# IFR 2968 Frequently Asked Questions

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*The IFR 2968 TETRA Radio Test Set is the industry standard for testing TETRA mobiles and base stations during design, manufacture, service and repair. This application note answers common questions concerning the capabilities and configuration of the IFR 2968, and provides solutions to common problems that may arise during testing.*

## Introduction

TETRA is a complex system with many features and a high degree of customisation to suit the requirements of individual networks and groups of end users. The IFR 2968 is therefore a complex product providing configuration to match the mobiles and base stations under test and supporting the diversity of features and operational behaviour. Inevitably the IFR 2968 requires some user familiarisation and experience in order to achieve the greatest benefit from it. Further, since TETRA is a relatively new system, some of the test methods and TETRA terminology may be unfamiliar to new users. This application note aims to distil IFR's practical experience with testing TETRA mobiles and base stations to assist IFR 2968 customers. Note that the term 'mobile' is used as a generic term throughout this application note to mean a radio terminal, whether vehicle mounted or hand portable.

This application note contains details and examples of certain procedures, but it is not a substitute for the IFR 2968 operating manuals. You should ensure that you have obtained and read the latest versions of these manuals relevant to the software version in your IFR 2968. For full operating details please refer to the following publications - these are the latest versions and are relevant to the latest Phase 3.2 software in the IFR 2968:

- 46882/324 IFR 2968 Phase 3.2 Operating Manual TETRA Supplement, Issue 10
- 46882/274 IFR 2965A/2966A/2967/2968 Operating Manual, Issue 13
- 46882/280 IFR 2965A/2966A/2967/2968 Programming Manual, Issue 12

Note: where references are made to specific numbered pages in these manuals, these apply to the printed versions. Electronic versions on CD-ROM may have slightly different page numbering.

## Validity of information

The information given in this application note is given in good faith and was believed to be correct at the time of publication, August 2002. However, this information is likely to be subject to change over time as the TETRA standard continues to develop and networks and equipment become more mature. You are advised to periodically check our web site www.ifrsys.com for updated information. Your assistance in informing IFR of any corrections, updates or additional questions would be much appreciated (mailto:info@ifrsys.com).

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## QUESTIONS AND ANSWERS SECTION

### Section 1 Q&A: IFR 2968 versions and options

**Q1.1**: What is the current software version for the IFR 2968? How do I determine whether an IFR 2968 is fitted with the latest software?

**A1.1**: The current software version is "Phase 3.2" (version 11.20). If you purchase a new 2968 it will have this version of software. To determine which software version is installed in a 2968, press the [HELP/SET-UP] hardkey then the [VERSION] softkey and check the version numbers as follows:

The current **Phase 3.2 software** is identified as follows:

| | | |
|---|---|---|
| A4 TETRA APP | 11.20 | 16/04/02 (see note) |
| A6/2MAINCODE 4M | 11.20 | 16/04/02 |
| TETRA application | 11.20 | 16/04/02 |

The previous **Phase 3.1 software** is identified as follows:

| | | |
|---|---|---|
| A4 TETRA APP | 11.10 | 18/01/01 (see note) |
| A6/2MAINCODE 4M | 11.10 | 18/01/01 |
| TETRA application | 11.10 | 18/01/01 |

The earlier **Phase 3.0 software** is identified as follows:

| | | |
|---|---|---|
| A4 TETRA APP | 11.00 | 25/04/00 (see note) |
| A6/2MAINCODE 4M | 11.00 | 25/04/00 or version 11.01 |
| TETRA application | 11.00 | 25/04/00 |

Note: Shown only when TETRA system is selected.

**Q1.2:** My IFR 2968 does not have the latest software version. Can it be upgraded, and is there a charge for this?

**A1.2:** Yes, it can be upgraded to Phase 3.2. If your IFR 2968 has the previous Phase 3.1 software (version 11.10) or the earlier Phase 3.0 software (version 11.00 or 11.01) then there is no charge for the upgrade to Phase 3.2. If your IFR 2968 has the earlier Phase 3.0 software you can upgrade straight to Phase 3.2 without first upgrading to Phase 3.1. If your IFR 2968 has the even earlier Phase 2 software (version 10.20 or lower) then you will need to purchase the "2968 PHASE 3" option before your IFR 2968 can be upgraded. Please contact your local IFR sales representative or distributor to arrange for an upgrade or to purchase the option "2968 PHASE 3".

**Q1.3:** Do I have to return the IFR 2968 to IFR for the software upgrade?

**A1.3:** No, this is not normally necessary. The software upgrade will normally be performed by your local IFR Approved Service Center, either on your premises or by return to a local service center, as agreed between you and the IFR Approved Service Center. The process takes about 45 minutes and does not require disassembly of the test set. However, if the IFR 2968 is due to be returned to an IFR Approved Service Center for repair or routine calibration, then the software upgrade can be requested at the same time. If your test set is a very early unit that has never been upgraded then it may require return to your local IFR Approved Service Center.

**Q1.4:** Is there a new version of the 2968 operating manual for the Phase 3.2 upgrade?

**A1.4:** Yes, but only the TETRA specific aspects have changed. Current versions are:

- 46882/274 Operating Manual for 2965/2966/2967/2968: issue 13, 25 June 2001
- 46882/324 TETRA Supplement for 2968 Phase 3.2: issue 10, 17 May 2002
- 46882/280 Programming Manual for 2965/2966/2967/2968: issue 12, 21 March 2002

If you receive a free-of-charge upgrade to Phase 3.2 from Phase 3.1 or Phase 3.0 you can also receive free-of-charge electronic copies of the updated TETRA supplement and programming manual in pdf format. If you are purchasing the "2968 PHASE 3" option to upgrade to Phase 3.2 from Phase 2, you will receive a new printed copy of the TETRA supplement. You may also purchase printed copies of any of the manuals if required - please contact your usual IFR sales representative. If you purchase a new 2968 you will receive printed copies of all 3 manuals.

**Q1.5:** What are the new functions in the Phase 3.2 software?

**A1.5:** The following is a brief summary of the new functions in the IFR 2968 Phase 3.2 software release with respect to the previous Phase 3.1 release.

- TETRA Test (TT) mode registration obtains TEI, Power Class, Receiver Class
- TETRA Test (TT) RF Loopback and TCH/S BER / RBER / MER measurement
- Enhanced autotest with up to six configurable call set-up and clear-down tests
- TIPv3 Compliant
- Mobile Originated SDS-TL text message, 160 characters with destination SSI / ESN
- Mobile Terminated SDS-TL text message, 120 characters user definable, timestamp
- Mobile Originated and Mobile Terminated 7-bit SDS-TL text messages
- SDS-TL Short Reports sent and received
- Mobile Originated Status with destination SSI / ESN
- Multiple Group Attachments, group detachment and group modification fully displayed
- Configurable Trunking Timers and Call Timers
- DTMF digits displayed during a call
- Mobile Originated Direct Mode call set-up and clear down (requires Option 32)
- Direct Mode call set-up parameters displayed (requires Option 32)

For more details refer to the IFR 2968 data sheet 46891/022 issue 9 (April 2002) and the IFR 2968 operating manual TETRA supplement 46882/324 issue 10 (May 2002).

**Q1.6:** My IFR 2968 still has old Phase 2 software. What functionality will I gain by purchasing the "2968 PHASE 3" option?

**A1.6:** The "2968 PHASE 3" option enables your IFR 2968 to be upgraded to the latest Phase 3.2 software. The Phase 3.2 release also incorporates the enhancements introduced in the two previous releases under the "2968 PHASE 3" option, Phase 3.0 and Phase 3.1.

Phase 3.0 was released in April 2000 with the following enhancements w.r.t. Phase 2:

- Autotest
- TIPv2 compliant
- TCH and MCCH on different frequencies
- Transmission trunking
- Open Loop and Closed Loop power control
- Neighbour Cell Broadcast and Cell Re-Selection
- Mobile Originated Status and SDS
- Group Attachments

Phase 3.1 was released in January 2001 with the following enhancements w.r.t. Phase 3.0:

- 800 MHz channel plan for Asia Pacific countries
- Zero offset channel plans and 410MHz channel plan with -6.25 kHz offset
- Power reading in Watts as well as dBm
- Re-start measurement averaging
- Channel plan NO PLAN for direct entry in Hz
- Off-air capability by setting expected level -40dBm
- Pre-defined call types: Group, Private, Phone, Emergency, User
- Mobile Terminated Phone Call with ESN
- Mobile Terminated Status and SDS
- Mobile Originated SDS-TL text message (limited length)
- Mobile Terminated SDS-TL text message (very limited)

Phase 3.2 was released in April 2002.

Refer to A1.5 above for details of the enhancements in Phase 3.2 w.r.t. Phase 3.1.

**Q1.7:** What functionality will I gain by purchasing Option 32 TETRA Direct Mode?

**A1.7:** The "TETRA DIRECT MODE" system (Option 32) is an addition to the "TETRA MOBILE" system (Option 30). When the TETRA DIRECT MODE system is selected, the IFR 2968 does not emulate a TETRA base station but receives and measures transmissions from a TETRA mobile operating in direct mode. When a TETRA mobile is set to operate in Direct Mode (DMO), it is able to transmit autonomously without synchronising or registering to the test set, and without requesting permission to transmit. No signalling messages from the test set are required in response to a TETRA mobile setting up a call in direct mode, nor is any such response expected by the mobile. Simply holding the PTT starts transmission. The format of the transmitted bursts is slightly different in direct mode, and the burst timing is decided by the mobile, not by the test set. The IFR 2968 transmitter measurements are modified accordingly to ensure that the direct mode transmissions are measured according to the direct mode specification.

**Q1.8:** Does Option 32 TETRA Direct Mode test any signalling functions?

**A1.8:** Yes, with the current Phase 3.2 software. The IFR 2968 supports Mobile Originated Direct Mode Call Set-Up and Cleardown in accordance with TTR 002 Direct Mode TIP v1.0.3. The IFR 2968 indicates when a direct mode call has been set up or cleared down, and displays the following information sent by the Direct Mode mobile relating to itself and the parameters of the call:

ITSI (MCC / MNC / SSI) of the mobile under test

Direct Mode power class of the mobile under test

Direct Mode call type (individual or group, clear mode or encrypted)

Direct Mode call priority level (normal, high, pre-emptive or emergency)

Called party ID (individual call) or called group ID (group call)

**Q1.9:** Can the IFR 2968 also set up a call to a Direct Mode mobile?

**A1.9:** No. The IFR 2968 does not send any signalling to a Direct Mode mobile, hence it does not support Mobile Terminated call set-up and cleardown. This can be tested if required by using a second Direct Mode mobile. The IFR 2968 should first be used to determine that the transmitting Direct Mode mobile is within specification, and to determine that the configurations and parameters of the Direct Mode mobiles are compatible.

**Q1.10:** If I purchase an IFR 2968 with only one of the TETRA system options can I add other options at a later date?

**A1.10:** Yes. The IFR 2968 can be purchased in one of the following configurations:

IFR 2968 + Option 30 TETRA MS + Option 31 TETRA BS + Option 32 TETRA DM

IFR 2968 + Option 30 TETRA MS + Option 32 TETRA DM

IFR 2968 + Option 30 TETRA MS + Option 31 TETRA BS

IFR 2968 + Option 30 TETRA MS

IFR 2968 + Option 31 TETRA BS

Further options can be purchased at a later date if not purchased initially. Please contact your local IFR sales representative or distributor for a quotation.

**Q1.11:** Can I purchase an IFR 2968 with none of the TETRA system options initially and add one or more TETRA options at a later date?

