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ASSEMBLY, TEST OF RADIO JOVE KIT TO TRACK SOLAR AND JUPITER RADIATION

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ABSTRACT
A radio JOVE telescope receiver and dipole antenna were assembled, characterized and tested to detect extraterrestrial signals from planet Jupiter. Two element dipole arrays were built for the detection of 20.1MHz radio emission from the Jupiter-Io interaction, strong solar burst, the galactic background and the transit of the galactic center. Using the specifications and the layout, the dipole array was constructed. The block diagram, the schematic diagram built for NASA was used to solder together the radio frequency band pass filter, audio Preamplifier and audio amplifier to make the radio JOVE receiver. This was characterized, tested and tuned by setting the tuning knob to 20.0MHz. The dipole antenna was connected to the receiver and a variety of radio frequency emissions were detected. These signals were captured on a personal computer via the radio Jupiter Pro 3.8.3 and radio skypipe 2.6.5 software compatible with windows 7 OS and has python programme which converts data from the sod format to ASCII format to conveniently analysed them. The device was confirmed working as the assembled Radio JOVE kit sends signals to system and were captured by the software on the system.
KEYWORDS: *Dipole Antenna; Solar Burst; Galaxy; Radiotelescope; skypipe*

INTRODUCTION

Radio astronomy is a subfield of astronomy that studies celestial objects at radio frequencies. Before 1931, to study astronomy meant to study the objects visible in the night sky. Indeed, most people probably still think that's what astronomers do—wait until dark and look at the sky using their naked eyes, binoculars, and optical telescopes, small and large. Before 1931, there was no idea that there was any other way to observe the universe beyond our atmosphere. (www.skatelescope.org/radio-astronomy)

Radio telescopes are instruments used to detect radio emissions from the sky, whether from natural celestial objects or from artificial satellites. They are in all shapes and sizes based on the kind of radio waves they pick up. However, every radio telescope has an antenna on a mount and at least one piece of receiver equipment to detect the signals..

Radio signals from Jupiter and the sun are very weak - they produce less than a millionth of a volt (1 microvolt, 1µv) at the antenna terminals of the receiver. These weak radio frequency (RF) signals must be amplified by the receiver and converted to audio signals of sufficient strength to drive headphones or a loudspeaker. The receiver also serves as a narrow filter, tuned to a specific frequency to hear Jupiter while at the same time blocking out strong earth based radio stations on other frequencies. The receiver and its accompanying antenna are designed to operate over a narrow range of short-wave frequencies centered on 20.1 MHz (megahertz). This frequency range is optimum for hearing Jupiter signals.

The antenna intercepts weak electromagnetic waves which have traveled some 500 million miles from Jupiter to the Earth. When these electromagnetic waves strike the wire antenna, a tiny RF voltage is developed at the antenna terminals. Signals from the antenna are delivered to the antenna terminals of the receiver by a coaxial transmission line.

MATERIALS, ASSEMBLING AND OPERATION

Description of Antenna and Receiver

The standard Radio Jove kit consists of parts to assemble two half-wave dipole antennas, coaxial cable, parts to build a radio receiver, PC software, and a manual.

1. The Radio Jove antenna consists of wire, coaxial cable, insulators, connectors, and other parts. The kit consists of two identical half-wave dipole antennas, which can be phased together with a feed line. Some soldering skills are required, as well as accurate measuring and cutting.

