Operating Manual

SWR-121 V/U

Graphical VHF/UHF Antenna Analyst

AEA Technology, Inc.

AEA Technology, Inc.

SWR-121 V/U^{TM} is a trademark of AEA Technology, Inc. 1997

Contents

WARNING: DO NOT leave this highly sensitive instrument connected to an antenna for long periods of time, as nearby lighning strikes can damage it without your knowledge.

SECTION 1   INTRODUCTION

What It Does

The SWR-121 V/U Antenna Analyst combines a microprocessor controlled frequency synthesizer with an accurate low-power SWR bridge to present a graphical display of SWR versus frequency. During normal operation, the Analyst continuously sweeps and plots the selected frequency range. You can define this "sweep" range using the Analyst's keypad.

Once installed on your PC, the optional SWR DIRECTOR software allows you to remotely control the Analyst as well as store and print plots.

Features
- Graphical display of SWR versus frequency
- Digital readout of SWR
- Digital readout of Return Loss
- Auditory cues
- Self-test and Calibration functions
- Automatic plot scaling
- Automatic centering
- Automatic plot averaging
- Automatic hold and Automatic off
- Battery-powered
- RS-232 interface
- Optional, PC-compatible SWR DIRECTOR software allows   remote control and display as well as plot storage and printing (software and serial cable available from AEA)
- Optional AC-1 Wall Cube (available from AEA)
- Optional softcase with shoulder strap and swivel hook (available from AEA)

Specifications

- Frequency Range . . . . 120-175 MHz, 200-225 MHz,
  . . . . 400-475 MHz
- Default Frequency
  Step Size . . . . 10 kHz
- Manual Frequency
  Step Range . . . . 10 kHz to 75 MHz
- Display Resolution . . . . . 0*-1000 kHz per dot
  . . . . (*single frequency)
- Display Width . . . . 0-110 MHz
  . . . . (110 x resolution setting)
- Impedance . . . . 50 ohms
- Output Power . . . . Approx. 5 mW into 50 ohms
- Harmonics
  and Spurious . . . . 30 dB below fundamental,
  . . . . typical
- SWR Range . . . . 1:1 to 10:1
- Return Loss Range . . . . . -0.3 dB to -50 dB
- SWR Proportional Tone . . Approx. 200 Hz x SWR value
- Accuracy . . . . ±10% typical, when calibrated
- Power Source . . . . lnternal batteries or external
  . . . . 12 to 16 VDC
- Battery Complement . . . . 8 AA Alkaline or Lithium
- Battery Saver Mode . . . . . Entered after 4 minute idle
- Display Update Time . . . Approx. 2 seconds per sweep
- Serial Port . . . . 9600 baud
- Size . . . . 4.3" W x 2.25" H x 8.5" L
  . . . . (including connector)
- Weight . . . . 1 lb. 10 oz.
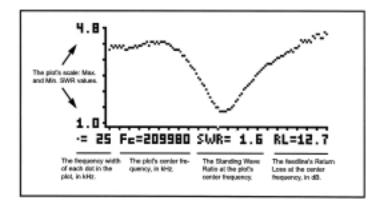 . . . . (including batteries)

SECTION 2 OPERATION

Set-Up
Attach the antenna under test to the antenna connector on the top of the Analyst. Then, press and hold the Analyst's ON key until the AEA logo appears on the display to indicate activation.

CAUTION: **Do not** *attach a load transmitting RF power to the antenna connector. RF power applied to the antenna connector will damage the Analyst. In addition, erroneous readings may occur in testing areas located in strong RF fields (i.e. near commercial broadcast stations). Damage may also occur when the antenna under test is near a transmitting antenna. Damage incurred in these situations is not covered under warranty.*

Display

Figure 1 - SWR-121 V/U Display

The display's plotting area is 110 dots wide. The vertical axis indicates the scalets maximum (top) and minimum (bottom) SWR values (Figure 1). The horizontal axis contains tick marks at intervals five times the display (dot) width value.

