

This TT402 Audio Transmission Test Set is configured as follows:

1) Measurements of voltage on dB scales are normally accompanied by units of "dBm", both on the front panel and over the IEEE-488 bus. This is actually a voltage measurement, and so may be considered to be equivalent to units of "dBu". The 0 dbm reference is 274 mV if the circuit impedance is set to 75 R; 374 mV if the circuit impedance is set to 140 R; or 775 mV if the circuit impedance is set to 600 R.

2) The output voltage of the T0402 oscillator is correct according to the LED array indication, and to commands received over the IEEE-488 bus, when the outputs are terminated in the correct circuit impedance for the selected oscillator output impedance.

3) The voltage measured in the Read Osc function is that which would be present at the oscillator's output terminals if a resistive termination of the correct circuit impedance were connected. The voltage measured is independent of the actual load connected (unless the load is of such low impedance that it causes overload).

1. Introduction

The new TT402 Audio Transmission Test Set represents an upgraded companion to the internationally well-known TP401 (formerly MJS401D) Audio Measuring System.

The TT402 is an extremely flexible, accurate and easy-to-use audio measuring system - like the TP401 - but with some additional features as requested by broadcasters and others measuring transmission systems. It provides a means of rapidly measuring:

- LEVEL
- LEVEL DIFFERENCE
- PHASE
- FREQUENCY
- HARMONIC DISTORTION
- CROSSTALK
- NOISE

Internal option slots are provided for:

- "A", "B" OR "C" WEIGHTED MEASUREMENTS
- IMD TO SMPTE, DIN, CCIF AND OTHER STANDARDS
- OPTIONAL FILTERS
- WOW AND FLUTTER
- RUMBLE
- FIM (FREQUENCY INTERMODULATION DISTORTION)
- IEEE-488 REMOTE CONTROL

Other (custom) options may be possible. Contact your dealer for details.

The instrument operates as a microprocessor-controlled stand-alone unit with all functions available at "finger tip", manual or autoranging, or as part of a computerised measuring system. Readout of most results is in digital and analogue form in a most logical way.

Close attention has been paid throughout the design stage to the requirements of current and potential users, in order to produce an instrument with as many features as possible, whilst still retaining simplicity of operation.

All the TT402's functions are accomplished electronically wherever possible, or by the use of special high-quality relays. This has the dual advantage of greatly increasing the accuracy and reliability of measurements, together with a reduction of the length and area of signal paths, providing much reduced susceptibility to interference. A further advantage is the ability to control all functions by remote control.

The "setting up" of the TT402 for a specific task is simply a matter of looking from left to right across the front panel, setting controls in the same order as the decisions would be made to perform a specific test. For example, to measure an audio signal level, select the input required at the left of the instrument, and moving across towards the right, select LEVEL function, range, filter(s), rectifier characteristic, and meter scale. Many of these options will be already set correctly at switch-on, and are always recalled when next entering the particular function. Therefore, measurements usually only require setting the function, and perhaps the range and input.

The oscillator can be set up to provide the required signal source. Oscillator set-up is done by measuring the oscillator output voltage with the TT402 using the READ OSC function. Since the same measuring system is used to measure both input and output signal of the device under test, any deviation of the measuring system is likely to cancel and not affect the measured results.

2. General

Measurements are displayed in both digital and analogue form. The digital presentation, which is the easiest, quickest and least error-prone way to read a steady result, is on a blue-green vacuum fluorescent display with contrast-enhancing filter. Units accompany the number as an integral part of the display. The analogue presentation, which is the easiest way to read varying signals (e.g. programme) or to make an adjustment for a peak, null or particular value, is on a large, internally illuminated moving-coil meter. Four scales are printed in white on a black background. The scale in use is indicated by an LED. Both digital and analogue displays are clearly visible in all lighting conditions from direct sunlight to total darkness.

The front panel's operational legends are in two pale colours on a dark brown background. These are visible down to low light conditions, assisting you in darkened studios or equipment bays.

In LEVEL, READ OSC, PHASE/LEVEL DIFFERENCE, THD+N, X-TALK, NOISE and RUMBLE functions, a second, identical vacuum fluorescent display indicates the frequency of the measured signal. This display is also used for error messages, e.g. frequency or level too high or low for a particular function. In IMD it displays the selected measurement standards (SMPTE, DIN, CCIF, etc.) and in Wow and Flutter, it displays drift as a percentage.

The TT402 can be set to auto-range if you wish, or to manual control of ranges if you prefer to retain control. Either way, results will be presented to you quickly, and with the minimum of fuss.

It was a goal, during the design of both this instrument and the TP401/MJS401D, to create a machine which could be set in front of any audio technician or engineer, which he or she could use immediately, without even needing to read the instruction manual. Many customers have commented to the effect that this goal has been reached in the TP401. The TT402 follows the same sound principles of ergonomic design.

3. Description of Controls and Facilities - Measurement Section

See figure 1 for front panel layout.

3.1 Inputs

The TT402 can be configured to measure either in dBm or dBu.

There are two differential inputs ("electronically balanced"), A and B. The CIRCUIT IMPEDANCE switch steps through three values of circuit impedance (termination impedance). If configured for dBm, this also sets the corresponding 0 dB reference. TERM/THRU applies a

termination resistor of the selected circuit impedance in TERM; in THRU, the impedance is not applied. It is still important, however, to select the correct CIRCUIT IMPEDANCE in THRU because of the 0 dB reference voltage selection. If configured for dBu, the 0 dB reference remains at 775 mV and TERM/THRU merely applies a resistance equal to the selected CIRCUIT IMPEDANCE.

