

TETRA BS Test

Software Option 897 942

Operating Instructions

(64_tetbs) Doc. Version: 0003-110-A

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For differences from former software versions: see the Timeline at the end of this supplement.

Introduction

What TETRA stands for

TETRA is a wireless communication standard for Professional Mobile Radio (PMR) and Private Access Mobile Radio (PAMR) applications. It is a digital format, i.e. speech is transmitted as binary data rather than by an analog format as for instance using frequency modulation. This way, it is much more difficult to tap a radio communication.

The acronym TETRA stands for:

TERrestrial Trunked RAdio


If you are familiar with measurements in the analog world, e.g. MPT 1327 or LTR, you will notice some similarities as well as some new measurements. While RF power and frequency error are measurements important to any system, measuring a vector error or looking at the constellation display may be a new experience because these measurements are specific to the modulation format applied by TETRA, which is $\pi/4$ DQPSK.

What is tested?

The TETRA BS Test option allows you to

- perform transmitter tests on TETRA base stations.
- feed a test signal to the BS, allowing to test the receiver.

Besides the TETRA option, you can also use the spectrum analyzer for in-band and out-of-band transmitter measurements. Refer to the operating instructions of the spectrum analyzer (248 290/1) in chapter 9 of this manual.

 The Tracking option may also be useful to test the RF cabling at the base station.

Measurements possible with TETRA – an overview

RF power	Power over time (graphics)
Frequency error	Modulation spectrum (graphics)
Residual carrier power	Constellation display (graphics)
Vector error	Support for BER measurements

General Preparations

Hardware and firmware compatibility

When ordering a new system or an upgrade to TETRA, the necessary hardware and firmware are installed. If this is the case, you can skip this section and proceed to Loading System Software.

However, if you want to run the TETRA system software on a unit which is possibly not prepared for TETRA, or if you encounter serious problems while running the TETRA system software, make sure the following conditions are met.

Call up the STATUS mask: **AUX** + **DEF.PAR** + **STATUS**

Check the status of the related firmware versions (SOFTWARE VERSIONS):

STABILOCK 4031 without FEX	STABILOCK 4032 without FEX
Host-MCU ≥ 4.14	Host-MCU ≥ 6.14
CRT-MCU ≥ 2.59	CRT-MCU ≥ 2.59
RF/AF-MCU ≥ 3.07	RF/AF-MCU ≥ 5.07
STABILOCK 4031 with FEX	STABILOCK 4032 with FEX
Host-MCU ≥ 4.14	Host-MCU ≥ 6.14
CRT-MCU ≥ 2.59	CRT-MCU ≥ 2.59
RF/AF-MCU ≥ 4.13	RF/AF-MCU ≥ 6.13

Make sure the STATUS mask shows DIG-MCU: D-AMPS

Call up the OPTIONS mask. It must show either Duplex + I/Q: installed or Duplex + FEX: installed.

Loading system software

The TETRA BS Test system program is supplied on a memory card.

- 1) Insert the memory card in the slot on the STABILOCK.
- 2) Press **[AUX]** + **[DATA]** to start the loading procedure, which may take about a minute (**[AUX]** is a hardkey on the front panel, **[DATA]** is a softkey, the description of which appears on the screen after pressing **[AUX]**).
- 3) When the system program is fully loaded, the status line indicates "Loading finished".
- 4) Leave the card in place. In this way STABILOCK can store entered test parameters on the card, so that you do not have to enter them again the next time you call up the system program (deactivate write protection if it is set on the memory card).
- 5) To call up the TETRA basic mask, press **[AUX]** + **[DATA]**. Fig. 10.1 shows the screen that appears then; it is called the TETRA basic test mask.

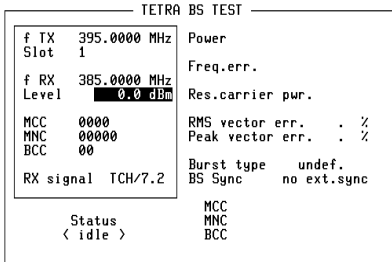


Fig. 10.1:

The basic test mask as it appears when the TETRA BS Test system program has been loaded.

DEF.SET TX-TEST RX-TEST ANALYZER RETURN

Test Setup (Connectors)

Levels of less than -110 dBm may appear when testing (e.g. receiver measurements), so the entire setup must be proof against EMI pickup and not radiate any either. The following measures are recommended for this purpose:

- Use double-shielded RF cables between the STABILOCK test set and the base station.
- Terminate the RF DIRECT socket of the STABILOCK with $50\ \Omega$ while not in use.
- Make sure that all plug-ins of the test set (back panel) are screwed in tightly.
- Close vacant plug-in slots on the test set (back panel) with dummy panels.

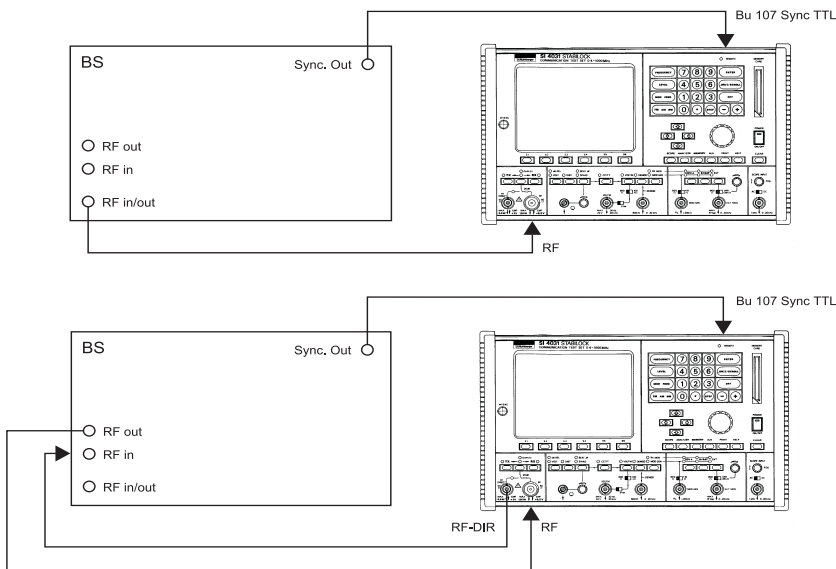


Fig. 10.2: Test setups with TETRA base station depending on the Connector setting in the DEF.SET mask. The figure above shows the setup for RF (TX) / RF (RX), the setup below for RF (TX) / RF-DIR (RX).