**A1.11:** No. At least one of Option 30 TETRA MS or Option 31 TETRA BS must be included at the time of initial purchase.

**Q1.12:** Can I purchase an IFR 2968 with Option 32 TETRA DM and add Option 30 TETRA MS at a later date?

**A1.12:** No. Option 32 TETRA DM is only available as an addition to Option 30 TETRA MS.

**Q1.13:** Does the IFR 2968 have an option for 800 MHz TETRA systems?

**A1.13:** Yes, but it is not an optional extra. 800 MHz TETRA is included as standard with its own pre-defined channel plan. The IFR 2968 also includes as standard the ability to test any TETRA system at any frequency from 100 MHz up to 1 GHz.

**Q1.14:** Does the IFR 2968 have a DC supply or battery pack option?

**A1.14:** No, operation is only possible from AC mains power. If you need to operate the test set from a low voltage DC supply (e.g. in a vehicle) you are recommended to obtain an inverter with adequate power. You may find that you can obtain a suitable inverter intended for operating mains powered appliances in caravans. IFR has not evaluated any such inverters and is not able to recommend particular products, therefore you should ensure that the AC supply requirements of the IFR 2968 are satisfied.

**Q1.15:** Does the IFR 2968 include automatic testing?

**A1.15:** Yes. Autotest mode for testing mobiles was introduced in Phase 3.0, and has been further enhanced in the latest Phase 3.2 release. Automatic test programs can include functional tests (registration, call set-up, call clear-down) as well as parametric tests (radio measurements). Phase 3.2 autotest provides the flexibility of up to six separate call set-up and clear-down tests as well as the ability to test receiver sensitivity automatically using TETRA Test (TT) mode RF loopback Bit Error Rate (BER) measurement.

**Q1.16:** Can the IFR 2968 test other radio systems besides TETRA?

**A1.16:** Yes. GSM digital cellular, MPT 1327 analogue trunking and automated analogue PMR testing can be added as options, either at time of initial purchase or at a later date. Legacy analogue cellular systems (AMPS, TACS, NMT 900/450) options are also available. The IFR 2968 also provides as standard traditional analogue radio testing capability for mobiles using FM, AM or PM modulation up to 1 GHz. Note that the GSM option only tests 900 MHz or lower frequency GSM mobiles, or the 900 MHz band of dual band/tri-band GSM mobiles, not the 1800 MHz or 1900 MHz bands. Dual band and tri-band GSM mobiles are supported by the IFR 2935 and IFR 2967 radio test sets.

**Q1.17:** Does the IFR 2968 support Tetrapol?

**A1.17:** No. Despite the similar sounding name, Tetrapol is not related to TETRA. Tetrapol is a proprietary FDMA PMR system from EADS-DSN Cogent (formerly Matra Communications) and is a completely different system from TETRA. IFR has no plans to provide system specific support for Tetrapol on the IFR 2968. However, since Tetrapol is an FDMA system, many of the measurements can be made using the traditional analogue radio testing capability of the IFR 2968.

**Q1.18:** Can the IFR 2968 test US PMR/PAMR/SMR systems such as P25, EDACS, iDEN?

**A1.18:** No. However, P25 (APCO Project 25) is supported on the IFR 2975 Radio Test Set. Refer to www.p25.com for details. EDACS is supported on the IFR 2945A and COM 120C Radio Test Sets. iDEN is a proprietary system from Motorola which is not currently supported by any IFR Radio Test Set. IFR has no plans to support P25, EDACS or iDEN on the IFR 2968.

**Q1.19:** Can I have a 2965A, 2966A or 2967 upgraded to a 2968?

**A1.19:** No, these instruments cannot support TETRA.

**Q1.20:** Is there an IFR TETRA Test SIM available, as there is for GSM?

**A1.20:** No. TETRA mobiles do not currently use SIMs, although a few do include a SIM holder. Currently all TETRA mobiles have to be configured using programming and customisation tools, although TETRA SIMs may be used in future. Currently there is no specification for a test version of the TETRA SIM as there is for GSM. This situation may change in future.

**Q1.21:** Does IFR supply cables, connectors and adaptors for connecting to TETRA mobiles?

**A1.21:** Yes and no. A small number of standard cables and adaptors (N-type, TNC, BNC) are available as accessories (refer to the IFR 2968 data sheet or contact your local IFR sales representative). For a wider selection of standard types you should consult your usual electrical distributor catalogues or specialist accessory suppliers. For proprietary connections you will normally need to contact the manufacturer or distributor of the mobile.

### Section 2 Q&A: Testing mobile and base station transmitters

**Q2.1:** How do I use the 2968 to control the mobile to transmit at a particular power level?

**A2.1:** TETRA mobiles use Open Loop Power Control (OLPC) in which the mobile calculates the power level at which to transmit, based on the strength of the signal received from the base station. A mobile that is close to a base station will receive a strong signal, consequently it can transmit at a low power level. When the mobile is connected to the IFR 2968, the power is determined by the strength of the received signal, i.e. the 2968 RF Generator Level, and by two of the parameters in the 2968 SYSTEM PARAMETERS menu, "ACCESS PARAMETER" and "MAX TX LEVEL".

The calculation is as follows:

- Take the 2968 RF GEN level, which will be in -ve dBm, and make it +ve.
- Add the ACCESS PARAMETER, which is in -ve dBm, range -53dBm to -23dBm.
- The result is the mobile's transmit power, subject to some modifications.

The calculated mobile transmit power is modified by the following conditions:

- The mobile is not allowed to transmit at a power level higher than MAX TX LEVEL
- The mobile cannot transmit at a power level higher than its power does, e.g. a Class 4 Mobile has a maximum power level of PL4 +30 dBm.
- The mobile cannot transmit at a power level lower than its minimum, i.e. PL7 i.e. 15 dBm.

- The mobile power is quantised to defined power level steps: PL1 +45 dBm, PL2 +40 dBm, PL3 +35 dBm, PL4 +30 dBm, PL5 +25 dBm, PL6 +20 dBm, PL 7+15 dBm.
- Some mobiles belong to an 'L' power class where their top power level is reduced by 2.5 dB, e.g. PL4L 27.5 dBm.

**Q2.2:** Why is the mobile power level approximately 5 dB too high or too low when I have set the 2968 RF Generator Level to the correct value for the power level required?

**A2.2:** Mobiles are permitted +/- 4 dB tolerance in measuring the RSSI (Received Signal Strength Indication), so it is not possible to guarantee a particular power level for a particular RF GEN level, except when the mobile is forced to the maximum or minimum power. If the 2968 signal generator is set at least 4 dB lower than the calculated value for maximum mobile power, the mobile should be using the maximum permitted power. If the 2968 signal generator is set at least 4 dB higher than the calculated value for minimum mobile power, the mobile should be using the minimum transmit power. For the intermediate power level steps, you can experiment with different RF Generator Level settings to achieve the required level.

**Q2.3:** Can I use the 2968 to control the mobile power directly, as with GSM?

**A2.3:** No. TETRA mobiles do not incorporate a direct power control mechanism, therefore the 2968 cannot directly command the mobile to a particular power level. However, some TETRA mobiles incorporate Closed Loop Power Control (CLPC) in which they will respond to a command to increase or decrease their power by one or more 5 dB power level steps. The 2968 can therefore be used first to force the mobile to minimum or maximum power level by using normal open loop power control, then to command the mobile to increase or decrease power from this known starting point. However, most TETRA mobiles do not support CLPC.

**Q2.4:** How do I ensure a repeatable method for testing mobiles on a particular power level?

**A2.4:** Use the MAX TX LEVEL parameter on the SYSTEM PARAMETERS menu to limit the mobile power to the particular power level required. Set the RF Generator Level to a low enough level (e.g. -100 dBm) to force the mobile to transmit at the maximum power level permitted.

If the MAX TX LEVEL is changed, a TETRA mobile that is already registered to the test set or active in a call may not necessarily alter its power in response to the change, since this is not a parameter that a mobile would expect to change on a real base station. In this case it may be necessary to clear down the current call or even de-register and re-register the mobile to the test set for the parameter change to take effect. However, if the mobile is tested in T1 Test Mode using the 2968 T1 test signal, the MAX TX LEVEL can be used to directly control the mobile's transmit power (with RF Gen Level set to -100 dBm).

**Q2.5:** Can I test the mobile's transmitter on different frequencies?

**A2.5:** Yes. The control channel (MCCH) may have to be on a specific frequency (channel number) in order for the mobile to recognise the test set and perform registration. However, during a call set-up, the mobile should obey an instruction from the IFR 2968 to transmit and receive on any traffic channel frequency (channel number) within the mobile's capabilities. When the mobile is idle on the control channel (MCCH) you can set the traffic channel (TCH) that will be used when a call is set-up. Hence you can test the mobile's transmitter on different frequencies by clearing down a call, changing the traffic channel number, and setting up a new call.

**Q2.6:** Can I test the mobile's transmitter over its entire receive / transmit frequency range?

**A2.6:** Yes, if the mobile has a flexible RF architecture that allows this operation. For example the 'TETRA 380 MS' channel plan can be used to test the mobile's receiver over the range 390 to 400 MHz, and the mobile's transmitter over the range 380 to 390 MHz. However, the IFR 2968 allows you to define a reverse channel plan so the mobile's receiver can be tested over the range 380 to 390 MHz and the mobile's transmitter over the range 390 to 400 MHz. Depending on the configuration of the mobile, you may be able to perform normal registration and call set-up with a reverse channel plan, or you may need to use T1 test mode to test on reverse frequencies. For further details, refer to 'Annex B: Configuring the IFR 2968 with a User Defined Channel Plan' in the application note 'Testing TETRA mobiles with the IFR 2968'.

**Q2.7:** Why do the TETRA mobile transmitter measurements stop after about a minute?

**A2.7:** The measurements do not stop, it is the mobile transmissions that have stopped. TETRA mobiles making group calls or simplex private calls normally incorporate an autonomous transmission timer which is typically one minute in duration, so that the mobile stops transmitting even if the user is still holding the PTT pressed. TETRA mobiles do not normally incorporate a transmission timer when making duplex private calls or phone calls, hence you should always set up a duplex call where possible (e.g. a phone call) when you want to examine transmitter measurements in detail. This also has the advantage of not requiring you to hold the PTT pressed. If you are testing in Direct Mode, you will not be able to set up a duplex call, so you should simply release and re-press the PTT to continue measuring.

**Q2.8:** Why does my TETRA mobile or base station exhibit excessive vector error?

**A2.8:** A number of causes can contribute to vector error performance exceeding the limits, so the 2968 provides further diagnostic displays to track down the cause of a vector error failure, including the constellation diagram, rotated vector diagram, and particularly the vector error vs. time displays with separate resolution of the phase error and magnitude error components. Vector error that is predominantly due to phase error may be a symptom of an unstable transmit frequency, i.e. the frequency error is varying during a single burst period, maybe because of oscillator settling problems. Vector error that is predominantly due to magnitude error may be a symptom of an unstable power level, i.e. the power is drooping during a single burst period, maybe because of an

inadequate power supply. If the RMS vector error is low but the peak vector error is very high, this may be a symptom of incorrect power ramping by the mobile - check the power profile display. These functions are accessed via the DUPLEX TEST mode. Refer to the operating manual Phase 3.2 TETRA supplement issue 10, chapter 8, for details of using these functions.

**Q2.9:** Can the 2968 measure Adjacent Channel Power (ACP)?

**A2.9:** No. The 2968 performs the routine measurements of the on-channel transmitted signal. TETRA ACP is a specialised high dynamic range measurement for conformance testing and some manufacturing test applications which can only be performed by the IFR 2310 TETRA Signal Analyzer. Refer to the IFR 2310 data sheet for details of measurement of ACP and other specialised measurement functions.

