44D Digital/Analog Broadband RF Wattmeter - User Manual

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Warranty Periods:
- Antennas and antenna mounting hardware - 5 years
- All other products - 1 year

44D User Manual

Table of Contents

Precautions and Safety Instructions

1. Read the user manual carefully. All **Warnings** and **Cautions** should be noted.
    * Contact Telewave Support with any questions.
    * Keep the user manual(s) for future reference.

2. Keep the 44D away from sources of moisture or excessive humidity.
    * Never pour any liquid into the openings or connectors.
    * Do not immerse into any liquid. The 44D is water resistant, not water proof

3. Do not store this 44D in an unconditioned environment for an extended time. Prolonged exposure to extreme heat, cold or moisture may cause damage.

4. Check the current capacity of the USB charger/power supply before connecting to the 44D.

5. Do not attempt to disassemble the 44D, there are no user serviceable parts inside.

6. Inspect the 44D if it has been dropped or exposed to excessive vibration.

7. Contact Telewave Support if any of the following conditions arise:
    * There are any obvious signs of damage – case, display, connectors, switches, or etc.
    * Any liquid appears to have penetrated into the case.
    * The 44D appears to malfunction or is giving obviously incorrect readings.
    * The 44D has been tampered with, or opened by anyone other than Telewave.

8. Follow all normal Radio Frequency safety rules and High Voltage safety rules.
    * Double check all connections and configurations before applying power to transmitters
    * Double check all connections and configurations before keying any transmitters
    * Be mindful of short and long-term exposure risks to Radio Frequency Radiation

WARNING: This symbol alerts you to the risk of personal injury, hardware damage or irrevocable loss of data.

CAUTION: This symbol denotes situations where instructions must be followed carefully to avoid personal discomfort or to obtain expected results.

Quick Start Guide

The complete 44D User Manual is available for download at www.telewave.com.

1. Unpack and inspect the 44D and accessories (USB cable, AC power supply, & AC adapter kit)
   a. Check the box and contents for any damage immediately after it arrives
   b. In case of damage or missing items, contact Telewave immediately, 408-929-4400 Opt 1.
2. Charge the Batteries
   a. Connect the supplied USB cable into the 44D (connector on the back) and into the supplied AC power supply. Plug the power supply into a 90 to 250 VAC (50 or 60 Hz) wall socket (Charging begins automatically – there is no charging indication when the 44D is off)
   b. The 44D must be charged for at least 2 hours before turning on for first use.

The 44D cannot be switched ON or OFF while charging via the USB. Disconnect the USB cable, toggle the power button, and then re-connect the USB to continue charging.

See the section "Lithium Battery Management" (next page) for battery management details

3. Build or procure "Primary Cables" (see "Appendix - Connecting the 44D to the Circuit")
4. Press and hold the power button until the blue power indication in the switch illuminates
5. The 44D will be functional in three to five seconds as indicated by:
   a. Backlight will be illuminated
   b. Frequency, temperature & battery indicators are displayed
6. The HOME screen & menu tree:

MENU	^MEAS	^CALC
V	Measurements	Calculations

Freq Range > Set low, medium or high frequency range
Modulation > Selects the type of modulation to measure
Settings   > Modify some look & feel parameters
Info & Help > Show Version, Telewave contact
Exit   > Return to the HOME screen

7. When in any MENU screen other than the HOME Screen, the function buttons will be UP, SELECT/EXIT, and DOWN.
   a. Press SELECT implements the selection & returns HOME
   b. Press EXIT aborts the selection and returns HOME
8. Set the Frequency Range before use, all other settings are optional
9. Once the 44D has been configured, the cables can be connected
   a. Connect the primary cable to the port labeled TX on the left side of the 44D (RF input)
   b. Connect the cable leading to the antenna to the port on the right side of the 44D (RF output)
10. The RF Sample port can be connected to any monitor or source test equipment. The sample port is bi-directional, with connectivity to both the Thru Line TX and Thru Line ANT port.

Wiring Diagram

Original Circuit

½ WL Increment

Insert test cables & 44D at the Component output

44D

TX   ANT
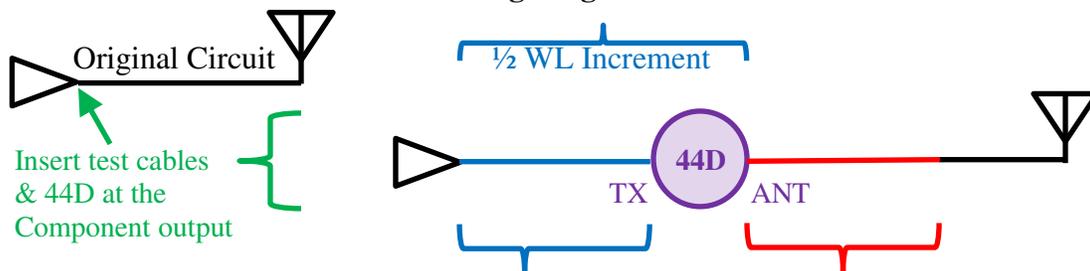
Primary Cable (1/2 WL increment minus 5") Secondary Cable (Optional = ½ WL increment)

Lithium Battery Management

Lithium-ion batteries are used in the 44D to supply power. The behavior of the 44D batteries is similar to other devices that use the same battery technology (cell phones, iPads, etc.). Please carefully read this section regarding battery safety and operation details.