Use the supplied BNC/BNC cable (382 678) to connect socket Bu 103 of the IF unit (back panel) to socket Bu 103 of the D-AMPS unit (see appendix: "Connectors on the rear"). Without this connection no transmitter measurements are possible.

For other TETRA-specific connectors (e.g. synchronization port) see section "Connectors on the rear" in the appendix of this TETRA manual. For generally available connectors and functions (e.g. AF signal generator and analyzer), see chapter 4 of the STABILOCK manual.

Parameters

This section acquaints you with the most important parameters that you need to set up prior to a test.



Remember that if you leave the memory card in the memcard slot of the STABILOCK, the parameters are written onto the card so they are re-loaded automatically to the STABILOCK next time you load the system software. This way, you do not have to key them in each time.

Basic parameters on basic mask

TETRA BS TEST	
f TX	395.0000 MHz
Slot	1
f RX	385.0000 MHz
Level	0.0 dBm
MCC	0000
MNC	00000
BCC	00
RX signal	TCH/7.2
Status	< idle >
	Power
	Freq.err.
	Res.carrier pwr.
	RMS vector err. . %
	Peak vector err. . %
	Burst type undef.
	BS Sync no ext.sync
	MCC
	MNC
	BCC

Fig. 10.3:

The left-hand side contains input parameters as explained below.

DEF.SET TX-TEST RX-TEST ANALYZER RETURN

f TX

The receiver frequency of the STABILOCK in MHz. If you change the value, the f RX value will automatically adjust itself to a value 10 MHz lower.

Slot (TX)

The timeslot for transmitter measurements. The STABILOCK takes measurements on one timeslot only.

If a continuous channel is measured, then the selection is irrelevant, because it will not produce different results.

If no results appear, and the BS transmits a discontinuous signal, try a different timeslot.

f RX

The transmitter frequency of the STABILOCK in MHz. If you want to achieve a duplex spacing other than 10 MHz, then set f TX first and then adapt the f RX value to the desired value.

Level

The power level at which the STABILOCK transmits to the base station.

MCC	The Mobile Country Code of the system under test.
MNC	The Mobile Network Code of the base station under test.
BCC	<p>The Base station Color Code of the BS under test.</p> <p>☞ For transmitter tests, the MCC, MNC and BCC are irrelevant.</p> <p>For receiver measurements, the values sent by the BS have to be used, otherwise the BS can not descramble the received signals.</p> <p>To use the correct MCC, MNC and BCC, you transfer the values shown on the right-hand side of the mask into the entry fields. Press the Set SCR softkey (if Autosync is selected) to have it done by the STABLOCK.</p>
RX signal	<p>Specifies how the STABLOCK sends test signals, when performing an RX test:</p> <p>TCH/7.2 makes the STABLOCK send scrambled PRBS sequences on a data traffic channel with a bit rate of 7200 bps. The signal is discontinuous and always sent in timeslot 1 in all frames except frame 18.</p> <p>☞ If Autosync is switched off and a TTL frame synchronization signal is fed into socket Bu 107, then the signal is also present in frame 18.</p> <p>SCH/F (Signaling channel full slot): As opposed to TCH/7.2, this signal is channel-coded and interleaved (block code, RCPC-coded, block interleaved and scrambled).</p> <p>Bit Pattern continuously transmits one of the following bit patterns: 0000, 1111, 0101, 1010, 1100, PN9 or unmod. The continuous transmission starts immediately after activation, and independent of the settings for Autosync and Search for training sequence.</p> <p>☞ PN9 transmits a pseudo noise bit sequence with a length of 511 Bits (2^9-1).</p> <p>☞ In section "Spectrum analyzer mask", you find spectra of the bit patterns.</p>

Basic parameters in DEF.PAR

When you press (DEF.SET) from the TETRA basic mask, the display changes to the DEFINE TETRA mask. Some parameters available there depend on the system for which the TETRA base station under test is programmed, other parameters allow you to select according to your personal preferences.

```

DEFINE TETRA
Result averaging      .10
Units      dBm (power)  % (vector error)

Connector      RF (TX)/RF-DIR(RX)
Search f.training seq. ON  Autosync ON
BS sync.delay      0 slope: ↑
Pre-Att RF  0.0 dB      Pre-Att RF-DIR  0.0 dB

Burst Corner Points
      t      Upper      Lower
< t2 period -15 sym  -40 dB  -99 dB
< t2 period  +0 sym   +3 dB   -99 dB
t2          +0 sym   +3 dB   -3 dB
> t2 period +15 sym   +3 dB   -99 dB
  
```

DEF.CP RETURN

Fig. 10.4:

Some parameters that are not changed so often can be found on the DEF.SET mask.

Result averaging

This parameter applies to measurements on the MIN-MAX display. The AVG (average) value is calculated from the last N measurements; N is the value you enter in this input field (valid range is from 2 to 200).

Units

These settings affect the display of measured power and vector error values. Select your preferential unit with the UNIT/SCROLL key. The measured RF power can be displayed in either dBm or Watt, the vector error as an absolute or percentage value.

Changing the power unit setting also changes the unit for all measurements outside TETRA. If you want to return to your own units after making TETRA measurements, leave the TETRA basic mask with the (RETURN) softkey, enter (AUX) + (DEF.PAR), and select the preferred unit, e.g. in the scroll field RF POWER.

Connector

Sets the cable paths (see **Fig. 10.2** for the cabling). The connector to be used can be selected between RF (TX) /RF (RX) and RF (TX) /RF-DIR (RX) using the (UNIT/SCROLL) key.

The connector normally used for RX and TX measurements is RF. The RF DIRECT connector allows for 20 dB higher RX signals. Note, however, that the measurement accuracy stated in the data sheet only applies to the RF connector.

Search f. training seq. ON: When synchronizing to the BS, the STABLOCK will try to locate the training sequence in the BS' signals. If it cannot find the training sequence, no test result is displayed.
OFF: No training sequence will be searched for, the signal will be displayed as is (which might result in a time shift).

Autosync ON: The software synchronization (see section "Synchronization") is used for synchronization in time. The TTL trigger (if any) is ignored.
OFF: The TTL trigger is used for synchronization in time (see section "Synchronization").
The following table shows the effects of the Autosync setting for RX test and TX test.