2. The receiver kit consists of 100 parts, including electronic components, solder, wiring, a circuit board, simple tools and a case. The receiver is “tuned” to a relatively narrow band of frequencies centered at 20.1MHz. It is powered by a 12V DC source, and outputs an amplified signal sufficient for listening over headphones or a powered speaker, and to provide a signal at the microphone input port on a personal computer. Assembly of the receiver is relatively straightforward, however some knowledge of solder and ability to identify electronic components is required.
3. The receiver works by taking the weak signal from the antenna and filtering out frequencies outside of a narrow band around 20.1 MHz, converting the frequencies to the KHz audio spectrum, and amplifying the signal. Filtering is accomplished by pairing capacitors, which resist direct current but pass oscillating current, with inductors, which resist changing current. Capacitors store the energy of resistance as an electric field, and inductors store energy collected as a magnetic field. Properly “tuned”, capacitors and inductors will swap energy between their electric and magnetic fields at a specific frequency, or resonance. The receiver takes advantage of this capacitor-inductor resonance to augment signals at approximately 20.1 MHz and dampen other frequencies. The direct conversion of the MHz frequency to KHz is accomplished by subtracting the received signal from a reference signal generated by an oscillator in an integrated circuit, or IC. The difference, for example from .001MHz to .01MHz, is a KHz signal in the audible range. Two integrated circuits and two transistors amplify the output signal, and one JFET transistor amplifies the incoming signal.
4. The Radio-Sky Pipe software provided in the kit enables the observer to record and store observations, provides visual feedback as to the strength of the signal being received on a real-time basis, and enables the observer to share results with other observers over the internet. The software is copyrighted by Radio-Sky Publishing, and further information can be found on their web site at http://www.radiosky.com/.

MATERIALS AND METHOD

List of Radio Jove antenna parts

Parts included in the Radio JOVE Antenna setup

- 1 50 ft. (15.24 m) #14 Gauge Bare Copper Wire (7-stranded)
- 1 70 ft. (21.336 m) RG59U Coaxial Cable (Beldon 8241)
- 4 WOODEN End Insulators (cylinders)
- 2 Plastic Center (dog bone) insulators
- 4 Twist-on F-connectors
- 1 Power combiner / splitter (2-to-1)
- 6 Ferritetoroids
- 1 100 ft. (30.48 m) x 3/16 in. Nylon Rope
- 4 10 ft. (3.048 m) x 1 in. WOODEN pipes (Sch 40)
- 4 1 in. WOODEN End Caps
- 4 1 in. WOODEN Couplers
- 4 3-4 in. x 3/8 in. Bolts
- 4 3/8 in. Nuts
- 1 Small can of WOODEN Cement (optional)
- 6 Tie wraps (optional)

Tools

- Soldering Iron (RS 64-2070C)
- Solder, 60/40, 0.050 in diameter rosin core (RS 64-006), or finer
- Wire Cutters (RS 64-1833) and Wire Strippers (RS 64-2129)
- X-acto Knife (or equivalent)
- Scissors
- Tape measure (at least 12 ft. is best)
- Small screwdriver and pliers
- Crescent Wrench
- Drill with > 1/4 in. and > 3/8 in. drill bit

Theory of Operation – Antenna

The antenna intercepts weak electromagnetic waves that have traveled some 500 million miles from Jupiter to the Earth or 93 million miles (1 Astronomical Unit = 1 AU) from the Sun. When these electromagnetic waves strike the wire antenna, a tiny radio frequency (RF) voltage is developed at the antenna terminals. Signals from each single dipole antenna are brought together with a power combiner via two pieces of coaxial cable. The output of the power combiner is delivered to the receiver by another section of coaxial transmission line.

The antenna system requires a fair-sized area for setup: minimum requirements are a 25 x 35 ft. flat area that has soil suitable for putting stakes into the ground. Since the antenna system is sensitive to noise it is best not to set it up near any high tension power lines or close to buildings. Also for safety reasons, please keep the antenna away from power lines during construction and operation. The best locations are in rural settings where the interference is minor. Since many of the observations occur at night it is wise to practice setting up the antenna during the day to make sure the site is safe and easily accessible.

