Microwave Optics System

WA-9314C

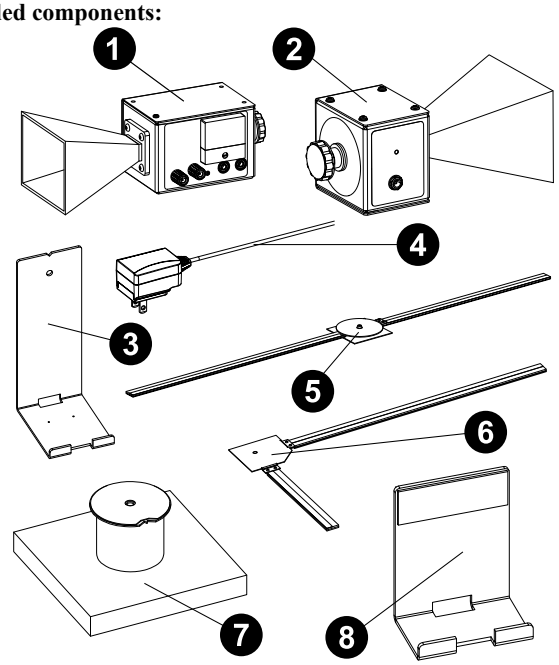
Introduction

There are many advantages to studying optical phenomena at microwave frequencies. Using a 2.85 centimeter microwave wavelength transforms the scale of the experiment, making variables that are usually obscured by the small scale of traditional optics experiments easy to see and manipulate. The Microwave Optics System is designed to take advantage of these benefits. The system includes a 2.85 cm wavelength Microwave Transmitter, a Microwave Receiver with variable amplification from 1X to 30X, and the accessory equipment needed to investigate a variety of wave phenomena.

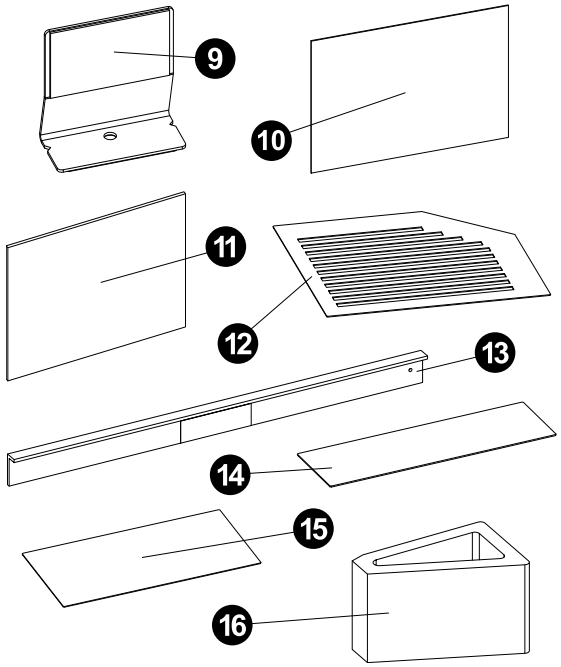
⚠ **WARNING:** Under some circumstances, microwaves can interfere with electronic medical devices. If you use a pacemaker or other electronic medical device, check with your doctor or the manufacturer to make sure that low power microwaves at a frequency of 10.525 GHz will not interfere with its operation.

Components

Included components:



1. Microwave Receiver (WA-9800A)
2. Microwave Transmitter (WA-9801)
3. 2× Microwave Mounting Stands (WA-9802)
4. 2× power adapters (9 V DC, 500 mA, miniature phone jack connector w/ positive tip)
5. Goniometer
6. Fixed arm assembly
7. Rotating table
8. 2× component holders



9. Rotating component holder
10. 2× metal reflectors
11. 2× partial reflectors
12. 2× polarizers
13. Slit extender arm
14. Narrow slit spacer
15. Wide slit spacer
16. Ethafoam prism mold
17. Styrene pellets (not shown)
18. 4× tubular plastic bags (not shown)

Recommended equipment:

- Microwave Accessory Package (WA-9315)
- Microwave Detector Probe (WA-9319A)
- PASCO voltage sensor, such as the Wireless Voltage Sensor (PS-3211)
- PASCO Capstone or Sparkvue data collection software

About the equipment

Gunn diode Microwave Transmitter

The Microwave Transmitter provides 15 milliwatts (mW) of coherent, linearly polarized microwave output at a wavelength of 2.85 cm. The unit consists of a Gunn diode in a 10.525 gigahertz (GHz) resonant cavity, a microwave horn to direct the output, and an 18 cm stand to help reduce tabletop reflections. The Transmitter is powered directly from a standard 115 or 220/240 V alternating current (AC) 50/60 Hz outlet using the included power adapter. Other features include a light-emitting diode (LED) power-on indicator and a rotational degree label on the back panel, which makes it easy to measure the angle of polarization.