RX test				
Autosync OFF	Search for training sequence ON/OFF ignored	Symbol delay regarded	ext. sync slope regarded	
Autosync ON	Search for training sequence ON/OFF ignored	Symbol delay ignored	ext. sync slope ignored	
TX test				
Autosync OFF	Search for training sequence OFF	Always yields measurement values	Symbol delay regarded	ext. sync slope regarded
	ON	Measurement values only if training sequence found	regarded	regarded
Autosync ON	Search for training sequence ON/OFF ignored	Symbol delay ignored	ext. sync slope ignored	

BS sync. delay This shifts the synchronization timing during an RX test. The shift amount can be between -10 and +999 symbols (1 symbol = 55.6 μs), and can be shifted relative to the rising (↑) or the falling (↓) edge (slope field) of the ext. TTL synchronization signal (on socket Bu 107).

slope



This settings are only applicable, when Autosync is switched off.



For entry of special characters under remote control (GPIB) please use for ↑ the character ^ (ASCII code 94) and for ↓ the character | (ASCII code 124).

Pre-Att RF
Pre-Att RF-DIR

To avoid RF level errors produced by the attenuation of the RF cables, you can compensate them separately for both RF sockets by entering them into the corresponding Pre-attenuation entry fields. If any other value than 0 is entered, the pointer **ATT** appears in all relevant masks to draw your attention to the correction of the measured and the transmitted RF level (for more information, see details of GENERAL PARAMETERS mask).

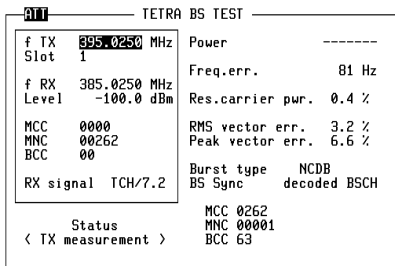


Fig. 10.5:
The pointer **ATT** indicates that a pre-attenuation value is entered for the RF socket and/or RF DIR socket.

MIN-MAX BURST MOD-SPEC CONST. STOP

Upper and Lower Burst Corner Points These fields allow you to enter the upper and lower limits represented in the burst template.

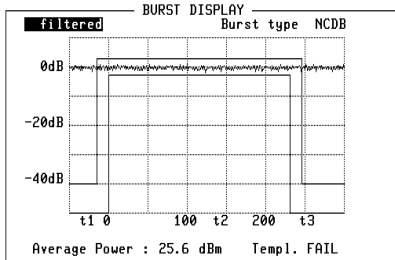


Fig. 10.6:
The figure shows where the input values take effect. If the measured curve is within the template, the display shows "PASS" on the lower right side, otherwise it indicates a "FAIL".

FREEZE ZOOM RETURN

The different parts of the template are expressed in their time/power coordinates; five different time sections are defined, for each section the upper and lower power limit can be entered. The time sections are defined by the last point of the subsequent section and the time entered on the display. Time is counted in symbol periods (sym). All time points are relative to the start or end of T2 period, which is the time at which the useful part of the burst (containing the relevant information) occurs.

The T2 period is the length of the active part of a (downlink) burst. T2 has a length of 246 symbols which is equivalent to 13.67 ms, for discontinuous signals. For continuous signals, the length does not apply.

The usage of the entry fields is explained using the following example:

	Burst Corner Points		
	t	Upper	Lower
< t2 period	-15 sym	-40 dB	-99 dB
< t2 period	+ 0 sym	+ 3 dB	-99 dB
t2	+ 0 sym	+ 3 dB	- 3 dB
> t2 period	+15 sym	+ 3 dB	-99 dB

Fig. 10.7: An example of the Burst Corner Points in the DEF.SET mask (default setting).

In the first row denoted "< t2 period", the lower and upper power limits can be entered for the time between the left-most point (which is 50 symbol periods before T2 begins) and the time entered in the t column. In this example, the first part of the template spans from the left side up to 15 symbols before T2; so this first period is 35 symbols long. There is no lower limit (indicated by the lowest possible entry of -99 dB relative to the average power over the burst) and the upper limit is -40 dB.

In the second row denoted "< t2 period", the power limits can be entered for the time between the previous t entry value (-15 symbols with respect to the beginning of T2) and the time entered in the t column of this row. In the example above, this spans the 15 symbols before T2 starts and the upper limit is +3 dB; this period is the power ramp-up period.

In the third row, the limits for the T2 period can be entered. If t = 0 sym is entered for the time as in this example, this period ends at the end of T2. If the limits are required for a shorter or longer period than just T2, the appropriate value can be entered in the t column. Positive values denote a prolonged T2 section, negative values can be used to shorten the period.

The "> t2 period" row can be used to enter the template limits for the ramp-down section. In the example, the upper power limit is set to 3 dB because the base station may still keep the power up for a short time; the lower limit is set to -99 dB again to allow to reach the power-off state (eg. NDDB).

The fifth period is used for the power-off state. This period does not have its own entry values; the period takes from the time entered in the last t field until the end of the display. The power limits are taken from the very first row where the base station is expected to be in the same power-off state (eg. NDDB).

10

☞ In order to get back to the values pre-programmed by Wavetek, press **DEF.CP** (default corner points). The factory settings are then restored (**Fig. 10.7**).

☞ For continuous signals, set all upper values to +3 dB, and all lower values to -3 dB.

Transmitter Measurements on BS

This section explains the basic TETRA measurements that are supported in the STABLOCK: transmitter measurements and receiver tests.

For transmitter measurements on discontinuous signals, as well as for all receiver tests, synchronization to the base station under test is required.

Synchronization

To synchronize the STABLOCK to the base station under test, there are various possibilities, which all have their different advantages. They are described below.

Synchronization in frequency

All measurements can be taken with or without frequency synchronization. If the reference oscillators of test equipment and unit under test are identical, the measured error should be zero (If the error differs remarkably from zero, then there might be an error in the frequency synthesis of the tested base station).

If the oscillators are not synchronized, then the references are independent from each other, and a more or less small frequency error is indicated, depending on the accuracy of both oscillators.

If you want to use the frequency synchronization, you can use either the STABLOCK or the base station as reference:

- To use the STABLOCK as frequency reference, connect the unit under test to the 10 MHz reference output (Bu 13 on the back panel) of the STABLOCK.
- To use the unit under test as frequency reference, connect its reference output to the 10 MHz reference input (Bu 12 on the back panel) of the STABLOCK.