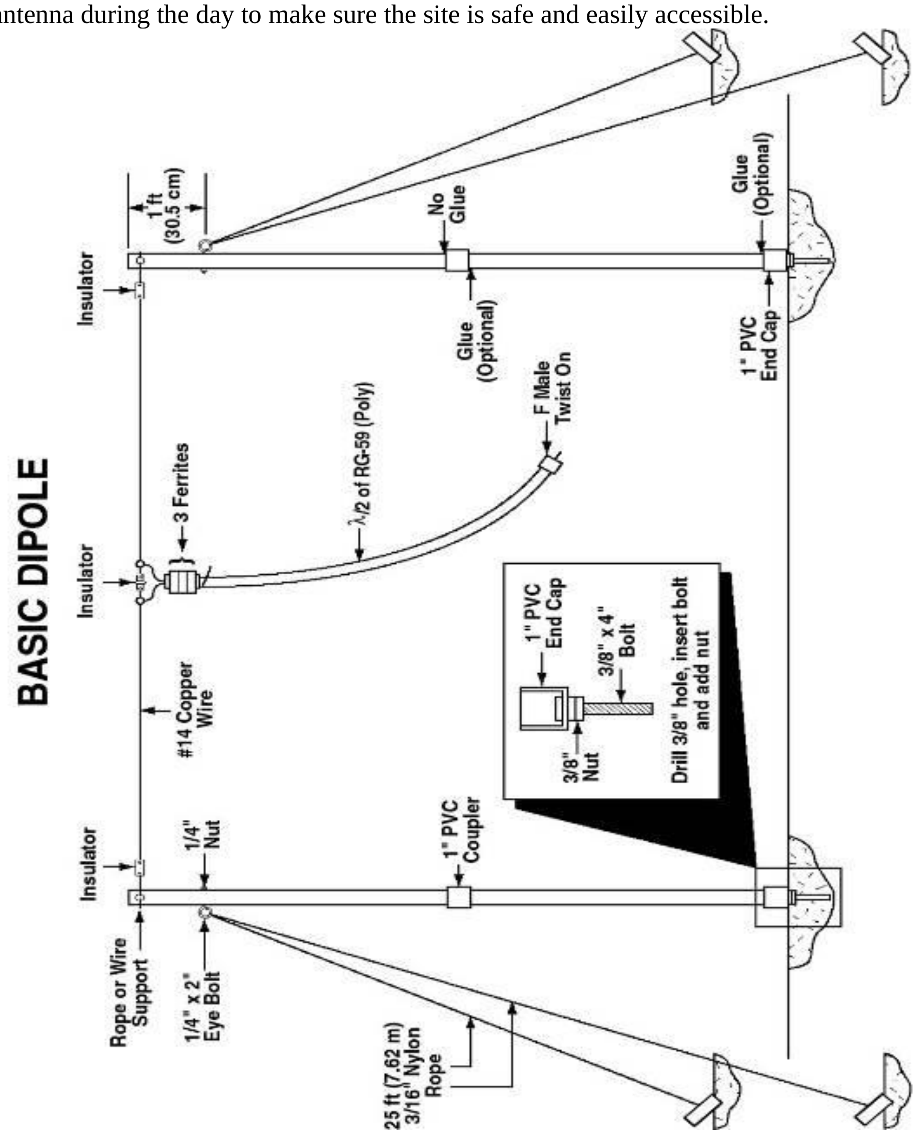

Fig 1: Setting up the Antenna

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The Dipole Antenna Assembled

Wires cut and Ropes measured - Copper wires were cut accurately to 23.3 feet's, while the coaxial RGB cables were cut; the Insulators wrapped; the Coax prepared and Soldered; All the individual wires were twisted together to form one continuous wire . The insulation around the center conductor were stripped, the coaxial cable looped over the center insulator. The coax center conductor and shield to the copper wires were soldered together. The Toroids and Connectors installed (The Coax and F-connector)

The Mounting Structure Assembled

1. The 10 ft. (3.05 m) wooden planks were cut into sizes giving allowance for the 1 feet (30.5cm) to go underground for greater stability.