For example, when the display width is set to 50 kHz, each tick mark represents a 250 kHz interval. The missing dot in the center of the horizontal axis represents the center frequency (center of the plot). The legend below the horizontal axis corresponds to the following information:

.	Frequency width of each dot in kHz
Fc	Center frequency in kHz
SWR	Standing Wave Ratio at the center frequency
RL	Return Loss, in decibels, at the center frequency

The digital readouts of SWR and Return Loss are updated each time the plot passes the center point.

Icons
The following icons may appear onscreen during various times of operation.

Display Hold - Appears when you enter the HOLD mode; indicates the display is frozen.

Hourglass - Appears when the Analyst is scaling the plot.
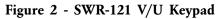
Display Dump - Indicates that the Analyst is transferring a plot to a computer display (using the optional SWR DIRECTOR software).

Unlocked Padlock - Appears when Analyst has lost phase-lock. It is normal for this icon to flash briefly; however, if it remains onscreen for more than a second, you may need to replace the batteries or calibrate the Analyst (refer to ADJUSTMENTS section).

Keypad

Figure 2 - SWR-121 V/U Keypad

The ON key activates the Analyst, while the OFF key deactivates the Analyst. The ENTER key is mainly used to rescale plots and select new center frequency values.

As previously mentioned, the Analyst continuously sweeps and plots the selected frequency range. To freeze the display when an interesting plot appears, press the HOLD/RUN key. In this HOLD mode, all operation is temporarily suspended. To resume active plotting, press HOLD/RUN again. Notice that the display settings have not changed.

When the Analyst is in the HOLD mode, power is removed from much of the circuitry, and the microprocessor is placed in a reduced-current, idle state. It is advisable to enter this mode whenever possible to prolong battery life.

NOTE: The Analyst will automatically enter the HOLD mode affer a four minute idle period. To direct the Analyst to shut off completely after the four minute idle period, install the jumper at AUTO-OFF (refer to ADJUSTMENTS

section). The Analyst will not automatically shut off if you have manually placed it in the HOLD mode.

Zero is automatically displayed.

150 KHZ

Figure 3 - Entering a Number

The number keys are used to enter new display width, center frequency, and frequency step size values. As you enter each number, it will appear onscreen followed by the abbreviation, "KHZ". In addition, the Analyst will automatically append a zero to the end of each value you enter. For example, if you enter "15" on the keypad, the Analyst will recognize and display this value as "150 KHZ" (Figure 3).

To clear an entry, input an invalid frequency such as "00000". Keep in mind that the Analyst recognizes only the numbers displayed onscreen as the new setting value. New display setting values remain in effect until you input another value or turn the Analyst off.

The display width value, which determines the length of the frequency sweep range, can be adjusted in two ways. Use the WIDTH▲ and WIDTH▼, keys to step through eight preset display width values (0, 10, 20, 50, 100, 200, 500, or 1000 kHz per dot), or enter a specific value (between 0 and 1000 kHz) on the keypad followed by either WIDTH key. If you enter a value greater than 1000 kHz, the display width will revert to its former value and normal operation will resume.

The center frequency, which determines the midpoint of the Analyst's frequency sweep range, can be adjusted in three ways. The first way is to use the FREQ▲ and FREQ▼ keys

to step the center frequency up and down in increments of 10 kHz. To modifv this default step size, enter a value on the keypad followed by the appropriate FREQ key. For example, entering 1 2 3 FREQ▲ will cause the Analyst to step up in Increments of 1230 kHz. Remember, the maximum step size value the Analyst will recognize is 75 MHz.

It is also possible to change the center frequency by entering a (five digit or less) value on the number keypad followed by the ENTER key. Again, the Analyst will append a zero to the end of the value you enter. If you enter a center frequency that is outside the Analyst's frequency range, an error beep will sound and plotting will resume according to the existing settings. If the center frequency and display width values create out-of-range frequencies on a section of the display, that section will remain blank.

Finally, there is an automatic centering function that allows you to zoom in and take accurate readings of the SWR at the null. To initiate this function, press the HOLD/RUN key to freeze the display. Then, hold down the FREQ▲ or FREQ▼ key and press the HOLD/RUN key again to move the center frequency to an SWR dip to the right or left, respectively, of its current position. The center frequency will automatically relocate to the position of the lowest dot on the side of the plot you have designated, and a new plot will begin.

Sweep Range
The sweep range is the frequency span the Analyst scans when plotting SWR values. This sweep range is defined by the center frequency and display width values.