Battery charging and discharging

The battery can be charged when the 44D is on or off, and can be charged from any USB source that can support a 2.4 amp load (wall charger, vehicle adapter, etc. – laptop not recommended) Charging begins automatically when power is applied to the USB port.

When the 44D is powered off there is no charging indication.
When the 44D is on, the battery life display turns yellow indicating the batteries are charging.

Depleted batteries will require 8 hours of charging time to reach a full charge.
Fully charged batteries will support about 8 hours of active operation.

Battery charge indication:	discharging:	Charging:
Bars 4 = Full	8 hours use time remain	trickle charge mode, see NOTE below
Bars 3 ~ 3/4	6-8 hours use time remain	normal charge mode, can use while charging
Bars 2 ~ 1/2	4-6 hours use time remain	normal charge mode, can use while charging
Bars 1 ~ 1/4	2-4 hours use time remain	normal charge mode, can use while charging
Flashing <1/4	0-2 hours use time remain	trickle charge mode, do not use the 44D

NOTE: The 44D can be used when charging, but when the charger is in trickle mode there is not enough current provided to operate the 44D; the batteries will eventually be depleted.

WARNING

The batteries must be discharged to 1/3 or less capacity before the unit can be transported by Air. This is a legal and safety requirement for all lithium batteries.
The internal batteries are not user serviceable. The 44D must be returned to Telewave for service if the batteries no longer accept or retain a sufficient charge.
Excessive cold or hot temperature can damage the batteries or create a fire hazard.

CAUTION

Fully charge the batteries upon initial receipt; also before and after long term storage.
Fully charge the batteries at least once a month during long term storage
The batteries may self-deplete and malfunction unless they are periodically re-charged.
Once the internal charging controller detects that the batteries are fully charged, it will reduce the charging rate to trickle. The rate will remain at trickle until the USB is unplugged.
The 44D can be left on the charger for longer than 24 hours, but this is not recommended.

Operation

Charging Power Supply & International Power Adapters

The included power supply for charging the batteries supports 90 to 250 volts at 50 or 60 hertz. The power plug on the power supply is an IEC international "Plug Type A".

Type A to **Type C, G, and I** adapters are included with the 44D. This AC adapter kit will allow the power supply to be safely connected to the power sockets in most countries.

Visit the International Electro technical Commission (IEC) website for a complete list of socket types, and power voltage/frequencies used in various countries: http://www.iec.ch/worldplugs/.

Description	Picture	Short list of Areas/Countries where the "Type" is used
Type A Plug on the power supply		North and Central America, Japan Directly compatible with **Type B** sockets
Type C Universal to Euro 2P AC Power Plug		Europe (except UK), Ireland, Cyprus, Malta Directly compatable with **Type E, F, J, K, & N** sockets
Type G Universal to UK 3P AC Power Plug		UK, Ireland, Cyprus, Malta, Malaysia, Singapore, Hong Kong
Type I Universal to AUS 3P AC Power Plug		Australia, New Zealand, Papua New Guinea, Argentina, China

Power Control

The 44D has a latching push power button in the lower left corner of the front panel.

To turn the 44D ON, push the power button until you hear a clicking sound and/or you see that the power switch rim is illuminated with a blue glow. After a few seconds the display backlight will illuminate, and the power up sequence will be shown in the display.

The power up sequence, as is seen in the display is:
- The screen backlight will illuminate after about two seconds
- Then the HOME screen will display
- After that the frequency, temperature and battery status indications will be displayed

Once the power up sequence is complete the HOME screen will indicate the settings that were selected when the 44D was previously turned off (units of measurement, backlight level, etc.) The power switch will remain partially depressed while the 44D is turned on.

To turn the 44D OFF, push the power button in slightly further, and release. The switch will return to the flush position, the blue rim light will extinguish, the display backlight will turn off and the display will become blank. There are no lights or display activity when the unit is off.

Sleep Mode

The 44D can be configured to go to "sleep" after few of minutes of inactivity. Inactivity is defined as no function select buttons have been pushed. If the 44D is connected to a transmitter and is reading power, it will still go to sleep if the sleep timer expires (no buttons were pushed.)

Sleep mode is indicated by the following:
- The display backlight will extinguish and the display will be blank/dark
- The 44D will emit a beep sound as it is going to sleep
- The blue ring around power button will remain lit

To wake the 44D, turn off the power button and then turn it back on.
The 44D will boot back to the previous configuration in a few seconds.

⚠ **CAUTION**: The 44D will only go into sleep mode when the HOME screen is displayed. When any screen other than HOME is displayed and the sleep timer expires, the 44D will wait for the user to complete the pending action; and then go to sleep.

⚠ **NOTE**: RF signals will flow though the through line sensor un-impeded with the 44D power turned on or off. Any live circuits that are monitored with the 44D will not be affected if the 44D goes to sleep or is turned off while connected to the circuit.

Menu Tree

HOME Screen and Fields Description

		Battery Status		
FWD (measured forward power)	Measured Value	Avg (W/dBm) or Peak (W/dBm)		
REFL (measured reflected power)	Measured Value	Avg (W/dBm)		
Calculated Info	Calculated Value	VSWR / Return Loss / Crest Factor		
Measured Frequency MHz		Measured Temperature C or F		
MENU	^MEAS	^CALC		

After the system has completed the power up sequence the default screen configuration is shown.