The Gunn diode acts as a non-linear resistor that oscillates in the microwave band. The output is linearly polarized along the axis of the diode, and the attached horn radiates a strong beam of microwave radiation centered along the axis of the horn.

> ⚠ **CAUTION:** The output power of the Microwave Transmitter is well within standard safety levels. Nevertheless, do *not* look directly into the microwave horn at close range when the Transmitter is on.

Schottky diode Microwave Receiver

The Microwave Receiver provides a meter reading that, for low amplitude signals, is approximately proportional to the intensity of the incident microwave signal. A microwave horn identical to the Transmitter's collects the microwave signal and channels it into a Schottky diode in a 10.525 GHz resonant cavity. The diode responds only to the component of a microwave signal that is polarized along the diode axis, producing a direct current (DC) voltage that varies with the magnitude of the microwave signal.

The Receiver features four amplification ranges (30X, 10X, 3X, and 1X) and a variable sensitivity knob that allows fine tuning of the amplification in each range. For convenience in class demonstrations, banana plug connectors allow you to send an output signal to a projection voltmeter or to PASCO data collection software. This output can also be used to closely examine the signal using an oscilloscope. Like the Transmitter, the Receiver is powered by a standard wall outlet using the included power adapter and has an LED power-on indicator. An 18 cm high mount minimizes tabletop reflections, and a rotational degree label on the back panel allows convenient measurements of the polarization angle.

The connector labeled "EXTERNAL ANTENNA" on the side of the receiver is for an optional Microwave Detector Probe (WA-9319A). Such a probe works the same way as the Receiver but has no horn or resonant cavity. The probe is particularly convenient for examining wave patterns which might be blocked by the horn.

> ✎ **NOTE:** The detector diode in the Receiver is a non-linear device. This non-linearity will not cause problems for most experiments. However, keep in mind that the meter reading is not directly proportional to either the electric field (E) *or* the intensity (I) of the incident microwave. Instead, it generally reflects an intermediate value.

Goniometer

The goniometer has a square metal base and two arms. The long arm is fixed, while the shorter arm (43 cm long) is free to rotate about the center of the base. Each arm has a magnetic strip on the underside and a metric scale on the top. The top of the base features a circular degree plate. Other accessories, such as the fixed arm assembly, the rotating table, or the rotating component holder, can be mounted on top of the degree plate's center post.

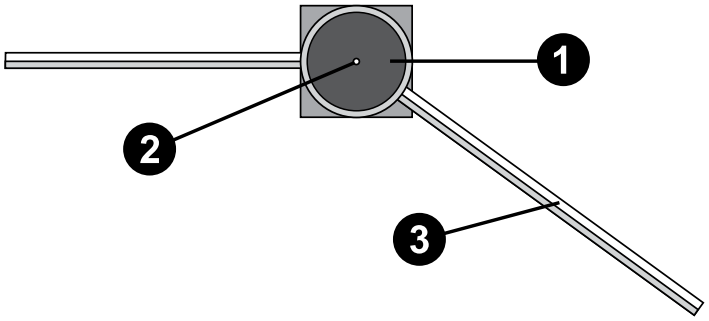


Figure 1. ❶: Degree plate. ❷: Center post. ❸: Metric scale.

Fixed arm assembly

The fixed arm assembly has a pentagonal metal base and two arms, as shown in Figure 2. The base has a circular magnetic pad on its underside and a hole that fits over the center post of the goniometer. Each arm has a magnetic strip on the underside and a metric scale on the top.