Synchronization in time

As the base station dictates timing in terms of timeslots, frames and multiframe, measurements have to take this timing into account. This can be accomplished in two different ways:

- **Hardware synchronization** (Autosync OFF) uses a TTL multiframe trigger pulse available on most base stations. Also useful is a frame triggering. This is a very reliable way, because the STABLOCK permanently adapts its timing to the BS trigger.
- **Software synchronization** (Autosync ON): Here the STABLOCK demodulates the BS signal and reads the scrambling parameters, MCC, MNC and BCC. It then adapts its timing automatically and adjusts itself permanently. Advantages: No additional signal is required, and you do not need to enter the MCC, MNC and BCC.

☞ Only one method can be active at a time. If the software synchronization succeeds, it has priority.

Measurements under remote control

Measurements can be controlled either manually, or by AUTORUN programs, or through the GPIB (IEEE-488 bus). Chapter 8 of the STABLOCK 4032 user manual details the general approach for GPIB control – connecting a PC, selecting the GPIB address, changing between masks, setting values for the input variables, reading measurement results. This section describes how to initiate TETRA measurements under AUTORUN or GPIB control. The following sections describe the measurements and the format of result fields.

In remote mode, the STABLOCK can perform single-shot measurements, as opposed to continuous measurements in manual mode. In order to initiate a new measurement, the following command is needed:

```
SPECIalMEAS
```

On graphical displays, the measurements are stopped after each result has been returned to the controlling PC. In order to take a new measurement, you must issue the `SPECIalMEAS` command. On the basic mask TETRA BS TEST (with purely numerical results) measurements run continuously but return results to the controlling PC upon a `SPECIalMEAS` command.

☞ Measurements in the MIN-MAX mask are stopped automatically after reaching the value `Result averaging` defined in the DEFINE TETRA mask.

Once a measurement has been initiated with `SPECIalMEAS`, results can be fetched with the `RESULTx` command, where x and the resulting output format is detailed below for each measurement separately; see appropriate box entitled "Test results under remote control".

Quality measurements from the basic mask

On the right-hand side of the TETRA basic mask, you can see some result fields and info fields. In the case of transmitter measurements, the following fields are frequently updated with measurement results:

Result field	Meaning	BS limit according to TETRA specifications
Power	This field shows the RF power as received at the input connector of the STABLOCK.	The power may vary by ± 1.5 dB at the highest level.
Freq.err.	The frequency deviation from the nominal carrier frequency is presented in Hertz (Hz).	± 0.2 ppm, i.e. ± 76 Hz at a frequency of 380 MHz.
Res.carrier pwr.	This is the power offset from the origin (in the I-Q plane). It is displayed as a percentage of the nominal power.	5%
RMS vector err.	The vector error is the magnitude of the vector from the ideal vector position (in the I-Q plane) to the measured point. The RMS vector error expresses an average over the whole burst (or the portion of the continuous signal that is measured).	0.100 (10%)
Peak vector err.	This is the peak value of the vector error from all symbols over the whole burst or period.	0.300 (30%)

Info field	Possible values
Burst type	NCDB (Normal continuous downlink burst) NDDB (Normal discontinuous downlink burst) SCDB (Synchronization continuous downlink burst) SDDB (Synchronization discontinuous downlink burst) undef. contin.
BS Sync	no ext. sync decoded BSCH ext. frame ext. multiframe

Test results under remote control		
IEEE command	String position	Result
RESULt1	12345678901234567890 aaaaaaaaaaa;bbbbbb; **	a = TX power (incl. dimension) b = Freq. error (Hz) * = Reserved
RESULt2	12345678901234567890 aaaaa;bbbb;ccccc; **	a = Residual carrier power (%) b = RMS vector error c = Peak vector error * = Reserved
RESULt4	12345678901234567890 aaaaaaaaaaaaaaaaaaaa	a = Burst type: NCDB NDDB SCDB SDDB undef. contin. (unused chars filled with spaces)
RESULt5	12345678901234567890 aaaaaaaaaaaaaaaaaaaa	a = BS sync. (status): no ext. sync decoded BSCH ext. frame ext. multiframe (unused chars filled with spaces)
RESULt6	12345678901234567890 aaaa;bbbb;cc;*****	a = Decoded MNC b = Decoded MCC c = Decoded BCC * = Reserved

Power versus time

- Why?
- Visual assessment of the (continuous or discontinuous) burst.
 - Measurement of transmit power during the burst.
 - Test whether the BS correctly ramps up and down at the edges of a discontinuous burst.
- Requirements
- Transmitter measurements must have been started with the **(TX-TEST)** softkey.
- How?
- Press **(BURST)**. The power/time template is then displayed.

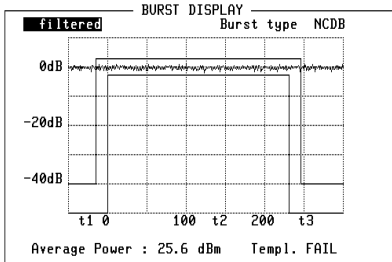


Fig. 10.8:

Typical burst measurement. The power level, measured in the centre of each symbol, displayed in the graphical representation. The power is also averaged over the 246 symbols that make up a burst; the numerical result is displayed below the graph.

FREEZE **ZOOM** **RETURN**

- The display can be toggled between filtered and unfiltered measurements. The term "filtered" refers to the TETRA filter which is usually required. If you want to see the "raw" data, you can switch to the unfiltered data display using **(UNIT/SCROLL)** key.
- The **Burst type** result field displays the signal type received by the STABLOCK, depending on the settings in the DEF.SET mask.
If Autosync is turned off, this field reads either *cont.(inuous)* or *discont.(inuous)*, otherwise the exact type is displayed (such as NDDB for normal discontinuous downlink burst).
- Press **(ZOOM)** to see a close-up of the upper ramp.

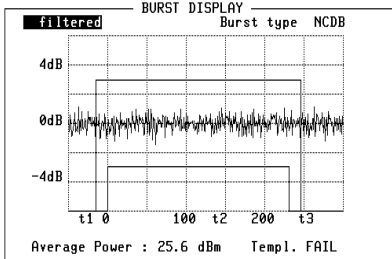


Fig. 10.9:

Close-up to a range of -4 dB to +4 dB.

FREEZE **NORMAL** **RETURN**

- Press (FREEZE) to stop updating the measurement results, then use (CONTIN) to continue.
- Select (RETURN) to get back to quality measurements on basic test mask.

