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INTRODUCTION

Electronic communication is the transfer of information from one point to another by a direct electrical connection (wire or cable), waveguide (optical fiber or microwave transmission line) or by wireless means (radio, television, microwave or lightwave).

There are many categories of electronic communication. For instance, voice communications can be 1-way as in a radio or television news broadcast, or voice communications can be 2-way as in conversations via telephone, intercom and both amateur and citizens band radio. Examples of non-voice communication include Morse code, teletype writer signals, computer data transmission and wildlife telemetry. Radio control is a form of communication in which the transmitted information controls a remote device such as a camera, garage door or model boat or plane.

CIRCUIT ASSEMBLY TIPS

The circuits that follow can be assembled from readily available supplies. You can usually substitute similar components if those specified are unavailable. For instance, a 25,000 (50K) ohm potentiometer can be substituted for a 10,000 (10K) unit. Be sure to bypass the power supply pins of operational and power amplifier IC's (tie them to ground with a 0.1 microfarad capacitor connected close to the IC). This will help prevent unwanted oscillation. For additional information, see "Getting Started in Electronics" (Radio Shack, 1983) and other books in this series.
CONNECTED COMMUNICATION LINKS

Connected communication links are those in which two or more stations are linked by a wire, cable, or waveguide.

Advantages include reliability, low noise, and simple electronics. However, connected links require right-of-way and can be very expensive to install. Furthermore, only connected stations can communicate.

SINGLE WIRE

Telegraph links. Ground required at each end.

TWISTED PAIR

Telephones (up to 15 channels) and digital data transmission.

COAXIAL CABLE

Can carry up to 90,000 voice channels.

HOLLOW WAVEGUIDE

Can carry microwave signal modulated with 100,000+ voice channels.

OPTICAL FIBER

Can carry lightwave modulated with 100,000 or more voice channels.

WIRELESS COMMUNICATION LINKS

Wireless communications links are those in which information is sent to one or more receivers by means of a modulated electromagnetic wave.

Advantages include long distance communication, transmission to and from land, air, and space vehicles, and both directional and non-directional transmission, subject to interfering noise.

RADIO

Broadcast and shortwave radio. Also amateur radio, citizen's band, mobile, etc.

VHF

Television and FM radio. Also aircraft, amateur radio, mobile, space, etc.

UHF

Weather balloons, television, mobile, navigation, amateur, satellite, deep space, etc.

MICROWAVE

Communications, satellite, long distance telephone, navigation, amateur, etc.

LIGHTWAVE

Line-of-sight computer data transmission, and voice links.
ELECTROMAGNETIC RADIATION

Electromagnetic radiation is energy in the form of a wave of oscillating electric and magnetic fields. The wave travels through a vacuum at a velocity of \(2.998 \times 10^8\) meters per second (186,284 miles per second). The wavelength of an electromagnetic wave determines its properties. X-rays, infrared, microwaves, radio waves, and light are electromagnetic radiation.

ELECTROMAGNETIC SPECTRUM

<table>
<thead>
<tr>
<th>Unit</th>
<th>Definition</th>
<th>Conversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>nm</td>
<td>Nanometer (1 nm = 0.000,000,001 m)</td>
<td>1 nm = 10(^{-9}) m</td>
</tr>
<tr>
<td>µm</td>
<td>Micrometer (1 µm = 0.000,001 m)</td>
<td>1 µm = 10(^{-6}) m</td>
</tr>
<tr>
<td>mm</td>
<td>Millimeter (1 mm = 0.001 m)</td>
<td>1 mm = 10(^{-3}) m</td>
</tr>
<tr>
<td>m</td>
<td>Meter (1 m = 39.37 inches)</td>
<td>1 m = 10(^{-1}) m</td>
</tr>
<tr>
<td>km</td>
<td>Kilometer (1 km = 1,000 m)</td>
<td>1 km = 10(^{-3}) m</td>
</tr>
</tbody>
</table>

Violet, Yellow, Near Infrared

Visible Light

X-rays, Ultraviolet, Infrared

WAVELENGTH VS FREQUENCY

The frequency of an electromagnetic wave is the number of cycles that occur in one second.

\[1 \text{ cycle/second} = 1 \text{ hertz} (\text{Hz})\]

If either the frequency or length of a wave is known, the unknown value can be calculated:

\[
\text{Frequency (Hz)} = \frac{C}{\text{Wavelength} (\lambda)}
\]

\[
\text{Wavelength} (\lambda) = \frac{C}{\text{Frequency} (\text{Hz})}
\]

\[C = 3 \times 10^8 \text{ meters per second}\]
INTERNATIONAL MORSE CODE

In 1836, Samuel F.B. Morse built the first working telegraph. He also devised a code that permitted telegraph operators to exchange information. His code is still used by telegraph, radio, and signal light operators. Here it is:

<table>
<thead>
<tr>
<th>Code</th>
<th>Sound</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>-</td>
</tr>
<tr>
<td>B</td>
<td>-...</td>
</tr>
<tr>
<td>C</td>
<td>-.-</td>
</tr>
<tr>
<td>D</td>
<td>-..</td>
</tr>
<tr>
<td>E</td>
<td>.</td>
</tr>
<tr>
<td>F</td>
<td>..-</td>
</tr>
<tr>
<td>G</td>
<td>...</td>
</tr>
<tr>
<td>H</td>
<td>--.</td>
</tr>
<tr>
<td>I</td>
<td>.-.</td>
</tr>
<tr>
<td>J</td>
<td>-..-</td>
</tr>
<tr>
<td>K</td>
<td>-.-.</td>
</tr>
<tr>
<td>L</td>
<td>-..</td>
</tr>
<tr>
<td>M</td>
<td>--</td>
</tr>
<tr>
<td>N</td>
<td>-</td>
</tr>
<tr>
<td>O</td>
<td>---</td>
</tr>
<tr>
<td>P</td>
<td>.--</td>
</tr>
<tr>
<td>Q</td>
<td>--.</td>
</tr>
<tr>
<td>R</td>
<td>-.</td>
</tr>
<tr>
<td>S</td>
<td>...</td>
</tr>
<tr>
<td>T</td>
<td>-</td>
</tr>
<tr>
<td>U</td>
<td>..</td>
</tr>
<tr>
<td>V</td>
<td>.-.</td>
</tr>
<tr>
<td>W</td>
<td>.--.</td>
</tr>
<tr>
<td>X</td>
<td>-.-.</td>
</tr>
<tr>
<td>Y</td>
<td>.-.-</td>
</tr>
<tr>
<td>Z</td>
<td>--.-</td>
</tr>
</tbody>
</table>

The code includes many additional punctuation marks, phrases and abbreviations.

LEARNING THE CODE

Think of the code as sounds, not dots and dashes. Say "dit" for dot and "dah" for dash. Thus, A is "dit dah" or simply "dit". B is "dah dit dit". C is "dah dah dit dit".

A code practice oscillator can help you learn the code. Even better is the cassette tape included with the "Tune in the World With Ham Radio" kit available from the American Radio Relay League (ARRL) in Newington, CT 06111. The text supplied with the kit is an excellent introduction to the world of amateur radio. It covers electrical theory, equipment, antennas, etc.
ELECTROMAGNETIC TELEGRAPH

There are many ways to make simple telegraphs. For example, the code practice oscillators on the previous page can be used in a solid-state telegraph system. The components of a do-it-yourself electromagnetic telegraph are given here. You can build the telegraph on the facing page in a few hours.

INVENTOR: S.F.B. Morse (1836)

6-32 HARDWARE

HEAT-SHRINKABLE TUBING

REMOVE VARNISH WITH MATCH FLAME AND FINE SAND PAPER.

(2X ACTUAL SIZE)

ELECTROMAGNET

PRESS KEY TO ACTIVATE SOUNDER

KEY

BATTERY (3 TO 4 VOLTS) ARMATURE SCREW SHOULD TOUCH SOUNDING PLATE WHEN THE KEY IS NOT PRESSED.

ALUMINUM PLATE (NON-MAGNETIC)

ARMATURE (FLEXIBLE)

CONNECT KEY, SOUNDER AND BATTERY WITH WIRES FITTED WITH BANANA PLUGS. USE WOOD OR PERFORATED BOARD FOR BASES. USE ALUMINUM BRACKETS FROM HARDWARE STORE OR MAKE FROM HOBBY SHOP METAL. CUT PLASTIC ARMATURE FROM ONE GALLON MILK CONTAINER. DOT = PRESS/RELEASE (CLICK/CLICK), DASH = PRESS/HOLD/RELEASE (CLICK/SPACE/C CLICK).
SOLID-STATE TELEGRAPHS

Transistors and integrated circuits make possible very sensitive telegraph systems.

Caution: Never install telegraph, intercom or telephone wires near outdoor power lines.

SIMPLE SOLID-STATE TELEGRAPH

1-OR 2-WIRE TELEGRAPH SENDER

2-WIRE TELEGRAPH SOUNDER

R1 controls volume. For more gain add 10 µF from Pin 4 to Pin 8. Do not use earphone.

Earth ground for 1-wire link. Circuit, not Earth, ground.
TELEPHONE RECEIVER

A simple telephone receiver is easily made from readily available materials:

1/8" hole
1/16" hole

4-32 nut
1/2" furniture leg tip

Electromagnet (page 8)

L-32 thin gap
PAPER THIN GAP

Steel armature
PLASTIC FILM

5/8" brass tubing (hobby shop)

ARMATURE IS 3/16" SQUARE,
1/32" THICK STEEL (SCRAP OR
CUT FROM SHEET). ATTACH TO
PLASTIC WITH DOUBLE-SIDED
TAPE

INVENTOR:
PROF. A.G. BELL (1876)

ADD 100 OHM RESISTOR.
CONNECT LEADS TO
BATTERY-POWERED
RADIO PHONE. TACK
TO TEST. VOLUME WILL
BE LOW SINCE COIL
RESISTANCE IS ONLY
1.54 OHMS.