Top Row indicates the Battery Life

The second and third rows indicate results measured from the main thru line connectors. These measurements are the primary function of the 44D.

The forth row indicates calculated results based on the measurements from rows two and three.

The fifth row indicates the measured frequency of the RF signal, and the ambient temperature of the critical RF detector circuits. The 44D compensates for temperature changes, allowing high accuracy at any ambient temperature within the specification range.

⚠ **NOTE**: All measured and calculated indications will be zero "0" or dash "---" until the average power level detected on the forward through line connector exceeds 5 watt (minimum.)

The bottom row indicates the current function of the three buttons located just below the screen. The purpose of each of these buttons change as the needed for easy configuration of the 44D.

The HOME screen function buttons are:
MENU   Open the MAIN menu
^MEAS   Rotate the **Measured** results display between Average or Peak Power
                        in Watts or dBm.
^CALC   Rotate the **Calculated** results display between VSWR / Return Loss,
                        and Crest Factor (indicated in dB in place of PAPR, no linear indication)

MAIN Menu

The main MENU allows access to these categories:
FREQ RANGE   Configure the frequency range Low, Medium or High
MODULATION   Choose the desired modulation type
SETTINGS   Adjust the display parameters
INFO & HELP   Read only attributes and Telewave contact information
EXIT   Return to the HOME screen

⚠ **CAUTION**: The frequency range must be set to the proper range before reading the power.

For the main MENU and all Sub-Menus
- Scroll up and down in the options by pressing the UP and DOWN buttons.
- Pressing the SELECT key will select the currently highlighted item.
- Selecting EXIT will return to the HOME screen without making any changes.

Frequency Range Menu

The menu will list all modulation types supported by the current hardware & firmware version

88-100 MHz	Select for measuring frequencies between 88 and 100 MHz
101-400 MHz	Select for measuring frequencies between 101 and 400 MHz
401-1000 MHz	Select for measuring frequencies between 401 and 1000 MHz (1 GHz)
EXIT	Return to the HOME screen

⚠ **CAUTION**: The Frequency Range is the only mandatory setting. The 44D will not be able to accurately measure the absolute power of the signal if the range is not set correctly.

Modulation

The supported list of modulation types is:

CW, FM, P25 (1&2), DMR/d-PMR, IDAS/NXDN, D-Star, Fusion

The modulation selection toggles between non-TDMA & TDMA type modulations.

- Analog/P25I/CW   Non-TDMA Modulation
- P25II/DMR   TDMA Modulation
- EXIT   Return to the HOME screen

Settings Menu

This menu is for setting the units of measurements and other behavioral parameters of the 44D:

Power Units	Select forward and reverse power display in Watts or dBm
Temperature	Select temperature display in Fahrenheit or Celsius
Backlight	Select the backlight intensity: Low, Medium, High
Power Saving	Select duration of sleep initiation timer
EXIT	Return to the HOME screen

Power saving selections:

Sleep in 30 Min	Select sleep after 30 minutes of inactivity
Sleep in 15 Min	Select sleep after 15 minutes of inactivity
Sleep in 5 Min	Select sleep after 5 minutes of inactivity
Disable Sleep	Select never sleep

Info & Help Menu

This menu is for query of the attributes of the 44D:

About	Display the serial number, hardware and firmware version of the 44D
Help	Display the phone number and email address of Telewave support
EXIT	Return to the HOME screen

Specifications

If the 44D is reading a signal that is outside the range of these specifications; the 44D will indicate that it is "Out of Range". Accuracy of the 44D is compromised when out of range.

Frequency Range

Calibrated Range	88 MHz to 1000 MHz (1 GHz)

Power Range (Constant Envelope) Modulation

Forward Power Average (Min to Max)	5 Watt to 500 Watts (37 dBm to 57 dBm)

Power Range (Non-Constant Envelope) Modulation

Forward Power Average (Min to Max)	5 Watt to 250 Watts (37 dBm to 54 dBm)
Forward Power Peak (Min to Max)	10 Watt to 500 Watts (40 dBm to 57 dBm)

RF and Measurement

RF Impedance of all RF Ports	50 Ohms
Thru-Line RF connectors supported	N-Female
Sample RF port connector supported	SMA-Female
Worse case VSWR (Return Loss) 50 Ohm Line	< 1.21:1 (> 20.5 dB)
RF Insertion Loss (through main RF connectors)	Less than 0.02 dB up to 500 MHz Less than 0.04 dB up to 1 GHz
RF Sample Port Insertion Loss	-50 dB +/- 2 dB from 200 MHz to 1 GHz -50 dB +0/-12 dB from 88 MHz to 200 MHz
See "Appendix – RF Sample Port Isolation" for isolation by frequency details	
Frequency Counter Accuracy	+10/-20 KHz at all frequencies
Maximum Settling Time (Time required to capture, Process, and display the result)	2 Seconds (Pulsed Digital/Analog) 2 Seconds (Continuous Digital) 1 Second (Continuous Analog)
Thru Line Coupler Directivity Minimum	>20 dB
RMS RF Power Measurement Accuracy	+/- 6% from 88 MHz to 1 GHz
Peak RF Power Measurement Accuracy	+/- 6% from 88 MHz to 1 GHz