The display shows the power at each symbol's POME (point of maximum effect), which is the centre of the symbol.

A PASS/FAIL indication is given depending on whether the power signal fits into the template. The template itself is user-selectable i.e. if you require a different template layout, define your own corner points on the DEF.SET mask.

- ☞ The template of a continuous signal differs from that for discontinuous signals: all upper and lower limits should be identical, e.g. +3 dB and -3 dB (see also section "Basic parameters in DEF.PAR").
- ☞ Note that only the upper 40 to 50 dB of the rising and falling edges are displayed.

Test results under remote control		
IEEE Command	String position	Result
RESULt1	12345678901234567890 aaaaaaaa*****	a = TX power (incl. dimension) * = Reserved
RESULt3	12345678901234567890 aaaaa;bbbb;cccc;***	a = Reserved b = Reserved c = PASS or FAIL * = Reserved
RESULt4	12345678901234567890 aaaaaaaaaaaaaaaaaaaa	a = Burst type: NCDB NDDB SCDB SDDB undef. contin. (unused chars filled with spaces)

Constellation display

Why?

- Test the modulation characteristics of the BS. For this purpose, the test set offers fast visual judgement of the modulation quality with the constellation display (graphic presentation of modulation quality) plus comprehensive indication of the measured figures on the numerical display.

Requirements

- Quality measurements must have been started by pressing **(TX-TEST)**.

How?

- Press **(CONST)** key. The constellation display is then shown (**Fig. 10.10**).

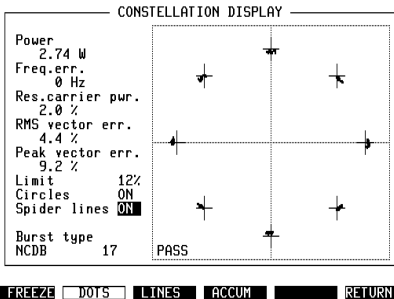


Fig. 10.10:

Constellation display (can be selected using the **(CONST)** after measurements have been started on the basic test mask). On the left-hand side, there are some numerical results; see section "Quality measurements" for explanations.

- In the Limit entry field you can set a percentual range (5% to 30% in steps of 1%) for measurement deviation from the ideal values. The circles are displayed, if you set the Circles entry field to ON (**Fig. 10.11**), and if ACCUM mode is selected.

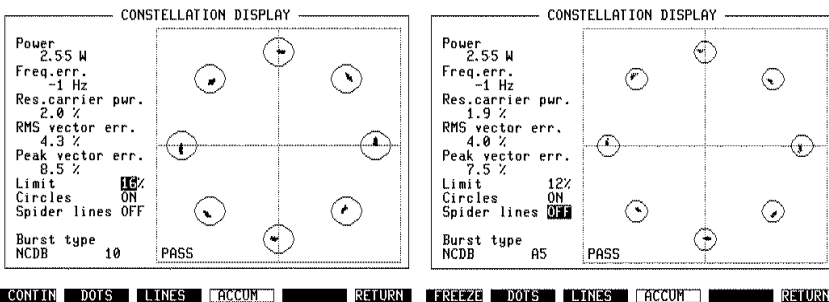


Fig. 10.11:

Limit Circles shown for a 16% limit (left) and a 12% limit (right).

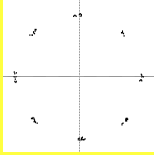
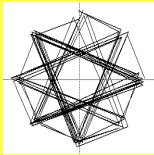
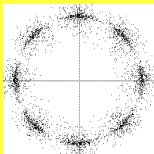
- In the Spider lines entry field you can toggle the display of spider lines on and off. The spider lines are small crosses, which mark the positions of the respective nominal points (**Fig. 10.10**).
- With the softkeys **(DOTS)**, **(LINES)** and **(ACCUM)** you select different display modes (explained in the box below).
- Press **(FREEZE)** to stop updating the measurement results, then use **(CONTIN)** to continue.
- Select **(RETURN)** to get back to quality measurements on basic test mask.

Available display modes

DOTS, the points of maximum effect (POMEs) are shown for one timeslot. This display, for a well adjusted transmitter, shows eight tightly limited accumulations of dots, offset by 45°. Before the points from a new measurement (next burst or timeslot) are displayed, the recent results are deleted.

LINES, consecutive points of maximum effect are connected. From this display it is possible to deduce the symbol contents (data stream). In addition, you can detect phase errors very clearly. But, in practical terms, this display is just a pretty show.

ACCUMulated, corresponds to the dots display but without their being deleted before each new measurement. This makes it possible to trace seldom occurring outliers (phase and magnitude).

Test results under remote control		
IEEE Command	String position	Result
RESULT1	12345678901234567890 aaaaaaaa;bbbbbb; **	a = TX power (incl. dimension) b = Freq. error (Hz) * = Reserved
RESULT2	12345678901234567890 aaaaa;bbbbbb;ccccc; **	a = Residual carrier power (%) b = RMS vector error c = Peak vector error * = Reserved
RESULT3	12345678901234567890 aaaaa;bbbbbb;cccc;***	a = Reserved b = Reserved c = PASS or FAIL * = Reserved
RESULT4	12345678901234567890 aaaaaaaaaaaaaaaaaaaaa	a = Burst type (unused chars filled with spaces)

Modulation spectrum

- Why?
 - Test whether the modulation spectrum of the BS maintains the permissible levels within the 25 kHz channel spacing (otherwise there is adjacent channel interference).
- Requirements
 - Quality measurements must have been started by pressing **(TX-TEST)**.
- How?
 - Press **(MOD-SPEC)** key.
 - Select in the scroll field whether the modulation spectrum is to be shown unfiltered (you see the signal on the input of the test set) or filtered (after the receive filter).
 - Move the cursor to the field below and select – using the **(UNIT/SCROLL)** – whether you want to see normal measurements (burst by burst), or averaged measurements, or a peak measurement (Max Hold).
 - Press **(RESET)** to restart the counting for averaged and peak measurement.
 - Press **(FREEZE)** to stop updating the measurement results, then use **(CONTIN)** to continue.
 - Press **(RETURN)** to get back to quality measurements on basic test mask.