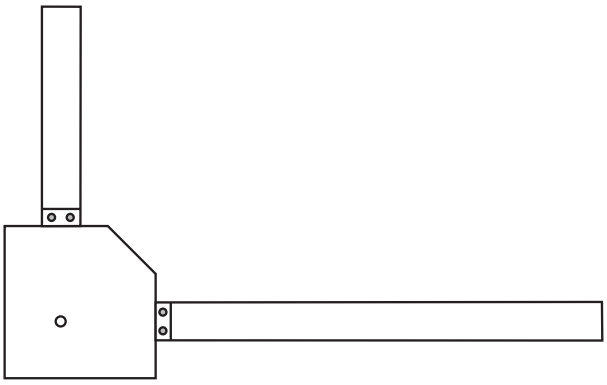


Figure 2

Rotating table

The rotating table has a circular metal base on top of a circular magnetic pad. Both the base and the pad have a hole which can fit on top of the goniometer's center post. The table also has a pedestal and a square platform, both made of ethafoam.

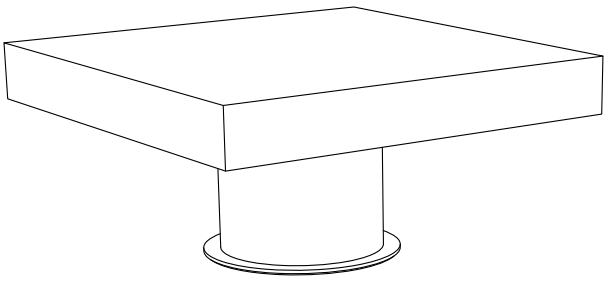


Figure 3

Holders

The component holders have magnetic pads on the front and back at the top of the holder. These holders are designed to fit on the arms of the goniometer or fixed arm assembly. The rotating component holder has a magnetic pad on one side of its upper part and a hole in its base, which fits over the goniometer's center post.

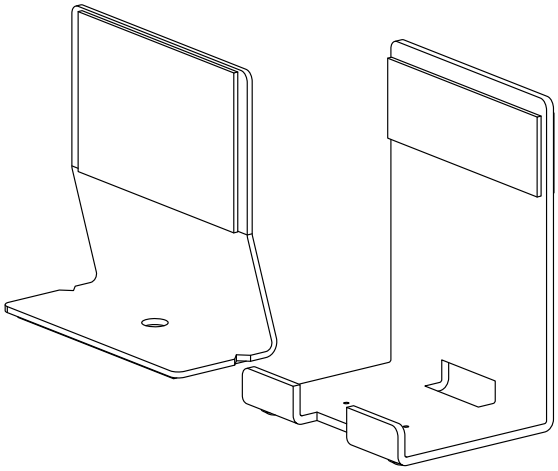


Figure 4: Rotating component holder (left) and component holder (right).

Reflectors

The metal reflectors are thin rectangular sheets of stainless steel that are 6 inches (12.2 cm) by 7 inches (17.7 cm). They can be mounted on the holders' magnetic pads or the slit extender arm's magnetic strip.

The partial reflectors are rectangular pieces of a composite wood-like material (Masonite®) that have a stainless steel pad on the back and a white finish on the front. The steel pad allows the reflector to be mounted on the holders' magnetic pads. They are approximately the same length and width as the metal reflectors.

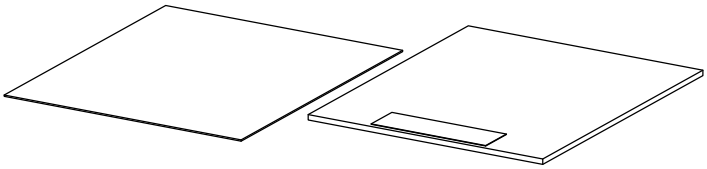


Figure 5. Left: Metal reflector. Right: partial reflector with stainless steel pad.

Polarizers

The polarizers are thin pentagonal sheets of stainless steel with eleven slots. The polarizers can be mounted on the holders' magnetic pads.