If TERM is selected, the termination is applied to both inputs.

The TT402 can be configured to initialize with or without input terminations applied. This is achieved by pole no. 3 of SW1 at the top of the main microcomputer PCB. If this switch is OFF, the test set will wake up with the input module in the THRU state; if ON, the input module will wake up in the TERM state.

3.1.1 Input Selection

The INPUT SELECT switch selects alternately input A or B. Input protection is comprehensive (see Specification), and ensures that the TT402 will recover quickly from gross overloads. This is particularly important when performing automatic test sequences.

3.2 Function Selection

Eleven FUNCTION push-buttons are used to select the TT402's main operating function.

3.2.1 Level

Either set a sensitivity manually on the dB COARSE and dB FINE controls, or set the TT402 to AUTO RANGE and let it do the work for you. Either way, the level of the incoming signal will be displayed on the rightmost alphanumeric display and on the analogue meter. Simultaneously the signal's frequency will be displayed on the leftmost display.

Filters can be any, all, or none, of:

- (i) 400 Hz high pass,
- (ii) 30k Hz low pass,
- (iii) 22 Hz - 22 kHz band pass,
- (iv) and (v) two options of your choice.

Rectifier may be RMS, AVG (average-responding, calibrated to RMS value of a sine wave) or PPM (peak programme meter). Scale may be dB NORMAL (± 12 dB about central 0), dB EXPANDED (± 1.5 dB about central 0) or VOLTS (0-10 or 0-3, linear).

The measured input is chosen using the alternate-action INPUT SELECT button. The CIRCUIT IMPEDANCE button steps through three values of circuit impedance (line termination impedance). If configured for dBm, this also sets the corresponding 0 dB reference. TERM/THRU applies a termination resistor of the selected circuit impedance in TERM; in THRU, the impedance is not applied. Thus measurements can either terminate a line, or bridge a line which is already terminated elsewhere. It is still important, however, to select the correct

CIRCUIT IMPEDANCE in THRU because of the 0 dB reference voltage selection. If configured for dBu, the 0 dB reference remains at 775 mV and TERM/THRU merely applies a resistance equal to the selected CIRCUIT IMPEDANCE.

Measured signals can be monitored aurally using either the internal loudspeaker or by plugging in headphones at the PHONES socket, which mutes the internal loudspeaker. In either case the level is controlled by the MONITOR potentiometer. The front panel SCOPE connector outputs a standard level signal, usually for visual monitoring on an oscilloscope.

3.2.2 Read Osc

This function is almost identical to Level. The differences are:

(i) The TT402 can be configured in either of two ways. One is to measure the voltage which would appear at the oscillator's output terminals if these terminals were loaded with the correct circuit impedance. It is a modified version of the oscillator's E.M.F., and is unaffected by the actual load applied to the oscillator's output. The other alternative configuration (and the only option if a T0404 oscillator is fitted) measures the actual oscillator output voltage at the "Oscillator A" connector.

(ii) No filters can be selected. This is to avoid measurement error.

3.2.3 Phase, Level Difference

In this function there is a simultaneous indication of phase, frequency, and level difference. Input "A" is the reference channel.

Frequency is displayed, as for most other functions, in the leftmost display. Phase difference is displayed in the rightmost display in degrees. If input B leads input A, then the reading will be positive. If A leads B, the reading will be negative. Results are displayed to a resolution of 1 degree.

Level difference is displayed on the dB NORM scale (only), with a range of ± 12 dB. If input A is +1 dBm and input B is -2 dBm, the meter will show -3 dB (i.e. B = -3 dB with reference to A).

This method of measuring level difference does not have the extreme accuracy of successive measurements through the same measurement system, as could be obtained by measuring alternately inputs A and B while in the LEVEL function. However, it is very useful to have frequency, phase and level difference displayed simultaneously when equalising stereo circuits or tape recorders.

The rear panel MAIN CHANNEL and ALTERNATE CHANNEL scope connectors display the signals which are applied to inputs A and B respectively. The levels at these connectors are not directly related to the incoming signal levels and should therefore only be used for monitoring their phase relationship.

3.2.4. THD+N

In this function, a signal is applied to the input terminals A or B. With nothing more to do (other than perhaps set the % DISTORTION range, if the TT402 is not set to AUTO RANGE), the THD+N content will be shown on the alphanumeric display and meter, along with the frequency. The signal may be from 19 Hz to 21 kHz, from -20 dBm or -20 dBu (depending on configuration), to 240 V, remotely or locally generated. The reading will be settled within 2 seconds if the RMS rectifier is used. No tuning or 100% level setting is necessary.

Any or all of the five filters may be used. Any of RMS, AVG and PPM rectifiers may be used. Scale may be dB NORM or % DIST. (The dB EXP scale is disbarred, since this implies an excessive degree of accuracy.)

The oscillator, if fitted, will automatically be set to sine wave.

3.2.5 IMD

Similarly to THD+N above, just apply a signal and push the button. The PCB for IMD measurement is an option in the TT402. DIL switches on the PCB set it to SMPTE, DIN, CCIF or OFF (disabled). The selected standard is displayed in the leftmost alphanumeric display.

The oscillator, if fitted, will be set automatically to generate the correct test signal.

No filters can be selected. The rectifier may be RMS, AVG or PPM. Scales may be dB NORM or % DIST.