However, the IFR 2968 can be useful in conjunction with the IFR 2310, with the TETRA mobile connected to both instruments via a power splitter. The 2968 is used to stimulate the mobile so that it can register and set up a call at a particular frequency and power level, whilst the 2310 is used to make the high dynamic range off-channel measurements.

**Q2.10:** Can the 2968 power measurement compensate for cable loss, attenuators, splitters?

**A2.10:** Yes. The compensation applies to all 2968 power measurements, not just TETRA, hence it is set up under the main instrument set-up menus rather than the TETRA system specific menus. Press the HELP / SET-UP hardkey then the softkeys SET-UP, TEST OPTIONS, rf port setup, then set the "receiver level offset" for the required compensation. Negative values compensate for an external loss, positive values compensate for an external gain.

**Q2.11:** Why does the power reading show a reverse video asterisk next to it?

**A2.11:** This is a warning that the 2968 has been set to compensate for an external gain or loss (see A2.10 above). If the compensation is no longer required, reset the receiver level offset to 0 dB.

**Q2.12:** Can the IFR 2968 measure directional ("through-line") power?

**A2.12:** Yes. IFR supplies a high accuracy directional power head as an optional accessory, part number 54421/003, enabling you to measure forward and reverse power and VSWR. You will also need the accessory socket adaptor 46884/645 to use the power head with the IFR 2968.

### Section 3 Q&A: Testing mobile and base station receivers

**Q3.1:** Can the IFR 2968 test the receiver sensitivity of TETRA mobiles?

**A3.1:** Yes. A variety of different test signals and test methods are provided in the IFR 2968 to support the capabilities and testing requirements of various TETRA mobiles.

- TETRA Test mode (TT) RF Loopback provides automatic or manual testing of receiver sensitivity (BER or MER / RBER) on the three different sensitivity class bits on the speech traffic channel (TCH/S), in a similar manner to the standard GSM method.
- Radio Conformance Test (T1) RF Loopback provides manual testing of receiver sensitivity (BER) on the T1 Type 1 (TCH/7.2) signal. The IFR 2968 generates the PRBS data and measures the BER of the received signal returned by the mobile under test.
- Radio Conformance Test (T1) signal generation provides the test source for a mobile to measure its own BER or MER, or for an external device to measure the BER / MER of the data recovered by the mobile under test. The IFR 2968 generates the PRBS data for three different T1 signal types: Type 1 (TCH/7.2), Type 2 (SCH/F) and Type 4 (TCH/2.4).
- 1 kHz tone encoded speech signal generation and audio SINAD measurement provide manual testing of receiver sensitivity on the speech traffic channel (TCH/S) for mobiles that do not support loopback or where the user is unable to access the manufacturer's test functions for measuring BER.

**Q3.2:** How do I measure receiver sensitivity using 'TT' RF Loopback?

**A3.2:** In Autotest the IFR 2968 performs the test(s) automatically. In manual test mode, you need to set up a duplex call and then select BER TT Loopback or RBER TT Loopback. Depending on the type of mobile, you may need to perform a Test Mode Registration beforehand. Refer to the 2968 TETRA Supplement issue 10, chapter 4, pages 6, 34, 36, 37 and 41 for details.

**Q3.3:** Why does the mobile drop the call while measuring receiver sensitivity?

**A3.3:** You may have set the RF GEN LEVEL too low for too long, or you may need to adjust the 'minimum Rx level for access' system parameter. TETRA mobiles need to be able to receive information from the base station (test set) signal in order to maintain a call; if the RF generator level is reduced too far, the error rate may be too high for the mobile to reliably decode the base station (test set) signal. This should not normally be a problem at the reference sensitivity level (-112 dBm) with a correctly functioning mobile.

TETRA mobiles need to be able to receive a signal from the base station (test set) that meets or exceeds the 'minimum Rx level for access'. The default value for this parameter on the IFR 2968 is -125 dBm, and you should ensure that this value is set prior to performing receiver sensitivity tests, in order to avoid call dropping.

**Q3.4:** Why doesn't 'TT' RF Loopback work with my mobile?

**A3.4:** You may need to perform a Test Mode Registration beforehand so that the mobile is enabled to respond to the TT loopback commands. This may require you to perform an enabling action on the mobile (e.g. entering an access code) and to send a TT test mode confirmation from the IFR 2968. Refer to the 2968 TETRA Supplement issue 10, chapter 4, pages 41 and 12 for details. Refer to the mobile manufacturer for specific details of enabling TT test mode on the mobile.

The mobile may not support TT test mode registration or TT RF Loopback, in which case you will not be able to perform BER/RBER /MER tests on the speech traffic channel, and you will not be able to include receiver sensitivity testing in automatic test programs. Refer to the mobile manufacturer for further information.

**Q3.5:** How do I test receiver sensitivity if a mobile does not support TT RF Loopback?

**A3.5:** If the mobile does not support TT RF Loopback, you will not be able to test receiver sensitivity automatically as part of an autotest program, and you will not be able to test it manually as part of normal functional and parametric testing using registration and call set-up. To test the receiver you will need to set both the mobile and the IFR 2968 to operate in T1 test mode. If the mobile supports T1 Loopback, you can perform a manual measurement of sensitivity using the IFR 2968. If the mobile does not support T1 Loopback, you will need to use the mobile's internal BER/MER measurement or external BER / MER measurement using a suitable application program supplied by the mobile manufacturer. Refer to the 2968 TETRA Supplement issue 10, chapter 4, pages 34 and 36 to 39 for details of operating the IFR 2968 in T1 test mode. Refer to the mobile manufacturer for details of operating the mobile in T1 test mode and internal or external BER/MER measurement applications.

**Q3.6:** What is the difference between 'TT' test mode and 'T1' test mode?

**A3.6:** TT' (TETRA Test) is a mode of operation that may be implemented in a TETRA mobile, in which certain additional functions for testing are enabled, but otherwise the mobile operates as normal for registering and setting up calls. The mobile manufacturer may also decide to modify, restrict or disable certain functions when in TETRA Test mode, e.g. group attachments and security functions may be disabled, and the mobile may adopt a special test identity rather than its normal network identity.

TT mode provides TT RF Loopback and Test Mode Registration. TT RF Loopback is operated by the IFR 2968 sending TETRA signalling commands to the mobile via the usual RF connection when the mobile is in a duplex call. Test Mode Registration is an additional signalling sequence performed after normal Registration, which confirms the use of TT test mode in the mobile and obtains information from the mobile that is essential for test automation (TEI, power class and receiver class).

T1 test mode is a special mode of operation that is required to be implemented in a TETRA mobile submitted for conformance testing according to ETSI EN 300 394-1 (TETRA Radio Conformance test specification). T1 test mode may also have applications in manufacturing or service testing. T1 test mode is a one way control mode, in which the IFR 2968 generates a signal to stimulate and control the mobile under test, but does not receive any signalling from the mobile. There is no protocol involved in T1 testing, other than the generation of the T1 signal control parameters. There is no registration and no call set-up, and the mobile does not send any signalling information in T1 test mode.

Flags in the T1 signal control information can instruct the mobile to turn its transmitter on or off and to transmit normal bursts or control bursts at a specified power level. The control information also informs the mobile of the T1 signal type (TCH/7.2, SCH/F or TCH/2.4) so that the mobile can receive and decode the information accordingly. Another flag in the control information can instruct the mobile to re-transmit the received data (T1 RF Loopback).

**Q3.7:** How do I access T1 test mode in the mobile under test?

**A3.7:** There is no standard mechanism for this, and the mobile may not necessarily support T1 test mode. Typically you may need to know a special key sequence or you may need a PC application for configuring, aligning and testing the mobile. Access to such facilities may well be restricted by the mobile manufacturer and you should contact the mobile manufacturer or supplier to discuss the appropriate level of access to test and diagnostic facilities.

**Q3.8:** How do I test the mobile receiver if I have no access to TT loopback or T1 test mode?

**A3.8:** TT loopback or T1 test mode should always be used where possible, since they provide the most objective and repeatable test of receiver performance. TT loopback is the most convenient as it can be automated. However, if the mobile does not support these modes, or if you cannot obtain access to the manufacturer's test modes, it is possible to perform an approximate test of receiver sensitivity using a conventional SINAD test. For this you will only need access to a suitable audio output from the mobile, typically a loudspeaker or accessory earpiece socket. Note that this will also test the quality of the mobile's audio circuitry.

If the mobile has adequate RF sensitivity, you should be able to determine that the SINAD is satisfactory at the reference sensitivity level. However, due to the use of the TETRA codec, the audio signal degradation at low RF levels behaves differently from analogue RF signals. This method will not work well at RF levels below the reference sensitivity level as the BER of the TETRA signal increases, particularly when errors occur in the Class 1 bits or when errors in the Class 2 bits cause erasure of speech frames. Refer to the 2968 TETRA Supplement issue 10, chapter 4, pages 34 and 35 for details of testing receiver sensitivity using audio SINAD.

**Q3.9:** What is the difference between MER, BER and RBER?

**A3.9:** MER is Message Erasure Rate, and it applies to TETRA channel types that include a parity check (e.g. the signalling channels such as SCH/F and the Class 2 bits in the speech frame). BER is Bit Error Rate and it applies to TETRA channel types that do not include a parity check (e.g. circuit data channels such as TCH/7.2 and the Class 1 and Class 0 bits in the speech frame). When errors occur in the channels with parity checks, the whole message is discarded (erased); when errors occur in the channels without parity checks, one or more bits in the message are in error.

BER tests on e.g. TCH/7.2 are much quicker than MER tests and provide a direct test of the RF receiver performance. MER tests on e.g. SCH/F take much longer because for every 432 bits in TCH/7.2 there is only one message in SCH/F, so it takes 432 times longer to

acquire the same number of samples on SCH/F. For example, the BS Class A TCH/7.2 BER test requires 5800 samples (bits) which takes less than one second; the BS Class A SCH/F MER test requires 6600 samples (messages) which takes 6 minutes and 36 seconds.

Hence the SCH/F MER test is normally only performed for R&D / conformance testing because it takes too long. Manufacturing, installation and maintenance testing normally uses the TCH/7.2 or TCH/S Class 0 BER test because it is much quicker and provides a direct test of the hardware. For performing acceptance tests / installation tests on base stations the much faster TCH/7.2 BER test is normally more suitable than the slow SCH/F MER test.

RBER (Residual Bit Error Rate) applies only to the speech traffic channel TCH/S, in which there are three different classes of bits with different levels of protection. If bit errors occur in the Class 2 bits, this will normally be detected by the parity check and two entire 30ms speech frames will be erased. If RBER TT loopback is selected, the mobile is instructed to signal erased frames by substituting the loopback bits with all 1s in each speech frame, hence it is only possible to measure BER of the Class 0 and Class 1 bits when frame erasure has not occurred. The Bit Error Rate, measured only in those frames where frame erasure has not occurred, is termed the Residual Bit Error Rate. If BER TT loopback is selected, the mobile always loops back the received bits and does not check for frame erasure. RBER measurement values are likely to be limited compared to BER values, since higher BER values in Class 0 and Class 1 bits are statistically more likely to be accompanied by bit errors (and hence frame erasure) in the Class 2 bits.