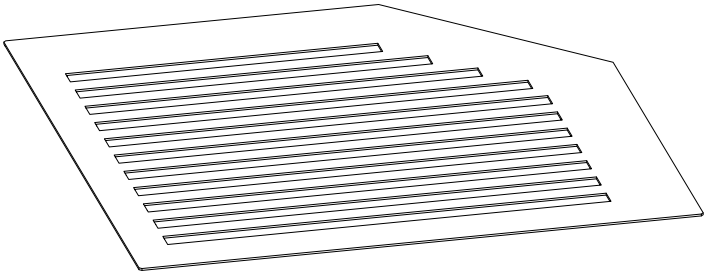


Figure 6

Slit extender arm

The slit extender arm is a piece of metal with an L-shaped cross-section, a magnetic strip on the back, and a small stainless steel pad on the front. The steel pad (indicated by the arrow in Figure 7) allows the arm to be mounted on the magnetic pads of the holders. The reflectors and spacers can be mounted on the magnetic strip.

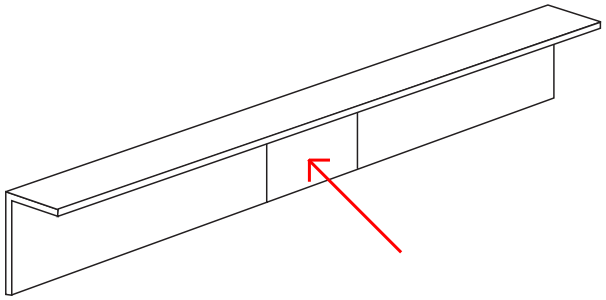


Figure 7: Position of stainless steel pad on slit extender arm.

Slit spacers

The narrow and wide slit spacers are rectangular pieces of stainless steel designed to be used for diffraction experiments. The narrow slit spacer is 2.375 inches (6 cm) by 6 inches (17.7 cm), and the wide slit spacer is 3.5 inches (9 cm) by 6 inches (17.7 cm). The spacers can be mounted on the slit extender arm's magnetic strip or the holders' magnetic pads.

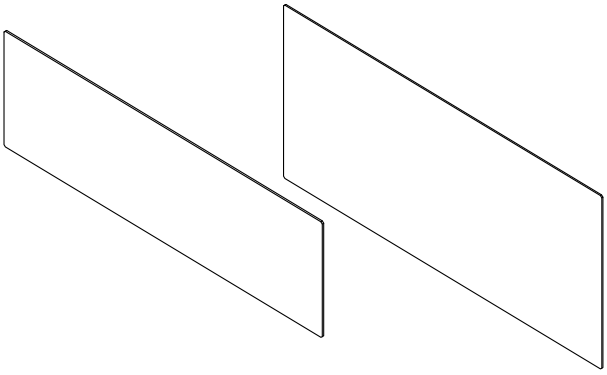


Figure 8

Ethafoam prism mold

The prism mold has a triangular shape and is designed for use in refraction experiments. It can be mounted on the rotating table, which will make sure it is at the same height as the Transmitter and Receiver.

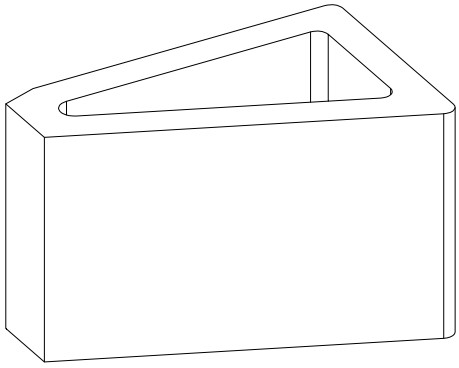


Figure 9

Tubular plastic bags

The tubular plastic bags are designed for use in fiber optics experiments. A bag can be filled with styrene pellets and used as a "light pipe" to demonstrate internal reflection.

Styrene pellets

The styrene pellets can be used with the prism mold for refraction experiments, or with the tubular plastic bags for fiber optics experiments.

Setup

Set up the Transmitter and Receiver

Before performing experiments, follow these steps to attach the Transmitter and Receiver to the Mounting Stands:

1. Remove the hand screw from the back panel of the Receiver.
2. Attach the Receiver to the Mounting Stand, as shown in Figure 10. Place one washer on each side of the stand.