USB Connector, Battery and Charging

Battery Life	8 hours on time for fully charged batteries
Battery Charge Time	8 hours to fully charge depleted batteries
USB Charger VAC Requirements	90 to 250 VAC at 50 or 60 Hz
Universal Power Plug Adapter Kit IEC (International Electrotechnical Commission)	Charger comes with an IEC **Type A** plug Adapter kit converts to **Type C, G or I** plug Compatible **Type B, E, F, J, K, & N** socket
USB Charger VDC Requirements	5 Volts DC at maximum 2.4 Amps (Simultaneous charging and operation)
USB Connector	USB 2.0 Type B Jack

Mechanical

44D weight	3 lb (1.4 kg)
44D dimensions (LWH) inches (CM) Incl. knobs/feet/connectors - not incl. the handle	6.75" x 5.50" x 4.00" (17.15 x 14.00 x 10.15 cm)
Shipping weight 44D only Shipping weight with optional case	4 lb (1.8 kg) 5 lb. (2.3 kg)
Shipping dimensions (LWH) inches (cm)	10.00" x 8.00" x 6.00" (25.40 x 20.30 x 15.25 cm)

Environmental

International Protection Marking	IEC Standard 60529, IP54
Temperature (High – Storage & Operation)	MIL-810-F, Method 501.4
Humidity	MIL-810-F, Method 507.4
Shock	MIL-810-F, Method 516.5
Humidity Range (Operating / Storage)	35% to 85% non-condensing
Temperature Range Operating (USB Connected)	+32°F to +113°F (0°C to +45°C)
Temperature Range Operating (USB Disconnected)	-4°F to +122°F (-20°C to +50°C)
Temp Range Storage (Long) (USB Disconnected)	+68°F to +86°F (+20°C to +30°C)

Miscellaneous: Accessories, Options, Maintenance

Included Accessories

The 44D comes with:

- Universal (wall wart type) USB power supply (2.4 Amp or greater load capacity)
- USB type A to type B cable
- Universal AC Plug Adapter Kit (complete adapter kit)
    - Type C Male to US Female Adapter (1 each)
    - Type G Male to US Female Adapter (1 each)
    - Type I Male to US Female Adapter   (1 each)

If replacement parts are needed, please source locally

Optional TC44 Leather Carry Case

For transport and storage of the 44D and accessories.   Contact Telewave to order.

Optional "Quick Connect - QC" Thru-Line Connectors

The default connector on the 44D TX and ANT ports is N-Female. The connector is a 4 hole flange "Quick Connect" style, & is field replaceable (internal stinger does not require soldering.)

QC style connectors other than N-Female can be purchased via 3rd party vendors.

Telewave recommends that the connectors not be replaced, but instead use an N to X adapter for situations where an N-Female connector is not compatible with the local cable environment.

The default N style QC connector must be placed back onto the 44D before it is returned to Telewave for any calibration or repair. Telewave will preplace the connector with the default connector, if any type other than "N Female" is attached to either of the thru-line ports.

Maintenance & Calibration

There are no user serviceable parts inside the 44D. Opening the cover voids the calibration.

Telewave recommends returning the 44D to the factory every year for inspection & calibration. Calibration must be done at Telewave, contact Telewave sales for a quote.

Before each 44D is calibrated it will be inspected. A report will be provided detailing any issues found (including battery health test report.) Any deficiencies found will be repaired (warranty for free, non-warranty if customer authorized) and then the 44D will be calibrated. Unrepaired deficiencies may cause calibration failure. Firmware version will be updated to latest, no charge.

To return a 44D to Telewave for calibration or repair; complete the RMA request form located on our web site at https://www.telewave.com/rma-request-form/.

For Sales / RMA request assistance contact sales@telewave.com or call 408-929-4400 Option 1.

For Technical Support assistance contact support@telewave.com or call 408-929-4400 Option 2.

Storage

The 44D can be stored for long periods of time in a climate controlled (cool & dry) environment with no damage. It is recommended to store the 44D in the TC44 Case, or it can be wrapped in a cloth and placed into a box or other container.

If the 44D is accidently left on or turned on when placed into storage, the power controller will eventually turn off the 44D. Even when turned off, the batteries will discharge during storage. The 44D should be removed from storage one a month & fully charged, before return to storage.

WARNING:
Excessive cold or hot temperature can damage the batteries or create a fire hazard.
Verify that the 44D is completely dry before long term storage inside any container.

CAUTION:
Fully charge the batteries upon initial receipt; also before and after long term storage.
Fully charge the batteries at least once a month during long term storage
The batteries may self-deplete and malfunction unless they are periodically re-charged.

Cleaning

The 44D will not be damaged by wiping with a wet cloth, fog, mist, or light rain; when positioned with the display facing to the side or up (either set of rubber feet are facing down.)

To clean the 44D, put some mild liquid soap onto a soft but moist cloth or towel. Wipe the dirt from the 44D with a light touch. Use a rinsed moist towel to clean any residual soap from the 44D. The 44D can air dry or be towel dried.

The optional case can be cleaned using the same procedure.

WARNING:
Make sure the power supply and USB cable are dry before connecting to AC power. An electrical shock hazard exists if the components are wet when plugged in to a mains outlet.
Do not use more than a few drops of water or soap when cleaning the 44D
Excessive water or soap could leak into the 44D and may cause damage or a malfunction.
• The USB connector on the back of the 44D is vulnerable to water intrusion if the 44D is positioned display down.