3.2.6. X-TALK

The crosstalk function inserts a bandpass filter, with a "Q" of 5, into the measurement path from the selected input. This filter is tuned automatically, between 19 Hz and 21 kHz, by the frequency of one of the following reference signals:

- (i) If the signal level at the non-selected input exceeds -20 dBm or -20 dBu (depending on configuration), this will be taken as the reference.
- (ii) If the signal level at the non-selected input is below -20 dBm or -20 dBu and a T0402 or T0404 is fitted, the frequency to which this oscillator is set will be taken as the reference frequency.
- (iii) If the signal level at the non-selected input is below -20 dBm or -20 dBu and no oscillator is fitted, the "Oscillator A" connector becomes an input for the reference signal.

The measurement is simply a level measurement. It does not refer the measured level to another level. For example, if the measured X-TALK on input B is -80 dBm, and the reference applied to input A is +8 dBm, the crosstalk is -88 dB.

The oscillator, if fitted, will be set to sine wave.

Any of the five filters may be selected. Rectifier may be RMS, AVG or

PPM. Scales may be dB NORM or VOLTS.

The rear panel MAIN CHANNEL and ALTERNATE CHANNEL scope connectors display the signals which are applied to the selected input and the reference channel (whatever that may be) respectively. The levels at these connectors are not directly related to the incoming signal levels and should therefore only be used for visual correlation.

3.2.7 Noise CCIR 468-3

This function behaves similarly to the level function, except:

- (i) Either the weighting filter, or the bandpass filter for unweighted measurements, is in circuit. This is selected and indicated by the WTD/UNWTD switch and LEDs. Both of these filters conform to the frequency response and accuracy requirements of CCIR 468-3 as revised, and CCIR 468-2.
- (ii) No other filter can be selected.
- (iii) The rectifier is a quasi-peak type conforming to CCIR 468-3 and 468-2. The LEDs over RMS, AVG and PPM are extinguished.
- (iv) No other rectifier can be selected.
- (v) Scales allowed are dB NORM and VOLTS.

The displayed units are dBq (decibels quasi-peak), if the dB NORM scale is selected.

3.2.8. Noise CCIR ARM

This behaves similarly to Noise 468-3, except:

- (i) If the weighting filter is in use, it has 6 dB less gain than for CCIR 468-3.
- (ii) The rectifier is AVG. No other rectifier can be selected.
- (iii) The displayed units will be dBm or dBu, as configured, if the dB NORM scale is selected.

The TT402 can be configured to disable the NOISE CCIR ARM function. This is achieved by pole no. 4 of SW1 at the top of the main microcomputer PCB. If this switch is OFF, the function can be selected, both from the front panel and via the IEEE 488 bus (if fitted); if ON, the push button becomes inoperative and if an attempt is made to select the function over the bus, the message "ERROR 25" will be produced.

3.2.9 Wow and Flutter, Drift

This is an option for the TT402. On the option PCB are DIL switches. One selects centre frequency to 3k15 Hz or 3k00 Hz, the other selects the measurement standard. The standards are the quasi-peak group (IEC 386, CCIR 409-2; DIN 45 507, BS 4847) or the average-responding group (NAB and JIS).

The % DISTORTION range is used to select the meter range for wow and flutter. Ranges 10% to 0,1% are valid. Other ranges produce the error message "<RANGE" or "RANGE>" in the rightmost display.

The speed error is displayed on the leftmost display in the form "+1.23% DRFT" or "+12.3% DRFT".

The oscillator, if fitted, will be automatically set to generate a crystal-controlled sine signal of the correct centre frequency.

The WTD/UNWTD button and LEDs select and indicate weighted or unweighted measurement. All the standards quoted above require the same weighted frequency response. Unweighted, the quasi-peak group require response from 0,1 Hz to 200 Hz, whereas NAB and JIS require response from 0,5 Hz to 200 Hz. This switching is performed automatically.

The input signal must be at least 100 mV RMS. If it is insufficient, the message "LEVEL LOW" will appear in the leftmost display.

No filters can be selected. The rectifier is internal, and no other can be selected. Scale is % only.

3.2.10. Rumble

This is an option, on the same PCB as the Wow and Flutter/Drift option. A DIL switch selects between IEC98A and BS4852 measurement standards. The only difference is the rise time of the meter, which is a VU-meter for IEC98A, and a slugged response which is otherwise VU-like for BS4852. This slugged response helps produce a steady reading, especially for unweighted measurements, whose bandwidth extends down to 2 Hz.

The measurement is level-like in operation. Weighted (bandpass centred on 315 Hz) or unweighted (10 Hz to 315 Hz) response may be selected. No other filters can be selected. The rectifier is internal, and no other can be selected. Scales are dB NORM or VOLTS.

3.2.11. Other option functions

There is one unmarked button within the FUNCTION group. This is available for other functions, now or in the future.

One currently available option is FIM (Frequency Intermodulation Distortion) to DIN 45 411. This is available on the same PCB as the Wow and Flutter/Drift and Rumble options. It is operated just as for Wow and Flutter, but is not weighted.

Another option planned is K_2-5 , i.e. selective harmonic distortion measurement. On selecting the function for the first time, the second harmonic will be measured and applied to the meter in the usual way, and displayed in the rightmost display in the form "K2 0.013 %" or similar. On pressing the function button again, the harmonic will step through the series 2, 3, 4, 5, 2 etc. On entering the function again, the last measured harmonic will be recalled. The harmonic will also be selectable by remote control, and measurements returned to the controller.

It is also expected that Quantisation Distortion will be available as an option, when agreement is reached on a standard.

4. T0402 Oscillator

The T0402 is supplied as standard with a T0402 oscillator fitted. To special order, it may be supplied without. If not fitted, a blank panel is substituted. The mainframe is wired to accept the T0402.