**Q3.10:** Which types of T1 test signals are generated for mobile testing?

**A3.10:** The 2968 generates the following T1 signals for mobile testing:

- T1 type 1: TCH/7.2 PRBS in TN1 FN1-17
- T1 type 2: SCH/F PRBS in TN1 FN1-17
- T1 type 4: TCH/2.4 PRBS in TN1 FN1-17

There is also another T1 signal defined which the 2968 does not generate:

- T1 type 3: BSCH PRBS in SSN1 + SCH/HD PRBS in SSN2 in TN1 FN1-17

All four of these T1 signals have the following in common:

- AACH PRBS in BBK in TN1 FN1-18 in every multiframe
- BSCH (T1 sync info) in SSN1 in TN1 FN18 in every multiframe
- BNCH/T (T1 sys info) in SSN2 in TN1 FN18 in every multiframe
- TCH/7.2 PRBS + AACH PRBS in TN2, TN3 and TN4 FN1-18

All T1 signals conform to ETSI EN 300 394-1 v2.3.1 subclause 5.3.2.1

**Q3.11:** What is the content of the PRBS information generated by the IFR 2968 T1 signals?

**A3.11:** The IFR 2968 PRBS information conforms to ETSI EN 300 394-1 v2.3.1 subclauses 5.3.2.1 (T1 signal for mobile testing) and 5.3.2.2 (T1 signal for base station testing), which specify ITU-T O.153 511 bit PRBS.

The hex data below represents 944 bits of the standard 511 bit ITU-T O.153 PRBS, i.e. one complete sequence of 511 bits followed by 433 bits of the next repetition of the sequence. Read from left to right, i.e. binary sequence is 11111111100000111101111110001 .....

ff83df17 32094ed1 e7cd8a91 c6d5c4c4 4021184e 5586f4dc 8a15a7ec 92df9353 3018ca34 bfa2c759 678fba0d 6dd82d7d 540a5797 7039d27a ea243385 ed9a1de1 ff07be2e 64129da3 cf9b1523 8dab8988 8042309c ab0de9b9 142b4fd9 25bf26a6 60319469 7f458eb2 cf1f741a dbb05afa a814af2e e073

This data is pure O.153 PRBS not subject to any channel coding, scrambling or framing. Mobile and base station equipment performing internal or external self-measurement of BER should expect to receive this sequence when there are no bit errors.

**Q3.12:** Can the 2968 generate PRBS for testing AACH, BSCH and SCH/HD channel types?

**A3.12:** AACH PRBS is provided on all MS T1 signals. Note that the AACH PRBS is over all 18 frames, unlike the other logical channels which have PRBS over frames 1 to 17 only.

The 2968 does not generate the T1 type 3 signal containing BSCH PRBS and SCH/HD PRBS data. The BSCH and SCH/HD channels are generated in all MS T1 signals, but only in frame 18, and they contain T1 synchronisation and control information rather than PRBS. However, for the purpose of performing an R&D / conformance test of BSCH and SCH/HD MER, the BSCH and SCH/HD (BNCH/T) in frame 18 may be adequate, although the test will be slower than with a T1 type 3 signal since BSCH and SCH/HD are only present in frame 18.

**Q3.13:** Can the IFR 2968 test base station receivers?

**A3.13:** Yes. The IFR 2968 generates the uplink T1 type 7 (TCH/7.2) signal defined in ETSI EN 300 394-1 subclause 5.3.2.2 for testing base station receiver Bit Error Rate (BER), including channel type 8 (SCH/F) in frame 18 in timeslot 1. It does not generate an uplink T1 type 8 (SCH/F) signal in frames 1 to 17 for testing base station receiver Message Erasure Rate (MER), although the SCH/F in frame 18 could be used for this purpose. The 2968 synchronises the timing of its uplink T1 type 7 signal to that expected by the base station. Base stations normally perform their own BER measurement on the uplink signal that they receive, so the IFR 2968 does not expect the BS to perform RF loopback on the T1 signal, and does not perform BER measurement on signals transmitted by the base station.

**Q3.14:** What is the synchronisation connection between the base station and the IFR 2968?

**A3.14:** Two synchronisation methods are provided in the IFR 2968.

The IFR 2968 can synchronise its timing to a synchronisation pulse generated by the base station. The BS sync pulse is defined in ETSI EN 300 394-1 v2.3.1 subclause 4.1.1 (6th bullet point). The repetition rate is the multiframe rate (1.02s) but the pulse width is undefined - only the rise and fall times are defined (<50 ns). The 2968 can be triggered on either the rising edge or the falling edge of the pulse. It is the timing of this edge that matters, so if the timing is defined w.r.t. the rising edge then the timing of the falling edge (and hence the pulse width) is irrelevant. The synchronisation pulse is connected to the IFR 2968 via the rear panel ACCESSORY connector (25 way D-type), pin 2 is the pulse input, pin 4 is signal ground. For full details refer to issue 10 of the IFR 2968 Operating Manual TETRA supplement for Phase 3.2, chapter 5.

The 2968 can also synchronise automatically to the signal generated by the BS. However, the automatic synchronisation only works for a BS that is generating a signal according to ETSI EN 300 394-1 subclause 5.2.1.2, and that is expecting to receive a signal according to ETSI EN 300 394-1 subclause 5.3.2.2.

**Q3.15:** How do I perform a test on a base station receiver with the IFR 2968?

**A3.15:** This will depend on the type of base station. Typically you will need a control program or a terminal emulator running on a PC with a serial port connection to a test / control port on the base station. For some base stations you will need to connect a synchronisation pulse lead between the base station and the IFR 2968 ACCESSORY socket. For other base stations you will be able to synchronise the 2968 automatically to the signal generated by the base station. Ensure that the IFR 2968 system parameters menu item "SYNC TO BASE STATION" is set to PULSE or AUTO as appropriate. For full details refer to issue 10 of the IFR 2968 Operating Manual TETRA supplement for Phase 3.2, chapter 5.

For the specific details of operating a particular base station in a receiver testing mode you should refer to the base station manufacturer. For some TETRA base stations, IFR can supply application notes on request for testing the base station with the IFR 2968. However, please note that since these contain manufacturers' proprietary details we can only supply this information to authorised persons; normally this is restricted to the base station manufacturer's personnel or authorised agents.

**Q3.16:** What is the purpose of the base station system parameters "SYNC PULSE OFFSET" and "AUTO SYNC PATH DELAY" ?

**A3.16:** The SYNC PULSE OFFSET defines the time between the rising or falling edge of the sync pulse and the start of the IFR 2968 uplink T1 signal (frame 1, timeslot 1, symbol number 0). The sync pulse output by the base station has an arbitrary, but fixed, relationship to the expected timing of the uplink T1 signal. You should refer to the base station manufacturer for the required value of this parameter if you are using pulse synchronisation. This parameter is irrelevant if you are using auto synchronisation.

The AUTO SYNC PATH DELAY defines a delay in the generation of the IFR 2968 uplink T1 signal when it is synchronised to the downlink signal generated by the base station. With zero delay, the start of the IFR 2968 uplink T1 signal (frame 1, timeslot 1, symbol number 0) occurs exactly two timeslots after the start of the base station downlink T1 signal. However, base stations in a receiver testing mode may expect to receive the uplink signal later than this time (as with a mobile some distance from the base station). You should refer to the base station manufacturer for the required value of this parameter if you are using auto synchronisation. This parameter is irrelevant if you are using pulse synchronisation.

**Q3.17:** Why does the base station indicate a BER measurement of around 50% even though the IFR 2968 is synchronised and the signal level is above the reference sensitivity level?

**A3.17:** 50% BER is normally an indication that there is no correlation between the received data and the expected data, i.e. the received data appears to be completely random rather than the expected PRBS. This can occur because the receiver is not receiving the expected sequence, or because the receiver's comparison with the expected sequence is not synchronised to the received sequence. These problems can occur if the base station receiver and the 2968 signal generator are using different scrambling sequences. Scrambling is a TETRA process that is used on all traffic and signalling channels, which applies a particular bit pattern (the scrambling sequence) to invert some of the data bits. Scrambling is used to ensure that the modulation is randomised, and to guard against inadvertent co-channel reception from an unwanted base station using a different scrambling sequence.

Check the setting of the "MCC-MNC-BCC UPDATE" parameter in the base station system parameters menu. It is essential that the 2968 uplink T1 signal is scrambled with the same scrambling sequence that the base station is using to de-scramble the signal, otherwise the data content of the signal will be uncorrelated with the PRBS that the base station is expecting to receive. If the base station conforms to ETSI EN 300 394-1, subclause 5.2.1.2, it indicates the expected scrambling sequence by means of the MCC, MNC and BCC parameters in its synchronisation burst. If the IFR 2968 is set to MCC-MNC-BCC UPDATE: AUTO, it will automatically set the scrambling of its uplink signal according to these parameters in the signal received from the base station. However, if the base station does not conform to subclause 5.2.1.2, or if the base station receiver is to be tested separately from the base station transmitter, the IFR 2968 must be set to MANUAL update, and the required values of MCC, MNC and BCC must be set to match those expected by the base station.

After you have set the 2968 correctly for the required uplink scrambling, it may be necessary to re-start the BER measurement on the base station so that it can re-synchronise its BER measurement to the correct PRBS.

Note that the 2968 manual test screen display of the MCC/MNC/BCC parameters always shows the values indicated by the base station synchronisation burst, whether or not it is auto updating to these values.

**Q3.18:** Can the 2968 signal generator compensate for cable loss, attenuators, splitters etc.?

**A3.18:** Yes. The compensation applies to all 2968 RF generator signals, not just TETRA, hence it is set up under the main instrument set-up menus rather than the TETRA system specific menus. Press the HELP / SET-UP hardkey then the softkeys SET-UP, TEST OPTIONS, rf port setup, then set the "RF Gen level offset" for the required compensation. Negative values compensate for an external loss, positive values compensate for an external gain.

**Q3.19:** Why does the signal generator level setting show a reverse video asterisk next to it?

**A3.19:** This is a warning that the 2968 has been set to compensate for an external gain or loss (see A3.18 above). If the compensation is no longer required, reset the RF Gen level offset to 0 dB.

**Q3.20:** Can I use the 2968 to test receiver selectivity?

**A3.20:** The 2968 can provide the T1 wanted signal used for performing tests of adjacent channel rejection, co channel rejection, spurious response rejection and blocking rejection, as defined in the TETRA radio conformance test specification ETSI EN 300 394-1. You will need additional equipment to generate the T2 interfering TETRA signal (e.g. IFR 2050T) and the T3 interfering CW signal (e.g. IFR 2040 series) and to combine the signals.

**Q3.21:** Can the IFR 2968 be used for dynamic (fading) sensitivity tests?

**A3.21:** The IFR 2968 can be used in conjunction with an external fading simulator to produce the signals for dynamic sensitivity tests. IFR does not supply fading simulators, and we are not in a position to evaluate or recommend third party fading simulators. However, the following companies are known to produce fading simulators:

Elektrobit (www.elektrobit.com)
Sofimation (www.sofimation.com)

The above is not necessarily a complete list

Normally you will need to cycle the IFR 2968 [RF SELECT] hardkey until you have selected 2-port operation, with the signal generator output on the TNC port, and the mobile or base station transmitter connected to the N-type port. If the mobile or base station has a single antenna connection for Rx and Tx, you will need a combiner between the fading simulator output and the antenna connection (and possibly an attenuator to protect the fading simulator output). Fading simulators typically require a fairly high RF input level, hence the use of the 2968 TNC port which can generate a TETRA signal at a maximum level of -20 dBm. Normally the level of the faded signal is controlled by the fading simulator, not by the 2968 RF GEN LEVEL which remains at the level required by the fading simulator input. Note that dynamic sensitivity tests require a much greater number of samples for statistical validity than do static sensitivity tests, which means that they are normally only performed for R&D or conformance testing purposes.