CAUTION:
• Do not use powder or abrasive soap. These soaps may scratch the case or display cover glass. Scratches or similar damage to the display cover glass are not warrantied.

Appendix: Connecting the 44D to the Circuit

Concepts

RF power will transfer from the source to the destination with the most efficiency when:

- The source and load impedance are the same
- The source and the load are separated from each other by a cable that has been cut so that the electrical length of that cable is a ½ wavelength increment.

When the cables are ½ electrical wavelength increment long, any reflected energy from a load or source mismatch will arrive at the source 180 degrees out of phase compared to the energy emanating from that source. The reflected energy will cancel a portion of the source energy.

Cutting the cables to the proper length in the LMR environment has the following advantages:

- Energy reflected by mismatches is dissipated, rather than bounce back and forth
- Power amplifiers and other components will run cooler (less energy to dissipate)
- Power meters can more accurately read forward vs. reverse power in the circuit
- Impedance mismatches at an antenna/feed interface are less likely to be masked by the losses encountered with long feed lines.
- Inserting a meter into the circuit has less impact on the behavior of the circuit.

To properly connect the 44D to the circuit to be tested, the cables used to insert the 44D into the circuit should be of a length that is close (within 10%) to an increment of ½ wavelength. These cables are a "Primary Cable" (always need) and a "Secondary Cable" (sometimes need).

When calculating the length of the "primary cable", subtract 5 inches (12.5 cm) from the length of the cable to allow for the insertion of the 44D.

When calculating the length of the "secondary cable", do NOT subtract any length for the 44D. This cable should be an exact ½ wavelength increment in length.

It is suggested to have one or two primary cables built for each band that needs to be tested. For example, a cable built to 159 MHz would cover 144 MHz to 174 MHz. Another cable built for 455 MHz would cover 440 to 470 MHz. The key is using the same cables in a consistent manner so that the test results are repeatable, and any system changes are noticed during maintenance.

⚠️ **CAUTION**: The formulas for calculating the cut length of the cable does not consider the length of any lead wire from a connector on a radio, amplifier, cavity or other device in the RF system. In some situations, the length of internal leads and/or cavity loop lengths may need to be considered and the length of the primary and secondary cables shortened to properly compensate.

44D Connection Diagram
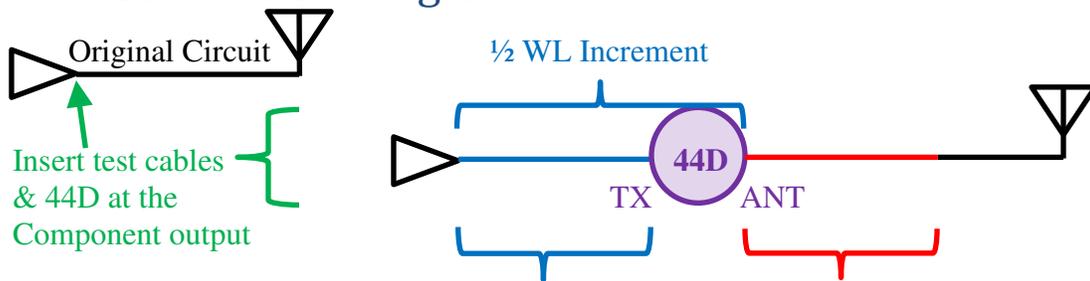
Primary Cable (1/2 WL increment minus 5") Secondary Cable (Optional = ½ WL increment)

Calculating the Primary & Secondary Cable Cut Length

The steps to calculate the length of the cables are:

Find the base cable length:
(Speed of Light in a vacuum (299,792,458 Meters/Second) divided by (Frequency in Hertz))
　　　Times (Velocity Factor of the cable in %) Times (wave length required… 0.5 for ½ etc.)

Sample = ((299792458/445000000) * 0.85 *0.5) = 0.29 meters or 28.6 cm

Subtract 2 cm for the 2 N Male connectors on the end of the cable:
Sample = 28.6 cm minus 2 cm (for two each N Male connectors = 26.6 cm

Subtract 12.5 cm for the 44D:
Sample = 26.6 cm minus 12.5 cm (the distance across the thru line sensor) = 14.1 cm

In this example, the final cut length for the cable would be 14.1 cm.

If a cable is required after the 44D (to reach back to the feed line as an example), that cable should be built to ½ wave length without compensating for the 44D = 26.6 cm cut length

⚠️ **CAUTION**: The samples above are for a ½ wave length cable. The cables can be made longer as needed. Make the cables lengths at a ½ wave length increment: 1.0, 1.5, 2.0, etc.

Sample Primary and Secondary Cable Lengths

The tables assume that the cables will have N Male connectors at each end, thus 2 cm will be subtracted already for the cable cut length.

⚠️ **CAUTION**: The formulas for calculating the cut length of the cable does not consider the length of any lead wire from a connector on a radio, amplifier, cavity or other device in the RF system. In some situations, the length of internal leads and/or cavity loop lengths may need to be considered and the length of the primary and secondary cables shortened to properly compensate.