4.1 Frequency range

Sine or square waves can be output between 10 Hz and 300 kHz. Square wave is normally symmetrical but can be ordered with mark:space ratios of 2:1 or 1:2. This can be useful for polarity identification. Note, however, that if asymmetric square wave is ordered, the DIM signals will not conform to Otala's specification.

The T0402 can be configured to disable selection of the square wave output from the front panel. This is achieved by DIL switch no. 5 on the rear of the oscillator digital PCB. If this switch is ON, square wave can be selected; if OFF, square wave cannot be selected. Square wave can always be selected via the IEEE 488 bus (if fitted), regardless of the setting of the DIL switch.

Wow and flutter signals are crystal-controlled at 3k15 Hz or 3k00 Hz. IMD signals are to SMPTE, DIN, CCIF or Otala's DIM standards.

Frequency is controlled manually by four controls:

- (i) The front (inner) rotary control, NORM FREQ, is endless, with magnetic detents and a flywheel. Using this control, the T0402 can be stepped in 1% steps over the entire frequency range.
- (ii) For faster changes over large intervals, the STEP buttons step in decades. They behave sensibly when reaching a limit; for example: 1 kHz - 10 kHz - 100 kHz - 300 kHz, then 100 kHz - 10 kHz etc.
- (iii) To obtain a precise frequency, it is occasionally necessary to use the rear (outer) rotary control, FINE FREQ. This has a range of $\pm 1\%$ (equal to two steps of the NORM FREQ control).
- (iv) The x10/ALT button switches between the above system, and a table of frequencies in EPROM. The table can be selected, by means of DIL switches 7 & 8 on the rear of the oscillator digital PCB, from four tables selected at time of order. One of the tables available is ISO 1/3 octaves from 20 Hz to 20 kHz.

This button is also useful for swapping rapidly to and from a reference. For example, if altering an equaliser, use the x10 system to check out a corner frequency, then ALT will bring you straight to 1 kHz. x10 will return you to your corner frequency again. This works in the other direction, too, of course. Check out your 1/3 octave frequencies, then return to a 1 kHz reference in x10, then back to your 1/3 octave frequency. Both x10 and ALT remember the last frequency they were set to.

4.2 Level range

The T0402 can be configured either for dBm or dBu. If configured for dBm, the output level will be correct when the outputs are loaded with the correct termination impedance; this impedance is not necessarily equal to the source impedance. For instance, one standard has a

source impedance of 75 Ω and a termination impedance of 600 Ω .

If configured for dBu, the output level will be correct when the outputs are not loaded.

The two outputs are both at the same level, which may be from +28 dB to -70 dB, depending on configuration and waveform.

Level is controlled, similarly to frequency, with three controls:

- (i) The front (inner) rotary control, NORM LEVEL, is endless, with magnetic detents and a flywheel. Using this control, the TQ402 can be stepped in 0,1 dB steps over the entire level range.
- (ii) For faster changes, the 10 dB buttons are useful.
- (iii) For a precise level setting, it is occasionally necessary to use the rear (outer) rotary control, FINE LEVEL. This has a range of $\pm 0,1$ dB (equal to two steps of the NORM LEVEL control).

The approximate level in use is indicated on an LED ladder.

The TQ402 can be configured to initialize at one of two output levels. This is achieved by DIL switch no. 2 on the rear of the oscillator digital PCB. If this switch is ON, the oscillator will wake up at 0 dB; if OFF, the oscillator will wake up at -60 dB.

4.3 Output muting

Each output can be muted individually. There is no change of source impedance when muted.

The TQ402 can be configured to initialize with the outputs active or muted. This is achieved by DIL switch no. 1 on the rear of the oscillator digital PCB. If this switch is ON, the oscillator will wake up with both outputs active; if OFF, the oscillator will wake up with both outputs muted.

4.4 600 ohm termination

The outputs can be terminated internally with 600 ohms, if required. This can be useful for testing of line bridging equipment. The termination is applied to both outputs simultaneously.

4.5 Output resistance (R_{out})

More commonly referred to as output impedance, this is constant and predominantly resistive through and above the audio frequency range. The R_{out} button steps through three impedance values, normally 75 Ω , 140 Ω and 600 Ω .

The TQ402 has two outputs, labelled "A" and "B". These outputs are isolated from each other and from ground (balanced and floating). Each has an output resistance equal to that shown on the front panel.

If the TQ402 is configured for dBm, levels are correct when the output(s) concerned are loaded with a customer-specified impedance, which is not necessarily equal to the source resistance. For example,

one version is for 600/600, 140/140, and 75/600 ohms.

If the TT402 is configured for dBu, levels are only correct when the outputs are unloaded.

The T0402 can be configured to initialize at any one of the three output resistances. This is achieved by DIL switches 3 & 4 on the rear of the oscillator digital PCB, according to the table below.

SW3	SW4	
ON	ON	75 R
ON	OFF	140 R
OFF	ON	600 R
OFF	OFF	75 R

Common mode balance is excellent, both in respect of output voltage and of output impedance. Withstanding voltage is 240 V RMS at 50 Hz, each output to ground or between outputs A and B, or less if limited by the connectors.

5. IEEE-488 Remote Control

This is an option to the TT402, and provides full remote control of the TT402 and T0402, excepting only:

- (i) The mains on/off switch,
- (ii) The MONITOR level control,
- (iii) The FINE FREQ control of the T0402; however, frequency setting over the bus is performed with finer resolution than the manual 1% steps, so it is probably unnecessary. The FINE FREQ control can be switched in or out of operation, along with the FINE LEVEL control, by the LOCAL LOCKOUT command.
- (iv) The FINE LEVEL control of the T0402.