REMOTE STATION

PUSH-TO-TALK INTERCOM

CIRCUIT OSCILLATES?
REDUCE R2.

BASE STATION

S1: DPDT SWITCH.
R2: CONTROLS 741
GAIN. OK TO USE
FIXED RESISTOR.
R3: CONTROLS VOLUME.

IMPORTANT: BYPASS
POWER SUPPLY PINS
TO GROUND WITH
0.1 uF CAPACITORS.

USE SHIELDED CABLE
TO REDUCE NOISE.
(Power line hum, etc.). GROUND
THE SHIELD.

ADD ON/OFF
SWITCH TO
SAVE BATTERY LIFE.
LIGHTWAVE COMMUNICATIONS

1876 - ALEXANDER GRAHAM BELL INVENTED THE PHOTOPHONE, A DEVICE FOR SENDING VOICE OVER A BEAM OF SUNLIGHT.

1880 - BELL AND SUMNER Tainter SENT VOICE MESSAGES OVER A 213 METER PATH.

1966 - K.C. KAO PROPOSED LONG DISTANCE OPTICAL FIBER COMMUNICATIONS.

MODULATION

A LIGHTWAVE CAN CARRY DIGITAL DATA OR ANALOG INFORMATION SUCH AS VOICE. SHOWN BELOW ARE SOME WAYS IN WHICH A LIGHT WAVE CAN BE ANALOG MODULATED.

ANALOG SIGNAL

TYPICAL ANALOG SIGNAL (TEMPERATURE, TONE, ETC.).

AMPLITUDE

ANALOG SIGNAL CONTROLS INTENSITY OF LIGHT.

PULSE AMPLITUDE

ANALOG SIGNAL CONTROLS INTENSITY OF PULSES.

PULSE FREQUENCY

ANALOG SIGNAL CONTROLS FREQUENCY OF PULSES.

LIGHT SOURCES

MANY LIGHT SOURCES CAN BE USED IN LIGHTWAVE COMMUNICATION SYSTEMS. AMONG THE EASIEST TO USE ARE:

1. SUNLIGHT - USED IN THE FIRST LIGHTWAVE COMMUNICATORS AND STILL VERY EASY TO USE.

2. INCANDESCENT LAMP - LAMPS WITH SMALL FILAMENTS CAN BE VOICE MODULATED. NOT SUITABLE FOR HIGH FREQUENCY SIGNALS.

3. LIGHT Emitting Diode (LED) - IDEAL SOURCE. BOTH VISIBLE AND INVISIBLE WAVELENGTHS CAN BE MODULATED AT HIGH FREQUENCIES.

LIGHT DETECTORS

DETECTORS FOR LIGHTWAVE COMMUNICATION LINKS ARE USUALLY SOLID-STATE DEVICES. AMONG THE MOST COMMONLY USED ARE:

1. SOLAR CELL - INEXPENSIVE AND EASY TO USE. PEAK SENSITIVITY IS ~ 880 nm. CAN BE USED FROM ~ 450 nm TO ~ 1200 nm.

2. PHOTOTRANSISTOR - FASTER AND MORE SENSITIVE THAN SOLAR CELLS. SAME SPECTRAL RESPONSE. EXTERNAL LENS HELPFUL.

3. LIGHT Emitting Diode (AN LED) CAN DETECT THE EMISSION FROM A SIMILAR LED. RED AND NEAR-INFRARED LEDs WORK BEST AS DETECTORS.
LIGHTWAVE SYSTEMS

MODULATED LIGHT WAVES CAN BE SENT THROUGH AIR (FREE SPACE) OR ULTRA-CLEAR OPTICAL FIBERS.

<table>
<thead>
<tr>
<th>Link</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>FREE SPACE</td>
<td>1. No license</td>
<td>1. Hard to align</td>
</tr>
<tr>
<td></td>
<td>2. Privacy</td>
<td>2. Line of sight</td>
</tr>
<tr>
<td></td>
<td>3. Jam proof</td>
<td>3. Rain and fog</td>
</tr>
<tr>
<td>FIBER</td>
<td>1. Very low noise</td>
<td>1. Installation</td>
</tr>
<tr>
<td></td>
<td>2. Lightning proof</td>
<td>2. Higher cost</td>
</tr>
</tbody>
</table>

FREE SPACE LINKS

SHORT RANGE SYSTEMS (0 TO 10 FEET) VERY EASY TO DESIGN AND ALIGN. LONGER RANGES USUALLY REQUIRE EXTERNAL LENSES AND TRIPODS.