Velocity Factor 66%

For cables such as: RG-214, RG-213, RG-174, RG-58, and RG-6A

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1 Wave Length Cables

Cable Lengths (Primary Cable and Secondary Cable)

VF	66.0%	Meters		Centimeters		Feet		Inches	
WL	1.0	Pri	Sec	Pri	Sec	Pri	Sec	Pri	Sec
MHz	30.0	6.450	6.575	645.0	657.5	21.2	21.6	254.0	258.9
MHz	40.0	4.802	4.927	480.2	492.7	15.8	16.2	189.0	194.0
MHz	50.0	3.812	3.937	381.2	393.7	12.5	12.9	150.1	155.0
MHz	60.0	3.153	3.278	315.3	327.8	10.3	10.8	124.1	129.0
MHz	70.0	2.682	2.807	268.2	280.7	8.8	9.2	105.6	110.5
MHz	80.0	2.328	2.453	232.8	245.3	7.6	8.0	91.7	96.6
MHz	90.0	2.053	2.178	205.3	217.8	6.7	7.1	80.8	85.8
MHz	100.0	1.834	1.959	183.4	195.9	6.0	6.4	72.2	77.1
MHz	110.0	1.654	1.779	165.4	177.9	5.4	5.8	65.1	70.0
MHz	120.0	1.504	1.629	150.4	162.9	4.9	5.3	59.2	64.1
MHz	130.0	1.377	1.502	137.7	150.2	4.5	4.9	54.2	59.1
MHz	140.0	1.268	1.393	126.8	139.3	4.2	4.6	49.9	54.9
MHz	150.0	1.174	1.299	117.4	129.9	3.9	4.3	46.2	51.1
MHz	160.0	1.092	1.217	109.2	121.7	3.6	4.0	43.0	47.9
MHz	180.0	0.954	1.079	95.4	107.9	3.1	3.5	37.6	42.5
MHz	190.0	0.896	1.021	89.6	102.1	2.9	3.4	35.3	40.2
MHz	200.0	0.844	0.969	84.4	96.9	2.8	3.2	33.2	38.2
MHz	210.0	0.797	0.922	79.7	92.2	2.6	3.0	31.4	36.3
MHz	220.0	0.754	0.879	75.4	87.9	2.5	2.9	29.7	34.6
MHz	230.0	0.715	0.840	71.5	84.0	2.3	2.8	28.2	33.1
MHz	240.0	0.679	0.804	67.9	80.4	2.2	2.6	26.7	31.7

2 Wave Length Cables

Cable Lengths (Primary Cable and Secondary Cable)

VF	66.0%	Meters		Centimeters		Feet		Inches	
WL	2.0	Pri	Sec	Pri	Sec	Pri	Sec	Pri	Sec
MHz	240.0	1.504	1.629	150.4	162.9	4.9	5.3	59.2	64.1
MHz	260.0	1.377	1.502	137.7	150.2	4.5	4.9	54.2	59.1
MHz	280.0	1.268	1.393	126.8	139.3	4.2	4.6	49.9	54.9
MHz	300.0	1.174	1.299	117.4	129.9	3.9	4.3	46.2	51.1
MHz	320.0	1.092	1.217	109.2	121.7	3.6	4.0	43.0	47.9
MHz	340.0	1.019	1.144	101.9	114.4	3.3	3.8	40.1	45.0
MHz	360.0	0.954	1.079	95.4	107.9	3.1	3.5	37.6	42.5
MHz	380.0	0.896	1.021	89.6	102.1	2.9	3.4	35.3	40.2
MHz	400.0	0.844	0.969	84.4	96.9	2.8	3.2	33.2	38.2
MHz	420.0	0.797	0.922	79.7	92.2	2.6	3.0	31.4	36.3
MHz	440.0	0.754	0.879	75.4	87.9	2.5	2.9	29.7	34.6
MHz	460.0	0.715	0.840	71.5	84.0	2.3	2.8	28.2	33.1
MHz	480.0	0.679	0.804	67.9	80.4	2.2	2.6	26.7	31.7
MHz	500.0	0.646	0.771	64.6	77.1	2.1	2.5	25.5	30.4
MHz	520.0	0.616	0.741	61.6	74.1	2.0	2.4	24.3	29.2
MHz	540.0	0.588	0.713	58.8	71.3	1.9	2.3	23.1	28.1
MHz	560.0	0.562	0.687	56.2	68.7	1.8	2.3	22.1	27.0
MHz	580.0	0.537	0.662	53.7	66.2	1.8	2.2	21.2	26.1
MHz	600.0	0.515	0.640	51.5	64.0	1.7	2.1	20.3	25.2

4 Wave Length Cables

		Meters		Centimeters		Feet		Inches	
VF	66.0%								
WL	4.0	Pri	Sec	Pri	Sec	Pri	Sec	Pri	Sec
MHz	600.0	1.174	1.299	117.4	129.9	3.9	4.3	46.2	51.1
MHz	625.0	1.121	1.246	112.1	124.6	3.7	4.1	44.1	49.1
MHz	650.0	1.073	1.198	107.3	119.8	3.5	3.9	42.2	47.2
MHz	700.0	0.986	1.111	98.6	111.1	3.2	3.6	38.8	43.7
MHz	725.0	0.947	1.072	94.7	107.2	3.1	3.5	37.3	42.2
MHz	750.0	0.910	1.035	91.0	103.5	3.0	3.4	35.8	40.8
MHz	775.0	0.876	1.001	87.6	100.1	2.9	3.3	34.5	39.4
MHz	800.0	0.844	0.969	84.4	96.9	2.8	3.2	33.2	38.2
MHz	825.0	0.814	0.939	81.4	93.9	2.7	3.1	32.1	37.0
MHz	850.0	0.786	0.911	78.6	91.1	2.6	3.0	30.9	35.9
MHz	875.0	0.760	0.885	76.0	88.5	2.5	2.9	29.9	34.8
MHz	900.0	0.734	0.859	73.4	85.9	2.4	2.8	28.9	33.8
MHz	925.0	0.711	0.836	71.1	83.6	2.3	2.7	28.0	32.9
MHz	950.0	0.688	0.813	68.8	81.3	2.3	2.7	27.1	32.0
MHz	975.0	0.667	0.792	66.7	79.2	2.2	2.6	26.2	31.2
MHz	1000.0	0.646	0.771	64.6	77.1	2.1	2.5	25.5	30.4