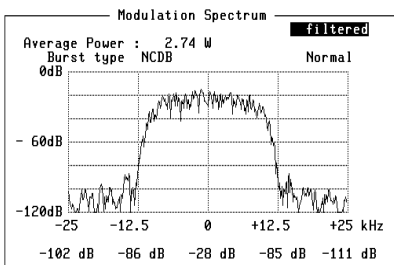


Fig. 10.12: Modulation spectrum, with power over the burst. The values below the graph indicate the relative power at the frequencies offset by 0, ±12.5 kHz, ±25 kHz from the center frequency.

RESET **FREEZE** **CONTIN** **RETURN**

Test results under remote control		
IEEE Command	String position	Result
RESULTt1	12345678901234567890 aaaaaaaa;*****	a = TX power (incl. dimension) * = Reserved
RESULTt2	12345678901234567890 aaaaa;bbbbb;cccc;*	a = Rel. power at –25 kHz b = Rel. power at –12.5 kHz c = Rel. power at 0 kHz * = Reserved
RESULTt3	12345678901234567890 aaaaa;bbbbb;*****	a = Rel. power at +12.5 kHz b = Rel. power at +25 kHz * = Reserved
RESULTt4	12345678901234567890 aaaaaaaaaaaaaaaaaaaa	a = Burst type (unused chars filled with spaces)

Under remote control only measurement mode Normal is supported.

Statistical evaluation (MIN-MAX)

- Why?
- Read the average value of measurement results.
 - Identify short-term deviations.
- Requirements
- Quality measurements must have been started by pressing (TX-TEST).
- How?
- Press the (MIN-MAX) key.
 - Press (FREEZE) to stop updating the measurement results, then use (CONTIN) to continue.
 - Press (RESET) to re-start the averaging process and the minimum and maximum value hold.
 - Select (RETURN) to get back to quality measurements on basic test mask.

The MIN-MAX screen (see Fig. 10.13) shows all the different numerical measurements with current (recent) results in the left-hand column. The two columns in the middle indicate the minimum and maximum results achieved since either the statistical measurements were invoked or since the (RESET) key was last pressed.

The last N values are averaged and the result is displayed in the right-hand column. The value N can be set in the DEF.PAR mask (see parameter "Result averaging" in section "Basic parameters in DEF.PAR").


Fig. 10.13:

Typical MIN-MAX screen. The averaging takes place over the last 10 measurements as displayed in the bottom line (Res.avg.). In this example, 29 measurements were taken since the start of the test.

	Curr.:	MIN-MAX		Avg:	
		Min:	Max:		
Power :	35.2	35.1	35.4	35.2	W
Frq.err.:	-2	-2	2	0	Hz
Res.pwr.:	2.3	1.8	2.6	2.2	%
RMS VE :	4.3	.9	4.5	4.1	%
Peak VE :	8.0	7.0	10.4	8.1	%
Res.avg.:	010	0029			

RESET FREEZE CONTIN RETURN

Test results under remote control		
IEEE Command	String position	Result
RESULT1	12345678901234567890 aaaaaaaaa;bbbbbb; **	a = TX power (incl. dimension) b = Freq. error (Hz) * = Reserved
RESULT2	12345678901234567890 aaaaa;bbbbbb;cccc; **	a = Residual carrier power (%) b = RMS vector error c = Peak vector error * = Reserved
RESULT6	12345678901234567890 aaaaa;bbbbbb;cccc; **	a = TX power Min. b = TX power Max. c = TX power Avg. * = Reserved
RESULT7	12345678901234567890 aaaaa;bbbbbb;cccc; **	a = Freq. error (Hz) Min. b = Freq. error (Hz) Max. c = Freq. error (Hz) Avg. * = Reserved
RESULT8	12345678901234567890 aaaaa;bbbbbb;cccc; **	a = Res. carrier power (%) Min. b = Res. carrier power (%) Max. c = Res. carrier power (%) Avg. * = Reserved
RESULT9	12345678901234567890 aaaaa;bbbbbb;cccc; **	a = RMS vector error Min. b = RMS vector error Max. c = RMS vector error Avg. * = Reserved
RESULTA	12345678901234567890 aaaaa;bbbbbb;cccc; **	a = Peak vector error Min. b = Peak vector error Max. c = Peak vector error Avg. * = Reserved

 Measurements in the MIN-MAX mask are stopped automatically after reaching the value `Result` averaging defined in the DEFINE TETRA mask.

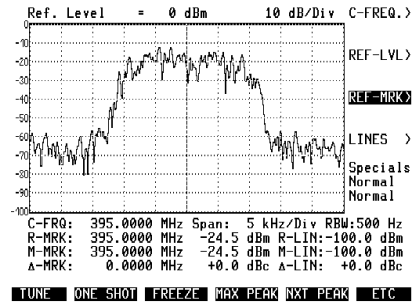
ATTENTION: Please ensure the GPIB timeout is higher than the measurement duration. Otherwise the GPIB program will return a timeout error due to measurements which are still running.

Spectrum analyzer mask

The displayed SPECTRUM ANALYZER mask is based on the spectrum analyzer hardware option (ordering code: 248 291). For details of this mask, refer to the operating instructions for the spectrum analyzer.

When activated from the basic mask (in status <idle>), the Spectrum analyzer mask will take over the f TX frequency selected in the basic mask. The default span is 5 kHz/div., the default REF level is +50 dBm.

Fig. 10.14:
Analyzer called up from basic mask
(Ref. Level was changed to 0 dBm later on).



If a signal is present, the spectrum is analyzed and displayed. Some sample spectra are shown in Fig. 10.15.

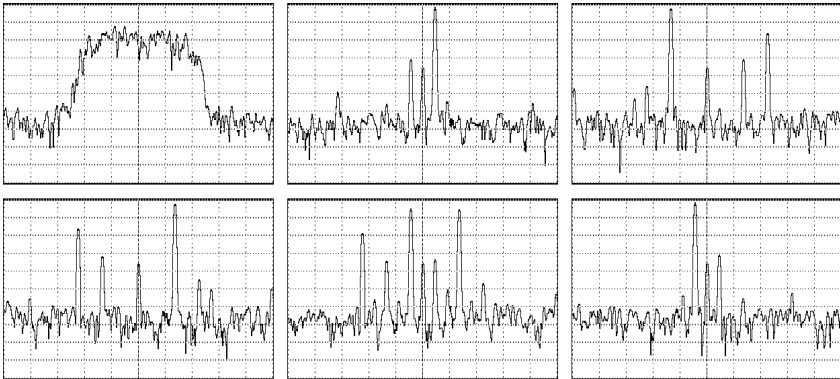


Fig. 10.15: Sample spectra.

