

Application Note

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Testing TETRA mobiles with the IFR 3901

by Clive Rodmell



The Aeroflex IFR 3901 is the successor to the IFR 2968 TETRA Radio Test Set, the industry standard for the test, service and repair of all TETRA mobiles. The IFR 3901 offers enhanced functionality, faster measurements and greater ease of use.

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This application note is an introduction to testing TETRA mobiles with the Aeroflex IFR 3901 Digital Radio Test Set using the Option 110 TETRA MS System personality. It takes you through the basics of configuring the IFR 3901, registering the mobile to the test set, placing calls from the mobile to the test set and placing calls from the test set to the mobile. These operations result in the mobile transmitting and/or receiving so that you can make parametric measurements on its radio transmitter and/or receiver. The test set needs to be configured to match the configuration of the mobile under test as you are unlikely to be able to test the mobile if this is not done correctly.

The term "mobile" is used throughout this application note to mean any TETRA radio terminal that is used for communication, whether vehicle mounted or hand portable. In the context of testing on the IFR 3901, the term "mobile" should be taken as synonymous with any of the commonly used terms: "terminal", "radio", "radio terminal", "mobile", "mobile radio", "vehicle mount mobile", "carphone", "mobile phone", "phone", "portable", "hand portable", "hand-held", "handset", "handy", "mobile station", "MS".

The IFR 3901 (with Option 110 TETRA MS System personality) not only tests the mobile's radio transmitter and receiver parameters, it also allows you to check the mobile's functional behavior and configuration. TETRA mobiles support different types of calls, and the available functionality will depend on the particular make and model of mobile and the configuration programmed into it. Therefore the IFR 3901 permits a number of different call types to be exercised (private, group, phone, emergency) as well as status messages and short data messages.

Once you are familiar with the operations that are necessary to configure the test set and operate the mobile and test set, you can simplify your routine test procedure and shorten your routine test time by using the IFR 3901's built-in AutoTest system. You can load and edit AutoTest scripts to suit the requirements of your test procedure and the mobile under test.

There may be circumstances where you are unable to register the mobile and place calls, because of lack of information or because the mobile has not been configured. To assist in such cases, the IFR 3901 allows you to test the mobile in a special test mode (T1 test mode) by selecting the TETRA MS T1 System personality. This mode also tests other aspects of the mobile that may not be possible in its normal mode of operation.

This application note is only a summary and example of procedures. For full operating details please refer to the following publications:

- IFR 3901 Operating Manual (on the documentation CD ROM, also available in printed form)
- IFR 3901 Programming Manual (on the documentation CD ROM)

Getting Started

Check that the information bar at the bottom of the IFR 3901 display shows 'TETRA MS'. If it does not, select the 'TETRA MS' system as follows: Press the CONFIG hardkey once or twice to display the CONFIG floating menu. Use the cursor keys to highlight 'Systems', 'TETRA', 'MS' and press the SELECT hardkey. The infor-

mation bar should now show 'TETRA MS' in the bottom left-hand corner.

Before you can test a TETRA mobile, you will need to make a RF connection between the TETRA mobile and the IFR 3901. See 'RF connection between the mobile and the IFR 3901' below.

Private radio systems such as TETRA are more network specific than public mobile phone systems such as GSM. TETRA mobiles are individually programmed with a configuration specific to the TETRA network and the user of the mobile. This configuration is normally performed as a file downloaded to the mobile from a PC application, and may be known as a 'code plug' or 'parameter file' or 'customization file'.

Before you can start testing TETRA mobiles you must set up a few essential network parameters on the IFR 3901. These parameters configure the test set to emulate the particular TETRA network for which the mobile has been configured, so that the mobile thinks that the test set is a real TETRA base station in its home network. If any of these parameters do not match the mobile's configuration the mobile is likely to ignore the IFR 3901 and not perform registration or call placement. See 'Essential Network Parameters' below.

RF connection between the mobile and the IFR 3901

Normally you should use the high power N-type "T/R" socket on the test set in a single-port duplex configuration. The LED above the T/R port should be lit, and the LEDs above the GEN and ANT ports should be unlit. If this is not the case, select the 'TEST: Manual - Tiled' display, TAB to the RF Settings tile and use the soft-keys to set RF Out to T/R and RF In to T/R. Ensure that you do this with the TETRA MS system selected, since these settings are specific to the selected system.

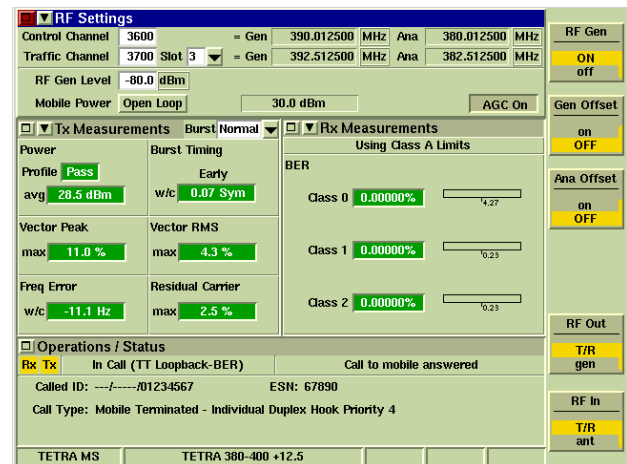


Figure 1 - TETRA MS system Manual Tiled display with 'TETRA 380-400 +12.5' channel plan selected and RF Out / RF In on T/R port

Vehicle mounted mobiles normally have a standard type of RF connector for their antenna connection, typically BNC or TNC, which makes for straightforward connection to the test set.

Hand portables are likely to have a proprietary antenna connection and a separate proprietary RF test socket or accessory/pro-

gramming connector incorporating an RF connection. There will normally be an internal electronic switch to select the antenna or the accessory/test connector, which may be driven by an accessory connecting lead or test lead. Using the cradle from the manufacturer's car installation kit normally provides a good RF connection but you need to ensure that this does enable the external antenna connection by itself when not used as part of a complete installation with DC supply.

Some hand portables have a screw-in antenna; you can unscrew the antenna, replace it with an adaptor and connect a lead to the test set. You need to obtain a suitable adaptor from the manufacturer unless it is a standard RF connection such as SMA. Note: the antenna connection on some hand portables looks like SMA but has a shorter central pin than a standard SMA male connector so you need to ensure that the adaptor that you screw in does actually make contact.

In all cases you should refer to the manufacturer or supplier for guidance on making a RF connection.

If your RF connecting lead has a known loss, you can configure the IFR 3901 to take this loss into account when setting its signal generator level and when measuring the mobile's transmitter power level. Press the CONFIG hardkey once or twice to display the CONFIG floating menu and select Offsets. Set the "RF Generator Level Offset" (mobile Rx level) and the "RF Analyzer Level Offset" (mobile Tx level) for the required compensation and use the softkeys to turn the offsets ON. Ensure that you do this with the TETRA MS system selected, since these settings are specific to the selected system. Negative values compensate for an external loss, positive values compensate for an external gain.

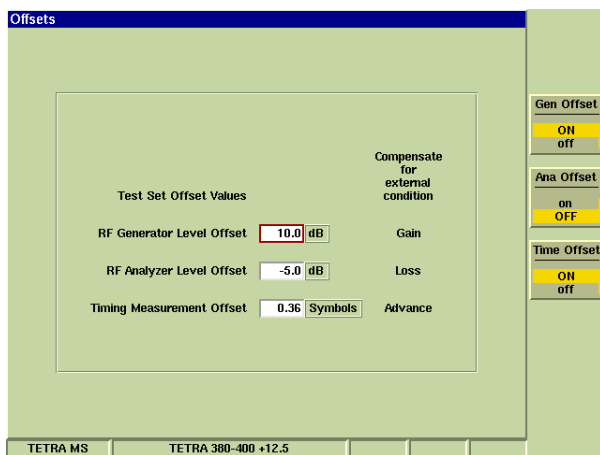


Figure 2 - RF Offset configuration

If you cannot make a direct RF connection to the mobile, you will not be able to perform calibrated measurements of transmitter power level or receiver sensitivity. However, you may be able to perform a functional test using an off-air connection. Connect the test set to a suitable coupler or antenna via the T/R port and ensure that only the LED above the T/R port is lit. Alternatively, a better off-air connection will be achieved by connecting separate transmit and receive antennas to the GEN and ANT ports, which provide a higher maximum output level and a more sensitive input than the duplex T/R port. In this case, ensure that the GEN and

ANT port LEDs are lit and the T/R port LED is unlit, using the RF Out and RF In softkeys in the RF Settings tile. Leave the mobile's antenna attached and place the mobile in a stable position a short distance from the antenna, e.g. 10-20 cm, or located correctly within the coupler. Configure the 3901 with the off-air coupling loss (CONFIG: Offsets). If the coupling loss is unknown, try offset values of -30 dB initially and adjust as required.

Note: beware that by using an off-air connection the mobile may also receive real off-air signals, and that other users of the radio spectrum may receive the mobile's transmissions. You should set the IFR 3901 'CONFIG: System ID & Access Parameters: Max Tx Level' parameter to 15 dBm to limit the mobile to its minimum power level. You are recommended to use a fully screened test chamber to ensure that you are not making unauthorized transmissions and causing interference. As a further safeguard if you are operating on the same frequency as a nearby TETRA base station, you should set the IFR 3901 'CONFIG: System ID & Access Parameters: Base Station Color Code' parameter to a different value from that used by the real base station, but not 0.

