Application Note

2303 Stabilock®

TETRA Mobile Station Tester

Determining the pre-attenuation of TETRA radios using the 2303 Stabilock and the 4914 Antenna Coupler

Boosting wireless efficiency

In order to gain meaningful test results, a clean test setup is a basic prerequisite. Various components are significant in the test setup; the test set and the RF cable are constants. The pre-attenuation values of the individual components, i.e. the signal loss at cables and connectors should be determined just once. So measurements at TETRA radios over a direct link (cable) are rather uncomplicated.

However, if you are using an antenna coupler rather than a cable, the coupling loss is unknown and must be determined before the measurement and for each radio model individually. This document describes how to easily identify the coupling factors when using Willtek's 2303 Stabilock and the 4914 Antenna Coupler.

Reference radio

The coupling factors (pre-attenuation values) should be evaluated using an intact TETRA terminal with typical RF parameters that can be used as a reference. Such a TETRA radio is also referred to as a "golden mobile". With a "bad" terminal as a reference, the coupling values measured would not be typical values and hence useless for subsequent tests.

Transmit and receive frequencies differ by the duplex spacing (typically 10 or 45 MHz). As the pre-attenuation is a function of the frequency, the coupling factors must be determined separately for both the transmit and the receive direction.

RF shielding chamber

The test setup can optionally be protected against the impact of electromagnetic radiation from TETRA base stations or nearby other TETRA radios. Willtek's 4921 RF Shield is a shielding chamber suitable for the purpose.

The pre-attenuation values determined with the RF Shield are not identical with those valid without the shielding chamber. If you are using the shielding chamber while determining the coupling factors, it should also be used for testing later on.

Pre-attenuation in the transmit path

Power class arrangement

Each TETRA terminal belongs to a power class giving the maximum possible transmit power of the radio (see Table 1). In order to identify the pre-attenuation value in the transmit (TX) path, the power class of the radio must be known; it is impossible otherwise to correctly determine the coupling attenuation.

Table 1: TETRA Power Classes

Power class	Maximum TX power
1 (30 W)	45 dBm
1L (17.5 W)	42.5 dBm
2 (10 W)	40 dBm
2L (5.6 W)	37.5 dBm
3 (3 W)	35 dBm
3L (1.8 W)	32.5 dBm
4 (1 W)	30 dBm
4L (0.56 W)	27.5 dBm

Note:
In conjunction with the Willtek 2303 Stabilock, TETRA radios of power classes 1 and 1L should only be tested through an attenuator (10 dB or more), and the pre-attenuation should be determined with this attenuator only, as the maximum permissible input power of the Stabilock is 10 W.

Power levels

In addition, the MS is capable of adapting its power level to the external requirements in 5-dB steps. In open loop power control, the TETRA MS adjusts its transmit power based on the signal quality from the base station in the downlink. The weaker the signal from the base station, the more radio frequency (RF) power is transmitted by the MS. If the BS signal gets stronger, the MS reduces its RF power again. So don't be surprised to find the MS change its output power when you change the Stabilock's one!

On a traffic channel, reducing the Stabilock's power level might be the right way to change the power transmitted by the MS.

The TETRA MS must be able to change its output power in steps or multiples of 5 dB.

The power accuracy must be ±2 dB at the nominal power level equivalent to the power class, and ±2.5 dB at all other nominal power levels. The difference between two adjacent power steps must be 5 dB ±2.5 dB except for TETRA mobile stations with power class modifier L, where the step width between the highest supported power level and the next lower one must be 2.5 dB ±2.5 dB.

Determining the TX pre-attenuation values and the best position on the coupler

The following steps describe how to determine the pre-attenuation values in the transmit path and also the best position on the Willtek 4914 Antenna Coupler.

1. Connecting the antenna coupler:

   a. Without RF Shield: Connect the antenna coupler to the 2303 Stabilock using an appropriate RF cable.

   b. With RF Shield: Plug the 4914 Antenna Coupler into the fixture inside the 4921 RF Shield. Connect the RF plug of the coupler with the internal RF connector of the RF Shield. Also, connect the RF Shield with the test set (2303 Stabilock) using a defined RF cable.

2. Switch on the 2303 Stabilock.

3. Select menu Setup > Definitions and set the RX und TX pre-attenuation values to zero.

4. Start the TMO mode and enter a low RF level (e.g. –95 dBm).

Note:

Applying a low RF level in the 2303 Stabilock is important as this forces the TETRA terminal to transmit at its highest RF level.

5. Enter valid network and channel parameters. Either use a channel in the middle of the frequency range used by the TETRA terminal, or determine the pre-attenuation values for different frequencies separately, e.g. on the lowest, middle and highest frequency.

6. Place the TETRA radio on the XY Shuttle of the coupler and apply shuttle position A1. If you are using a shielding chamber, close it.

7. Start a test.

8. Set up a radio connection with the TETRA terminal and ensure that it is transmitting continuously (either with a duplex call or by keeping the PTT key pressed).