Use of the IEEE-488 bus, which has attracted enormous support over many years, means that an "open system" can be configured using the TT402 with T0402, any IEEE-488 controller, a Neutrik switch box (in development) (or any other manufacturer's switch box), and other instruments from an enormous selection produced by many manufacturers around the world.

The syntax for remote control operation of such a versatile instrument is necessarily extensive, and therefore a separate IEEE-488 Instruction Manual is available, which contains full details and some example programmes.

Commands are in plain language (English with some French and German), rather than short mnemonics. The result is that test programmes tend to be self-documenting, and are therefore easier to write and maintain. Experience within the company has proved that anyone who is not afraid to try to write a BASIC programme can soon have a successful test programme running. It is not necessary to be a professional programmer.

Many commands may be abbreviated, and some words omitted altogether. In other cases, the order of phrases is unimportant. The aim has been to create a command language which is so natural (similar to the way we speak) that it is only necessary to read the IEEE-488 manual once.

Some examples of valid commands are:

```
FUNCTION X-TALK;RECTIFIER AVG;SCALE DB NORM
Input A; Filters 30k + option A; Rect average
Freq?
Oscillator Rout 600;Osc level +8 dBm
```

Measurements are returned in engineering notation, in ASCII form, with units following. This form is understandable both by humans and readily by most computers. For example:

```
3.1500E3 Hz
-4.76 dBm
775E-3 V
Level low
```

The last example is a case of a message indicating an out-of-limits measurement condition.

Auto-ranging is a feature which is available in order to make test programmes easy. However, it can be enabled or disabled just as easily when required. For example, if the approximate incoming level of a signal is known in advance, it is quicker to set the TT402 to a fixed level range when making a level measurement.

The remote controller is able to read back the complete status of the TT402 and T0402. By means of this facility, users can set up the machine to make a reading, then capture the complete status so that the controller can subsequently set up the machine identically. This represents a very easy way to generate a test programme.

A general-purpose test programme which runs on IBM PCs and compatibles is also available to facilitate testing, especially sweeping and graphical presentation of the data from sweeps. This programme can also be called from BASIC by means of the SHELL command. The programme used manually has a "learn" mode, where commands are stored in a file, and can be subsequently executed. A BASIC programme can also command the programme to use a command file. This is the easiest possible way to make the TT402 and T0402 do sweeps and present the data graphically. Naturally the data can also be stored in a file for subsequent printing or processing.

It is useful to be able to stop an automatic test sequence when an item under test appears faulty, and continue using the instrument manually in order to diagnose the fault. The TT402 excels in this respect.

The same instrument can be used as part of an integrated automatic test system, then carried away for use on its own elsewhere when required. This alone, in large organisations, may be able to save the cost of several machines.

NEUTRIK TT 402 AUDIO TRANSMISSION TEST SET - SPECIFICATION

Inputs

Two true differential inputs, A & B.

Impedance: (THRU) 100 K (50 K each terminal to ground)
(TERM) selectable 75 Ω , 140 Ω , 600 Ω . Others to order.

Maximum withstand voltage: (THRU) 240 V RMS at 50 Hz, each terminal to ground or between terminals, or less if limited by input connector.
 ± 63 VDC, each terminal to ground.
(TERM) 0,5 W (+27 dBm) in selected load resistance, between terminals.
240 V RMS at 50 Hz, and/or ± 63 VDC, both terminals to ground, or less if limited by input connector.

Common mode rejection: >70 dB, 20 Hz-10 kHz, for peak signal voltages as detailed below.

Common mode range: DC does not reduce the common mode range, once it has settled out. The instantaneous voltage on each input terminal must be less than the following: In LEVEL, READ OSC, X-TALK, NOISE, RUMBLE functions:
According to setting of "dB COARSE" range.
 ± 9 V peak for ranges -10 dB (300 mV) to -90 dB (30 μ V)
 ± 90 V peak for ranges +10 dB (3 V) and 0 dB (1 V)
 ± 350 V peak for ranges +40 dB (100 V) to +20 dB (10 V)
or less if limited by input connector.

In THD, IMD functions:

± 9 V peak for differential-mode signal voltages of +11 dBu or less.
 ± 90 V peak for differential-mode signal voltages from +11 dBu to +31 dBu.
 ± 350 V peak for differential-mode signal voltages above +31 dBu; or less if limited by input connector.

In W&F function:

± 350 V peak, or less if limited by input connector.

Level Measurement

Range: +45 dBm to -95 dBm for meter centre 0 (dB scales).
+50 dBm to -107 dBm measurement range (dB scales).
100 V to 30 microvolts for full scale, in 1-3-10... steps (volts scales).

Sensitivity accuracy: Cumulative worst case, no filters selected, $\pm 0,2$ dB on dB scales, $\pm 2\%$ on volts scales.

Frequency response: $\pm 0,1$ dB, 20 Hz to 20 kHz, w.r.t. 1 kHz.
 $\pm 0,2$ dB, 15 Hz to 100 kHz, w.r.t. 1 kHz.

Phase, Level Difference Measurement

Phase is indicated on the rightmost alphanumeric display in degrees. Level difference is indicated on the analogue meter in dB on the dB NORM scale. Frequency is indicated on the leftmost display.