ALIGNMENT METHODS INCLUDE:

1. REFLECTOR - USE RED LED AND PLACE LINE REFLECTOR NEXT TO RECEIVER. POINT TRANSMITTER AT REFLECTOR.

2. TELESCOPE - BORESIGHT (DEPARTMENT STORE ETC), A SMALL TELESCOPE MOUNTED ON THE TRANSMITTER.

OPTICAL FIBER LINKS

EXPOSED FIBER

PLASTIC FIBER IS INEXPENSIVE AND CAN BE CUT WITH A SHARP KNIFE. DISTANCES OF FROM SEVERAL TO MANY HUNDREDS OF FEET POSSIBLE.

USE LEDS AND DETECTORS IN PLASTIC RECEPTACLES LIKE THESE OR CONNECT FIBER DIRECTLY TO DEVICES WITH EPOXY AND HEAT SHRINK TUBING.
Electronic Photophone

After he invented the photophone in 1880, Alexander Graham Bell invented the electric photophone. In the non-electric photophone, a beam of sunlight was directly modulated by voice pressure against a flexible mirror or movable grating. In the electric photophone, sunlight was modulated by a mirror attached to a telephone receiver. Shown here is a modern version of the electric photophone.

Keep battery leads short and connect 0.1μF capacitors from power supply pins of each chip to ground.

Important: The speakers may emit very loud sounds, do not place your feet close to either speaker.

Caution: Both operators must wear sunglasses and avoid staring at reflected sunlight.

Use tripods for best results. Reflected sunlight from flexible reflector should form a distinct spot when directed against a nearby wall.

Note that the speakers function as sound sources in receive mode.
LIGHTWAVE CODE TRANSMITTERS

SIMPLE CODE COMMUNICATORS CAN BE USED TO SEND MESSAGES, WARNING SIGNALS, ETC.

FLASHLIGHT SYSTEM

INFRARED SYSTEM

PULSE MODULATED SYSTEM

LIGHTWAVE CODE RECEIVERS

THESE RECEIVERS MUST BE KEPT FROM EXTERNAL LIGHT SOURCES. THE FIRST TWO ARE LIGHT-ACTUATED TONE GENERATORS.
FLASHLIGHT VOICE TRANSMITTERS

These simple AM systems demonstrate that incandescent lamps can be voice modulated.

BASIC VOICE TRANSMITTER

PHONE JACK

RADIO OR AMPLIFIER

1K

B1

3V

L1

NO. 243 OR 222 LENS

T1

MUST BE BATTERY POWERED.

T1 IS MINIATURE 1K: B.2 OUTPUT TRANSFORMER. SINCE MOST PHONE JACKS ARE B.2, MUCH BETTER RESULTS WILL BE OBTAINED WITH TWO BACK-TO-BACK TRANSFORMERS. CONNECT 1K WINDINGS OF THE TRANSFORMERS TOGETHER, THEN CONNECT ONE 8.2 WINDING TO RADIO OR AMPLIFIER AND THE OTHER TO THE LAMP AND BATTERY.

BETTER VOICE TRANSMITTER

AVERAGE CURRENT THROUGH Q2 IS 230mA. USE POWER TRANSISTOR IF Q2 OVERHEATS.

Q1 2N2222

R1 1.5K

R2 2N2222

Q2 4.7K

R3 4.7K

L1 NO. 243 OR 222 LENS

HEAT SINK MAY BE NECESSARY.

SOUND QUALITY IS GOOD.

BATTERY POWERED AMPLIFIER

SPEAKER

POWERED

TRANSISTOR VOICE RECEIVER

T1

R1 47K

R2 47K

Q2 2N2222

Q1 2N2222

C1 1µF

C2 47µF

R3 4.7K

R4 1K

+9V

OK TO DELETE Q1, R1 AND C1 AND CONNECT SOLAR CELL BETWEEN Q2’S BASE (CELL ANODE) AND GROUND (CELL CATHODE).

FOR MORE VOLUME USE RECEIVER ON PAGE 29.
AM LIGHTWAVE TRANSMITTER

THIS TRANSMITTER WILL SEND YOUR VOICE TO THE RECEIVER ON FACING PAGE. AT NIGHT AND WHEN LENSES ARE USED, A RANGE OF SEVERAL HUNDRED OR MORE FEET IS POSSIBLE. INFRARED LED WILL GIVE BEST RESULTS. HIGH-BRIGHTNESS RED LED WILL ALSO WORK, ESPECIALLY WHEN OPTICAL FIBER IS USED. USE TRIPODS FOR BEST RESULTS IN FREE-SPACE MODE. LENS CAN BE MAGNIFIER.

R2 - GAIN CONTROL
R5 - LED BIAS CONTROL. ADJUST RS FOR BEST SOUND QUALITY AT RECEIVER. R7 - LIMITS CURRENT APPLIED TO LED.

KEEP BATTERY LEADS SHORT.

AM LIGHTWAVE RECEIVER

Q1 MUST BE SHIELDED FROM EXTERNAL LIGHT. USE COLLIMATOR IN FRONT OF LEN. USE DEVELOPED COLOR FILM. AS INFRARED FILTER.