The center frequency value determines the midpoint of the

sweep range, while the display width value determines the length of the sweep range. Specifically, the display width value determines the resolution of each dot on the display. For example, when the display width is set to 10 kHz, each dot on the display is 10 kHz wide. Therefore, since the plotting area is comprised of 110 dots, the total frequency range represented in the plot is 1100 kHz (110 x Display Width).

Now, assume the center frequency is set to 200 MHz. Divide the total frequency range (1100 kHz) by two (550 kHz) to determine the minimum and maximum sweep values. Subtract 0.550 from 200 to determine the minimum value, and add 0.550 to 200 to determine the maximum value. The sweep range in this example is 199.45 MHz to 200.55 MHz.

When the Analyst is first activated, the center frequency defaults to 150 MHz and the display width defaults to 0 kHz. When the display width is set to 0 kHz, the Analyst outputs a single frequency (center frequency value) that is represented throughout the plot. This is particularly useful when you are trying to minimize SWR at a specific frequency.

NOTE: When the display width is set to 0 kHz, an audible beep will sound approximately three times per second at a pitch that is proportional to the SWR (as long as the SWR does not exceed 10:1). This feature allows you to make adjustments to the antenna without having to visually consult the display. To disable the beep, remove the jumper at SWR TONE (refer to ADJUSTMENTS section).

Plot Scaling
To maximize display resolution, the Analyst automatically prescans the selected frequency range for a maximum scale value. The highest SWR value (between 1.5:1 and 10:1)

identified within the range becomes the vertical scale's maximum value. After the Analyst has identified the maximum scale value, the Hourglass icon, which is displayed while the Analyst is scanning the range, will disappear and plotting will begin. SWR values slightly higher than the maximum value are plotted on the three lines just above the top of the vertical axis, and any SWR values outside the current range are plotted on the top line of the display. The bottom of the vertical scale always represents an SWR value of 1:1, and is labeled "1.0".

NOTE: Do not attempt to change any display settings, etc. while the Hourglass icon is displayed.

Once the Analyst has scaled the plot for maximum resolution, the vertical scale will not change unless you alter the center frequency or display width values, or press the ENTER key. The Analyst will also rescale the plot whenever you exit the HOLD mode.

To disable the automatic plot scaling feature press the HOLD/RUN key to freeze the display. Then, hold down the ENTER key while pressing HOLD/RUN again. When the automatic plot scaling feature is off, the top of the vertical axis will represent an SWR value of 10.0:1. To turn this feature back on, simply repeat the above process.

NOTE: Although the SWR reads out to only one decimal place, the vertical resolution of the plot is usually more accurate, particularly at low SWR's. However, if the highest SWR identified within the range is less than or equal to 1.5:1, the maximurn scale value will be set to "1.5" and each tick mark on the vertical axis will represent a change in SWR of less than 0.01:1. Consequently, received signals or noise may cause some random fluctuations in the plot.

NOTE: An open antenna connector does not appear to be an open circuit at Ultra High Frequency (UHF). As a result, an open antenna connector, when combined with circuit limitations, may result in open-circuit SWR readings that are lower than expected. This is normal, and will have negligible effect on the accuracy of SWR plots.

SECTION 3   OPERATIONAL TIPS

SWR at a Single Frequency

To minimize an antenna's SWR at a single frequency, input the desired center frequency value, select a display width of 0 kHz, and tune the antenna to its lowest SWR setting. Each time you press the ENTER key (with automatic plot scaling enabled), the top of the vertical axis will assume the value of the highest SWR value at that time (to a minimun, of 1.5:1). This ensures maximum display resolution.

Making a 2:1 SWR Plot

To measure the bandwidth of an antenna between 2:1 SWR points, first make sure automatic plot scaling is on. Select the desired display width value and a center frequency value that is close to the antenna's resonant point. Replace the antenna with a 100-ohm resistor (assuming 50-ohm operation). Press ENTER. In a few seconds, the top of the vertical axis will be labeled "2.0". Reconnect the antenna.