## Section 4 Q&A: Testing the audio performance of TETRA mobiles

**Q4.1:** Can I perform audio testing whilst the IFR 2968 is in TETRA mode?

**A4.1:** Yes. Press the [AF TEST] hardkey and you have access to the 2968's audio generators and audio analysis facilities, including an audio frequency spectrum analyser. Refer to the 2968 TETRA supplement issue 10, chapter 4, pages 34 and 35 for details. Refer to the main 2965A/2966A/2967/2968 Operating Manual for details of AF TEST mode. The 2968 continues to generate a TETRA signal, thus maintaining the mobile in conversation, whilst in AF TEST mode.

**Q4.2:** Can I use an external audio source to modulate the 2968 TETRA signal for testing the mobile's audio circuitry and earpiece / loudspeaker?

**A4.2:** Not directly. Audio signals carried on a TETRA RF signal have to be digitised and encoded with a TETRA codec. The IFR 2968 does not incorporate a TETRA codec, and the cost of licensing the TETRA codec precludes IFR from offering this as an option for the IFR 2968. However, testing with external audio sources is possible, see A4.3 below.

**Q4.3:** How can I test the mobile's audio circuitry with the 2968?

**A4.3:** The 2968 provides a "TALKBACK" function, i.e. it stores the digitised and encoded speech transmitted by the mobile and replays it to the mobile's receiver 2 seconds later. In a duplex call, this is a continuous process. In a simplex call, the last 2 seconds of speech is stored and played back repeatedly. This avoids the need for the 2968 to include a TETRA codec, since the speech is stored and re-transmitted in its already encoded form.

The Talkback facility can be used for testing with external audio sources by setting up a duplex call and testing transmit and receive audio functions together. Connect the required external audio source to the mobile's audio input, e.g. an accessory remote microphone input, and set the 2968 to talk-back mode. The audio input to the mobile should be heard or received at the mobile audio output after a 2s delay, subject to any degradations introduced in the mobile's audio input / output circuitry and TETRA codec.

With the mobile set up in a duplex call in talk-back, you can also select [AF TEST] mode and make use of the 2968 audio generation and audio analysis facilities for performing a complete end-to-end test of the mobile's audio transmit and audio receive performance.

Alternatively, you can use the 2968's TETRA encoded 1 kHz test tone for testing the mobile's audio receive performance in isolation, which can be useful in determining the source of a problem (receive or transmit) if the combined audio transmit / receive performance is poor.

**Q4.4:** What is the IFR 2968 generating when it is set to 'test tone'?

**A4.4:** It is generating a TETRA encoded version of a 1 kHz tone, representing a level of approximately 12 dB below the theoretical maximum output level. The test tone is pre-computed data that is

stored in the 2968, hence the frequency and level are fixed. It is not generated in real time from an audio signal since the 2968 does not have a TETRA codec.

The 1 kHz test tone that the 2968 generates is the result of extensive simulation work to obtain the best result; however, TETRA mobiles will not necessarily be able to reproduce a perfect steady 1 kHz tone from this data. TETRA codecs are not good with steady tones, and are subject to level fluctuations.

**Q4.5:** Can I use the 2968 TETRA test tone for audio SINAD measurements?

**A4.5:** Yes. Although the 1 kHz tone may be reproduced in a TETRA receiver with some amplitude fluctuations, it generally results in a SINAD >26 dB, particularly when measured through a CCITT psophometric filter. This can be a useful work-around if the mobile under test does not provide access to a means of measuring Bit Error Rate for testing RF receiver sensitivity. Refer to the 2968 TETRA supplement issue 10, chapter 4, page 35 for details.

**Q4.6:** Can I use the 2968 to test audio at frequencies other than 1 kHz?

**A4.6:** Yes, if you test audio transmit and audio receive together, using a duplex call and talk-back in the IFR 2968. Refer to A4.3 above for details.

### Section 5 Q&A: Functional testing of TETRA mobiles

**Q5.1:** Can the IFR 2968 test text messaging, as with SMS text messages in GSM?

**A5.1:** Yes, with the Phase 3.2 software. The TETRA equivalent of SMS is known as SDS-TL (Short Data Service - Transport Layer) and it handles text messaging in a similar (but not identical) manner to GSM. TETRA mobiles can send and receive text messages using either the standard TETRA 8-bit text coding scheme or the GSM-compatible 7-bit text coding scheme. GSM 7-bit text coding enables TETRA mobiles on TETRA networks to send or receive text messages to or from GSM mobiles on GSM networks. The IFR 2968 can send and receive text messages using either 7-bit or 8-bit text coding. SDS-TL is also used for other applications besides text messaging, and the IFR 2968 allows you to send and receive your own user-defined content as hex data. For details refer to the 2968 Phase 3.2 TETRA supplement issue 10, chapter 4, pages 24 to 28, and chapter 3, pages 20 to 26.

**Q5.2:** Can the IFR 2968 support 16-bit UCS2 and Cyrillic text messages?

**A5.2:** Yes, but it will not decode or display these alphabets - use the 'type 4 data in hex' facility to send messages or view received messages in these formats.

**Q5.3:** What is the 'commanded registration' function used for?

**A5.3:** Commanded registration is of limited use. This is a TETRA function in which the network requests information from a TETRA mobile that is already registered to the network. N.B. it does not and can not force a TETRA mobile to register to the IFR 2968 when the essential network parameters do not match the mobile (see A6.4 and A6.10 below). The commanded registration function requests the mobile to re-register and supply its full ITSI (MCC, MNC, SSI) and report its group attachments. IFR originally included this function in the IFR 2968 because there was no clear definition of the circumstances under which TETRA mobiles would supply this information. However, the requirements that are now defined in the TIP make this function of limited usefulness: the mobile only performs a normal registration to its home network, so the MCC and MNC are already known; the mobile performs attachment of its selected group or its multiple groups at the time of registration so the groups are already known. Some TETRA mobiles do not support this function, so you are recommended not to use it for normal testing on the IFR 2968.

**Q5.4:** What is the 'TT test confirm' function used for?

**A5.4:** 'TT test confirm' is used for mobiles that implement the 'TETRA Test' (TT) mode for performing an extended (test mode) registration, and the [ TT test confirm ] softkey should be pressed after TT test mode has been enabled on the mobile and the mobile has registered to the IFR 2968. It requests the mobile to supply its TEI, power class and receiver class, as well as confirming the TT test mode selection on the mobile, thus enabling it to use TT BER / RBER loopback during a duplex call for measuring receiver sensitivity. For details refer to 'TT test mode' in the 2968 Phase 3.2 TETRA supplement issue 10, chapter 4, page 41.

**Q5.5:** What is the SYSTEM SET-UP: MOBILE PARAMETERS menu used for?

**A5.5:** This menu has four items: SSI, GSSI, power class and receiver class. For explanation, refer to the 2968 Phase 3.2 TETRA supplement issue 10, chapter 3, pages 34 and 35.

- SSI: normally obtained from the mobile at registration and does not need to be entered. The 2968 uses this value when making private or phone calls to the mobile, so if you change it then the mobile should not respond to the call set-up.
- GSSI: normally obtained from the mobile's attachment of the selected group at registration, or subsequently, and does not need to be entered. The 2968 uses this value when making group calls to the mobile, so if you change it to a value that does not match one of the mobile's attached groups then the mobile should not respond to the call set-up.
- Power class: obtained automatically from the mobile if it responds to a TT test mode extended registration, otherwise the value should be entered manually to match the power class of the mobile under test. This parameter is used to determine the maximum power level expected from the mobile using open loop power control, and it is used in autotest to determine the level for the mobile high power level test pass/fail.
- Receiver class: obtained automatically from the mobile if it responds to a TT test mode extended registration. This parameter is used in autotest to determine the BER / RBER / MER limits to be applied to the receiver sensitivity tests.

**Q5.6:** Does the IFR 2968 test DGNA (Dynamic Group Number Assignment)?

**A5.6:** No. The IFR 2968 generally supports only those protocol functions that are required to enable the test set to perform parametric tests on the mobile, or to obtain useful information about the configuration and capabilities of the mobile. The IFR 2968 also endeavours to support protocol functions that can be initiated by the mobile under normal conditions and to either implement the requested function or to reject the mobile's request cleanly. DGNA is only initiated by the network, not the mobile, and does not enable parametric testing, nor does it obtain useful information from the mobile.

**Q5.7:** Does the IFR 2968 test TETRA Packet Data?

**A5.7:** No. The IFR 2968 supports the TETRA Core Services and also TETRA Short Data Service (SDS). These services are supported by most TETRA mobiles, and they also fulfil the requirements of enabling parametric testing and obtaining useful information from the mobile.

**Q5.8:** Why has transmission trunking behaviour changed in the Phase 3.2 software?

**A5.8:** In the Phase 3.2 software the IFR 2968 implements trunking timers for a better and more flexible simulation of real network operation conforming to TIPv3 Core Services. There is now a quiet period (return to MCCH) between the PTT release on the mobile under test and the commencement of the 2968 simulating another user talking. This quiet period, and the 2968 talk period, are user configurable in the new SYSTEM PARAMETERS: CALL TIMERS menu (for details refer to the 2968 Phase 3.2 TETRA supplement issue 10, chapter 3, pages 19 and 20). There is now also a user configurable hang timer which will automatically clear down a group call after a period of inactivity.

**Q5.9:** Why has the AUTORUN PARAMETERS menu changed in the Phase 3.2 software?

**A5.9:** The Phase 3.2 software allows the user to configure up to six separate call set-up and clear down operations for enhanced flexibility. These have replaced the previous inflexible autorun tests of PLACE CALL, CLEAR FROM MOBILE, CALL MOBILE and CLEAR FROM LAND. There is an additional TT TEST MODE autorun test for use instead of the REGISTRATION test with mobiles performing an extended TT test mode registration. For details refer to the 2968 Phase 3.2 TETRA supplement issue 10, chapter 7, pages 5 to 16.

**Q5.10:** Why is 'TEST MODE REGISTRATION' not in System Parameters in Phase 3.2?

**A5.10:** This is only applicable to mobiles that support an extended TT test mode registration to supply their TEI, power class and receiver class, and to enable the use of TT loopback. Test mode registration involves the sending of a 'test mode confirm' command to the mobile after it has completed its normal registration, including the attachment of groups if required. Mobiles vary in the number of groups they attach at registration, and the time taken to do so, and there is no indication in the group attachment signalling to inform the 2968 when the mobile has attached all of the groups that it is going to attach.

Therefore, in Phase 3.2, the 2968 MANUAL test mode provides a [TT test confirm] softkey for the user to press when the mobile is ready to receive the command. The AUTOTEST mode 'TT TEST MODE' test provides a user configurable 'wait for group attachment' timer.

**Q5.11:** What has happened to mobile terminated SDS types 1, 2, 3 and 4 in Phase 3.2?

**A5.11:** The most commonly used SDS functions are SDS type 4 SDS-TL text messages, SDS type 4 simple text messages, and status messages, and these are the functions that appear when the [send message] softkey is pressed. The other less commonly used SDS functions (SDS types 1, 2, 3 and SDS type 4 in hex) are available on a second level by pressing the [other SDS] softkey.

**Q5.12:** What has happened to the mobile classmark display in Phase 3.2?

**A5.12:** This is now accessed via the [show detail] softkey, which additionally gives access to details of group attachments, status messages and short data service (SDS) messages.

**Q5.13:** When a mobile registers and attaches multiple groups, each group identity is immediately over-written by the next one. Is it possible to see this information?