2. Holes drilled in the wooden pank for the bolts and wires.
3. 4 eyebolts and nuts were attached to the wooden planks at the hole drilled 1 foot (30.5 cm) below the top of the four poles

Field Setup of Dipole Antenna

1) We laid out each dipole antenna flat on the ground with the ends of each dipole facing in the EAST-WEST direction (Figure 9a). Separate each dipole by about 20 feet (6.3 m). When the antenna is completely setup, the dipole wires are horizontal to the ground and the ends are pointing in an EAST-WEST direction.

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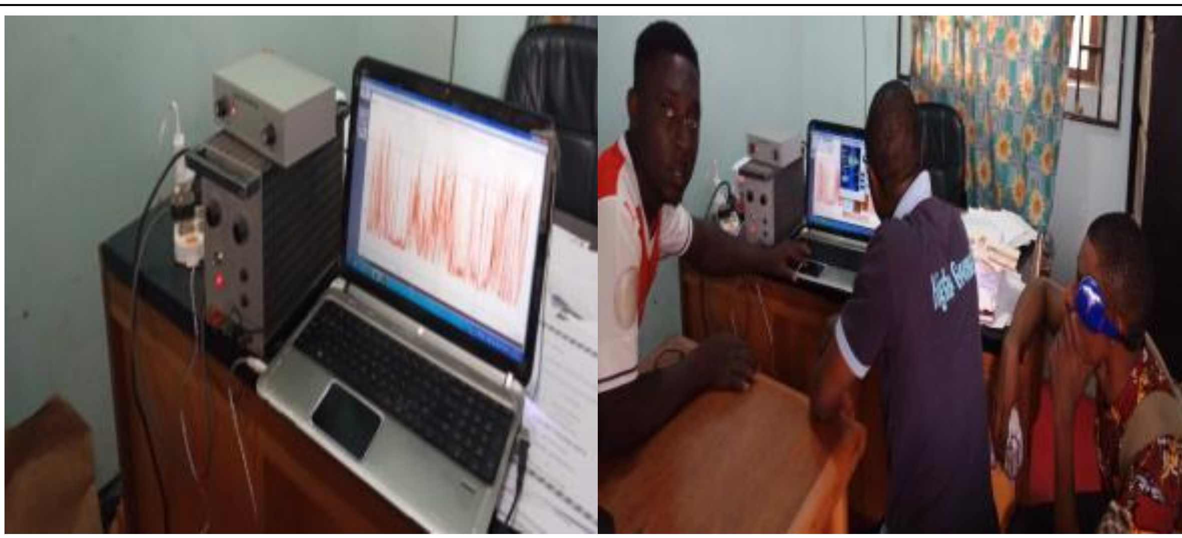
2) Using one 25 ft. (7.6 m) section of rope, we looped it twice through an eyebolt (Figure 8c). and then tied loops into each end of the rope.
3) One person held up the pole straight while one or two others attach the rope loops to the tent stakes and push them into the ground (Figure 9b). We push them in at an angle where the top of the stake faces away from the pole. Once the pole is fairly secure, the foot of the pole (protruding bolt) is pushed into the ground to add stability.
4) Steps 2 and 3 were repeated for the other pole making sure the poles stay vertical. The WOODEN poles will flex and show some bending, but that is okay. Make sure that the guy ropes are secure enough that the wire antenna is roughly horizontal (not too much sagging). Do not tighten the guy wires too tight because this will cause undue stress on the dipole antenna.
5) At a North-South distance of 20 ft. (7.6 m) from the first dipole, steps 2-4 were repeated and set up the other half of the antenna was done. We made sure both antennas were parallel and were roughly facing in the EAST-WEST direction

ii. Coaxial Cables of the Antenna connected to JOVE Receiver

1) The two coaxial feed lines connected to the power combiner on the twin-side by screwing on each F-connector to the threads of the combiner
2) The 1 λ coaxial cable (long coax) connected to the single-side of the power combiner.
3) Connect the other end of the 1λ coax to the antenna input on the JOVE Receiver.