When the plot is complete, determine the distance between the two points where the plot crosses the top of the vertical axis. To do this, count the number of horizontal tick marks between the two intersections. Then, plug this number into the following formula: N x Display Width x 5 = Bandwidth, where N = number of horizontal tick marks. Bandwidths at SWR's up to 10:1 can be measured in a similar manner using a resistor of the value R = SWR x 50.

Plot Smoothing

Internally or externally generated noise can cause randomness in a plot, particularly when the full-scale SWR is low. To help eliminate this problem, the Analyst averages eight SWR samples, taken approximately 750 microseconds apart, at each frequency. This average value is plotted. Before you save a plot using the SWR DIRECTOR software, increase the number of samples averaged to ensure the cleanest possible

plot. To do this, first press the HOLD/RUN key. Then, while holding down the WIDTH▲ key, press HOLD/RUN again. Subsequent plots will display the average of 128 samples. Keep in mind that this increases plotting time substantially. To revert to the eight sample default, repeat the above procedure using the WIDTH▼ key.

NOTE: When the display width is set to 0 kHz, the number of samples taken at each point is always eight.

SECTION 4   ADJUSTMENTS

Internal Access

There are six screws on the rear cover of the Analyst. Remove the four corner screws to access the circuit board, which contains trimmer capacitors, potentiometers, and function selection jumpers. Note that you do not need to remove the battery cover screws when accessing the circuit board. After removing the rear cover screws, carefully flip the cover to the left to avoid pulling the battery connection wires from the circuit board. The circuit board should remain in the top cover.

To access the battery compartment, remove the two screws behind the rubber foot. When replacing the rear cover, make sure the foot's pegs are positioned in the slots in the top of the battery cover before reinstalling the screws.

Jumper Setting Replacement

The audible beep and automatic off functions, described in the OPERATION section, are controlled by circuit board jumpers. When installed, these jumpers act as "shorting plugs" that connect two pins together. If these jumpers are not installed, they should be left on one of the two pins to allow easy reinstallation.
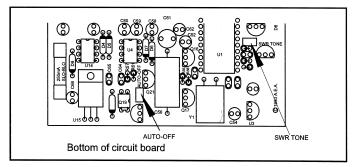

Figure 4. SWR-121 V/U Jumper Locations

To change a jumper, access the circuit board by removing the rear cover of the Analyst (refer to INTERNAL ACCESS section). Identify the jumper block located near the lower right corner of the circuit board (Figure 4). Identify the desired jumper and, using a pair of small-tip needlenose pliers, gently clamp the top of the jumper and lift upward. To install the jumper, carefully place it over both pins on the circuit board and slide it down as far as possible. To take a jumper out of service, carefully place it over just one of the pins and slide it down as far as possible (Figure 5).
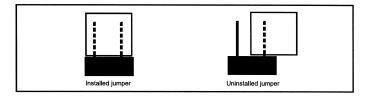

Figure 5 - SWR-121 V/U Jumper Installation/Removal

Checking the Batteries

To obtain an approximate battery level reading, first remove any load attached to the antenna connector. Then, enter the calibration mode by holding down the ENTER key while turning on the Analyst. After the Analyst has performed a series of self-tests (refer to SELF-TESTS section), the letters "F" and "R" (which indicate Forward and Reflected voltages from the bridge), will appear near the top of the display. When the batteries are fresh, the letters will appear on the right side of the display. As battery levels decrease, the letters will move toward the left side. When the letters reach the center of the display, a low battery symbol will appear, indicating that the batteries should be replaced soon, as only a few hours of use remain.

Battery Replacement
Before you replace the batteries, turn the Analyst off. Then, remove the battery compartment cover as described in the INTERNAL ACCESS section. To avoid damaging the Analyst, insert the batteries according to the markings on the inside bottom of the case. All eight batteries should be replaced at the same time. Alkaline or high energy Lithium batteries are recommended for longest life.

SECTION 5   SELF-TESTS

To perform the following self-tests, hold the ENTER key down while turning on the Analyst.

During this process,

- The firmware version is displayed onscreen.
- The LCD module is tested.
- A checksum test is made on the program ROM.
- The synthesizer is tested at several frequencies.
- The serial port is tested (insert a 3.5 mm stereo plug, with Tip connected to Ring, into the serial jack).