Level range: +45 dBm (higher input) to -32 dBm (lower input).
Level difference range: ± 12 dB.
Accuracy of level difference: ± 0.3 dB, cumulative worst case.
Accuracy of phase: ± 1 degree, 20 Hz to 20 kHz.
 ± 5 degrees, 10 Hz to 100 kHz.

Noise Measurement

Standards: CCIR 468-3 (=468-2), weighted and unweighted.
CCIR ARM (Dolby standard).
Filter fully conforming to revised CCIR 468-3 in frequency response and accuracy.

Residual noise: CCIR 468-3 (=468-2): < -103 dBu weighted, < -106 dBu unweighted (600 Ω source).
CCIR ARM: < -111 dBu, weighted or unweighted (600 Ω source).

For IEC "A", "B" and "C" weighting, see "Filters" section.

Frequency measurement

Range: On leftmost display.
 < 10 Hz to 499,99 kHz.
Accuracy: ± 30 ppm.
Display: The lesser of 5 digits or 0,001 Hz.
Update rate: 3 to 5 readings per second at any frequency.

THD+N measurement

Fully auto-nulling and auto-level setting from any source, external or internal.

Frequency range: 19 Hz to 21 kHz.
Residual distortion: 0,002% max., 0,0008% typical at 1 kHz, 0 dBu.
Accuracy: $\pm 1,5\%$ of reading.
Measurement time: 2 seconds typical (depends on rectifier selected, and distortion content).

IMD measurement (Optional)

Fully auto-level-setting. No tuning is involved. Automatically sets T0402 oscillator, if fitted, to generate correct test signal.

Standards: SMPTE, DIN, CCIF. Set by DIL-switches on card, or by remote control.

Residual distortion: 0,002% SMPTE & DIN
0,004% CCIF.

Measurement time: < 3 seconds.

Test signals: SMPTE & DIN detector is identical. Lower frequency < 280 Hz. Upper frequency $> 6,5$ kHz. Level ratio $\leq 5:1$
CCIF Lower frequency $> 12,5$ kHz.
Difference frequency from 60 Hz to 1 kHz.
Level ratio 1:1.

Crosstalk measurement

Bandpass filter, Q approx. 5, inserted in measurement path from selected input.

If the level present at the non-selected input exceeds -20 dBm or -20 dBu (depending on configuration), the filter will be automatically tuned to this frequency.

If the level present at the non-selected input is below -20 dBm or -20 dBu, and an oscillator is fitted, the filter will be automatically tuned to the frequency of the oscillator.

If the level present at the non-selected input is below -20 dBm or -20 dBu, and no oscillator is fitted, the filter will be automatically tuned to the frequency of a signal presented externally to the "Oscillator A" connector.

Frequency range: 19 Hz to 21 kHz.

Centre frequency accuracy: $\pm 2,5\%$ of reference frequency.

Typical S/N enhancement: 25 dB at 1 kHz, 14 dB at 5 kHz, 10 dB at 10 kHz, 9 dB at 15 kHz. Reference 20 Hz-20 kHz bandwidth, white noise, RMS rectifier.

Wow and flutter measurement (Optional)

Standards: IEC 386, CCIR 409-2, DIN 45 507, BS4847; NAB, JIS.
Selectable by DIL switch on card or by remote control.

Centre frequency:
3,15 kHz or 3,00 kHz, selectable by DIL switch on card or by remote control. The oscillator, if fitted, is automatically set to the correct centre frequency.

W&F ranges: 10%, 3%, 1%, 0,3%, 0,1% for full scale.

Drift: On leftmost display; $\pm 15\%$ max. Independent of W&F range selection.

Level range: >100 mV.

Weighting characteristic according to all the above standards.

Unweighted frequency response: 0,1 Hz to 200 Hz (IEC, CCIR, DIN, BS);
0,5 Hz to 200 Hz (NAB, JIS).

Rumble measurement (Optional)

On same option card as Wow & Flutter.

Standards: IEC98A or BS4852, selectable by DIL switch on card or by remote control.

Frequency response:
Fully meets the accuracy requirements of the standards.
Weighted, 31,5 Hz to 3150 Hz. Unweighted, 2 Hz to 3150 Hz.

Filters

400 Hz Highpass:

Maximally flat 6th order (120 dB/decade).

Passband ripple <0,2 dB, 600 Hz - 100 kHz. -3 dB frequency 400 Hz $\pm 4\%$.

30 kHz Lowpass:

Maximally flat 6th order (120 dB/decade).
Passband ripple <0,2 dB below 20 kHz. -3 dB frequency
30 kHz +2%/-6%.

22 Hz - 22 kHz Bandpass:

Maximally flat 6th order lowpass section
(120 dB/decade). -3 dB frequency 22 kHz +3%/-5%.
Maximally flat 3rd order highpass section
(60 dB/decade).
-3 dB frequency 22 Hz ±4%.
Passband ripple <0,2 dB, 50 Hz - 15 kHz.

Options:

Any 1 or 2 can be fitted. Currently available boards
include: "A", "B" and "C" weighting (IEC651 etc); 30 kHz
lowpass; IBA crosstalk weighting filter; user designed
filter ("skeleton" board with op-amps, power supplies,
input & output, etc.)
Format is a plug-in filter motherboard which can accept
1 or 2 daughter boards containing the actual filters.

Meter system

Rectifiers selectable from front panel;

RMS: True RMS, crest factor >12 at 0 dB meter indication.
AVG: Average responding, calibrated to RMS value of sine
wave.
PPM: Peak Programme Meter to BS5428.