Essential Network Parameters

The essential network parameters are:

- Channel Plan
- Control Channel
- Mobile Country Code (MCC)
- Mobile Network Code (MNC)

These parameters are explained below:

Channel Plan

The channel plan is the range of radio frequencies used by the mobile's transmitter (uplink) and the mobile's receiver (downlink), e.g. 380-400 MHz. The IFR 3901 provides a number of pre-defined channel plans covering the frequency bands 380-400 MHz, 410-430 MHz, 450-470 MHz, 805-870 MHz and 870-921 MHz (refer to Annex A for details). Normally you will be able to test a TETRA mobile by selecting the appropriate pre-defined channel plan. If this is not the case, the IFR 3901 allows you to define your own channel plans (refer to Annex B for details).

Pre-defined channel plan 'TETRA 380-400 +12.5' will be correct for most TETRA mobiles used for Emergency Services/Public Safety in Europe and some non-European countries. If this does not work, try the 'TETRA 380-400 ZERO' channel plan instead.

Pre-defined channel plan 'TETRA 410-430 +12.5' will be correct for many TETRA mobiles used for Public Transport, Utilities, Logistics and Commercial/PAMR users in Europe and some non-European countries (although some transport and utilities' users with a Public Safety remit may be on the 380-400 MHz band). If this does not work, try the 'TETRA 410-430 ZERO' channel plan instead. The pre-defined channel plan 'TETRA 410-430 -6.25' is known to be used in South Africa.

Pre-defined channel plan 'TETRA 805-870 +12.5' (or 'TETRA 805-870 ZERO') will be correct for many TETRA mobiles used in Asia Pacific countries and some other non-European countries.

The 450-470 MHz and 870-921 MHz bands were not known to be in use anywhere at the time of writing of this application note (October 2004).

Control Channel

TETRA control channels can be at any frequency (channel number) within the frequency band in that the TETRA standard does not prescribe particular channel numbers to be reserved for control channels. However, individual TETRA systems may have their own definitions of channel numbers that are reserved for control channels. Some TETRA mobiles will scan all frequency channels within the band to look for a suitable control channel, others may be configured so that they only look at the channel numbers defined as control channels for their particular system. If you are testing a TETRA mobile that does not scan the band, you will need to ensure that the IFR 3901 control channel is set to a frequency (channel number) that the mobile has been configured to look at.

When you select a TETRA channel plan on the IFR 3901, the default setting for the control channel is the lowest frequency in the channel plan since it is common practice for mobiles that scan to start at the lowest frequency and work up the band. The default setting for the traffic channel is 100 channels (2.5 MHz) higher than the control channel. Some TETRA mobiles may be supplied or configured in versions that only cover part of a frequency band. For these mobiles you will need to set the control channel and traffic channel (in the 'TEST: RF Settings' tile) to channels that are covered.

Mobile Country Code (MCC)

The Mobile Country Code specifies the country of the mobile's home network, for example the MCC for the UK is 234. It is used in conjunction with the Mobile Network Code (see below). TETRA Mobile Country Code values can be found in Annex K of ETSI EN 300 392-2 v2.4.1. You can also select a named country from the drop-down list in the IFR 3901 CONFIG: System ID & Access Params menu.

Mobile Network Code (MNC)

The Mobile Network Code (MNC) specifies the home network for which the mobile has been configured, in conjunction with the Mobile Country Code (MCC). TETRA Mobile Network Code values are allocated by the radio communications regulatory authority in each country, for example within the UK the MNC allocated for the 'Airwave' public safety network is 78.

TETRA base stations broadcast their MCC and MNC values regularly and a TETRA mobile looks for a base station (or a test set) belonging to its home network, i.e. broadcasting the correct MCC and MNC values. Unless the mobile permits 'migration' onto another network, the test set MCC and MNC values must match those configured in the mobile.

Obtaining the Essential Network Parameters for your mobile

It is not always easy or obvious determining the essential network parameters for a particular TETRA mobile but this information must be obtained before you can test the mobile on a test set. There are a number of options that may be appropriate to the situation:

- Refer to the manufacturer or supplier of the mobile or the network operator or other body with responsibility for provision and programming of the mobile.
- Use menu functions or diagnostic menu functions on the mobile (if available) to display the network parameters.
- Use the mobile's programming tool (if available) to read the network parameters.
- If the mobile is known to work with a nearby base station, use the 3901 in the TETRA BS System to determine the essential network parameters and set up the 3901 in the TETRA MS System to match the real base station.

For further assistance, refer to Aeroflex Application Note "IFR 3901 Frequently Asked Questions".

Factory Default Configuration

TETRA mobiles are normally configured with network and channel plan parameters after manufacture. If the mobile has not yet been configured for a particular network it may have a factory default configuration to allow factory final test, otherwise it may not be possible to perform any registration or call setup operations. There may be significant differences between the factory default configuration and the normal configuration that is programmed into the mobile for operation on a TETRA network:

- The channel plan may be a proprietary numbering scheme not conforming to the ETSI/TIP channel numbering scheme. Typically the lowest supported frequency may have channel number 0000 or 0001 and frequency offsets may not be used. You will need to define a new channel plan in the IFR 3901 CONFIG: Channel Plan menu (see Annex B).
- The control channel may be pre-set to the lowest or middle frequency of the band, or some other factory default channel, or the mobile may default to scanning the band.
- The MCC and MNC values are likely to be proprietary test values not corresponding to real TETRA country and network code combinations.
- The subscriber identity (SSI) may be the same default value in every mobile.
- The mobile may not be configured with groups or gateway addresses in which case some functions such as group calls or phone calls may not be possible.

Configuring the IFR 3901

Use the following sequence to configure the IFR 3901 with the essential network parameters:

If the information bar at the bottom of the display does not already show 'TETRA MS', select the 'TETRA MS' system as follows:

Press the CONFIG hardkey once or twice to display the CONFIG floating menu.

Use the cursor keys to highlight 'Systems' and 'TETRA' and 'MS' and press the SELECT hardkey. (The rotary knob may be used to scroll down the list or an external USB mouse may be used to point and click).

The information bar should now show 'TETRA MS' in the bottom left-hand corner.

Press the CONFIG hardkey once or twice to display the CONFIG floating menu and select Channel Plan.

Select the required channel plan:

either

Press SELECT, scroll up or down the list with cursor keys or rotary knob, press SELECT

or

Turn the rotary knob to step through the list of channel plans directly

or

Use an external mouse to point and click on the drop-down list.

The information bar should now show the name of the selected channel plan next to 'TETRA MS'. The CONFIG: Channel Plan screen shows information about the selected channel plan.

Press the CONFIG hardkey to display the CONFIG floating menu and select 'System ID & Access Params'.

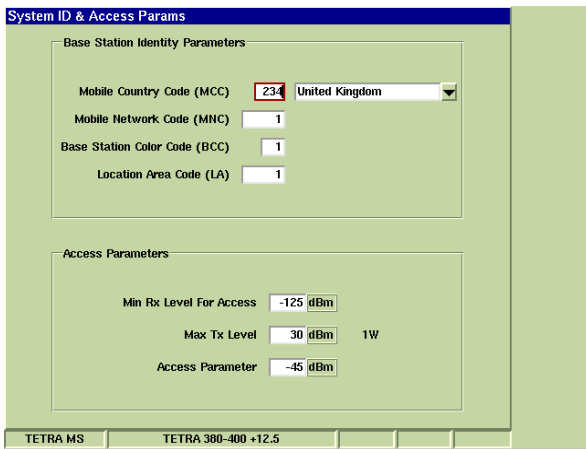


Figure 3 - System ID & Access Params configuration

Use the cursor keys (or an external USB mouse) to navigate to the MCC and MNC parameters, enter the required value for each parameter and press ENTER. For example, MCC 234 for the United Kingdom and MNC 78 for the Airwave network. Country codes can also be selected from the drop-down list of named countries (press SELECT and use the rotary knob).

Press the TEST hardkey to return to the TEST: Manual Tiled screen.

The RF Settings tile shows the default Control Channel and Traffic Channel numbers for the selected channel plan. Alongside are the actual frequencies of the test set RF Generator (mobile Rx frequency) and RF Analyzer (mobile Tx frequency). If different channels are required, TAB to the RF Settings tile and use cursor key navigation (or mouse point-and-click) to enter the required channel numbers.

For full details of configuring the IFR 3901, refer to following parts of the IFR 3901 Operating Manual:

Chapter 3 'Local control of the test set platform'

Chapter 21 'Accessing'

Chapter 21 'Channel Plans'

Chapter 23 'Initial configuration of the TETRA MS System'

Chapter 23 'The test tiles: RF Settings tile'

Testing the mobile

Once the IFR 3901 has been set-up to emulate a base station belonging to the mobile's home network, it is then possible to perform a number of tests on the mobile. You are recommended to familiarize yourself with the mobile's operation using the IFR 3901 in TETRA MS Manual Tiled mode before configuring and running Auto Test scripts. Alternatively you may test the mobile in T1 test mode. Refer to the IFR 3901 Operating Manual for details of T1 test mode (Chapter 24).