NOTE: If you do not insert a 3.5 mm stereo plug into the serial jack, the serial port test will fail. However, this test is not critical. You may proceed to the ADJUSTMENTS section to perform an alignment and/or battery check.

If one of the above tests fails, the "OK" message will not appear on the display. If this happens, note which test failed and contact AEA's technical support department (refer to IN CASE OF TROUBLE section).

After the self-tests have been performed, the outputs of the bridge amplifiers will be displayed (refer to CALIBRATION section).

To begin normal operation, press ENTER.

SECTION 6   CALIBRATION

NOTE: Normally, calibration is not required unless Analyst components have been replaced.

Always perform calibration with fresh batteries in the Analyst. If adjustments are made with old batteries, erroneous SWR measurements may result when the batteries are eventually replaced. Any external power should also be disconnected from the Analyst during calibration. If the calibration mode is entered while the Analyst is powered by an external source, the letters "F" and "R" will appear near the center of the display. As long as the letters are vertically aligned within a dot or two, accuracy will be maintained.

To perform the following calibration functions, access the circuit board as described in the INTERNAL ACCESS section. Refer to the PARTS PICTORIAL for lead connections and part locations.

Timebase
While the Analyst is off, connect a frequency counter to the top of R101(near the center of the circuit board). Turn the Analyst on and adjust C81 for a reading as close as possible to 1.200 MHz.

VCO's (Voltage-Controlled Oscillators)
Connect a voltmeter between TP1 and Grourd. Set the display width to 0 kHz and the center frequency to 175 MHz. Adjust R81 for a reading of approximately 15 volts. If you cannot reach 12.5 volts, adjust for maximum voltage. Enter a center frequency of 140 MHz and adjust R79 for a reading of 14 volts. Enter a center frequency of 225 MHz and adjust C14 for a reading of approximately 14 volts. Enter a center frequency of 475 MHz and adjust C4 for a reading of approximately 16 volts.

Viewing Angle

To modify the display contrast, adjust R62 while viewing the screen at a normal angle.

Bridge Amplifier Gain

Remove any load connected to the Analyst. Then, hold the ENTER key down while turning on the Analyst. After the Analyst has performed several self-tests, the letters "F", and "R" which indicate the Forward and Reflected voltages from the SWR bridge, will appear onscreen. Adjust R89 and R88 to vertically align the "F" and "R", respectively, at the ALIGN HERE arrow near the right side of the display. Note that the right side of the display represents 5 volts (full-scale) while the left side represents 0 volts.

SECTION 7   OPERATION FROM A TERMINAL

The serial interface allows remote control of the Analyst (without display) from a terminal or terminal emulator. To communicate with the Analyst, the terminal (emulator) must be set to 9600 baud, no parity, eight data bits, and one stop bit. The active keys are listed below:

0-9 . . . . Function the same as the digit keys on Analyst

U . . . . Steps frequency up (same as FREQ▲ key)

D . . . . Steps frequency down (same as FREQ▼ key)

O . . . . Zooms out

I . . . . Zooms in

Enter . . . . . . Functions the same as ENTER key on Analyst

Backspace . . . Resweeps immediately, without changing scale

Spacebar . . . . Freezes the display*

+ . . . . Turns automatic plot scaling on

- . . . . Turns automatic plot scaling off

/ . . . . Turns plot smoothing on

\ . . . . Turns plot smoothing off

< . . . . Moves center frequency to lowest SWR in plot

> . . . . Moves center frequency to highest SWR in plot

? . . . . Returns SWR string**

* On the Analyst, only the HOLD/RUN key will exit the HOLD mode. From a terminal, any key will do so, and if it is one of the above mentioned keys, it will also perform its regular function.

** Typing a "?" will return a string of the form SWR @ 123450 kHz = 12.34, followed by a carriage return and linefeed. The display width is automatically reset to 0 kHz for fastest response. Remember to omit the 1 kHz digit (always 0) when entering a frequency. The Analyst will supply it automatically.

You may also precede the "?" with a frequency value. For example, typing "14230?" will set the center frequency to 142.3 MHz as well as return the SWR to this frequency.