Other rectifiers not selectable from front panel:

Quasi-peak: to CCIR 468-3 (=468-2), used in conjunction with NOISE
CCIR 468-3 function.
W&F: Quasi-peak, to IEC 386 etc.
VU-meter, to ANSI C-77 as required by NAB.
Rumble: VU-meter, to ANSI C-77 as required by IEC98A, etc.
Slow average-responding as required by BS4852.
Level difference:
True RMS.

Scales

dB NORM: ±12 dB about 0 reference, generally conforming to
BS5428: Part 9:1981, type IIb. If configured for dBm,
"0" indication when set to 0 dB range indicates the
voltage which would dissipate 1 mW in the selected
CIRCUIT IMPEDANCE (0 dBm). If configured for dBu, it
indicates 775 mV (0 dBu).
dB EXP: ±1,5 dB about 0 reference. When the measured voltage
falls outside ±2 dB approx., the scale is automatically
switched to dB NORM, and is switched back to dB EXP when
the measured voltage returns to within ±1,8 dB.
%DIST, VOLTS: 0-10 and 0-3, linear.

The scale in use is indicated by an LED at the scale end. If dB
selected but dB NORM in use as described above, dB NORM LED flashes
rapidly. Other indications are steady.

Connections

Input: XLR option: Neutrik NC3FD type, silver plated. Pin 1 = screen & frame. Pin 2 = Live or in-phase. Pin 3 = Return or anti-phase.

Jack option: Broadcast type 3-pole 1/4" jack socket. Tip = Live or in-phase. Ring = Return or anti-phase. Sleeve = Screen and frame.

Euro option: Siemens C42334-A176-A11.
Top = Live or in-phase. Middle = Return or anti-phase. Bottom = Screen and frame.
Suitable mating connector Siemens C42334-A282-A1.

Oscillator: XLR option: Neutrik NC3MD type, silver plated. Pin 1 = screen & frame. Pin 2 = Live or in-phase. Pin 3 = Return or anti-phase.

Jack option: Broadcast type 3-pole 1/4" jack socket. Tip = Live or in-phase. Ring = Return or anti-phase. Sleeve = Screen and frame.

Euro option: Siemens C42334-A176-A11.
Top = Live or in-phase. Middle = Return or anti-phase. Bottom = Screen and frame.
Suitable mating connector Siemens C42334-A282-A1.

Scope:
(front panel) BNC, buffered from measuring system. Signal is that presented to the rectifier.
Output impedance: 50 Ω typical.
Minimum load impedance: 1 K.
Output level: Standard, 245 mV RMS (0,7 V P-P) approx. for 0 dB indication on dB scales; 316 mV RMS (0,9 V P-P) approx. for 10 indication on 0-10 scale or 3,16 indication on 0-3 scale. By replacing an internal link this level can be set 10 dB higher but will overload before the rectifier.

Scope:
(rear panel) BNC, buffered from measuring system. Signals are those applied to input main and sub channels.
Output impedance: 50 Ω typical.
Minimum load impedance: 1 K.
Output level: Varies, according to function, signal level, range, etc.

Phones: Broadcast type 3-pole 1/4" jack socket. Tip = Live, Ring = Return, Sleeve = Ground & frame. Signal is unbalanced.
Inserting jack plug mutes internal loudspeaker.
Output impedance: 68 Ω $\pm$ 10%.

Power: IEC 3-pole.

IEEE-488 (optional):
Connector and stud mount standoffs fully conforming to IEEE-488:1978.

IEEE-488 (GPIB) Interface (Optional)

Facilities: All controls except Power on/off, Monitor level and Fine Level & Fine Frequency (T0402) are controllable. All measurements are available.

Capability Identification Codes:

SH1, AH1, T2, TE0, L2, LE0, SR0, RL0, PP0, DC1, DT0, C0, E1. Remote-Local is handled differently from IEEE-488 in order to make manually assisted automatic testing easier. The instrument can be controlled remotely, manually, or part manually and part remotely. See the IEEE-488 Interface Instruction Manual for full details. Subsets SR0 and PP0 are expected to be changed to SR1 and PP1 by later software upgrade.

Commands are in plain language (English with some French and German). Measurements and status / error messages are returned in engineering notation and plain language, readily understood by both computers and humans.

Isolation: The IEEE-488 bus is galvanically isolated from the measurement system in order not to create ground loops through the system controller and other devices.

Power requirements

Voltage: Selectable on rear panel: 100 V, 120 V, 220 V or 240 V RMS, $\pm 10\%$, 50 Hz or 60 Hz.
Consumption: Approx. 50 VA.

General

Operating temperature range:
0 deg. C. to 35 deg. C., non-condensing.
Dimensions: Portable version with handle 525mm wide, 160mm high, 445mm deep.
Portable version without handle 475mm wide, 160mm high, 380mm deep.
Rack mount version: Standard 19" rack mounting. 3U = 5 1/4" = 133mm high, 390mm deep.
Weight approx. 13 Kg including oscillator.

TT402 OSCILLATOR (Optional)

Plugs in to pre-wired slot in TT402. Full remote control (except Fine Frequency and Fine Level) via IEEE-488 if fitted (to TT402).

Waveforms: Sine, square or twin tone.

Frequency range:

Sine/square: 10 Hz to 300 kHz.

W&F: 3150 Hz or 3000 Hz.

IMD: SMPTE 60 Hz & 7 kHz @ 4:1.

DIN 250 Hz & 8 kHz @ 4:1.

CCIF 14 kHz & 15 kHz @ 1:1.

DIM-30, DIM-100.

Distortion: Measured at +18 dBm into two 600 R loads.