Before attempting any testing, ensure that the IFR 3901 has been powered on for at least 2 minutes (up to 10 minutes in cold conditions) so that its frequency reference has time to warm up and stabilize. Ensure that the environmental conditions are within the rated range of operation for both the mobile and the test set.

For a vehicle-mount mobile, ensure that the power supply is adequate. General purpose variable voltage DC supplies are often not suitable even though the average current consumption of the mobile may be within the power supply's rated output. Specialist fixed voltage (12 V or 13.8 V) stabilized power supplies with high current ratings are usually the most suitable. A fully charged vehicle battery is an alternative. If there is any doubt about the mobile's performance, try testing with a higher rated power supply, or with the mobile installed in a vehicle.

For a hand-portable mobile, ensure that the battery charge level is adequate. If there is any doubt about the mobile's performance, fully charge the battery before testing the mobile.

Registration

Configure the IFR 3901 to match the configuration of the mobile under test and make an RF connection between the mobile and the test set. Ensure that the 3901 RF Generator is set to a suitable level for the mobile to recognize the test set signal, e.g. -80 dBm. Power on the mobile; within a short period (typically 10 to 20 seconds) you should see an indication on the test set that the mobile has registered ("Registered (ITSi Attach)") and there may be other parameters displayed. For further details about registration refer to the IFR 3901 Operating Manual Chapter 23 'Mobile Registration'. The mobile is also likely to provide an indication that it has registered and is ready for use. Typically the signal strength is indicated and the mobile may indicate 'Ready' or 'In Service' (this may be an LED) and/or the currently selected group and/or the calling mode (e.g. group, private, phone).

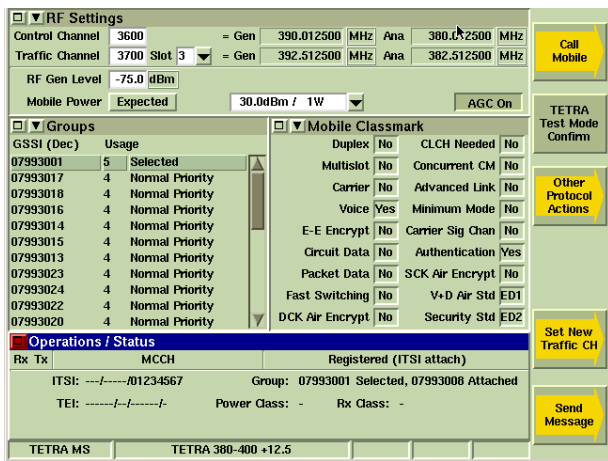


Figure 4 - Registered (ITSI Attach) state with additional tiles showing attached groups and mobile classmark

If the IFR 3901 does not indicate that the mobile has registered, the mobile may indicate e.g. 'Searching', 'Connecting' or 'No Service' or a warning LED and typically will not display signal strength. Refer to Annex C for troubleshooting suggestions if the mobile does not register.

Placing a call from the mobile to the IFR 3901

The IFR 3901 supports the various different call types that can be placed by the mobile (Mobile Originated or MO calls), and indicates the type of call placed as well as the call parameters (e.g. called party ID). Group, private, phone (PSTN, PABX, ISDN), broadcast and emergency calls are supported, simplex and duplex (where applicable), hook signaling and direct setup (where applicable), PTT operation (for simplex calls). For the purpose of making transmitter and receiver measurements, you should use a duplex call if possible. Mobile originated calls can normally be cleared down from either the mobile or the test set.

Refer to the IFR 3901 Operating Manual chapter 23 'Mobile Originated Calls', for detailed descriptions of mobile originated call operations. These descriptions contain generalized information about typical procedures for placing calls from TETRA mobiles to the IFR 3901. If this information is insufficient, refer to the mobile manufacturer's instruction manual for further information specific to the particular mobile.

You may find that the types of calls supported by the mobile and the method by which these calls are placed are dependent on the particular configuration programmed into the mobile. Some mobiles are configured to automatically revert to Group Call mode if you select Private Call mode or Phone Call mode and you do not place a call within a short timeout period. Refer to the mobile supplier or network operator for configuration information if required.

Placing a call from the IFR 3901 to the mobile

The IFR 3901 supports the various different call types that can be placed to the mobile (Mobile Terminated or MT calls). Group, private, phone (PSTN, PABX, ISDN), emergency, and user-defined

calls are supported, simplex and duplex (where applicable), hook signaling and direct setup (where applicable), PTT operation (for simplex calls). For the purpose of making transmitter and receiver measurements, you should use a duplex call if possible. Mobile terminated individual calls can normally be cleared down from either the mobile or the test set; mobile terminated group calls can only be cleared down from the test set.

Refer to the IFR 3901 Operating Manual chapter 23 'Mobile Terminated Calls', for detailed descriptions of mobile terminated call operations. These descriptions contain generalized information about typical procedures for placing calls from the IFR 3901 to TETRA mobiles. If this information is insufficient, refer to the mobile manufacturer's instruction manual for further information specific to the particular mobile.

You may find that the types of calls supported by the mobile and the method by which these calls are received are dependent on the particular configuration programmed into the mobile. Refer to the mobile supplier or network operator for configuration information if required.

The IFR 3901 allows you to define the parameters for mobile terminated group calls, private (individual) calls, phone calls and emergency calls. Once these parameters have been set up, the different call types can be placed from the TEST: Operations / Status tile, using the [Call Mobile] softkey followed by [Group Call], [Private Call], [Phone Call] or [Emergency Call].

The IFR 3901 also allows you to define your own type of call using any combination of the call setup parameters, and to place this type of call using [Call Mobile] [User Defined Call]. This can be useful for combinations not covered by the standard call types, e.g. [Phone Call] is always a duplex call using hook signaling but you could define [User Defined Call] to be a simplex phone call or to use direct setup. You can also use the [User Defined Call] function for additional combinations that are covered by the standard call types, e.g. you may want to define both a simplex private call (using [Private Call]) and a duplex private call (using [User Defined Call]).

The call types are configured and defined using the following procedure:

[CONFIG] [CONFIG] to display the CONFIG floating menu

Select 'Call Types'

Select Call Type: 'Group' or 'Private' or 'Phone' or 'Emergency' or 'User Defined'

(set up call parameters as required for each Call Type)

[TEST] to return to the TEST: Manual Tiled screen.

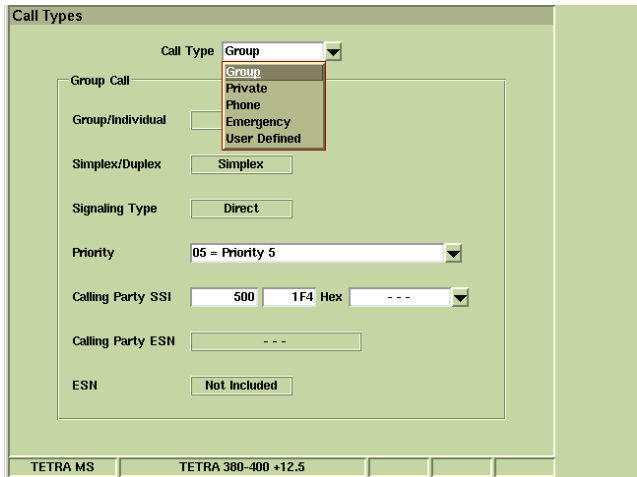


Figure 5 - Call Types configuration

A TETRA mobile will normally only support a subset of the possible combinations of call types and parameters, usually dependent on its configuration as well as the inherent capabilities of the mobile design. If you attempt to place a call to a mobile of a type that the mobile does not support, the mobile may reject the call setup in which case the 3901 indicates "Requested service not available on MS" and remains on the control channel (MCCH).

Alternatively, the mobile may offer to proceed with a variation of the call type that it does support, a process known as "call modification by the called party". Typically a mobile may modify a direct setup call to a hook signaling call (the mobile alerts the user and waits for the user to answer) or it may modify a duplex call to a simplex call if it does not support duplex calls for the call type requested. In this case, the 3901 indicates (and accepts) the type of call offered by the mobile when the call is connected.

Analyzing Transmitter Parameters

Once in a call, with the TETRA mobile transmitting, the IFR 3901 performs measurements on the radio transmitter: power, power profile, timing error, frequency error, and modulation accuracy (vector error). These measurements are shown in the 'Tx Measure' tile. If you have limit checking enabled (in CONFIG: Tx Measurements Limits), you can see at a glance whether the transmitter parameters are within specification by the green (pass) or red (fail high) or blue (fail low) status of the measurements. If you have multiple burst averaging enabled (in maximized 'Tx Measure' tile), the measurements are colored yellow during the initial acquisition period. Note that the 'Tx Measure' tile will only show measurements for Normal Bursts or Control Bursts, as selected in the title bar of the tile. If you want to see measurements on both burst types simultaneously, you can select a second 'Tx Measure' tile, one for Normal Bursts, the other for Control Bursts.