Velocity Factor 85%

For cables such as: LMR-400/240, RG-8U, RG-8X, EcoFlex, CXP-1318, and RF600/400/240

1 Wave Length Cables

Cable Lengths (Primary Cable and Secondary Cable)

		Meters		Centimeters		Feet		Inches	
VF	85%								
WL	1.0	Pri	Sec	Pri	Sec	Pri	Sec	Pri	Sec
MHz	30	8.349	8.474	834.9	847.4	27.4	27.8	328.7	333.6
MHz	40	6.226	6.351	622.6	635.1	20.4	20.8	245.1	250.0
MHz	50	4.951	5.076	495.1	507.6	16.2	16.7	194.9	199.9
MHz	60	4.102	4.227	410.2	422.7	13.5	13.9	161.5	166.4
MHz	70	3.495	3.620	349.5	362.0	11.5	11.9	137.6	142.5
MHz	80	3.040	3.165	304.0	316.5	10.0	10.4	119.7	124.6
MHz	90	2.686	2.811	268.6	281.1	8.8	9.2	105.8	110.7
MHz	100	2.403	2.528	240.3	252.8	7.9	8.3	94.6	99.5
MHz	110	2.172	2.297	217.2	229.7	7.1	7.5	85.5	90.4
MHz	120	1.979	2.104	197.9	210.4	6.5	6.9	77.9	82.8
MHz	130	1.815	1.940	181.5	194.0	6.0	6.4	71.5	76.4
MHz	140	1.675	1.800	167.5	180.0	5.5	5.9	66.0	70.9
MHz	150	1.554	1.679	155.4	167.9	5.1	5.5	61.2	66.1
MHz	160	1.448	1.573	144.8	157.3	4.7	5.2	57.0	61.9
MHz	180	1.271	1.396	127.1	139.6	4.2	4.6	50.0	54.9
MHz	190	1.196	1.321	119.6	132.1	3.9	4.3	47.1	52.0
MHz	200	1.129	1.254	112.9	125.4	3.7	4.1	44.5	49.4
MHz	210	1.068	1.193	106.8	119.3	3.5	3.9	42.1	47.0
MHz	220	1.013	1.138	101.3	113.8	3.3	3.7	39.9	44.8
MHz	230	0.963	1.088	96.3	108.8	3.2	3.6	37.9	42.8
MHz	240	0.917	1.042	91.7	104.2	3.0	3.4	36.1	41.0

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2 Wave Length Cables

Cable Lengths (Primary Cable and Secondary Cable)

VF	85%	Meters		Centimeters		Feet		Inches	
WL	2.0	Pri	Sec	Pri	Sec	Pri	Sec	Pri	Sec
MHz	240	1.979	2.104	197.9	210.4	6.5	6.9	77.9	82.8
MHz	260	1.815	1.940	181.5	194.0	6.0	6.4	71.5	76.4
MHz	280	1.675	1.800	167.5	180.0	5.5	5.9	66.0	70.9
MHz	300	1.554	1.679	155.4	167.9	5.1	5.5	61.2	66.1
MHz	320	1.448	1.573	144.8	157.3	4.7	5.2	57.0	61.9
MHz	340	1.354	1.479	135.4	147.9	4.4	4.9	53.3	58.2
MHz	360	1.271	1.396	127.1	139.6	4.2	4.6	50.0	54.9
MHz	380	1.196	1.321	119.6	132.1	3.9	4.3	47.1	52.0
MHz	400	1.129	1.254	112.9	125.4	3.7	4.1	44.5	49.4
MHz	420	1.068	1.193	106.8	119.3	3.5	3.9	42.1	47.0
MHz	440	1.013	1.138	101.3	113.8	3.3	3.7	39.9	44.8
MHz	460	0.963	1.088	96.3	108.8	3.2	3.6	37.9	42.8
MHz	480	0.917	1.042	91.7	104.2	3.0	3.4	36.1	41.0
MHz	500	0.874	0.999	87.4	99.9	2.9	3.3	34.4	39.3
MHz	520	0.835	0.960	83.5	96.0	2.7	3.1	32.9	37.8
MHz	540	0.799	0.924	79.9	92.4	2.6	3.0	31.4	36.4
MHz	560	0.765	0.890	76.5	89.0	2.5	2.9	30.1	35.0
MHz	580	0.734	0.859	73.4	85.9	2.4	2.8	28.9	33.8
MHz	600	0.704	0.829	70.4	82.9	2.3	2.7	27.7	32.7