UNLESS TRANSMITTER LED EMITS RED LIGHT. C3

KEEP BATTERY LEADS SHORT. C3 AND C4 PREVENT OSCILLATION. C4 (CONNECT CLOSE TO CIRCUIT.)

CAUTION: THIS CIRCUIT CAN PRODUCE VERY LOUD SOUNDS. DO NOT PLACE SPEAKER CLOSE TO YOUR EARS OR USE EARPHONE.
**PFM LIGHTWAVE TRANSMITTER**

Adjust Rs until tone is not heard from receiver. +9V R7 controls LED current.

**PFM LIGHTWAVE RECEIVER**

Unlike AM, PFM gives uniform volume over entire reception range.

Reduce R2 to reduce gain of first 741.

Rs and C3 form a low-pass filter. Increase C3 from 1 µF to 10 µF to change emphasis from high to low frequencies.

---

**Diagram Details**

Transmitter: R2 controls gain of 741. Microphone amplifier SSM generates steady stream of pulses having a repetition rate controlled by Rs. Audio signal applied to pins of SSM modulates the pulse rate. Use super bright red or infrared LED. Keep battery leads short. PFM gives uniform receiver volume.

Receiver: Q1 receives pulses from the LED. The pulses are amplified by the first 741. The second 741 is connected as a comparator that delivers an output pulse when the input pulse exceeds the reference voltage set by R4. The pulses are low-pass filtered by Rs and C3 and amplified by the 386. Adjust Rs of transmitter and R4 of receiver for best sound quality.

Caution: This circuit C5 can produce very loud sound: do not place speaker close to your ear or use earphone.
RADIO COMMUNICATIONS

1886—Heinrich Hertz sent waves from a spark discharge to a loop of wire. A small spark appeared at a gap in the loop.

1895—Guglielmo Marconi invented the wireless telegraph.

1899—Marconi sent "..." across Atlantic Ocean.

MODULATION

When a pure radio-frequency wave (the carrier) is mixed with a signal such as voice, the wave is said to be modulated.

DAMPED WAVE (SPARK GAP)

OK for code, but not legal since many wavelengths are emitted.

CARRIER WAVE

Pure, unmodulated radio-frequency wave; no signal carried.

AMPLITUDE MODULATION

Constant frequency; amplitude varies with input signal (voice, etc.).

FREQUENCY MODULATION

Constant amplitude; frequency varies with input signal (voice, etc.). Gives noise-free reception.

AMATEUR RADIO

Radio communication has always attracted many thousands of enthusiastic amateur radio operators. They were among the first to discover that shortwaves permit worldwide communication. They provide communications during natural disasters and emergencies, and they communicate with fellow amateurs across town and halfway around the world.

Amateur or ham radio operators are licensed and assigned a call sign by the Federal Government. Prospective hams must pass a written exam. For more information, contact the American Radio Relay League (ARRL) in Newton, CT 06470. The ARRL sells excellent publications for both prospective and established hams.

CITIZENS BAND RADIO

The Citizens Band is 40 channels in the vicinity of 27 MHz. These channels are intended for two-way personal and business communication. One channel (9) is reserved for emergency transmissions. Though no license is required, citizens band (CB) operators have fewer privileges than amateur radio operators. For example, maximum transmitted power is limited to 4 watts.

FEDERAL COMMUNICATIONS COMMISSION

The Federal Communications Commission (FCC) regulates radio communication in the United States. Violations of FCC regulations can result in severe penalties. You can write the FCC (Gettysburg, PA 17326) to request information about its regulations.
DIODE RECEIVER BASICS

A radio-frequency (RF) electromagnetic wave will cause a fluctuating current to flow in a wire antenna:

- Current produced by tone-modulated RF signal.
- Current produced by voice-modulated RF signal.

The fluctuating current can be transformed into sound by removing the positive or negative half of the wave with a diode.

The signal is now said to be rectified. The two halves of the wave will not cancel one another. When the output is monitored, therefore, the audio signal superimposed on the RF signal can be heard from a small earphone connected to the diode.

SIMPLE RF TUNING COIL

1. Wrap plastic film can with 1-1/2" wide, 2-sided tape.
2. Wrap 1-3/8" wide section of tape with 30 Ga. magnet wire.
3. Sandpaper the insulation from thin strip along coil.
4. Cement coil to base.

TUNE BY ADJUSTING SLIDER ON L1. LOUD POPS MAY OCCUR WHEN SLIDER IS MOVED. VOLUME CAN BE VERY LOUD. CAUTION: DON'T USE EARPHONES.
SHORTWAVE LISTENING

FEW HOBBIES ARE AS REWARDING OR INTELLECTUALLY STIMULATING AS SHORTWAVE LISTENING. YET MANY PEOPLE HAVE NEVER LISTENED TO A SHORTWAVE RADIO, EVEN A VERY INEXPENSIVE SHORTWAVE RADIO CAN RECEIVE BROADCASTS FROM HUNDREDS OF STATIONS AROUND THE WORLD. MANY OF THEM ARE IN ENGLISH. SHORTWAVE BROADCASTS CAN BE DIVIDED INTO THREE BROAD CATEGORIES:

INTERNATIONAL BROADCASTS—THOSE ORIGINATE FROM BOTH PRIVATE AND GOVERNMENT STATIONS AND ARE INTENDED FOR A WIDE AUDIENCE. PROGRAMMING, OFTEN IN ENGLISH, INCLUDES NEWS, WEATHER, INTERVIEWS, DRAMA AND LISTENER MAIL.