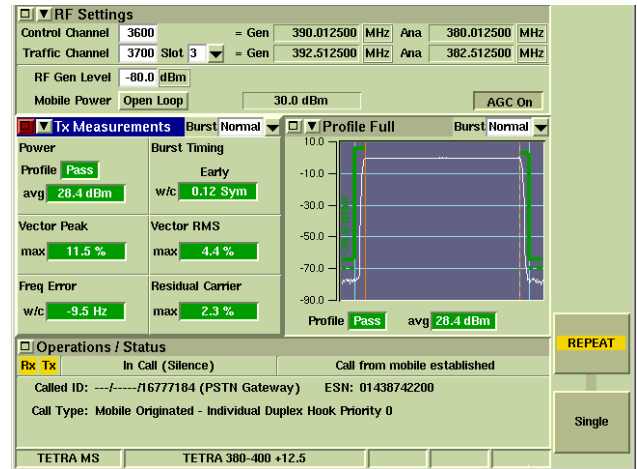


Figure 6 - Tx Measurements with limit checking and additional tile showing power profile

The power measurement pass/fail limits are applied to the power level that the test set is expecting the mobile to be transmitting, shown in the RF Settings tile. The mobile power level during a call is controlled indirectly, by varying the test set RF Gen Level (known as 'Open Loop Power Control'). The mobile power cannot always be predicted accurately, in which case the test set shows a warning triangle by the expected mobile power. You should also set the Mobile Power Class parameter in the CONFIG: Mobile Parameters menu so that the test set knows what the mobile's maximum power level is supposed to be.

More detailed RF investigation can be undertaken by selecting one or both of the central tiles to show one or more of the following graphical display types. Focus on the drop down selection [▼] on the title bar, press SELECT (or mouse-click) and use the cursor keys (or mouse) to select the required display type:

- Power, Profile Full: power vs. time profile for a complete burst
- Power, Profile Ramps: power vs. time profile for burst ramp-up and ramp-down periods
- Mod Accuracy, Vector Error: vector error vs. time
- Mod Accuracy, Phase Error: phase error component vs. time
- Mod Accuracy, Magnitude Err: magnitude error component vs. time
- Mod Accuracy, Trajectory: phase trajectory diagram
- Mod Accuracy, Constellation: constellation diagram
- Mod Accuracy, Rotated Vector: rotated vector display

The maximize button on each of these display tiles gives access to full screen display tiles with additional functions. While you are viewing a maximized display tile, you can still operate the mobile e.g. to set up or clear down calls from the mobile or press / release the PTT, without returning to the Operations / Status tile. Ensure that the test set is set to Auto Answer a call setup from the mobile (in the 'CONFIG: Call Timers & Trunking' menu) so that you do not need to return to the Operations / Status tile.

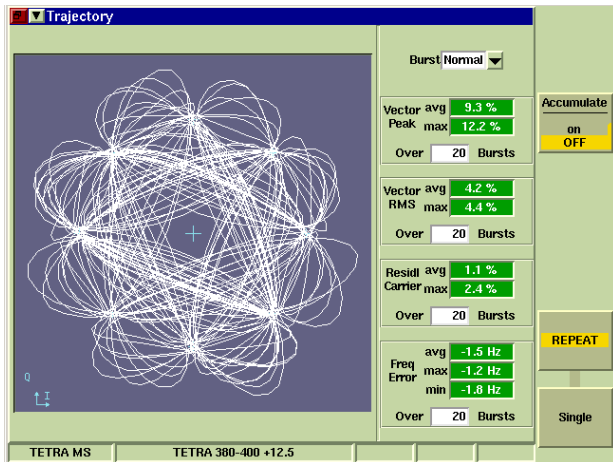


Figure 7 - Maximized Phase Trajectory display

If possible you should set up a duplex call (e.g. a phone call) before analyzing the transmitter performance, particularly if using the graphical display tiles for detailed analysis over an extended period. Simplex calls have two disadvantages for transmitter analysis:

- The mobile's PTT has to be held pressed in order to keep it transmitting
- Mobiles normally employ an autonomous transmit timer, typically of 1 minute duration, which causes the mobile to cease transmitting even though the PTT is held pressed.

You can also test the mobile's transmitter performance at different power levels. Normally this is controlled by altering the test set RF Gen Level so that the mobile adjusts its power level in response using Open Loop Power Control (OLPC).

Transmitter performance can also be measured with the mobile in T1 Test Mode, if the mobile supports this mode and you have access to it. You will need to select T1 Test Mode on the mobile. You will also need to select the 'TETRA MS T1' system on the IFR 3901. Refer to the IFR 3901 Operating Manual chapter 24 for full details of testing mobiles in T1 Test Mode.

Testing Receiver Parameters

Testing a mobile's receiver requires that an RF signal is generated with known baseband content so that the mobile can receive, demodulate and process the RF signal to recover the baseband signal. The recovered baseband signal is then analyzed to determine how well the mobile has recovered the baseband content from the RF signal. Normally this is performed with the RF signal generator at a low level, typically the Reference Sensitivity Level, to determine whether the mobile's receiver has adequate sensitivity.

Note: before performing receiver sensitivity tests, ensure that the IFR 3901 'minimum Rx level' parameter is set to its lowest value of -125 dBm (CONFIG: System ID & Access Params: Min Rx Level For Access). If this parameter is set to a higher value there is a risk that the mobile will drop the channel during sensitivity testing when the IFR 3901 RF Gen Level is reduced to a level lower than the value indicated in this parameter.

The traditional model for analog radio systems uses a 1 kHz sine wave modulated onto the RF carrier; the mobile recovers this as a baseband audio signal, which is subjected to a distortion or SINAD measurement. The model for digital radio systems (such as TETRA) uses digital data modulated onto the RF carrier, usually a Pseudo Random Binary Sequence (PRBS). To avoid the complications of obtaining a baseband digital data output from the mobile for analysis, the usual method for digital radio systems is for the mobile to re-transmit the recovered digital data to the test set, known as "RF Loopback". Analysis consists of bit-by-bit comparison of the recovered digital data with the original PRBS data to determine the number of bit errors. The proportion of bits in error out of the total number of bits is known as the Bit Error Ratio (BER).

TETRA mobiles may require that you perform special operations on both the mobile and the test set to enable the use of the loopback modes. Typically you will need to set the test set Mobile Country Code and Mobile Network Code parameters each to the test values of 1 (CONFIG: System ID & Access Params, MCC, MNC). Consult the mobile manufacturer for details of any special operation that needs to be performed on the mobile. Focus (TAB) on the Operations / Status tile. Following registration ('Registered (ITSI Attach)') you should immediately press the [TETRA Test Mode Confirm] softkey on the test set. You should now see 'Registered (Test Mode)' on the test set as well as the mobile's TETRA Equipment Identity (TEI), Power Class and Receiver Class. If these enabling operations have not been performed, or if the mobile does not support TT Test Mode, you will see 'Loopback set failure' when attempting to command the mobile into loopback.

The IFR 3901 tests the receiver sensitivity of TETRA mobiles by measuring BER on the digital data that is normally used to convey the digitized TETRA speech signal. To do this you need to set up a duplex call either from the mobile to the test set or from the test set to the mobile. Set up a phone call or a private duplex call to or from the mobile, whichever is most convenient and permitted by the mobile's configuration. Now press the [Loopback] softkey (Operations / Status tile) to command the mobile into 'TT (TETRA Test mode) Loopback'. The test set will show 'In Call (TT Loopback - BER)'. The test set will now generate PRBS data and will measure BER on the recovered digital data that is re-transmitted by the mobile.

To view the BER measurements, select one of the central tiles to show 'Rx Measurements'. Reduce the test set RF Gen Level (RF Settings tile) to a low level so that the mobile receiver introduces errors to the recovered data; typically you can expect the 'Class 0' bits to show an error of 3.5% to 5% when the RF Gen Level is somewhere in the range -112 dBm to -115 dBm. Restore the RF Gen Level to a 'safe' level of e.g. -80 dBm before attempting other operations so that the mobile can reliably receive the signal from the test set.

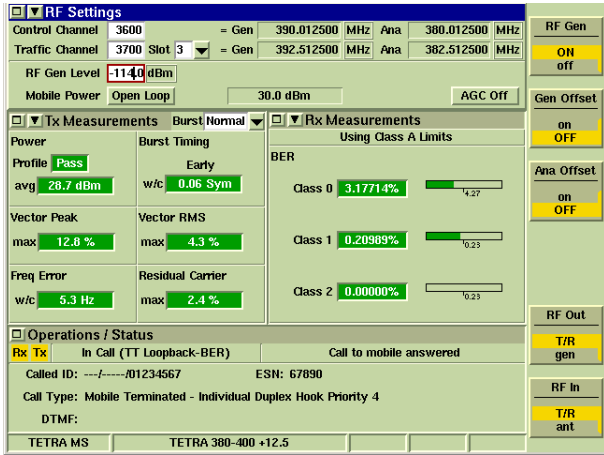


Figure 8 - Measuring receiver sensitivity at low RF level with mobile in TT Loopback-BER mode

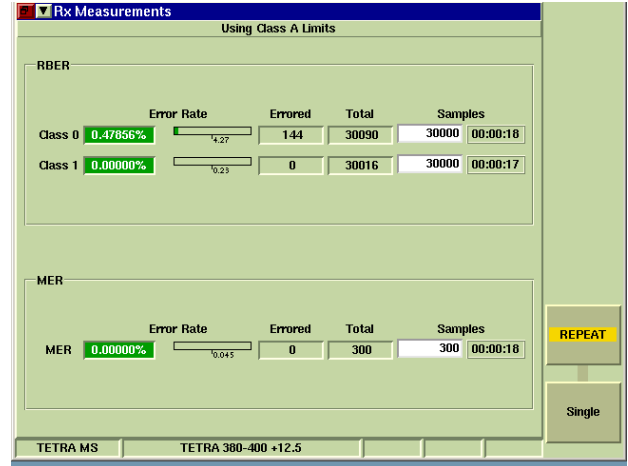


Figure 8A - Maximized Rx Measurements tile with mobile in TT Loopback-RBER mode

The digitized TETRA speech signal assigns the data bits to different 'classes' depending on how important they are to the overall speech quality. The 'Class 0' bits have the lowest impact on speech quality when they are in error hence they have no protection against errors and provide a direct assessment of the RF receiver performance. The 'Class 1' bits and 'Class 2' bits have a greater impact on speech quality when subject to errors hence they are protected in transmission. You should find that these bits exhibit a lower BER than the unprotected Class 0 bits.