**A5.13:** Yes. Press the [show detail] [groups] softkeys to see the GSSI values of the first ten attached groups, displayed in decimal and hex, with Class of Usage for each group. The [more groups] softkey provides access to further blocks of ten up to a total of 40 groups.

**Q5.14**: When a mobile sends a text message, the IFR 2968 only shows the first few characters. Is it possible to see the whole message?

**A5.14:** Yes. Press the [show detail] [SDS message] softkeys to see SDS-TL text messages in full up to 160 characters. The IFR 2968 also shows other details associated with the message and the intended destination address of the message.

**Q5.15:** Is it possible to change the time and date information that is sent when the IFR 2968 sends an SDS-TL text message to a mobile?

**A5.15:** Yes. The IFR 2968 obtains the time and date information from its real time clock, which can be changed by pressing the [HELP/SET-UP] hardkey followed by the softkeys [SET-UP] [MISC CONFIG] [time & date]. The sending of time and date information is enabled and disabled in the SDS-TL text message set-up menu (refer to the IFR 2968 Phase 3.2 operating manual TETRA supplement, issue 10, chapter 4, page 27, 'TIME STAMP'). Note that the year does not form part of the time stamp information sent by the IFR 2968.

**Q5.16:** Why can't I make group calls when the mobile is registered and the PTT pressed?

**A5.16:** TETRA mobiles can only make and receive group calls to or from groups that they have successfully attached to the network. Normally a TETRA mobile will attach one or more groups at registration, and you will be able to subsequently change the currently selected group. Ensure that the 2968 is not displaying "GSSI: NO GROUPS ATTACHED". If it is, this could be because the mobile group selection is explicitly set to 'NO GROUP', or because the mobile has not been configured with any group identities. Use the [show detail] [groups] keys to see details of the groups attached by the mobile. Use the mobile's group selector knob or buttons or menu functions to select a group. Depending on the mobile, you may need to explicitly set group mode in order to make group calls.

### Section 6 Q&A: Compatibility with TETRA mobiles and networks

**Q6.1:** Which TETRA mobiles can be tested by the IFR 2968?

**A6.1:** The following mobiles have been tested and demonstrated to work with the IFR 2968:

Cleartone CM9000/CM9000P vehicle mount
Marconi Elettra VT vehicle mount
Marconi PUMA-T hand portable
Marconi PUMA-T2 hand portable
Motorola MTM 300 vehicle mount
Motorola MTP 200/300 hand portable
Motorola MTH 300/300s small hand portable
Motorola MTH 500 small hand portable
Motorola MTM 700 vehicle mount
Motorola MTP 700 hand portable
Nokia TMR 400/400E/420 vehicle mount
Nokia THR 400/420E hand portable
Nokia THR 600/600E hand portable
Nokia THR 850 small hand portable
Simoco/Sepura SRM 1000 vehicle mount
Simoco/Sepura SRP 1000 hand portable
Simoco/Sepura SRP 2000 small hand portable
Teltronic MDT-400 vehicle mount
Thales Vector covert radio

Note: the above is not necessarily a complete list, and does not necessarily confirm full compatibility with every function on every mobile; however, all of the above mobiles can at least perform registration and call set-up with the IFR 2968 so that parametric measurements can be made. Where available, mobiles have been tested in different versions covering the 380-400 MHz public safety band, the 410-430MHz commercial band and the 800 MHz Asia Pacific band.

**Q6.2:** How do I make an RF connection between the IFR 2968 and the mobile?

**A6.2:** Vehicle mounted mobiles and larger hand portable mobiles will typically have a standard RF connector such as BNC, TNC or SMA, for which connectors and adaptors are readily available from third party suppliers. Smaller hand portable mobiles may require a proprietary antenna adaptor or RF test lead, which you may only be able to obtain from the mobile manufacturer. Normally you should connect to the IFR 2968 N-type socket ('150 W MAX') and ensure that both LEDs next to this socket are lit. For further details refer to 'RF connection between the mobile and the IFR 2968' in the application note 'Testing TETRA mobiles with the IFR 2968'.

**Q6.3:** What is the significance of "TIP" and which version does the IFR 2968 comply with?

**A6.3:** TIP (TETRA Interoperability Profile) is very significant for IFR as well as for the TETRA mobile and infrastructure manufacturers. It provides a common interpretation and implementation of the TETRA Air Interface to ensure that mobiles from multiple manufacturers operate on infrastructure from multiple manufacturers. For IFR, it is the means to ensure that mobiles from multiple manufacturers operate on the IFR 2968. IFR actively participates in the TETRA MoU TIP specification working group and IOP testing to ensure compatibility between the IFR 2968 and TETRA mobiles from all manufacturers. For more information on Interoperability (IOP) refer to www.tetramou.com/interoperability/index.asp.

The IFR 2968 complies with the following TIP specifications:

TTR 001-1 v3.0.13 June 2001: TIPv3 Core Services
TTR 001-2 v1.0.1 August 2001: TIPv3 Short Data Service (SDS)
TTR 001-6 v1.0.0 June 2001: TIPv4 Air Interface Migration
TTR 001-8 v1.0.0 October 2001: TIPv4 Testing Requirements
TTR 002 v1.0.3 November 2000: Direct Mode TIP

**Q6.4:** I have a TETRA mobile that claims to be TIP compliant, and the IFR 2968 claims to be able to test it, so why doesn't the mobile register to the 2968 when I switch it on?

**A6.4:** TETRA mobiles normally only register to base stations belonging to their home network for which they have been configured (programmed). Therefore the IFR 2968 must be set up to exactly match the essential parameters of the home network, otherwise the mobile is likely to ignore the test set. The essential parameters are as follows:

- Channel Plan: the frequency band and method of numbering the frequency channels.
- Channel Plan Frequency Offset: typically 12.5 kHz offset or 0 Hz offset
- Control Channel: particular control channel frequency if the mobile does not scan the band.
- Country Code (MCC) and Network Code (MNC): these identify the home network

For further details refer to the 2968 operating manual TETRA supplement issue 10, chapter 3, pages 7 to 11, and chapter 4, pages 2 to 3. You may need to contact the mobile manufacturer or network operator to obtain the essential parameter information. Country Code (MCC) values are published in ETSI EN 300 392-2 v2.3.2 Annex K. Network Code (MNC) values are normally allocated by the radio regulation authority in each country, and these values may not necessarily be published.

**Q6.5:** The essential network parameters have been set correctly but the mobile still does not register to the IFR 2968. Is there anything else that needs to be checked?

**A6.5:** Refer to 'Annex C: Troubleshooting when a mobile does not register' in the IFR application note 'Testing TETRA mobiles with the IFR 2968' for further assistance.

**Q6.6:** The mobile registers to the IFR 2968 but call set-up fails. What is wrong?

**A6.6:** Ensure that the traffic channel frequency (channel number) is within the range of frequencies supported by the mobile. It is particularly important to check this if the mobile only supports part of a frequency band. For example, the 'TETRA 380 MS' channel plan covers channels 3600 to 3999 (380-390 MHz mobile transmit, 390-400 MHz mobile receive); a mobile that only covers 385-390 MHz mobile transmit/395-400 MHz mobile receive will only cover the channels 3800 to 3999. Ensure that both the control channel and the traffic channel are within the mobile's supported frequency range. You may prefer to define a USER DEFINED channel plan covering only the mobile's supported frequency range so that you can only select channels within the supported frequency range.

**Q6.7:** Why is the IFR 2968 so particular about the network parameters?

**A6.7:** The IFR 2968 is not particular at all, however TETRA mobiles are particular. Until the essential parameters are set up on the test set (channel plan, offset, control channel, MCC, MNC), a TETRA mobile will normally ignore the test set completely and not send any signalling to the test set. Normally a mobile will not provide any indication to the user that it has found a TETRA base station signal unless the essential parameters are set correctly.

**Q6.8:** Why can't the IFR 2968 set the network parameters itself automatically?

**A6.8:** In theory, the 2968 could try all of the parameter values in turn until the mobile responds. However, with 999 possible country codes and 9999 possible network codes this is not a practical proposition. For each of the 10 million combinations, the 2968 would need to wait several seconds to give the mobile time to find the signal - having found a TETRA signal with the wrong MCC / MNC values, the mobile is not going to keep listening to the signal in case the values change, it will go off and search for signals with the correct values. If the channel plan (frequency band and offset) is unknown, this would increase the combinations further, and if the mobile does not scan the band then all 16000 frequency channels and offsets in the band would have to be tried each with all 10 million combinations of MCC /MNC.

**Q6.9:** GSM radio test sets don't require the correct network parameters to be set, why is this necessary for TETRA mobiles on the IFR 2968?

**A6.9:** A GSM phone attempts to register onto other networks (roaming) if it doesn't find its home network. Currently TETRA mobiles do not implement this behaviour, which is known as 'migration' in TETRA rather than 'roaming'. TETRA migration is defined as a two stage process in which the mobile would identify itself to the other network as a 'visitor' and would be assigned a visitor's identity for use on the other network which it could then use to register and make / receive calls on the visited network. As part of this process the mobile would provide the identity of its home network and its own identity.

The IFR 2968 (Phase 3.2 software) implements TETRA migration so that mobiles which do implement migration can register to the test set as a visitor and provide the identity of their home network. TETRA mobiles implementing migration should become available in the future, since migration has been defined as an optional part of TIPv4 functionality. However, this does not necessarily mean that a TETRA mobile supporting migration will attempt to register to any network - mobiles may be configured with lists of other networks with which they are allowed to attempt migration. In any case, the IFR 2968 still needs to be configured with the correct channel plan and offset required by the mobile.

All GSM mobiles use SIMs (Subscriber Identity Modules), and it is common practice to test GSM mobiles using Test SIMs, which provide the mobile with a test identity (IMSI) of 001/01/0123456789 when the SIM is inserted instead of the normal network subscription SIM. Currently TETRA mobiles do not use SIMs and there is no definition for a TETRA Test SIM. The nearest equivalent that is currently available in TETRA mobiles is the use of TETRA Test (TT) mode registration, in which the mobile assumes a home network identity of 001/00001 when TETRA Test mode is enabled on the mobile.

**Q6.10:** How do I find out the network parameters for a particular mobile?

**A6.10:** There are a number of options which 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.
- Check whether the mobile has actually been configured for a particular network or whether it contains a factory default configuration.
- If the mobile is known to work with a nearby base station, use the 2968 in base station test mode to determine the essential network parameters, and set up the 2968 in mobile test mode to match the real base station. See A6.11 below for details of how to do this.

**Q6.11:** How do I set up the 2968 to match the network parameters of a local TETRA BS?

**A6.11:** The following method can be used for setting up the 2968 to match the network parameters of a local TETRA base station that a TETRA mobile is known to work with, providing that the base station is reasonably close (e.g. 1-2 km) and you have an antenna that can receive a clean RF signal at a reasonable level (typically -75 dBm

or higher).

Firstly, use the 2968 in base station test mode ([SYSTEM] [TETRA base], requires Option 31 TETRA BS) to determine the frequency of the base station. Select channel plan NO PLAN ([SET-UP] [channel plan] [NO PLAN]) and go to [MANUAL] mode. Ensure that your antenna is connected to the TNC port in 2-port duplex mode with maximum sensitivity (refer to 'Off-Air Base Station testing' in the 2968 Phase 3.2 TETRA supplement issue 10, chapter 5, page 8). Use [expected power] and repeated [-10 dB step] then [return] to set expected power level of -40 dBm. Use the 2968 spectrum analyser in expanded mode with markers on (2968 Phase 3.2 TETRA supplement issue 10, chapter 8, pages 2, 7 and 8) to locate the frequency of the base station signal. Initially set a wide span to cover the possible frequency range (e.g. REF FREQ 405 MHz span 5 MHz/div will cover the range 380 MHz to 430 MHz). Use the [peak find] or [move marker] functions and the [set ref to M1] function to home in on the local base station signal. Repeat this process with reduced span widths ([ ◂ ▸ /div ]) until the characteristic TETRA modulated signal is centred on a span of 5 kHz/div. Make a note of the REF FREQ, adjusting it as required so that it is an exact multiple of 6.25 kHz.