Assembly of the Receiver

The receiver, antenna and software are part of the Radio Jove kit, purchased by the researchers with funds from TETFUND via the IBR Grant. The equipment contained in the kit is designed to observe the Sun and Jupiter at a frequency of 20.1MHz.

THE RECEIVER

The Radio Jove receiver is very simple to operate, including only a tuning and volume knob. During assembly, the receiver is adjusted to receive a signal at 20.1MHz when the tuning knob is in the 12 o'clock position. When making observations, the observer tunes the receiver to find a frequency with as little artificial interference as possible. Since the unit is built to receive only a narrow band of frequencies, the frequency used for observation will tend to be between 20.0MHz and 20.2MHz. Once the software was started and the initial conditions set, a moving graph appeared which showed the strength of the signal being received.

RF Bandpass Filter and Preamplifier

Signals from the antenna are filtered to reject strong out-of-band interference and are then amplified using a junction field effect transistor (JFET). This transistor and its associated circuitry provide additional filtering and amplify incoming signals by a factor of 10. The receiver input circuit is designed to efficiently transfer power from the antenna to the receiver while developing a minimum of noise within the receiver itself.

Local Oscillator and Mixer

The local oscillator (LO) and mixer perform the important task of converting the desired radio frequency signals down to the range of audio frequencies. The local oscillator generates a sinusoidal voltage wave form at a frequency in the vicinity of 20.1MHz. The exact frequency is set by the front panel tuning control. Both the amplified RF signal from the antenna and the LO frequency are fed into the mixer. The mixer develops a new signal which is the arithmetic difference between theLO and the incoming signal frequency. Suppose the desired signal is at 20.101MHz and the LO is tuned to 20.100MHz. The difference frequency is therefore 20.101-20.100 = .001 MHz, which is the audio frequency of 1 kilohertz. If a signal were at 20.010MHz it would be converted to an audio frequency of 10 kHz. Since the RF signal is converted directly to audio, the radio is known as a direct conversion receiver.

Low Pass Filter

To eliminate interfering stations at nearby frequencies, we use a filter which was like a window a few kilohertz wide through which Jupiter signals can enter. When listening for Jupiter or the Sun, the radio will be tuned to find a "clear channel." Since frequencies more than a few kilohertz away from the center frequency may contain interfering signals, these higher frequencies must be eliminated. This is the purpose of the low pass filter following the mixer. It passes low (audio) frequencies up to about 3.5 kHz and attenuates higher frequencies.

Audio Amplifiers

The purpose of the audio amplifiers following the low-pass filter is to take the very weak audio signal from the mixer and amplify it enough to drive headphones directly, or to drive an external amplified speaker assembly.