As an alternative to 'TT Loopback - BER', you can command the mobile into 'TT Loopback - RBER' mode by toggling the [Loopback BER / RBER] softkey in the Operations / Status tile. In this mode, the mobile does not tolerate any errors in the Class 2 bits (the most important bits) in the digital speech signal. When Class 2 bit errors are detected, the mobile indicates that it has discarded a whole 60 ms block of speech data, known as 'Message Erasure'. In 'TT Loopback - RBER' mode, the test set measures the 'Message Erasure Rate' (MER) and also measures the BER in blocks of speech data that have not been erased (the Residual BER or RBER).

The receiver measurements can be viewed in more detail by maximizing the Rx Measurements tile. The maximized tile also allows you to set the number of samples over which the BER measurement is averaged, and shows the time required for the test. Increasing the sample size improves the resolution of the measurement. If you have limit checking enabled (in CONFIG: Rx Measurements Limits), the numeric measurements and barcharts will be color coded to show the pass / fail / accumulating status.

For further information on receiver testing using TT Loopback, refer to the following sections of chapter 23 of the IFR 3901 Operating Manual:

- 'Rx Measurements Limits'
- 'Rx Measurements Tile'
- 'Operations / Status Tile'
- 'Registration Information'
- 'Mobile Receiver Testing'

If the mobile supports 'T1' test mode, it is also possible to test its receiver sensitivity in this mode, with or without the use of RF Loopback. Refer to IFR 3901 Operating Manual chapter 24 for details of using the 'TETRA MST1' system.

Testing on different frequencies

You may wish to assess the mobile's transmitter and/or receiver performance at different frequencies, for example at the lowest, middle and highest frequencies that the mobile supports. The IFR 3901 allows you to place the Control Channel and Traffic Channel on different frequencies. When you place a call, the test set assigns the mobile to the specified traffic channel and the mobile transmitter and/or receiver measurements are made at the Traffic Channel Tx/ Rx frequencies. With some mobiles, the test set can 'hand off' the mobile to a different traffic channel frequency during a call. Simply change the Traffic Channel number in the RF Settings tile. The handoff operation is recorded in the Operations / Status tile and the Protocol History tile.

If the mobile does not support the handoff operation, you will need to change the Traffic Channel number when the mobile is not in a call. When you have finished testing on a channel, clear down the call, change the Traffic Channel number and place another call; you can now make measurements at the Tx/Rx frequencies of the new Traffic Channel. Do not change the Control Channel number unless you want the mobile to search for a new Control Channel on a different frequency.

Functional Testing and checking the mobile's configuration

The IFR 3901 TETRA test set not only tests the mobile's radio transmitter and receiver parameters, it also allows you to check the mobile's functional behavior and configuration. You can also perform a subjective/functional test of the overall audio and RF operation of the complete mobile by using the 'talk-back' facility in the test set. When you select 'talk-back' mode, the test set stores the digitized speech transmitted by the mobile and re-transmits it to the mobile after a 2 second delay, sufficient time for you to say "hello hello hello" or "testing testing 1 2 3" for example. You can judge the overall quality of the transmitted and received speech by listening to your own voice.

By attempting to place different types of calls from the mobile to the test set you can check that the mobile has been correctly configured to enable the required call types to be placed using appropriate parameters. During a phone call you can press keys on the mobile's numeric keypad to check whether it has been configured to send DTMF digits (indicated on the test set). By attempting to place different types of calls from the test set to the mobile you can check that the mobile has been correctly configured to accept, reject or modify the required call types. You can also check that the mobile has been correctly configured with the required talk groups if the mobile attaches multiple groups at registration. You can view all of the attached groups after the mobile has performed registration and group attachment by selecting the Protocol: Groups tile.

You can also check that the mobile's configuration permits it to send and receive status messages and SDS messages. In the case of status messages, you can check that the mobile has been correctly configured to interpret the values of received status messages (by displaying the required text indication associated with the status value). To send messages to the mobile, press the [Send Message] softkey in the Operations / Status tile, followed by either [Status Message] or [Type 4 SDS-TL Text Msg]. To configure the parameters of these messages, select CONFIG: Messages. To view the details of a Status Message sent by the mobile to the test set, select the green envelope icon on the title bar of the Operations / Status tile or select the yellow envelope icon to view the details of an SDS Message.

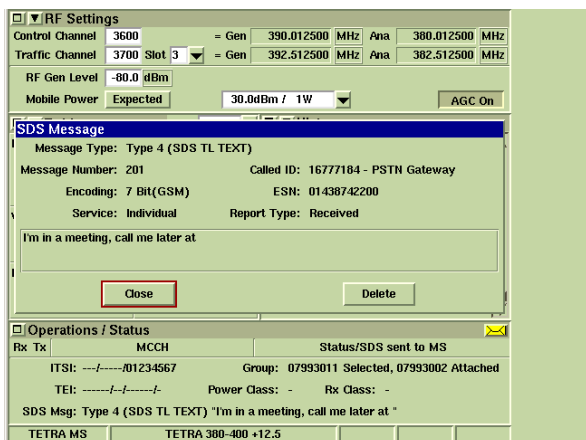


Figure 9 - Viewing details of SDS message sent by mobile

When you place or receive a simplex call on the mobile, the test set can simulate another user talking when you are not pressing the PTT on the mobile. This can either be continuous (the mobile receives from the other user for all of the time that you are not pressing the PTT) or timed (the test set simulates the other user talking (PTT press) and being quiet (PTT release) for configurable periods). Alternatively you can select no simulated 'other user' transmissions. To configure these operations, select CONFIG: Call Timers & Trunking.

All signaling operations that are performed by the mobile and the test set appear on the Operations / Status tile. This information is recorded in the Protocol History tile, along with a time-stamp for each activity (visible when the Protocol History tile is maximized). You can use this facility to check the configuration of the various timers within the mobile, e.g. talk timer, alerting time-out. While you are viewing the maximized Protocol History tile, you can still operate the mobile e.g. to set up or clear down calls from the mobile or press / release the PTT. Ensure that the test set is set to Auto Answer a call set up from the mobile (in CONFIG: Call Timers & Trunking menu) so that you do not need to return to the Operations / Status tile.

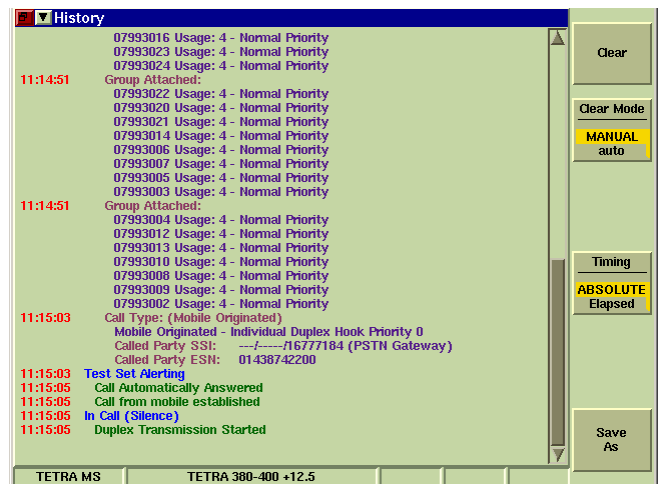


Figure 10 - Maximized Protocol History tile with timestamp

For full details of all of the above functional testing capabilities, refer to the IFR 3901 Operating Manual chapter 23.

Automatic Testing of TETRA Mobiles

The IFR 3901 TETRA MS System offers you the flexibility to perform a number of operations with the mobile and become familiar with its operation, capabilities and configuration. The various measurement tiles provide you with detailed analysis of the mobile's performance, which can be particularly useful for diagnosing faults or out-of-specification measurements. However, for mobiles that work correctly and are within specifications, the requirement is normally just to verify this quickly and easily. The IFR 3901 Auto Test System allows you to perform routine testing on TETRA mobiles easily and repeatably.