PERSONAL COMMUNICATIONS—THIS CATEGORY INCLUDES AMATEUR AND CITIZENS BAND RADIO.

UTILITIES—VIRTUALLY ALL BROADCASTS NOT LISTED ABOVE CAN BE CONSIDERED UTILITIES. THESE INCLUDE TIME SIGNALS, COMPUTER TRANSMISSIONS, WEATHER REPORTS, SATELLITE SIGNALS AND MANY KINDS OF INDUSTRIAL AND GOVERNMENT TRANSMISSIONS. INCLUDED ARE TELECOMMUNICATIONS TO AND FROM SHIPS, AIRCRAFT, TAXIS AND COMMERCIAL VEHICLES. ALSO INCLUDED ARE TRANSMISSIONS FROM SPY RADIO CONTROL, TRACKING, SURVEILLANCE, TELEMETRY, WEATHER BALLOON AND OCEAN BUOY TRANSMITTERS.

MANY OF THESE TRANSMISSIONS ARE BROADCAST AT FREQUENCIES BETWEEN THE BROADCAST BAND AND 30 MHZ. THE SIMPLE RECEIVER ON THE FACING PAGE CAN RECEIVE SIGNALS FROM 1 TO 6 MHZ. IN ONE EVENING THIS RADIO RECEIVED SIGNALS FROM ASIA, EUROPE, SOUTH AMERICA AND NORTH AMERICA. THE ANTENNA WAS A 14' INDOOR WIRE.

SHORTWAVE RECEIVER

THIS SIMPLE RECEIVER CAN BE ASSEMBLED ON A SOLDERLESS BREADBOARD. THOUGH THIS RECEIVER DOES NOT SEPARATE STATIONS AS WELL AS A COMMERCIAL RECEIVER, IT IS SURPRISINGLY SENSITIVE AND WILL RECEIVE STATIONS FROM AROUND THE WORLD.

L1 IS 25-50 TURNS OF 30 GAUGE MAGNET WIRE WRAPPED AROUND PLASTIC FILM. SEE TUNING COIL ASSEMBLY DETAILS ON PAGE 34.

C1 IS 10-35 pf VARIABLE CAPACITOR FROM DISCARDED RADIO OR 10-40 pf OR SO CRYSTAL OSCILLATOR TUNING CAPACITOR.

TUNE BY SETTING L1'S SLIDER TO ANY POSITION AND ADJUST C1. CHANGE L1'S SLIDER POSITION FOR DIFFERENT FREQUENCY RANGES.

CAUTION: VOLUME CAN BE VERY LOUD, ESPECIALLY WHEN L1'S SLIDER IS MOVED AWAY FROM L1 AND LOCAL STATIONS COME IN. NO EARPHONES!
ANTENNAS

The performance of radio transmitters and receivers is very much dependent on their antennas. The simplest antenna is a wire or rod whose length equals or is 1/4 or 1/2 the wavelength of the received signal. Three common wire antennas are:

VERTICAL WHIP  DIPOLE

\[ \lambda = \text{WAVELENGTH} \]
\[ L = \text{LENGTH (FT)} \]
\[ F = \text{FREQUENCY} \]

\[ \frac{1}{4} \lambda \]
\[ L = \frac{234}{F} \text{ (MHz)} \]

Example:
1/4 \( \lambda \)
L = 234/27 = 8.67 ft

LONG WIRE

Good for shortwave reception.

ROPE OR CORD INSULATOR

STANDOFF INSULATORS

Drip Loop: Lead-in (for rain) wire

STATIC DISCHARGE UNIT (does not guarantee lightning protection)

RADIO SHACK Sells Antenna Supplies and Antennas.

ANTENNA SAFETY

The installation of an antenna requires careful attention to safety. Carelessness can result in serious injury or a fatal electrical shock. You must:

1. Never install any part of an antenna near a power line.

2. Never touch any part of an antenna that contacts a power line.

3. Disconnect and do not use an antenna during an electrical storm.

4. Connect outdoor antennas to a well grounded static discharge unit.


ROPE OR CORD

MULTISTRAND COPPER WIRE

INSULATOR

STATIC DISCHARGE UNIT DIVERTS STATIC ELECTRICAL CHARGE TO GROUND.

LEAD-IN WIRE

TO RECEIVER

GROUND

SPARK GAP
BASIC RADIO TRANSMITTERS

Radio-frequency (RF) waves are created when an electrical current is switched rapidly on or off. This is why a radio receiver emits a burst of static during a lightning discharge or a pop when a nearby appliance is switched on.