LIMITED WARRANTY

AEA Technology, Inc., warrants to the original purchaser that the SWR 121 V/U shall be free from defects in material or workmanship for a period of one year from the date of shipment. All units returned to the factory, delivery charges prepaid, and deemed defective under this warranty, will be replaced or repaired at this company's option. No other warranties are implied, nor will responsibility for operation of this instrument be assumed by AEA Technology, Inc.

There are no warranties that extend beyond express warranties stated herein. No other warranties are express or implied. AEA TECHNOLOGY SPECIFICALLY DISCLAIMS ALL IMPLIED WARRANTIES, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. AEA TECHNOLOGY SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCEDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

Remedies for any breach of warranty, either express or implied, are limited to repair, replacement, or return of the instrument, at the option of AEA Technology, Inc.   Any warranty is valid for the original purchaser only.

All warranties of performance are disclaimed.

AEA Technology assumes no liability for applications assistance or customer product design.

IN CASE OF TROUBLE

If your SWR-121 V/U Antenna Analyst doesn't seem to be working properly, please try the following suggestions before sending the unit in for repair:

- When the Analyst is being used as a portable instrument, low batteries are the most likely cause of difficulty. See instructions on how to check batteries.
- If the Analyst is plugged in, is your power supply providing 12 to 16 volts DC under load? In other words, is your power supply capable of delivering at least 12 volts while the unit is ON? If you're not sure, try another 12 volt power supply. Also make sure the center pin of your power cable is positive. If it is not, then the Unit's internal fuse is probably blown. Replace the fuse and rewire the power cable for center pin positive.
- Make sure all cables are securely connected. Check cable continuity with an ohmmeter.

If you can't seem to solve the problem yourself, our Technical Service staff may be reached at 800-258-7805 or +1-760-931-8979 7AM-4PM M-F Pacific Time, or by e-mail at **techsupport@aeatechnology.com**. Users are also encouraged to check the Application Notes and Software for updates using the "Literature and Software" button in the tool bar at **www.aeatechnology.com**.

Please let us try to help you over the phone before sending the unit in. Many of the products we receive for service are in perfect working order when we receive them. Calling us for technical assistance can save you both time and money.
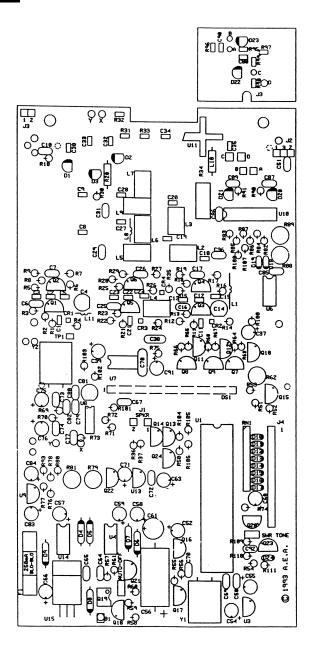
If you call for assistance, please have your Unit serial number available and have the unit and antenna connected and powered ON. The technician you speak with may ask you to perform certain functions to aid in diagnosis. If you have a voltmeter, you might have the SWR 121 open so you can report measurements to the technician.
If you contact us via e-mail, we ask that the Model and Serial numbers be included in the message, along with a brief description of the problem. You will normally receive a response within 24 hours (during the business week).

If the unit needs to be returned to the factory, the user is requested to call (760) 931-8979 for a Return Merchandise Authorization (RMA) number. The user is also requested to include a statement giving a complete description of the problem, including the conditions under which it occurred. Include return information (name, company, address, and daytime phone number) with each unit.
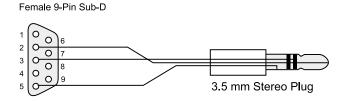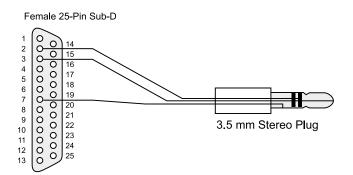Units should be sent to:

AEA Technology, Inc.
5933 Sea Lion Place Suite 112
Carlsbad, CA 92010
Attn: RMA_____

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APPENDIX A   PARTS PICTORIAL

APPENDIX B   INTERFACE CABLES

Female 9-Pin Sub-D

3.5 mm Stereo Plug

Female 25-Pin Sub-D

3.5 mm Stereo Plug

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