The IFR 3901 Auto Test System is driven by test scripts for maximum flexibility and repeatability. A script can set up all of the parameters required for testing, independently of any changes

made to these parameters in the TETRA MS manual test system. A script can specify the tests to be performed, and the pass / fail limits applicable to these tests, independently of the limits set in the TETRA MS system. A script can be generic, or specific to a particular mobile model and configuration.

Typically a test script starts with a power-on registration by the mobile. This is a necessary precursor to other operations, and obtains the mobile's SSI to identify the mobile tested. The test script then normally includes at least one call setup operation (typically one mobile originated call and one mobile terminated call, preferably duplex) to provide some functional testing and to place the mobile on a traffic channel transmitting and receiving so that parametric measurements can be made on the mobile's transmitter and receiver. You can also perform the subjective 'talk-back' test if required when a call is set up. All operations requiring user intervention are completed first, so that the parametric measurements can then run unattended. Normally the test script will end with the call cleared down from the test set, avoiding the need for user intervention at the end of the test.

Each test in the test script produces a result and a pass/fail assessment against limits. At the end of the test script an overall pass/fail verdict is produced. The test results can be printed out and/or stored for future reference.

Once you have a suitably configured Auto Test script to suit your test requirements and the capability /configuration of the mobile type being tested, you should be able to test mobiles automatically. However, you are advised to become familiar with the configuration requirements of manual testing in the TETRA MS System first, so that you understand the parameters that need to be configured in an Auto Test script. Most of the parameters that you need to configure in the TETRA MS System for manual testing have equivalent Auto Test script configuration commands. Some parameters are fixed in Auto Test - see the IFR 3901 Operating Manual chapter 22 'Fixed Parameters'. Additionally, you should ensure that you have correctly specified the 'set_power_class' command so that the automatic test program knows what the mobile's maximum power level is supposed to be.

To perform an automatic test, select the Auto Test System (CONFIG: CONFIG: System: Auto Test) and load the required test script. The script is run by pressing the [Run Script] softkey (only available when a script has been loaded). The test set will prompt you for the actions that you need to perform with the mobile, such as powering it on, placing calls, clearing down calls, answering calls, and verifying satisfactory speech quality.

If your mobile supports TETRA Test mode (TT) RF Loopback and Test Mode registration, you can include these in your Auto Test script to enhance your automated testing. For a compatible mobile, if you include the optional parameter 'test_mode' in the 'test_registration' command, you will not only enable the use of TT RF Loopback in the mobile, you will also obtain three parameters from the mobile that are essential for test automation. The mobile's TETRA Equipment Identity (TEI) is an electronic hardware serial number that uniquely identifies the hardware under test, whereas the SSI is only a programmable user identity that can be changed and may not be unique. The mobile's Power Class

informs the test script of the mobile's maximum power capability. The mobile's Receiver Class informs the test script of the appropriate test limits to apply to the receiver BER/MER/RBER tests depending on the classification of the receiver as Class A, Class B or Class E.

If your mobile supports TT Loopback, you can include Rx BER/MER/RBER tests in your test script. Normally a single test of Rx BER Class 0 is appropriate for routine testing of receiver sensitivity. If your mobile does not support TT Loopback, you cannot test the mobile's receiver sensitivity in an Auto Test script since the test set does not have control over the mobile and does not have access to the mobile's received data for performing a bit error comparison.

For full details of configuring and operating Auto Test scripts, refer to the IFR 3901 Operating Manual. Chapter 5 provides general information on the Auto Test System. Chapter 22 defines the specific commands for the TETRA MS System.

Summary

This application note has taken you through the basics of configuring the IFR 3901 Digital Radio Test Set and testing TETRA mobiles manually in the TETRA MS System and automatically in the Auto Test System. TETRA mobiles are more complex than GSM mobile phones and are highly network-specific and configuration-dependent therefore this application note cannot provide you with all of the information that you might require for testing TETRA mobiles. Some of the necessary information must be obtained from the manufacturer or supplier of the mobile, or the operator of the network for which the mobile has been configured.

Further information on the IFR 3901 can be found in:

- IFR 3901 Operating Manual (on CD ROM documentation set, also available in printed form)
- IFR 3901 Programming Manual (on CD ROM documentation set only)
- Application Note "IFR 3901 Frequently Asked Questions"

The following annexes provide further detailed application information:

- Annex A is an explanation and definition of the IFR 3901 pre-defined channel plans.
- Annex B provides explanations and step-by-step descriptions of how to set up your own user-defined channel plans for mobiles that do not conform to any of the pre-defined plans.
- Annex C is a troubleshooting guide for when a mobile does not register to the test set.

ANNEX A: TETRA CHANNEL PLANS

Explanation of channel plans

The channel plan maps the uplink frequency (MS Tx Freq, test set RF Ana Freq) and the downlink frequency (MS Rx Freq, test set RF Gen Freq) to a channel number. This is necessary because the TETRA signaling protocol uses channel numbers rather than explicit frequencies to assign TETRA mobiles to frequency channels. It is thus essential that the mobile and the base station (or the test set) each have the same understanding of how channel numbers map to frequencies. TETRA mobiles and base stations conforming to the TIP (TETRA Interoperability Profile) use the standard channel numbering scheme defined in ETSI TS 100 392-15. This is implemented in the IFR 3901 pre-defined channel plans.

Channel numbers map to frequencies with a 25 kHz channel spacing hence the frequencies are integer multiples of 25 kHz, subject to a possible frequency offset. The channel plan also defines how the TETRA channel frequencies are located (offset) within the frequency band:

- If the channel boundaries are at integer multiples of 25 kHz, the center frequency is offset by +12.5 kHz from the frequency indicated by the channel number (offset channel plan).
- If the channel center frequencies are at multiples of 25 kHz, the center frequency has zero offset from the frequency indicated by the channel number (zero offset channel plan).

The IFR 3901 supports both options, as well as the less common 6.25 kHz offsets.

PRE-DEFINED TETRA CHANNEL PLANS IN THE IFR 3901

TETRA 380-400 +12.5

Uplink 380 MHz to 390 MHz (Mobile Transmit)

Downlink 390 MHz to 400 MHz (Mobile Receive)

Duplex Spacing 10 MHz

Offset +12.5 kHz

Channel Numbers 3600 to 3999

TETRA 380-400 ZERO

Uplink 380 MHz to 390 MHz (Mobile Transmit)

Downlink 390 MHz to 400 MHz (Mobile Receive)

Duplex Spacing 10 MHz

Offset 0 Hz

Channel Numbers 3600 to 4000

TETRA 410-430 +12.5

Uplink 410 MHz to 420 MHz (Mobile Transmit)

Downlink 420 MHz to 430 MHz (Mobile Receive)

Duplex Spacing 10 MHz

Offset +12.5 kHz

Channel Numbers 0800 to 1199

TETRA 410-430 -6.25

Uplink 410 MHz to 420 MHz (Mobile Transmit)

Downlink 420 MHz to 430 MHz (Mobile Receive)

Duplex Spacing 10 MHz

Offset -6.25 kHz

Channel Numbers 0801 to 1200

TETRA 410-430 ZERO

Uplink 410 MHz to 420 MHz (Mobile Transmit)

Downlink 420 MHz to 430 MHz (Mobile Receive)

Duplex Spacing 10 MHz

Offset 0 Hz

Channel Numbers 0800 to 1200

TETRA 450-470 +12.5

Uplink 450 MHz to 460 MHz (Mobile Transmit)

Downlink 460 MHz to 470 MHz (Mobile Receive)

Duplex Spacing 10 MHz

Offset +12.5 kHz

Channel Numbers 2400 to 2799

TETRA 450-470 ZERO

Uplink 450 MHz to 460 MHz (Mobile Transmit)

Downlink 460 MHz to 470 MHz (Mobile Receive)

Duplex Spacing 10 MHz

Offset 0 Hz

Channel Numbers 2400 to 2800

TETRA 805-870 +12.5

Uplink 805 MHz to 825 MHz (Mobile Transmit) note

Downlink 850 MHz to 870 MHz (Mobile Receive) note

Duplex Spacing 45 MHz

Offset +12.5 kHz

Channel Numbers 2000 to 2799

Note: TETRA is not usually deployed below 806/851 MHz (Channel 2040) hence the IFR 3901 default Control Channel is 2040 rather than 2000.

TETRA 805-870 ZERO

Uplink 805 MHz to 825 MHz (Mobile Transmit) note

Downlink 850 MHz to 870 MHz (Mobile Receive) note

Duplex Spacing 45 MHz

Offset 0 Hz

Channel Numbers 2000 to 2800

Note: TETRA is not usually deployed below 806/851 MHz (Channel 2040) hence the IFR 3901 default Control Channel is 2040 rather than 2000.

TETRA 870-921 +12.5

Uplink 870 MHz to 876 MHz (Mobile Transmit)

Downlink 915 MHz to 921 MHz (Mobile Receive)

Duplex Spacing 45 MHz

Offset +12.5 kHz

Channel Numbers 0600 to 0839

TETRA 870-921 ZERO

Uplink 870 MHz to 876 MHz (Mobile Transmit)

Downlink 915 MHz to 921 MHz (Mobile Receive)

Duplex Spacing 45 MHz

Offset 0 Hz

Channel Numbers 0600 to 0840

Refer to the IFR 3901 Operating Manual Chapter 21 'Channel Plans' for information on selecting pre-defined channel plans. Channel plan details are displayed on the 3901 'CONFIG: Channel Plan' screen for the currently selected channel plan.