From upper left to lower right the following bit patterns are shown:
PN9 (PRBS 2^9-1), 0000, 1111, 0101, 1100, 1010.

The parameters are: Ref. level 0 dBm, C-FRQ 395.0000 MHz, Span 5 kHz/Div, RBW 500 Hz.

Receiver measurements on BS

- Why?**
- Test the receiver sensitivity of the BS. To pass the test, it must identify the signal transmitted by the STABLOCK as PRBS sequence.
- Requirements**
- The RX signal must be either TCH/7.2 or SCH/F.
 - Receiver measurements must have been started by pressing **(RX-TEST)**.
- How?**
- Wait until the Status display shows T1 (PRBS) on RX. Now the STABLOCK sends the standard PRBS 511 Bit sequence on the selected logical channel. The signal is sent for 17 frames on timeslot 1, followed by a mute frame (Exception: In case of external frame synchronisation the T1 signal is also transmitted in frame 18, slot 1). The sequence is repeated throughout the test.
 - Use the **(Set SCR)** softkey to send the values of MCC, MNC and BCC back to the BS.
 - Find the BS's assessment of the received signals on its display (depending on BS type).

TETRA BS TEST		
f TX	395.0000 MHz	Power
Slot	1	Freq.err.
f RX	385.0000 MHz	Res.carrier powr.
Level	-100.0 dBm	RMS vector err. . %
MCC	0000	Peak vector err. . %
MNC	00000	Burst type SCDB
BCC	00	BS Sync decoded BSCH
RX signal	TCH/7.2	MCC 0262
Status	< T1 (PRBS) on RX >	MNC 00001
		BCC 63

Fig. 10.16:
Receiver measurement of TCH/7.2.

Set SCR STOP

RS-232-C Interface

Application Notes

If STABILOCK is fitted with the D-AMPS module, the "RS-232/Centronics Interface" hardware option cannot be installed in slot 6 (as noted on the according rear panel), but slot 8 also can be used if still free. To allow data communication with other units or printout on conventional printers, the D-AMPS module also has a fully functional RS-232-C interface (socket Bu 105).

Requirements for operation

The RS-232-C interface of the D-AMPS module will only work if your Communication Test Set satisfies the following requirements:

STABILOCK 4031	HOST-MCU \geq 3.83
STABILOCK 4032	HOST-MCU \geq 5.03
STABILOCK 4032 MS	HOST-MCU \geq 4.03
RS-232-C driver software	DIG-MCU \geq 1.20

If the STATUS mask (called up with `AUX` + `DEF.PAR` + `STATUS`) shows an older status, a software update will be necessary.

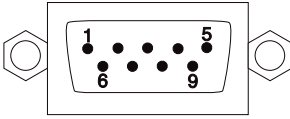
- Do not start the TETRA BS Test system program: the RS-232-C interface of the D-AMPS module will *not* work properly if the TETRA BS Test system program is called up at the same time.

Control commands and transmission protocol

The RS-232-C interface of the D-AMPS module offers exactly the same functions as the RS-232-C interface of the hardware option "RS-232/Centronics Interface". All control commands for the interface are explained in Chapter 8 under the IEEE section "Special commands". Setting the transmission protocol (baud rate, number of data bits, parity, handshake, etc.) is explained in Chapter 4, section "General Parameters".

Special features Special operating parameters for the RS-232-C interface are normally assigned with the commands WRITE[3000...] or SLAVE3000... (see Chapter 8). Replace control sequence 3000 by control sequence **2010** if you want to assign the RS-232-C interface of the D-AMPS module special operating parameters.
Example: not WRITE[300012...] but WRITE[201012...].

Pinning of RS-232-C interface



Bu 105	
Pin 1 = DCD	Pin 5 = GND
Pin 2 = RXD	Pin 6 = nc
Pin 3 = TXD	Pin 7 = RTS
Pin 4 = DTR	Pin 8 = CTS
	Pin 9 = nc

Appendix

TETRA BS nominal power levels

The following table lists the nominal power levels of a TETRA base station:

BS power class	Nominal power level
1 (40 W)	46 dBm
2 (25 W)	44 dBm
3 (15 W)	42 dBm
4 (10 W)	40 dBm
5 (6.3 W)	38 dBm
6 (4 W)	36 dBm
7 (2.5 W)	34 dBm
8 (1.6 W)	32 dBm
9 (1 W)	30 dBm
10 (0.6 W)	28 dBm

What is TETRA anyway?

TETRA is a wireless communication standard for Professional Mobile Radio (PMR) and Private Access Mobile Radio (PAMR) applications, e.g. for public safety organizations. Fast call setup times, closed user groups rather than calls into the public switched telephone network, and group calls are some of the features that make TETRA different from standards for public use like GSM. Both duplex and simplex operation are supported – simplex meaning you have to press a button while talking (the button is called PTT = "press to talk").

The standard comprises specifications for various applications and technologies, as there are trunked mode (TMO), packet data (PDO), and direct mode (DMO) operation. But most applications are expected to use TMO and DMO to exchange speech and data; this part of the specification is called Voice + Data (V+D).

Some background information on TETRA

TETRA is a trunked radio standard defined by ETSI, the European Telecommunications Standards Institute. The scope, however, is not restricted to use within Europe. Its primary use is for companies and organizations with frequent radio communication needs; police organizations, transportation companies, taxis are some examples of potential users. Of course, every organization and company could have their own set of frequencies and infrastructure (base stations, repeaters). This is expensive both in terms of money (especially if the area cannot be covered by one base station) and spectrum (which is limited). A trunked radio network operator may instead offer services (air time) to many companies, thus managing and administering some part of the spectrum and provide a regional or national network with interfaces to international trunked networks and the public switched telephone network.

The main advantages of a trunked network, when comparing it to cellular systems like GSM, are the fast call setup (in simplex operation, you just press a push-button and talk; the radio and the system will find an empty channel immediately with virtually no delay) and the possibility of group calls. Also, emergency services prefer to have a radio network of their own: in case of disaster relief, cellular channels are usually blocked because everybody outside the emergency services is already trying to make phone calls over the cellular network.

Technically speaking, TETRA is a system applying the Time Division Multiple Access (TDMA) method (plus the possibility of having multiple frequencies in addition). This means, several users share one frequency: speech and data are transmitted in digital format and multiplexed into timeslots. All of the four different TETRA timeslots on one carrier bear different channels, so there can be as much as four different calls on one 25 kHz carrier frequency (One channel within the system must carry the Main Control Channel, referenced here as the Base channel).