BROADBAND RF TRANSMITTER

Stroke: wire across file. Bursts of noise will be emitted by a nearby radio. Since many different wavelengths are produced ("hash"), the signal is equally strong across the broadcast band.

BROADBAND PULSE TRANSMITTER

When S1 is pressed, a distinct "pop" will be heard from a nearby radio. This circuit avoids a direct short circuit across the battery. Instead, C1 is shorted by S1 after being charged through R1.

NARROW BAND RF TRANSMITTER

C1 and L1 form a resonant circuit. Therefore, the range of wavelengths produced when S1 is pressed is narrow.

Signal peaks at 550 kHz when \( C1 = 0.005 \mu F \).

TUNABLE RF TRANSMITTER

Use file to remove narrow strip of insulation along length of L1. Stroke tuning wire along bare coil turns while listening to nearby radio.

Peak frequencies measured with actual circuit for two values of C1.
TRANSISTOR RF TRANSMITTER

A single transistor can be connected as an oscillator that supplies a series of radio-frequency pulses. The basic Hartley oscillator shown here will send RF pulses to a shortwave or broadcast band radio several feet away.

Q1: Try various NPN transistors (2N2222, etc.). Not all will work. Or reverse battery polarity and try PNP transistors.

R1: Change R1's setting to vary oscillation frequency.

B1: Use a penlight cell or a mercury or silver oxide button cell. Warning: Never attempt to solder leads to miniature power cells! They will explode.

CIRCUIT OPERATION

This transmitter emits an RF signal that can be received across a wide part of the broadcast and shortwave spectrum, particularly the 16-meter band and beyond. The signal can also be received at the lower end of the 68- to 108-MHz FM band.

L1 is a homemade air-core RF coil. Use 30 gauge wrapping wire or magnet wire. Use magnet wire for smaller coil. Burn the varnish from ends of L1 with a match and lightly buff charred varnish with sandpaper. Before winding, punch small hole in one end of straw (right end of coil above). Insert 2" of wire through hole and wind 30 turns. Punch second small hole (left end of coil) and insert 2" loop of wire (tap) through hole. Wind back 15 turns back over first winding. Punch hole through winding and insert end of wire. If wrapping wire is used, cut tap loop and twist exposed wires.

C1: Use 0.1 µF to transmit an audio tone. Use 10 µF to transmit a stream of pulses. Use a miniature electrolytic capacitor.

R1: Change R1's setting to vary oscillation frequency.

B1: Use a penlight cell or a mercury or silver oxide button cell. Warning: Never attempt to solder leads to miniature power cells! They will explode.
**CODE TRANSMITTER**

This transmitter will send tone to nearby broadcast band radio tuned to near 700 kHz. Transmitting range is several feet.

\[ \text{L1 is air core coil. Use 8' of 30 gauge magnet wire. Tap is at center of coil.} \]

Press S1 to transmit tone.

\[ \text{S1} +3V \quad \text{C1} \quad \text{TAP} \quad \text{R2} \quad \text{100} \text{K} \quad \text{R1} \quad \text{1K} \quad \text{C2} \quad \text{0.1} \text{uF} \quad \text{C4} \quad \text{1} \text{uF} \quad \text{C3} \quad \text{470} \text{pF} \quad \text{Q1} \quad \text{2N2222} \quad \text{R3} \quad \text{50K} \quad \text{R4} \quad \text{100} \quad \text{R5} \quad \text{2N2222} \quad \text{R6} \quad \text{1K} \quad \text{C5} \quad \text{0.005} \text{uF} \quad \text{C6} \quad \text{47} \text{uF} \]  

\[ \text{L1: Form 1-1/2' loop at center of B'} \text{wire. Wind wire on straw, inserting loop through} \]
\[ \text{hole punched in center of straw.} \]

RF output is clean sine wave near 700 kHz. Adjust R3 for clear, loud tone. Retune radio as necessary. Insert small steel nail inside L1 to lower transmission frequency. Use during day for maximum range.

**VOICE TRANSMITTER**

The RF oscillator of this transmitter is identical to the one on the facing page. Refer there for L1 assembly.

Input is electret microphone. OK to connect 1k to connect 1k side of B'. 1k transformer to input.

\[ \text{ANTENNA} \quad (9.9' \text{ maximum}) \]

\[ \text{MIC} \quad \text{C1} \quad \text{0.1} \text{uF} \quad \text{Q1} \quad \text{2N2222} \quad \text{R2} \quad \text{150} \text{K} \quad \text{R3} \quad \text{50K} \quad \text{R4} \quad \text{100} \quad \text{R5} \quad \text{1K} \quad \text{C5} \quad \text{0.005} \text{uF} \quad \text{C6} \quad \text{47} \text{uF} \]

RF output is clean sine wave near 700 kHz. Place microphone close to earphone connected to tape recorder. Then tune nearby radio to receive signal from transmitter. Adjust R3 for best sound. Retune radio as necessary. Remove recorder and speak into microphone.