Annex B: Configuring the IFR 3901 with a User Defined Channel Plan

The parameters described below are automatically configured by selecting one of the standard channel plans pre-defined on the IFR 3901. If the mobile does not conform to one of the pre-defined channel plans you will need to configure the IFR 3901 with a User Defined channel plan containing the details of the channel plan used by the mobile.

There are two aspects to the channel plan configuration:

- System Information (Sys Info) parameters are used to supply information in the IFR 3901's control channel signal to tell the mobile about the channel plan.
- Channel Block parameters tell the IFR 3901 how to map channel numbers to frequencies.

When you are using one of the pre-defined channel plans, the IFR 3901 takes care of all of these parameters for you. When you are using a User Defined channel plan, it is your responsibility to set up both the Sys Info parameters and the Channel Block parameters in a manner that makes sense to the mobile under test. The IFR 3901 intentionally does not make any linkage between the two sets of parameters, which allows you full flexibility in defining your own system; however this means that you must set all of the parameters correctly.

The IFR 3901 simplifies the definition of a new channel plan. First you can see all of the Sys Info and Channel Block parameters for all of the existing channel plans so you can see how the different parameters are used in practice. Second you can create your new channel plan by copying and modifying an existing plan that is nearest to your requirements. Third you can check the mapping of channel numbers to receive and transmit frequencies in the TEST: RF Settings tile.

Figure 12 - Creating a new user-defined channel plan

Some TETRA radios have a flexible RF architecture and are capable of setting their receiver and transmitter frequencies independently at any frequencies within their supported frequency range, sometimes over an extended range covering more than one channel plan, e.g. 380 MHz to 430 MHz for both receiver and transmitter. Such mobiles typically obey all of the Sys Info param-

eters, where possible. Other mobiles have fixed separate receiver and transmitter frequency ranges with a fixed duplex spacing; such mobiles may ignore some or all of the Sys Info parameters.

Sys Info Parameters:

Frequency Band

Specifies the reference frequency for the frequency band being used, range 0 to 15. For channel plans conforming to the ETSI standard (ETSI TS 100 392-15), this parameter specifies the 100 MHz block that contains the downlink frequencies. For example for the 380 to 400 MHz band, the reference frequency is 300 MHz and thus the value of the Frequency Band parameter is 3. The IFR 3901 shows the ETSI standard interpretation of this parameter. For a proprietary channel numbering scheme, the correct value of this parameter may be zero or 'don't care'.

Offset

Specifies the channel center frequency offset, range 0 to 3. For channel plans conforming to the ETSI standard (ETSI EN 300 392-2) this parameter is interpreted as the following offsets from integer multiples of 25 kHz: 0 = No Offset, 1 = +6.25 kHz, 2 = -6.25 kHz, 3 = +12.5 kHz. For example, if the center frequency of the first channel is 380.012500 MHz, the value of the Offset parameter is 3, indicating +12.5 kHz offset from 380.000000 MHz. The IFR 3901 shows the ETSI standard interpretation of this parameter. For a proprietary channel numbering scheme, the correct value of this parameter may be zero or 'don't care'.

Duplex Spacing

Specifies the separation between the downlink (mobile Rx) frequency and the uplink (mobile Tx) frequency, range 0 to 7. For channel plans conforming to the ETSI standard (ETSI TS 100 392-15), the interpretation of this parameter is partly dependent on the value of the Frequency Band parameter. Typical values used are 0 (10 MHz) in 380 MHz or 410 MHz systems and 1 (45 MHz) in 800 MHz or 870 MHz systems, although many other values are defined in the ETSI standard: 0 Hz, 1.6 MHz, 4.5 MHz, 5 MHz, 7 MHz, 8 MHz, 10 MHz, 18 MHz, 30 MHz, 36MHz, 39 MHz, 45 MHz. The IFR 3901 shows the ETSI standard interpretation of this parameter in conjunction with the frequency band, hence you should set the Frequency Band (Sys Info) parameter before setting Duplex Spacing (Sys Info). For a proprietary channel numbering scheme, the correct value of this parameter may be zero or 'don't care'.

Reverse Operation

Specifies whether the uplink (mobile transmit) frequency is above or below the downlink (mobile receive) frequency, range 0 or 1. For channel plans conforming to the ETSI standard (ETSI EN 300 392-2), the interpretation of this parameter is: 0 (normal) means that the uplink (mobile transmit) frequency is lower than the downlink (mobile receive) frequency, i.e. the duplex spacing is subtracted from the downlink frequency to obtain the uplink frequency. 1 (reverse) means that the uplink frequency is higher than the downlink frequency, i.e. the duplex spacing is added to the downlink frequency to obtain the uplink

frequency. The IFR 3901 shows the ETSI standard interpretation of the parameter. For a proprietary channel numbering scheme, the correct value of this parameter may be zero or 'don't care'.

Channel Block Parameters:

Channel Block 1

Normally you will only need to define parameters for Channel Block 1. Unless you use Channel Block 2, check that it is set to Excluded.

Lowest Channel number

Set this parameter to the lowest channel number that your channel plan uses. Normally this will correspond to the channel that is the lowest frequency; however if you have a complicated channel plan, the lowest channel number is not necessarily the lowest frequency channel. See Annex A for examples of channel numbers used in the pre-defined channel plans.

Highest Channel number

Set this parameter to the highest channel number that your channel plan uses. When you enter a channel number for Control Channel or Traffic Channel (TEST: RF Settings tile), the test set will only allow you to enter a number within the range Lowest Channel number to Highest Channel number.

Lowest Chan. Downlink Freq

This parameter establishes the mapping between channel numbers and frequencies for your User Defined channel plan and it is essential that this parameter is defined correctly. Two points are particularly important to note:

- Enter the downlink (mobile Rx) frequency that corresponds to the lowest channel number.
- The downlink (mobile Rx) frequency that you enter must be the exact center frequency of the lowest numbered channel. Remember that there is intentionally no linkage between the Sys Info parameters and the Channel Block parameters. If your channel plan uses an offset from the 25 kHz multiples, it is not sufficient just to set the offset in Offset, you must include the offset in the Channel Block Lowest Chan. Downlink Freq parameter so that it is the actual mobile receiver frequency that you want the test set RF Generator to be tuned to, e.g. for the lowest channel in 'TETRA 380-400 +12.5' (12.5 kHz offset) enter 390.012500 MHz.

Duplex Offset

This parameter defines the linkage between the mobile Tx frequency and the mobile Rx frequency. The IFR 3901 uses this value to set its RF analyzer frequency to the mobile Tx frequency (mobile Tx frequency = mobile Rx frequency - Duplex Offset). Typically this value will be 10.000000 MHz or 45.000000 MHz, e.g. for the lowest channel in 'TETRA 380-400 +12.5' (12.5 kHz offset), mobile Tx frequency = (390.012500 MHz - 10.000000 MHz) = 380.012500 MHz.

You can also define a reverse channel plan by entering a negative value for this parameter. Remember that there is intentionally no linkage between the Sys Info parameters and the channel

block parameters. If your channel plan uses reverse duplex, it is not sufficient just to set the Reverse Operation parameter to 1 (Reverse). You must set the Channel Block Duplex Offset parameter to a negative value so that the IFR 3901 will set its RF analyzer frequency (mobile Tx frequency) higher than its RF generator frequency (mobile Rx frequency).

Channel Spacing

This parameter defines how the IFR 3901 calculates the mobile Rx frequency that corresponds to a particular channel number "n" according to the formula:

mobile Rx frequency (channel n) = (n - lowest channel number) x channel spacing + lowest channel downlink frequency

Normally this parameter is set to 25.000 kHz, the TETRA channel spacing, so that each increment of the channel number increases the mobile Tx and Rx frequencies by 25 kHz. You can, if required, define a backwards channel plan by setting a negative channel spacing so that incrementing the channel number reduces the mobile Tx and Rx frequencies.

Channel Block 2

Normally you will not need to use more than one channel block, so channel block 2 should be set to Excluded so that the IFR 3901 ignores it. However, if your channel plan has a fragmented numbering scheme then you can define it using an additional channel block. Typically a fragmented numbering scheme arises when additional channels are added to an existing channel plan at frequencies below the original lowest frequency. An example of this is GSM 900, where the original channels in the P-GSM band are numbered 1 to 12 and additional channels were later added (the E-GSM band below the P-GSM band) numbered 975 to 1023 and 0. Numbering fragmentation should not occur if the ETSI standard channel numbering scheme is used since channel numbers 0000 to 4000 are defined as the bottom and top of a 100 MHz band, so all frequencies are covered.

Note: a particular TETRA system may have gaps in its allocation of frequency channels rather than being allocated a contiguous block of spectrum but you do not need to define separate channel blocks if the channel numbering includes the non-allocated channels. You may however wish to define separate non-contiguous channel blocks if you wish the IFR 3901 to restrict your Control Channel and Traffic Channel selections to allocated channels.

Configuring the IFR 3901 with the User Defined Channel Plan parameters

Follow the sequence below to create a new user defined channel plan.