9. Note down the TX power value.

10. Repeat step 9 for all the shuttle positions (A1, A2.... E5).

11. Select the shuttle position at which the highest TX value was achieved. Note down the position for subsequent measurements.

12. Perform another ten power measurements in this position and calculate the average value.

13. Calculating the TX pre-attenuation value:
    Compare maximum power value of the TETRA terminal (according to its power class, see Table 1) with the calculated TX average value on the best shuttle position. The difference of the two values is the TX pre-attenuation value.

Example: 1 W radio (power class 4)

30 dBm (expected maximum power) – 19.7 dBm (measured power) = 10.3 dB (TX pre-attenuation value)

Pre-attenuation in the receive path

This section is a step-by-step description how to determine the pre-attenuatino values in the receive direction (RX), in the shuttle position previously identified. The test setup must be the same as when the TX pre-attenuation values were identified.

TETRA terminals transmit at one of maximum seven defined transmit levels. The transmit level at any time depends on the receive level, see Table 2.

Table 2: Interrelation between transmit and receive levels

RF receive level	Transmit power control step	Transmit level
RX level < –96 dBm	1	45 dBm
–96 < RX level < –91 dBm	2	40 dBm
–91 dBm < RX level < –86 dBm	3	35 dBm
–86 dBm < RX level < –81 dBm	4	30 dBm
–81 dBm < RX level –76 dBm	5	25 dBm
–76 dBm < RX level < –71 dBm	6	20 dBm
RX level > –71 dBm	7	15 dBm

Note:

TETRA terminals of power classes 1L, 2L, 3L, 4L always transmit their maximum power level by 2.5 dB lower than shown in Table 2. This is true for the maximum power only, otherwise Table 2 applies.

Example:

At power control step 2, TETRA radios of power class 2L transmits at their maximum power level of 37.5 dBm. At power control step 3 they transmit 35 dBm.

TETRA radios always switch their transmit power up or down in 5-dB steps, depending the level of the received RF signal. The following switching levels apply:
–96 dBm, –91 dBm, –86 dBm, –81 dBm, –76 dBm , –71 dBm

If the receive level changes across one of these threshold values, the radio switches to the next lower or higher transmit power control step.

With these characteristics in mind, the RX pre-attenuation values can be calculated as follows:

1. Go the to the Setup > Definitions menu to set the RX pre-attenuation value to zero, and the TX pre-attenuation value to the value previously identified.

2. Start the TMO mode and enter a low RF transmit level (e.g. –95 dBm).

Note:

The TETRA terminal adapts its transmit power faster if you start at a low RX level (high 2303 transmit level) and subsequently increase the RX level, as described in this document.

3. Apply the same network and channel parameters as when the TX pre-attenuation values were identified.

4. Place the TETRA terminal on the XY Shuttle of the 4914 Antenna Coupler and set up the shuttle position determined for the TX pre-attenuation. If you are using the RF Shield, close it.

5. Start the test.

6. Establish a radio connection and ensure that the TETRA radio is transmitting continuously (either by a duplex call or by keeping the PTT key pressed).

7. Ensure that the TX value measured corresponds to the expected maximum power level of the radio.

8. Increase the RX level by 1 dB, wait a few seconds (it takes a few seconds until the TETRA radio adapts its transmit power) and observe the TX power level measured.

9. Repeat step 8 until the TETRA terminal changes to the next power control step (TX value decreases by 5 dB).

10. Calculating the RX pre-attenuation value:
Compare the RX level set with the nominal RX level at the switching point between the two power control steps. The

difference of the two values is the RX pre-attenuation value.

Example: 1 W radio (power class 4)

–70 dBm (RX level set) – [–81 dBm (nominal RX level)] = 11 dB (RX pre-attenuation value)

11. In the Setup > Definitions menu, set RX pre-attenuation to the calculated value.

12. Set up a call in TMO mode, slowly change the RX level and verify that the TETRA terminal switches its transmit power level according to Table 2.

This way, the pre-attenuation values can be identified without difficulty using a TETRA reference terminal (golden mobile). These values can then be used while testing the RF characteristics of other TETRA radios of the same model.

2303 Stabilock and Options

2303 Stabilock TETRA Mobile Station Tester	M 100 203

Hardware Options

2360 OCXO Option	M 248 715
2361 Battery Option	M 205 015

Software Options

2330 DMO Option	M 897 400
2331 Autotest Option	M 897 401

Accessories

Battery Module, 7.2 Ah	M 205 012
12 V Car Adapter	M 860 389
Power Supply	M 248 328
1500 Battery Charger	M 204 097
External Charger Bundle (battery, power supply, 1500 Battery Charger)	M 248 972
Trolley Carrying Case	M 300 871

4914 Antenna Coupler and Accessories

4914 Antenna Coupler	M 248 719
4914 Antenna Coupler Package (with cable for instrument with N-type jack)	M 248 699
4921 RF Shield & 4914 Package (with RF Shield and cable)	M 248 353
PDA Shuttle for 4914 and 4916	M 248 692

Visit **www.willtek.com/tetra** for more information on Willtek's TETRA products!

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