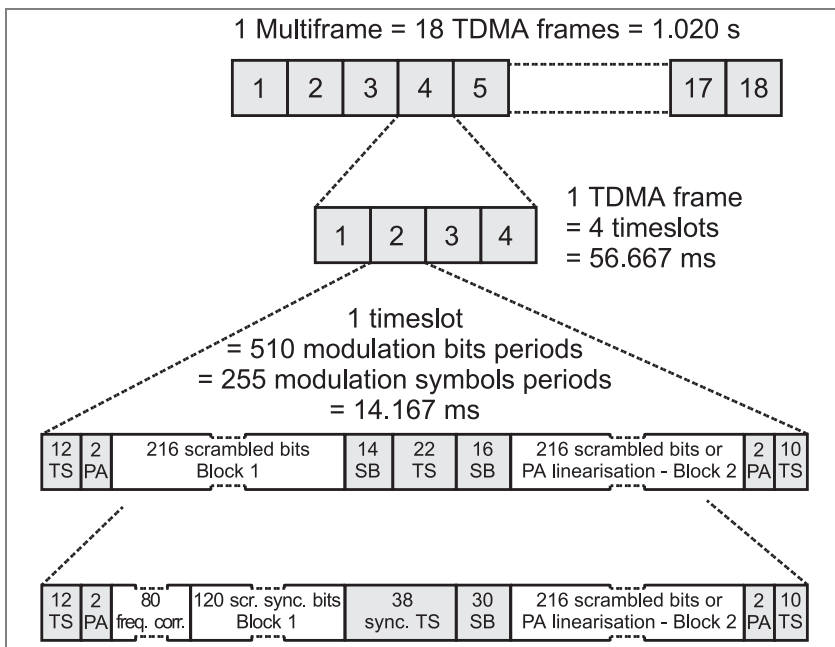


Fig. 10.17: TETRA multiframe. The upper one is an NCDB (Normal Continuous Downlink Burst), the lower one is an SCDB (Synchronisation Continuous Downlink Burst). TS = Training Sequence, PA = Phase Adjustment, SB = Scrambled Bits.

Speech is digitized and compressed into less than 4.6 kbit/s. Data channels support up to 7.2 kbit/s; the standard allows to allocate up to four timeslots for one transmission so that data rates up to 28.8 kbit/s can pass the TETRA air interface. This is comparable to today's modems on the fixed-line telephone system.

The modulation format is $\pi/4$ DQPSK (differential quaternary phase-shift keying). This modulation method shifts phase in steps of $\pm\pi/4$ or $\pm3\pi/4$ depending on the symbol to transmit. With each phase change you can transmit one symbol containing two bits. In a vector diagram of the modulation signal, the ideal positions of the eight possible signal vector states are on a circle (see Fig. 10.18). The error vector is the line drawn between the ideal signal vector and the real (measured) signal vector. Modulation accuracy is determined by measuring the RMS (Root Mean Square) difference between the real signal and the ideal signal. For this the magnitude of the individual vector error on each symbol in a slot is measured; the RMS vector error gives the square root of the sum of squares divided by the number of symbols in the slot.

TETRA uses error-tolerant modulation and coding formats. The information to be transmitted (e.g. speech) is usually coded adding some redundant information like CRC. This information can be used to identify reception errors and to reconstruct the correct bit stream with a highly sophisticated bit error correction

algorithm. But if the correction function is operating at its limits (e.g. because transmitter and receiver are far from each other so that the signal quality is very poor), speech quality could suddenly turn from good to bad. Therefore, well-adusted modulators are still necessary.

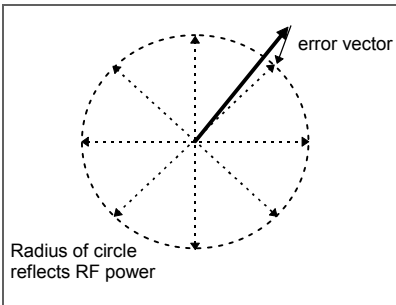


Fig. 10.18:
Representation of the modulation in the vector plane.

Other parameters that must lie within their respective limits are residual carrier power and, of course, the frequency error and the RF power. The residual carrier power is the I and Q imbalance of the modulator. In the figure above, it would mean that the circle is not around the coordinate origin but slightly shifted. It could also result in some residual carrier power outside discontinuous bursts (when the BS is supposed to remain "silent").

Connectors on the rear

On the rear of the D-AMPS module (slot 5/6), you can find various connectors. This section explains what they can be used for.

☞ Not all of these signals are available all the time. If you require some of them and you do not find them operational, please contact Wavetek for a special application software.

Socket	Signal	Dir.	R _i	V _{max}	Application
Bu 103	IF	in	270 Ω	±14 V	External IF signal feed from Bu 103 on slot 3
Bu 104	AF	in	3 kΩ (approx.)	±5 V	Reserved
Bu 105	RS-232	in/out			For external control, see section "RS-232-C interface" in this option manual
Bu 106	AUX				
Pin 1	AnalogInI	in	3 kΩ	±5 V	\ Input for external I/Q signal / (TX, IF)
Pin 2	AnalogInQ	in	3 kΩ	±5 V	
Pin 3	GND				\ Analog I/Q TX signals / output
Pin 4	GND				
Pin 5	GND				
Pin 6	GND				
Pin 7	ITXout	out			
Pin 8	QTXout	out			
Pin 9	GND				
Pin 10	GND				\ RX signal, I/Q /
Pin 11	GND				
Pin 12	GND				\ Input from fading simulator /
Pin 13	QoutM	out			
Pin 14	IoutM	out			
Pin 15	ext Q	in	5 kΩ	2.5 V ±2.5 V _p	
Pin 16	ext I	in	5 kΩ	2.5 V ±2.5 V _p	\ Output to fading simulator / (RX I/Q signals)
Pin 17	GND				
Pin 18	QRX	out		2.5 V ±2.5 V _p	
Pin 19	IRX	out		2.5 V ±2.5 V _p	
Pin 20	GND				
Pin 21	Vcc				
Pin 22	GND				
Pin 23	-15 V				
Pin 24	GND				
Pin 25	+15 V				
Bu 107	SYNC	in	TTL	TTL	External synchronization, negative pulse > 125 ns
Bu 108	SYNC	out			External synchronization