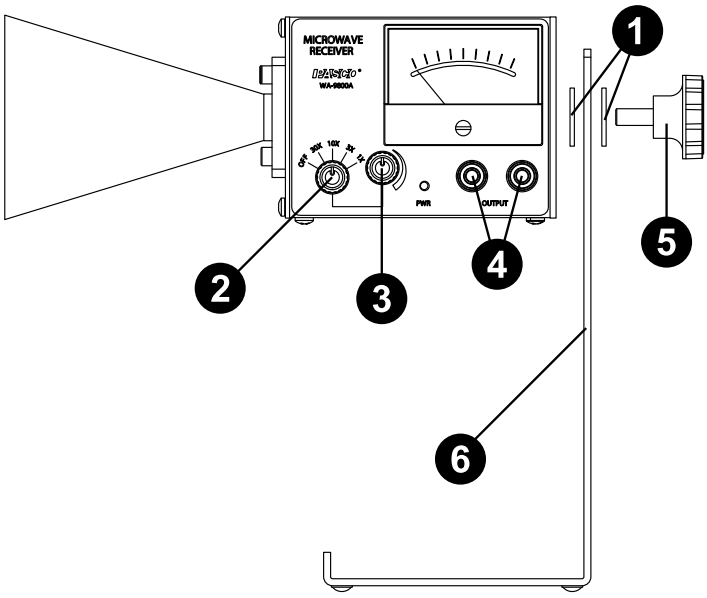


Figure 10: Attach the Microwave Receiver to the Mounting Stand. ❶: Washers. ❷: INTENSITY selection switch. ❸: VARIABLE SENSITIVITY knob. ❹: Output ports. ❺: Hand screw. ❻: Stand.

3. Repeat Steps 1 and 2 for the Transmitter.
4. *Optional:* To adjust the polarization angle of the Transmitter or Receiver, loosen the hand screw, rotate the unit to the desired orientation, and tighten the hand screw again. However, since the Transmitter and Receiver face each other in most experiments, you will need to match the polarization angle. For example, if you rotate one unit to an angle of 10°, you must rotate the other to -10° (350°) to achieve the proper polar alignment.

Operate the Transmitter and Receiver

1. Plug a power adapter cord into the port on the Transmitter's bottom panel (opposite the label), as shown in Figure 11, and plug the power adapter into a standard 115 or 220/240 VAC, 50/60 Hz outlet. The LED will light up when the unit is on.

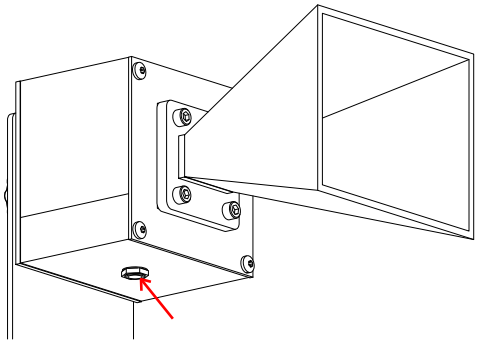


Figure 11: Position of power port.

2. Plug the other power adapter cord into the port labeled "9VDC@500mA" on the Receiver's side panel (opposite the label) and plug the adapter into another standard outlet.
3. Turn the Receiver's INTENSITY selection switch from OFF to 30X, the lowest amplification level. The LED will light up.

> **NOTE:** The INTENSITY selection settings (30X, 10X, 3X, and 1X) are the values you must multiply the meter reading by to normalize your measurements. The 30X selection, for example, means you must multiply the meter reading by 30 to get the same value you would measure for the same signal on the 1X selection. However, this calculation is only exactly accurate if you do not change the position of the VARIABLE SENSITIVITY knob between measurements.

4. Point the Receiver's microwave horn toward the incident microwave signal. Unless polarization effects are under investigation, adjust the polarization angles of the Transmitter and Receiver to the same orientation (IE both horns vertical or both horns horizontal).
5. Adjust the VARIABLE SENSITIVITY knob to attain a meter reading near the middle of the scale. If there is no deflection of the meter, increase the amplification by turning the INTENSITY selection switch clockwise. (Remember to always multiply the meter reading by the appropriate INTENSITY selection if you want to make a quantitative comparison of measurements taken at different selections.)

Zero the Receiver measurement

To zero the measurement displayed on the Receiver's meter:

1. Turn the INTENSITY switch to OFF.
2. Locate the mechanical zero adjustment on the meter, centered just below the meter face.
3. With the meter level and in the horizontal position, use a 1/8" flat-blade screwdriver to adjust the meter needle to read as close to zero as possible.