THD: At 1 kHz, 30 kHz BW : 0,003% max, 0,002% typ.

At 20 kHz, 80 kHz BW : 0,02% max, 0,015% typ.

As with other products having an output transformer, the THD rises at low frequencies (below approx. 63 Hz), to typically 0,007% at 30 Hz.

W&F source has THD+N <0,5%, typ. 0,2%.

SMPTE IMD: 0,008% typ.

DIN IMD: 0,007% typ.

CCIF IMD: 0,003% to 0,005% typ.

Frequency accuracy:

Sine/square: $\pm 0,15\%$ when Fine Freq control either disabled or set to centre.

W&F: ± 20 ppm.

Settling Time:

30 Hz - 20 kHz, <500ms. Typically 5 cycles.

20 kHz - 300 kHz, <100ms.

Controls STEP:

In $\times 10$ state, increase or decrease frequency by decades.

If out of range, will step to frequency limit.

First step back from limit will be to last in-range frequency.

In ALT state, step through a table of steps. Table is selected on internal DIL-switch. Several tables are provided including 1/3 octave. Alternatives to order.

Control NORM FREQ:

1% steps of frequency. Enabled in sine/square and $\times 10$ only. Endless control with flywheel and magnetic detents.

Control FINE FREQ:

$\pm 1\%$ of nominal frequency. Continuously variable.

Controls 10 dB:

10 dB steps. If out of range, will step to level limit. First step back from limit will be to last in-range level.

Control NORM LEVEL:

0,1 dB steps of level. Endless control with flywheel and magnetic detents.

Control FINE LEVEL:

$\pm 0,1$ dB from nominal level. Continuously variable.

Level accuracy & stability:

$\pm 0,1$ dB max, $\pm 0,05$ dB typ.

Residual noise:

Muted, 600 R source, RMS, unweighted 22 Hz - 22 kHz.
Better than the worse of -124 dBm and a 20 dB/decade
oblique segment passing through 10 kHz at 105 dB below
the oscillator level setting.

Residual hum: Muted, <-130 dBm.

Output impedance:

75 R, 140 R, 600 R, selectable. Others to order.*

Output balance:

Each output is balanced and floating. The two outputs
are isolated from each other.

Common-mode signal: Better than 50 dB below
differential-mode signal, 10 Hz - 10 kHz, 600 R source,
600 R differential-mode load, 600 R common-mode load
from centre tap of differential-mode load to ground.

Level range: Into one, or each of two, resistive loads of the
selected impedance:

Sine/square/W&F: +22 dBm to -70 dBm.

SMPTE/DIN: +21 dBm to -70 dBm.

CCIF/DIM: +19 dBm to -70 dBm.

Control "600 OHM TERM":

Loads both outputs internally with 600 R.

Controls "MUTE A", "MUTE B":

Mute the specified output without altering the source
impedance.

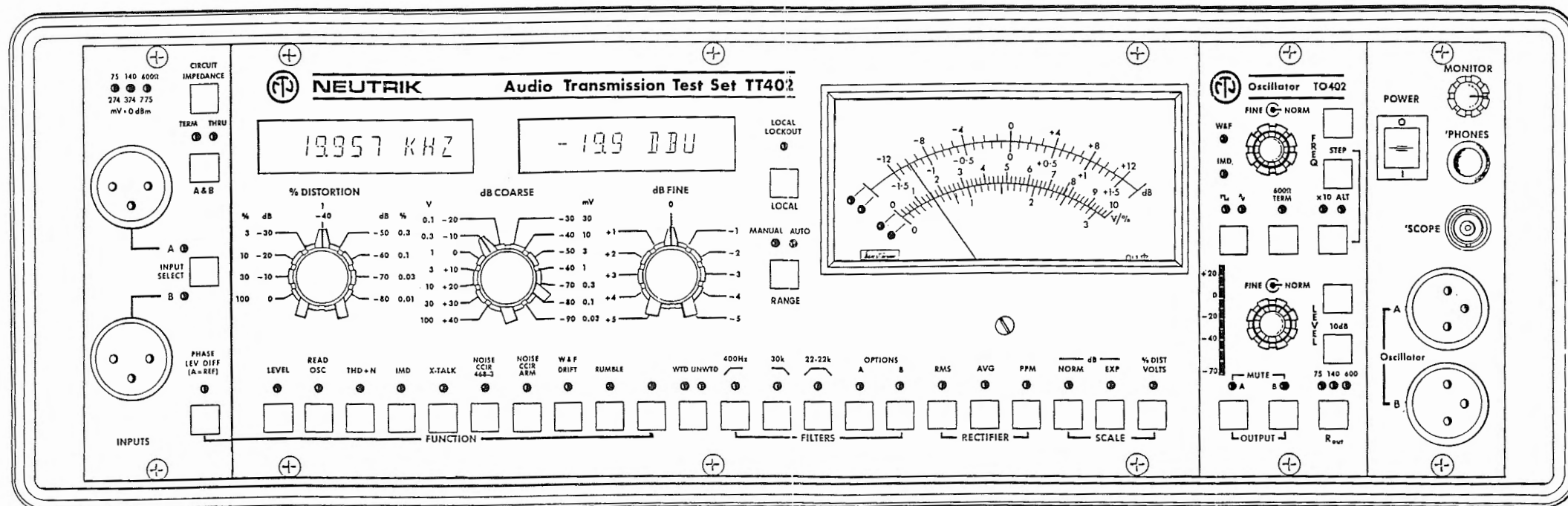


FIGURE 1 Front panel layout