Secondly, return to SYSTEMS mode, which overrides the DUPLEX mode settings, and enter the REF FREQ value as the TX FREQUENCY and press the [all slots] softkey. The 2968 should receive, demodulate and decode the base station signal and display the MCC, MNC and BCC values ('Base station identity information', page 5 of chapter 6 of the 2968 Phase 3.2 TETRA supplement issue 10). Make a note of the MCC, MNC and BCC values.

Thirdly, return to TETRA mobile test mode ([SYSTEM] [TETRA mobile]), and set up the 2968 System Parameters with the same MCC and MNC as the local base station. It is advisable to set a different value of BCC (but not zero) to guard against co-channel reception of the real base station by the mobile. Calculate the channel plan and channel number from the base station frequency (see A6.12 below) and set up the 2968 with the channel plan and control channel number to match the local base station.

Finally, connect the TETRA mobile to the 2968 (not forgetting to reset the RF SELECT to the N-type port in 1-port duplex mode) and set the 2968 RF GEN LEVEL to a high level (e.g. -50 dBm) to guard against inadvertent reception of the local base station signal (see warning on 'RF Interference' in the 2968 Phase 3.2 TETRA supplement issue 10, chapter 2, page 2). Switch on the mobile and it should now register to the IFR 2968. The mobile may also be capable of scanning the frequency band to find the 2968's MCCH on a different channel if it can be screened or otherwise prevented from receiving the local base station signal.

**Q6.12:** How do I convert a frequency in Hz to a TETRA channel plan and channel number?

**A6.12:** There is a straightforward calculation to do this. When you are testing a base station or a direct mode mobile, or a mobile in T1 test mode, you do not need to convert the frequency to a channel number, because you can use the 2968 with channel plan NO PLAN and enter the transmitter frequency directly in Hz. However, when you are testing a mobile in normal trunked mode (MCCH) you will need to set up the 2968 with a channel plan and channel number. The TETRA signalling protocol uses the channel number, not the frequency, when the mobile is assigned to a traffic channel or control channel. Therefore the channel plan and channel number must be correct for these procedures to work, i.e. both the 2968 and the TETRA mobile must have the same understanding of what the channel number means when it is converted to frequencies for tuning transmitters and receivers.

The calculation and examples below are valid for the standard channel numbering scheme defined in ETSI TS 100 392-15 v1.2.1 and required by the TIP (TTR 001-1 v3.0.13 TIPv3 Core Services). The numbering is defined in terms of the base station transmitter frequency:

- Identify the relevant base station (downlink) frequency, accurate to 1 kHz or better
- The frequency should be the centre frequency of the TETRA modulated signal
- The frequency should be an exact multiple of 25 kHz, 12.5 kHz or 6.25 kHz
- Round the frequency up or down so that it is an exact multiple of 6.25 kHz
- Subtract an integer multiple of 100 MHz, leaving a remainder less than 100 MHz
- The integer gives the value of the band parameter.
- Divide the remainder by 25 kHz
- The result should be in the range 0 to 3999 see note below
- The result should be xxxx.00, xxxx.25, xxxx.50 or xxxx.75
- Result xxxx.00: channel = xxxx, offset = 0 Hz
- Result xxxx.25: channel = xxxx, offset = +6.25 kHz
- Result xxxx.50: channel = xxxx, offset = +12.5 kHz
- Result xxxx.75: channel = xxxx+1, offset = -6.25 kHz

Example 1: BS frequency = 393.612500 MHz
Subtract 300 MHz: remainder = 93.612500 MHz, band = 3 (300 MHz)
Divide by 25 kHz: result = 3744.50, channel = 3744, offset = +12.5 kHz
Therefore channel plan = TETRA 380 MS (includes +12.5 kHz offset), channel = 3744

Example 2: BS frequency = 421.568750 MHz
Subtract 400 MHz: remainder = 21.568750 MHz, band = 4 (400 MHz)
Divide by 25 kHz: result = 862.75, channel = 862+1 = 863, offset = -6.25 kHz
Therefore channel plan = TETRA 410-6 MS (includes -6.25 kHz offset), channel = 0863

Example 3: BS frequency = 867.425000 MHz
Subtract 800 MHz: remainder = 67.425000 MHz, band = 8 (800 MHz)
Divide by 25 kHz: result = 2697.00, channel = 2697, offset = 0 Hz
Therefore channel plan = TETRA 800+0 MS (zero offset), channel = 2697

Note: the ETSI numbering scheme permits a small overlap of the

100 MHz bands (2.4 MHz overlap), since the channel numbering extends to 4095. For example, a base station covering 395.000 MHz to 400.000 MHz would probably use channel numbers 3800 to 4000 on band 3, rather than numbering the last channel as channel number 0000 on band 4.

**Q6.13:** Can I test a TETRA mobile that does not conform to the ETSI channel numbering?

**A6.13:** Yes. The USER DEFINED channel plan allows you to define your own channel numbering scheme to match e.g. manufacturers' proprietary numbering schemes, or to support other TETRA channel plans which may be defined in future. Typically a TETRA mobile may have a proprietary channel numbering scheme when it has a factory default configuration before it has been configured for a particular network, e.g. the lowest frequency supported by the mobile may be numbered as channel 0001. The IFR 2968 can support any frequency from 100 MHz to 1 GHz. Refer to the 2968 Phase 3.2 TETRA supplement issue 10, chapter 3, pages 7 to 10 and pages 39 to 42, for details of the USER DEFINED channel plan. Refer also to chapter 11, pages 1 to 3, for details of the pre-defined and user defined channel plans.

**Q6.14:** Can I ignore channel plans and channel numbers and set the 2968 frequency in Hz?

**A6.14:** Yes, but not for normal trunked mode mobile testing. The IFR 2968 provides a 'NO PLAN' channel plan for setting the 2968 frequency in Hz instead of using a channel number. You can also set frequencies directly in Hz in DUPLEX TEST mode; however these frequency settings will be over-ridden when you return to SYSTEMS. If you select NO PLAN in SYSTEMS mode and set the required frequency in Hz, this will carry over to DUPLEX TEST mode. Refer to the 2968 Phase 3.2 TETRA supplement issue 10, chapter 3, for details of using NO PLAN: pages 7 to 10 (MS), pages 27 to 29 (BS), pages 31 to 33 (DM).

Important note: When you are testing a base station or a direct mode mobile, or a mobile in T1 test mode, you can ignore channel numbers and enter the transmitter frequency directly in Hz. However, when you are testing a mobile in normal trunked mode (MCCH) you will need to set up the 2968 with a channel plan and channel number. The TETRA signalling protocol uses the channel number, not the frequency, when the mobile is assigned to a traffic channel or control channel. Therefore you must use the correct channel plan and channel number for normal mobile testing.

### Section 7 Q&A: Signalling and protocol operations

**Q7.1:** Does the IFR 2968 test signalling operations with Direct Mode mobiles?

**A7.1:** Yes, with the Phase 3.2 software and Option 32. Mobile Originated Direct Mode call set-up and clear down is supported in accordance with DMO TIP TTR 002 v1.0.3. Relevant call set-up parameters are displayed, providing information about the DMO mobile under test and the type of call performed. The IFR 2968 does not test Mobile Terminated Direct Mode call set-up, i.e. it does not simulate a Direct Mode mobile setting up a call to other Direct Mode mobiles.

**Q7.2:** Can I see the signalling messages and parameters that the 2968 sends to the mobile and receives from the mobile?

**A7.2:** Yes. Full protocol analysis is provided with TETRALOG, an optional PC based application that analyses the signalling messages (PDUs) and parameters (information elements) that are sent and received by the IFR 2968. The sequence of messages is displayed graphically as a message sequence chart (MSC). Each PDU and information element can be viewed fully decoded according to ETSI EN 300 392-2 v2.3.2. For further details please refer to the data sheet for 81514 TETRALOG and contact your local IFR sales representative or distributor.

**Q7.3:** Is it possible to read the individual bits of the PDU fields that the 2968 receives?

**A7.3:** Yes. TETRALOG shows the contents of every PDU received (and sent) by the 2968.

These are shown as:

- hex data for the complete MAC PDU after channel decoding (TMV-SAP)
- hex data for fragmented PDUs after re-assembly of the MAC fragments
- hex / binary / decimal data (as appropriate) for each information element
- decoded meaning for each information element (PDU field)

The 2968 also has the DATA screen in which individual burst data can be seen, before and after channel decoding, in hex and binary as appropriate. However, this only captures and shows a single burst and does not decode the PDU (which can be done in TETRALOG).

**Q7.4:** Is it possible to edit the PDU fields that the 2968 sends ?

**A7.4:** Partially. Specific parameters can be set in the SET-UP: System Parameters menu, and these will affect the contents of the information elements (fields) in the PDUs that are sent by the 2968. In particular, the CALL TYPES: and MESSAGES: menus allow configuration of various CMCE parameters. However, the 2968 is not designed as an editable protocol test script tester, i.e. it does not execute TTCN test scripts. The PDU fields which are not editable by the user are set by the 2968 protocol software. Visibility of the fields is provided by the optional TETRALOG application, which shows the value and meaning of every field (information element) in every PDU sent and received by the 2968.

**Q7.5:** Is it possible to view and edit the SYSINFO and SYNC messages sent by the 2968?

**A7.5:** You can see the values of the editable parameters in the [SET-UP] [System Params] menu. You can see the full content of SYSINFO and SYNC messages using TETRALOG. You will see the SYSINFO and SYNC messages in TETRALOG when you change any of the parameter values or if you press the [restart MCCH] button, also when you clear down a call. You need to have TETRALOG in 'view all layers' mode since these messages only appear at MAC and MLE layers. For information on the SYSINFO and SYNC parameters that can be changed, refer to the 2968 Phase

3.2 manual issue 10, chapter 3 pages 6 to 16; chapter 4 pages 2 to 3; chapter 11 pages 1 to 4.

### Section 8 Q&A: Testing mobiles with encryption and authentication

**Q8.1:** Can I test TETRA mobiles that use encryption and / or authentication?

**A8.1:** Yes. The IFR 2968 does not test the encryption or authentication aspects, but the mobile functional aspects and RF performance can be tested without using encryption or authentication. Refer to A8.4 and A8.8 below for further information.

**Q8.2:** Does the IFR 2968 test Air Interface Encryption (AIE) or End to End encryption (E2E)?

**A8.2:** The IFR 2968 does not support either form of encryption. The IFR 2968 conforms to TIPv3 Part 1 (Core Services) which does not support either form of encryption.

**Q8.3:** Will the IFR 2968 support encryption in a future upgrade?

**A8.3:** IFR currently has no plans to support encryption in the IFR 2968. The architecture of the IFR 2968 Radio Test Set does not provide for a secure embodiment of the security keys and algorithms. Implementing encryption algorithms and security keys within the Test Set would be an unacceptable breach of the requirement of the SFPG (Security and Fraud Prevention Group) to keep these secure. IFR would not be in a position to undertake the necessary security measures associated with handling the encryption keys and algorithms.