4 Wave Length Cables

Cable Lengths (Primary Cable and Secondary Cable)

| VF	85%	Meters		Centimeters		Feet		Inches	
WL	4.0	Pri	Sec	Pri	Sec	Pri	Sec	Pri	Sec
MHz	600	1.554	1.679	155.4	167.9	5.1	5.5	61.2	66.1
MHz	625	1.486	1.611	148.6	161.1	4.9	5.3	58.5	63.4
MHz	650	1.423	1.548	142.3	154.8	4.7	5.1	56.0	61.0
MHz	700	1.311	1.436	131.1	143.6	4.3	4.7	51.6	56.5
MHz	725	1.261	1.386	126.1	138.6	4.1	4.5	49.6	54.6
MHz	750	1.214	1.339	121.4	133.9	4.0	4.4	47.8	52.7
MHz	775	1.170	1.295	117.0	129.5	3.8	4.2	46.1	51.0
MHz	800	1.129	1.254	112.9	125.4	3.7	4.1	44.5	49.4
MHz	825	1.091	1.216	109.1	121.6	3.6	4.0	42.9	47.9
MHz	850	1.054	1.179	105.4	117.9	3.5	3.9	41.5	46.4
MHz	875	1.020	1.145	102.0	114.5	3.3	3.8	40.2	45.1
MHz	900	0.988	1.113	98.8	111.3	3.2	3.7	38.9	43.8
MHz	925	0.957	1.082	95.7	108.2	3.1	3.5	37.7	42.6
MHz	950	0.928	1.053	92.8	105.3	3.0	3.5	36.5	41.5
MHz	975	0.900	1.025	90.0	102.5	3.0	3.4	35.5	40.4
MHz	1000	0.874	0.999	87.4	99.9	2.9	3.3	34.4	39.3

Appendix: RF Sample Port Isolation

The "RF Sample Port" provides a simple and safe path to connect test equipment to the circuit under test. The port is bi-directional, meaning that a signal from either direction of the thru line coupler can be monitored, or a signal can be injected into both directions of the thru line coupler.

The Sample Port is passive and has a usable bandwidth from 30 MHz to 1 GHz.
The active components of the 44D have a narrower bandwidth of 88 MHz to 1 GHz.

The isolation provided by the sample port is consistent at 50 dB +/- 2 dB from 200 MHz up though 1 GHz (the highest frequency supported by the 44D.)

Below 200 MHz the isolation begins to increase as shown in the tables below until it reaches a maximum of ~62.5 dB at 30 MHz. The response is detailed below for situations where absolute power levels need to be measured (from the circuit under test) or injected (into the circuit).

Sample Port response across the full 30 to 1000 MHz
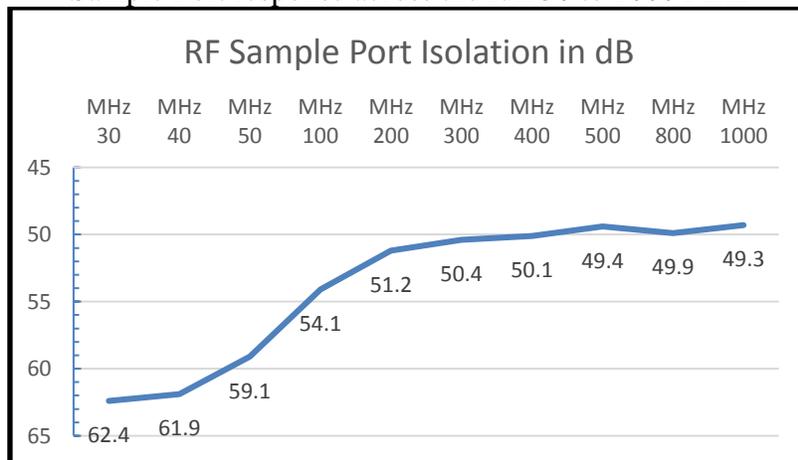
Sample Port response across 30 MHz to 200 MHz`
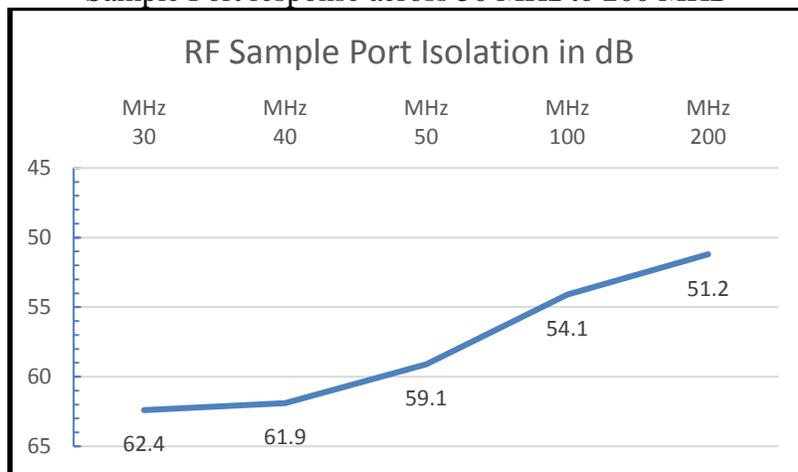
⚠️ **NOTE**: RF signals will flow though the through the sample port un-impeded with the 44D power turned on or off. Any live circuits that are monitored with the 44D will not be affected if the 44D goes to sleep while connected to the circuit.