCES

[1]. ETSI EN 300 392-2 Terrestrial Trunked Radio (TETRA) Voice plus Data (V+D) Part 2 for Air Interface (AI) Conformance Testing Specifications
[2]. ETSI European Telecommunications Standards Institute
[3]. https://en.wikipedia.org/wiki/Error_vector_magnitude