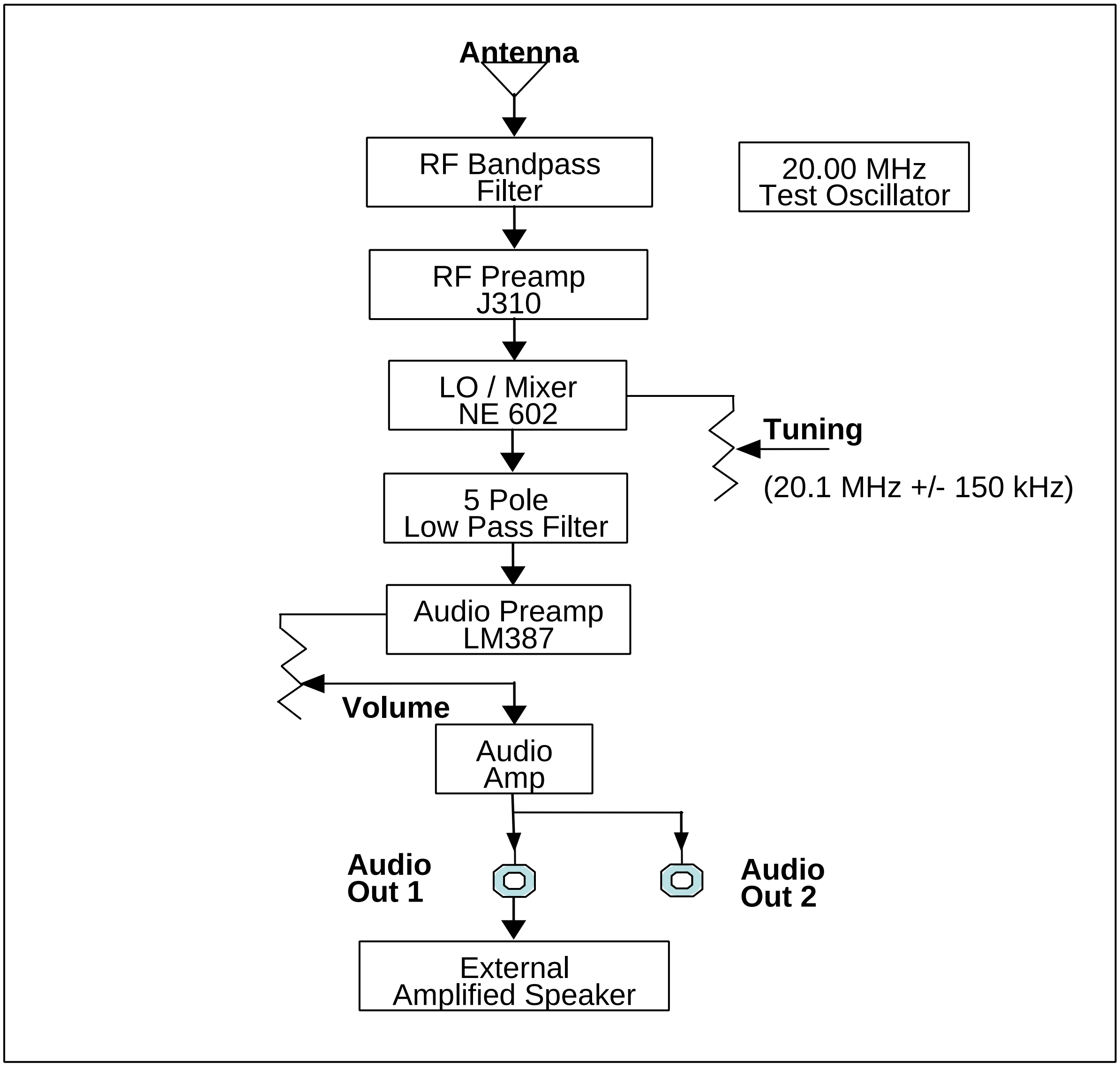


Figure 3: JOVE receiver block diagram

OBSERVATION

The researchers conducted half-day sessions using the assembled kit, laptop computer and Radio-Sky Pipe software. Using the program to conduct observations was reasonably simple, but requires much sensitivity.

The normal observing set-up included routing the antenna through a step-calibration device and an additional filter before being plugged into the receiver. One audio output was connected to a battery-powered speaker and the other was connected to the microphone input port of a laptop. A 12v power supply was connected to the receiver.

CONCLUSIONS

The research involved a start-up investigation of extraterrestrial radio frequency signals. A very low frequency receiver called the radio JOVE receiver was assembled using the circuit schematics. A dipole antenna was also constructed, after all necessary testing have been completed, the JOVE receiver was connected to the RGB coaxial cable of the dipole antenna. Softwares were used to captured the signals from about 500 million miles from the Jupiter and 93 million miles from the sun to our personal computer and outlined the strength and variations of these signals. The device was tested and confirmed working to amplify radio frequency signals from Jupiter.

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