Assemble the accessories

The arms of the goniometer and fixed arm assembly slide through the holes in the component holders, as shown in Figure 12. Make sure the magnetic strip on the bottom of the arm grips the base of the carriage. To adjust the position of the holders, slide the holders along the arms. Attach the mounting stands of the Microwave Transmitter and Receiver to the arms of the goniometer or fixed arm assembly in the same way.

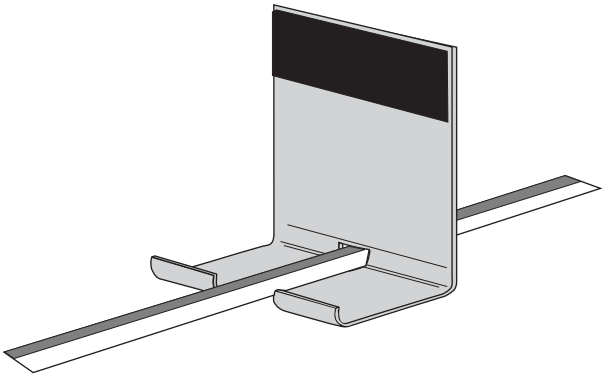


Figure 12: Component holder mounted on arm.

For most experiments, the Transmitter should be attached to the long arm of the goniometer, and the Receiver should be attached to the shorter, rotatable arm. This maintains a fixed relationship between the microwave beam and any components mounted on the goniometer's long arm or degree plate. In turn, the Receiver can move easily to sample the output.

Reflectors, partial reflectors, polarizers, slit spacers, and the slit extender arm can all attach magnetically to the component holders. The metric scales along the goniometer and fixed arm assembly arms, as well as the degree plate at the junction of the goniometer arms, allow easy measurement of component placement.

For best results, the apparatus should be mounted on a clean, smooth table during experiments. Before setting up the accessories, always brush off any material- particularly metal chips- that might have adhered to the magnetic strips and magnetic pads.

Maintenance

This equipment requires little regular maintenance. When not in use, the equipment can be stored in the shipping box. Before storing the equipment, inspect the magnetic strips and pads and remove anything, especially bits of metal, that may have adhered to them.

If technical problems arise with the equipment, do NOT attempt to fix the equipment yourself, especially if it involves the Receiver or Transmitter. Instead, contact PASCO scientific for advice. (See **Technical support** for contact information.)

Additional accessories

The following accessories, sold separately, are recommended for use with the Microwave Optics System.

Microwave Accessory Package

The Microwave Accessory Package (WA-9315) includes two components: a cubic lattice and a polyethylene panel. The cubic lattice contains 100 steel spheres arranged in a 5x5x4 array and is designed to be used for Bragg's crystal diffraction experiments. The polyethylene panel is designed to be used in Brewster's Angle experiments.

Microwave Detector Probe

The Microwave Detector Probe (WA-9319A) plugs directly into the EXTERNAL ANTENNA port on the side of the Microwave Receiver. The probe is essential for experiments in which the horn of the Receiver might otherwise interfere with the wave pattern being measured. The probe is approximately 7.5 cm by 14.5 cm and can be mounted on the magnetic pad of a component holder.

Experiment files

The Experiment Guide for the Microwave Optics System contains several student-ready activities which can be completed using the system and its recommended accessories. To view and download the Experiment Guide, visit the product page at pasco.com/product/WA-9314C and select the **Documents** tab.

Technical support

Need more help? Our knowledgeable and friendly Technical Support staff is ready to answer your questions or walk you through any issues.

Web	pasco.com/support
Chat	pasco.com
Email	support@pasco.com
Phone	1-800-772-8700 x1004 (USA) +1 916 462 8384 (outside USA)

Limited warranty

For a description of the product warranty, see the Warranty and Returns page at www.pasco.com/legal.

Product end-of-life disposal

This electronic product is subject to disposal and recycling regulations that vary by country and region. It is your responsibility to recycle your electronic equipment per your local environmental laws and regulations to ensure that it will be recycled in a manner that protects human health and the environment. To find out where you can drop off your waste equipment for recycling, please contact your local waste recycle or disposal service, or the place where you purchased the product. The European Union WEEE (Waste Electronic and Electrical Equipment) symbol on the product or its packaging indicates that this product must not be disposed of in a standard waste container.

CE statement

This device has been tested and found to comply with the essential requirements and other relevant provisions of the applicable EU Directives.

FCC statement

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

(1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.