Select 'CONFIG: Channel Plan' and press the [New Plan] softkey.

Select 'Channel Plan' and use the numeric keypad to enter a name for your new channel plan. Press each key multiple times to obtain the lower case letter, upper case letter, digit or symbol required (use the [0] key for a space). Press [ENTER] when the name entry is complete. The name must be different from any of the existing channel plan names.

Select 'Based on' and select an existing channel plan that has most in common with your new plan, in order to minimize the number of parameters needing to be changed. Note that this will make a copy of an existing channel plan for you to edit; the existing channel plan will be unaffected.

Sys Info parameters:

Frequency Band: select the required 100 MHz band e.g. 300 MHz

Offset: select 0 Hz, +6.25 kHz, -6.25 kHz or +12.5 kHz as required

Duplex Spacing: select the required spacing e.g. 10 MHz. Note: the available duplex spacing values depend on the frequency band so you must select the correct frequency band first.

Reverse Operation: select Normal or Reverse

Channel Block 1 parameters:

Lowest Channel: enter the required number e.g. 3600

Highest Channel: enter the required number e.g. 4000

Lowest Channel Downlink Freq: enter in MHz the downlink frequency (mobile Rx frequency) that corresponds to the lowest channel number in conjunction with the offset, e.g. 390.012500 MHz

Duplex Offset: enter in MHz the difference between the downlink (mobile Rx) frequency and the uplink (mobile Tx) frequency, e.g. 10.000000 MHz. Note: for a reverse operation channel plan you will need a negative value of duplex offset.

Channel Spacing: enter in kHz the required spacing (normally 25.000 kHz).

Channel Block 2 parameters:

Included / Excluded button: should normally show [Excluded]. Only set this to [Included] if you are defining a fragmented channel plan.

Lowest Channel, Highest Channel, Lowest Channel Downlink Freq, Duplex Offset, Channel Spacing: only required if you are defining a fragmented channel plan. Entry follows the same rules as for Channel Block 1.

Saving the new channel plan

Press the [Save] softkey to save your new user defined channel plan. The IFR 3901 will check that your parameters are allowable, for example the Highest Channel number must not be lower than the Lowest Channel number and downlink and uplink frequencies must be within the capabilities of the test set. Note: you must save the new channel plan otherwise you will lose your settings. The new channel plan will now be available in the drop-down channel plan selection list. Pre-defined and user-defined channel plans are common to all TETRA Systems, not just TETRA MS. You can define multiple new channel plans, as long as you give each plan a unique name. You can also copy your new channel plan to additional test sets via the floppy disk drive (UTILS: File Management, TETRA, Channel Plans: Export / Import).

User Defined channel plan definition is defined in detail in chapter 21 of the IFR 3901 Operating Manual.

Checking the configuration

Defining your own channel plan is complicated and you are advised to check that you have done it correctly, i.e. that the frequencies set by the IFR 3901 for the lowest and highest channels correspond to your channel plan. Remember that the TETRA frequency channel assignment is signaled using only the channel number, not the explicit frequencies, so it is essential that you have configured the test set to interpret channel numbers exactly the same as the mobile.

Go to TEST: RF Settings and set the Control Channel to your channel plan's lowest channel number (e.g. 3600). Check that the RF Gen Freq is set to the correct mobile Rx frequency (e.g. 390.012500 MHz) and that the RF Ana Freq is set to the correct mobile Tx frequency (e.g. 380.012500 MHz). Set the Control Channel to your channel plan's highest channel number (e.g. 3999). Check that the RF Gen Freq is set to the correct mobile Rx frequency (e.g. 399.987500 MHz) and that the RF Ana Freq is set to the correct mobile Tx frequency (e.g. 389.987500 MHz). If these values are correct, then you have correctly set the Channel Block parameters in your new channel plan.

Set the Control Channel and Traffic Channel as required. Test that you have successfully configured your channel plan (including the Sys Info parameters) by performing registration and call placement with your mobile on the IFR 3901.

Annex C: Troubleshooting when a mobile does not register

1. Ensure that the IFR 3901 has been powered up for sufficient time (typically 2 to 10 minutes) to allow its reference oscillator to warm up and stabilize at the correct frequency before attempting to test a mobile.
2. Check that the mobile is properly connected to the 3901 and that the lead or connector is suitable and not damaged. If you are using an accessory remote antenna connection, or an RF test connection, check that the mobile has recognized and switched over to using this connection automatically, otherwise you may need to select it manually.
3. Ensure that you have selected the TETRA MS System, not the TETRA MS T1 System. Registration and call processing operations are only supported in the TETRA MS System. Ensure that the mobile is in its normal operating mode (or TT test mode), not in T1 test mode or other special modes.
4. Ensure that you have selected the TETRA MS System before setting / checking the test set configuration. CONFIG parameters and TEST: RF Settings parameters are specific to each system and are thus liable to change when you switch systems.
5. Check that the IFR 3901 RF ports are configured correctly. Usually this will be the 'T/R' port (the N-type connector) in single port duplex configuration. The LED above the T/R port should be lit and the LEDs above the 'GEN' port and the 'ANT' port should be unlit.
6. Check that the RF Gen Level is at a reasonable level (e.g. -80dBm) and that it is not below the value of the 'CONFIG: System ID & Access Parameters: Minimum Rx level for access' parameter.
7. Check that any allowances for cable loss have been entered correctly on the 3901 (-ve values for loss), and that the Gen Offset and Ana Offset are ON if required.
8. Check that the IFR 3901 does not show '[+/-]' next to the RF Gen Level setting or the Power reading unless you wish to compensate for external loss or gain. To remove level compensation, use the Gen Offset and Ana Offset softkeys in the RF Settings tile to turn the level offsets OFF.
9. Check that you have set the correct Channel Plan, taking account of whether it is an offset channel plan or not. If in doubt, try offset and non-offset channel plans, or even different frequency bands if there is any uncertainty.
10. Check whether the mobile operates on all frequencies within the channel plan or not. If the mobile uses e.g. only the upper 5 MHz part of the band you will need to set the IFR 3901 control channel and traffic channel so that they lie within the mobile's supported band.
11. Check that you have set the correct Mobile Country Code (MCC) and Mobile Network Code (MNC) values to match the mobile's configuration.
12. Check whether the mobile has been programmed with its correct configuration for operation on a TETRA network, or whether it only has a factory default configuration.
13. Confirm that the parameters explained in 'Configuring the IFR 3901' are set correctly.
14. Check that the mobile has not inadvertently been set to Direct Mode. TETRA mobiles normally retain their Direct Mode setting when they are switched off and the mobile's display indication may be only subtly different from its normal trunked mode display.
15. Check that the mobile is not picking up a real TETRA base station and registering to that rather than to the test set. Plastic-cased hand-held mobiles tend to be more susceptible to interference than metal-cased vehicle-mount mobiles. If interference is a problem you are advised to place the mobile in a screened enclosure where possible and use a short double-screened RF connecting lead. If it is not possible to screen the mobile from these transmissions, set the test set control channel to the same frequency as the base station and set the test set RF generator to its maximum level.
16. Ensure that the 'CONFIG: System ID & Access Parameters: Base station Color Code (BCC)' parameter is not set to zero since this value signifies the use of pre-defined scrambling which some mobiles do not support.
17. If the mobile scans the frequency band for a control channel, allow sufficient time for it to do this (maybe up to 20 seconds).
18. If the mobile does not scan the frequency band, ensure that the IFR 3901 is set to one of the frequency channels in the mobile's search list.
19. Ensure that the 3901 Operations / Status tile indicates "MCCH", to confirm that you are transmitting a Main Control Channel. If not, press the softkeys [clear down] or [Other Protocol Actions], [Reset to MCCH].
20. Ensure that the "Power On Registration" flag is set to "Required", which forces the terminal to perform an ITSI Attach Registration. Ensure that the "Air Interface Encryption" flag is set to "Not Available". These settings can be viewed and altered in the 'CONFIG: Base Services' menu.
21. Check the mobile's display messages, signal strength /status icons and LEDs for any indication that it has seen the 3901 signal and may be attempting to register. However, TETRA mobiles commonly do not indicate the presence of a TETRA base station signal unless it satisfies the requirements for the mobile to register to it. You may be able to obtain more information from the mobile's diagnostic menus, if the mobile has such menus and if you are able to access them.
22. If the radio is known to work with a nearby base station, use the 3901 TETRA BS System (requires Option 111 TETRA base station test) to determine the essential network parameters and set up the 3901 in the TETRA MS System to match the real base station. This procedure is described in detail in the 'compatibility' section of Aeroflex Application Note "IFR 3901 Frequently Asked Questions".

23. Check whether the mobile has been configured to operate only on an encrypted network and not perform a clear mode registration. If this is the case, you will need to perform a TT test mode registration (if supported by the mobile) in order to perform some limited testing in clear mode.
24. If the mobile is encryption-only but does not support TT test mode, you should consult the manufacturer for advice on testing. This could consist of using the 3901 in the TETRA MS T1 System and driving the MS through a proprietary interface using proprietary test mode commands.
25. If the mobile still does not register after you have followed the above suggestions, the mobile may be faulty or you may need to consult the manufacturer, supplier or network operator for further information and assistance.

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