The transmitters on this and facing page conform to the requirements of the FCC given in 47 CFR, PART 15.113. When R3 is adjusted for clearest output signal, R1 is 3 volts and antenna length < 3 meters.

\[ 45 \]
AUTOMATIC TONE TRANSMITTER

This circuit transmits a brief (1/4 second) tone burst once every 10 seconds to an F.M. band receiver up to a few hundred feet away.

CIRCUIT OPERATION

Q1 oscillates at a frequency controlled by C5 and L1. Values shown give frequency near 100 MHz. Use variable capacitor for C5 to vary frequency.

1/4 sec → LED ON → 10 sec → LED OFF

RF SIGNAL → INTERVAL → DURATIONS OF RF SIGNAL (AUDIO FREQUENCY) AND INTERVAL CONTROLLED BY R2/C1 BY R4/R3/C2

To adjust, disconnect Q2's collector from C3. Tune F.M. radio until steady tone is received. Reconnect Q2. Do not operate circuit in continuous tone mode unless adjustments are being made. (See FCC rules below and on following page.) Install circuit in aluminum box. Mount L1 securely to circuit board. If L1 moves or vibrates, the frequency will shift. Both SSS chips can be CMOS/low-power types, but not all CMOS SSS's will work in circuit. Use circuit for paging, remote control, tracking, announcing visitors, etc. To transmit light level or temperature as a variable tone, replace R1 with photoresistor or thermistor.

SPECIAL FCC RULE

The FCC requires that "...the duration of each transmission shall not be greater than one second and the silent period between transmissions shall be at least 10 times the transmission duration but in no case less than 10 seconds." (47 CFR 15.122). With the values for R3, R4 and C2 given here, this circuit fulfills this rule. See next page for additional rules.
FCC REGULATIONS

FCC RULES YOU SHOULD KNOW ABOUT INCLUDE:

1. EAVESDROPPING IS PROHIBITED.

2. A LOW-POWER TRANSMITTER THAT INTERFERES WITH RADIO OR TELEVISION RECEPTION MUST NOT BE OPERATED.

3. REQUIRED: HOME-BUILT TRANSMITTER LABEL:

I HAVE CONSTRUCTED THIS DEVICE FOR MY OWN USE. I HAVE TESTED IT AND CERTIFY THAT IT COMPLIES WITH THE APPLICABLE REGULATIONS OF FCC RULES. PART IS.
A COPY OF MY MEASUREMENTS IS IN MY POSSESSION AND IS AVAILABLE FOR INSPECTION.

SIGNED: __________________________ DATE: __________

ADDITIONAL RULES GIVE PERMISSIBLE SIGNAL STRENGTHS AND OTHER RESTRICTIONS. SEE 47 CFR, PART 15, FOR DETAILS. WRITE TO THE SUPERINTENDENT OF DOCUMENTS, U.S. GOVERNMENT PRINTING OFFICE, WASHINGTON, DC 20402.

GOING FURTHER

RADIO SHACK SELLS EASILY ASSEMBLED TRANSMITTER AND RECEIVER KITS. RADIO SHACK ALSO SELLS A WIDE RANGE OF CB EQUIPMENT. BOOKS ABOUT RADIO COMMUNICATIONS CAN BE FOUND AT MOST LIBRARIES. POPULAR COMMUNICATIONS, 73, QST AND CQ ARE SOME OF THE MAGAZINES DEVOTED TO THE SUBJECT.

PROBABLY THE BEST GUIDE TO AMATEUR RADIO IS "THE ARRL HANDBOOK FOR THE RADIO AMATEUR." THIS ALL-INCLUSIVE BOOK, WHICH IS REVISED EACH YEAR, IS AVAILABLE FROM THE AMERICAN RADIO RELAY LEAGUE (NEWINGTON, CT 06111).

RESISTOR COLOR CODE

BLACK 0 0 x 1
BROWN 1 1 x 10
RED 2 2 x 100
ORANGE 3 3 x 1,000
YELLOW 4 4 x 10,000
GREEN 5 5 x 100,000
BLUE 6 6 x 1,000,000
VIOLET 7 7 x 10,000,000
GRAY 8 8 x 100,000,000
WHITE 9 9 __

FOURTH BAND INDICATES TOLERANCE (ACCURACY):
GOLD = ±5% SILVER = ±10% NONE = ±20%

OHM'S LAW: V=IR R=V/I I=V/R P=VI=I²R

ABBREVIATIONS

A = AMPERE R = RESISTANCE
F = FARAD V (OR E) = VOLT
I = CURRENT W = WATT
P = POWER Ω = OHM

M (MEG-) = × 1,000,000
K (KILO-) = × 1,000
m (MILLI-) = .001
µ (MICRO-) = .000 001
n (NANO-) = .000 000 001
p (PICO-) = .000 000 000 001