**Q8.4:** How can I test a TETRA mobile that uses encryption?

**A8.4:** TETRA mobiles are only able to use encryption if both the mobile and the network (or test set) support encryption, and if the network (or test set) permits its use. TETRA mobiles that are not able to use encryption attempt operation in clear. The system information generated by the IFR 2968 indicates to the mobile that the IFR 2968 does not support encryption and allows the mobile to operate in clear. Mobiles may be configured to display warning icons or generate warning beeps to the user when operating in clear, but this does not prevent them from being tested in the normal manner.

Encryption (or the lack of it) has no effect on the measurement of the RF performance, which is the primary purpose of the IFR 2968. The functional tests, and the obtaining of information from the mobile, can all be performed in clear, thus the only untested functionality is the additional signalling related to cipher keys and encryption. In any case, the security keys necessary for using encryption may be removed from a mobile for security reasons before it is sent to a third party for test and repair.

**Q8.5:** The IFR 2968 has a setting for "AIR INTERFACE ENCRYPTION" - what is this for?

**A8.5:** The menu "SYSTEM SET-UP: SYSTEM PARAMETERS: BASE SERVICES" allows the user to set the values of the "Base Station Services" parameters. These are 12 binary flags which indicate to a TETRA mobile which services are provided by the base station. One of these is for Air Interface Encryption and it can be set to "AVAILABLE" even though the IFR 2968 does not support Air Interface Encryption. Some users wish to have full control of all of these flags even though the IFR 2968 does not support all of the services. For normal mobile testing the Base Services flags should remain set to their factory default values, which indicate the services which the IFR 2968 does provide. N.B. these flags are simply information broadcast to the mobile under test; changing their values does not alter the functionality of the test set.

**Q8.6:** Can I check that the mobile attempts to perform an encrypted registration by setting the Base Services "Air Interface Encryption" flag to "Available"?

**A8.6:** No. The 2968 does not support encryption. It is not possible for the MS to register or set up a call to the 2968 in encrypted mode. The control channel information generated by the 2968 makes it clear to the MS that it does not support encryption (system code is "no security functions"). If the BS Services AI encryption field is set to "Available", the MS will look for, but not find, the cipher key information which it requires in order to use encryption. Depending on the MS, it may perform a registration in clear, or it may reject the test set as being unsuitable and indicate that there is No Service.

For normal MS testing this flag should always be set to "Not Available".

**Q8.7:** Does the IFR 2968 test Authentication or Mutual Authentication?

**A8.7:** The IFR 2968 does not test either type of authentication.

**Q8.8:** How can I test a TETRA mobile that uses authentication?

**A8.8:** Normal authentication is initiated by the TETRA network. The network sends a challenge to the mobile and checks the response returned by the mobile. The mobile should respond if challenged, but it should not be upset if it is not sent a challenge (as is the case with the IFR 2968). The IFR 2968 system information indicates that authentication is not supported, hence a TETRA mobile should not expect to be authenticated by the 2968.

Authentication (or the lack of it) has no effect on the measurement of the RF performance, which is the primary purpose of the IFR 2968. The functional tests, and the obtaining of information from the mobile, can all be performed without authentication, thus the only untested functionality is the additional signalling related to authentication challenge and response. In any case, the authentication keys may be removed from a mobile for security reasons before it is sent to a third party for test and repair.

**Q8.9:** Will the IFR 2968 support authentication in a future upgrade?

**A8.9:** IFR currently has no plans to support authentication in the IFR 2968. The architecture of the IFR 2968 Radio Test Set does not provide for a secure embodiment of the security keys and algorithms. Implementing authentication algorithms and security keys within the Test Set would be an unacceptable breach of the requirement of the SFPG (Security and Fraud Prevention Group) to keep these secure. IFR would not be in a position to undertake the necessary security measures associated with handling the

authentication keys and algorithms.

**Q8.10:** How can I test a TETRA mobile that uses mutual authentication?

**A8.10:** Mutual authentication involves the mobile authenticating the network as well as the network authenticating the mobile. This functionality is specified for TIPv5, and is always initiated by the TETRA network. There is currently no TIP specification for a TETRA mobile to initiate authentication of the network when the network has not authenticated the mobile. The IFR 2968 system information indicates that authentication is not supported, hence a TETRA mobile should not expect to be authenticated by the IFR 2968, and should not expect to authenticate the IFR 2968.

**Q8.11:** Will the IFR 2968 support mutual authentication in a future upgrade?

**A8.11:** No, this would be a breach of TETRA security. The purpose of mutual authentication is for TETRA mobiles to be sure that they are communicating with a real TETRA base station and not a spoof base station intercepting their calls. It is therefore important that the algorithms and keys for mutual authentication are only released to genuine TETRA networks and are not implemented in a radio test set.

**Q8.12:** Could the IFR 2968 test the authentication process without involving secure algorithms and keys in a future upgrade?

**A8.12:** This is a possibility, although currently IFR has no plans to implement this functionality. This process is supported in GSM testing through the use of a standard simple authentication algorithm for test purposes (XOR challenge with internal key) and through the use of standard Test SIMs incorporating the test algorithm and a known test key. Hence GSM test sets send an authentication challenge to a mobile and know what response to expect, without involving any breach of the secure algorithms and keys used on real networks.

Currently, TETRA mobiles do not use SIMs, there is no definition for a TETRA Test SIM, and no standard simple algorithm or known key for test purposes. Therefore such a test would be of limited value since the IFR 2968 would not know what response to expect.

### Section 9 Q&A: Miscellaneous functions

**Q9.1:** Can the IFR 2968 test TETRA mobiles off-air?

**A9.1:** Yes, but this should only be used as a last resort for functional testing if you are unable to achieve a direct RF connection between the mobile and the test set. Transmitter power and receiver sensitivity levels will be uncalibrated, and there are associated problems of the mobile receiving real base station signals and generating unauthorised transmissions. Refer to 'RF connection between the mobile and the IFR 2968' in the IFR application note 'Testing TETRA mobiles with the IFR 2968' for details.

**Q9.2:** Can the IFR 2968 receive TETRA base station signals off-air?

**A9.2:** Yes, when in reasonably close proximity, typically no more than 3 km line of sight and with a signal level not less than -75 dBm. For details of how to do this refer to 'Off-Air Base Station testing' in the 2968 Phase 3.2 supplement issue 10, chapter 5, page 8.

**Q9.3:** Can the IFR 2968 perform off-air BER testing (coverage monitoring or drive testing)?

**A9.3:** No. The IFR 2968 does not have the sensitivity or selectivity to perform off-air coverage monitoring. It can receive off-air base station signals in close proximity to a base station, e.g. 3 km line of sight, and can decode the base station signals down to a level of approx. -75 dBm. Below this level the spectrum analyser is still usable, but will not be as good as a dedicated off-air coverage monitor. It may be possible to improve this with an external RF amplifier and filters. The IFR 2968 is designed for measuring strong signals either directly connected or in close proximity off-air, hence it does not have the ability to receive weak signals in fringe coverage areas subject to multipath fading and interference.

There are other specialist test and measurement companies who do have coverage analysis products, a selection of which are listed below:

Actix www.actix.com
Rotadata www.rotadata.com
Nemo Technologies www.nemotechnologies.com
ATDI www.atdi.co.uk
The above is not necessarily a complete list.

**Q9.4:** Can the IFR 2968 test other base station components besides the transceiver?

**A9.4:** Yes. You can measure the different cables, couplers, filters, duplexers and amplifiers using the spectrum analyser function with its tracking generator. Individual losses can be easily measured within their frequency range. The tracking generator, when used with a directional coupler or a reflection bridge, will allow you to quickly check the antenna return loss. To use the tracking generator you need to de-select TETRA and select RF TEST mode as follows: [SYSTEMS] [SYSTEM] [no system] [RF TEST] [RF IN/OUT]. Set the RF GEN LEVEL as required, then select [spec ana] [expand ON off] [track ON off]. Set reference level, reference frequency and span/div as required. For further details, refer to the IFR 2965A/2966A/2967/2968 Operating Manual 46882/274.

The internal digital multimeter can be used to measure the voltage of both AC mains and DC power supply. AC / DC current, resistance and continuity tests can also be performed. You can use the multimeter with or without TETRA selected. Press [AF TEST] [MULTI METER] to access these functions. For further details, refer to the IFR 2965A/2966A/2967/2968 Operating Manual 46882/274.

**Q9.5:** Can I store and recall different TETRA system set-ups on the IFR 2968?

**A9.5:** Yes, using a memory card. You can store system set-up information, user defined autotest programs, autotest results and screen dump images onto named stores on a memory card. Refer to the IFR 2968 Phase 3.2 TETRA supplement issue 10, chapter 10, for details.

**Q9.6:** Why doesn't the store / recall facility work when I try to store /recall TETRA settings?

**A9.6:** The IFR 2968 store/recall facility incorporates both internal stores and external stores; external stores use a memory card. The internal stores (numbered 00 to 19) only store the settings relating to the 'NO SYSTEM' analogue functionality of the 2968. The external stores (numbered 20 to 99) use a memory card, and can store SYSTEMS set-up information, user defined autotest programs, autotest results and screen dump images. Refer to the IFR 2968 Phase 3.2 TETRA supplement issue 10, chapter 10, for details.

**Q9.7:** Can I use a FLASH memory card instead of a battery backed SRAM memory card?

**A9.7:** Yes and no. The IFR 2968 is unable to write to (program) FLASH memory cards, but it can read them. Therefore you need an SRAM card to save 2968 information to stores. Once you have done this, you can copy the SRAM card information to a FLASH card using a PC, and you can recall the stored information from the FLASH card to the 2968. You will not be able to rename or delete or alter the stored information in the FLASH card from the 2968 as it cannot write to the card. This could be useful if you wish to create a 'master' set of stored 2968 settings to be copied to a number of other 2968s. Create the master settings on an SRAM card and use a PC to make multiple read-only copies onto FLASH cards.

**Q9.8:** Can I capture a 2968 screen image and use it in PC applications?

**A9.8:** Yes, this is how we create the screen shots that you see in the IFR 2968 operating manual and TETRA supplement. Screen dumps are created by pressing the [COPY] hardkey, which gives you the option of copying the image to a printer, storing the image on a memory card, or simply holding the display. To capture the image on a PC you need to connect the PC serial port to the IFR 2968 serial port using a null modem cable, and you need to set the IFR 2968 to print using the serial port.

The data sent to the PC serial port will be printer control information. IFR can supply free of charge on request a DOS utility "2965scrn.exe" that captures the screen image from the printer control information and creates a bit image that can be saved as a .bmp file for inclusion in Windows applications. N.B. this utility is unsupported and unwarranted but it is tried and tested and has been used for many years.

To set up the IFR 2968 to print to a PC running the IFR screen capture utility, press the [HELP/SET-UP] hardkey, then the softkeys [SET-UP], [INPUT OUTPUT], [ serial set-up ], then set the following parameters:

baud rate: 9600
parity: none
data bits: 8
stop bits: 1
duplex echo: off

press [return] and [printer options] softkeys and set the following parameters:

printer port: serial
printer driver: HP LaserJet (III/IV)/DeskJet 150 dpi
time & date: no time and date on screen dump

press [return] [return] [return] [return] or [HELP/SET-UP] [return]

Now run 2965scrn.exe on the PC. Press [COPY] [COPY] and the 2968 screen image should gradually appear on the PC screen. When the image capture is complete, use the PC 'File' 'Save .BMP File' options to save the captured image to a named file on the PC. Note that when you next press [COPY] [COPY] the current captured image is over-written by the new one, so make sure you save each image to a separate file if you wish to keep it.

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