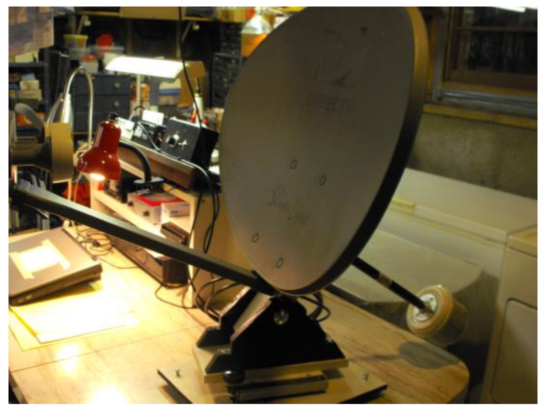
II. The 12 GHz 32 Inch Dish Radio Telescope

A. THE DISH ANTENNA

The antenna used for this radio telescope is a concave 32 X 24 inch TV satellite dish with a signal receiver (LNB) placed in an off-set (non-centered) position in front of the dish. The dish acts as a collector of radio frequency energy. The larger the dish is the more energy it is able to capture. This is a useful feature for radio astronomy, since radio frequency signals from space or from orbiting satellites are weak. Therefore a relatively large surface area is required to catch as much signal as possible. The concave dish then focuses the collected signal onto a signal receiver mounted in front of the dish.



To avoid overheating and serious damage to the signal receiver the dish antenna should not be pointed at the Sun for more than about three minutes. Also, its concave surface should be coated with matte black paint. The black paint does not interfere with radio frequency reception but reduces the intensity of heat (Infrared frequency radiation from the Sun).

B. THE LNB

The LNB (Low Noise Block) is the signal receiver referred to above. Sometimes it is also called the LNBC (Low Noise Block Converter). Center-mounted LNBs are located at the focal point of the concave dish as in the case with DMAS's 8-foot dish antenna. Most TV satellite dishes, however, are off-set, that is, positioned away from the central focal point, so that the LNB receives reflected signal from only a region, albeit a large region, of the dish sureface. The off-set position allows the dish to be set up in a vertical position to receive TV satellite signals from an oblique, skyward direction. Off-set dishes are a bit trickier to aim, but there is a method for doing so.

The LNB serves several purposes. It first of all receives the focused signal from the dish antenna. Secondly, it is tuned to the desired signal frequency and blocks (attenuates) all other frequencies, hence the B term (Block) in LNB. LNBs are designed to be receptive to a particular range of frequencies called the K_u band which runs from about 10 GHz to 18 GHz. The LNB of this radio telescope is tuned to a one GHz bandwidth from 10.7 to 11.7 GHz.

TV Satellite LNB

The next thing that an LNB does is amplify the weak signal reflected from the dish. And then, finally, because of high signal loss that occurs in electronic circuitry at high frequencies, the LNB down-converts the frequency of the signal from the K_u band to anywhere from 0.95 GHz to 2.15 GHz which is in the so-called L band of electromagnetic frequencies. Hence the letter C in LNBC for down Conversion.

The K_u band of frequencies is reserved for TV satellite reception (these are the frequencies at which TV satellites transmit) and is therefore not used professionally by radio astronomers, but it is useful educationally in amateur radio astronomy as is pointed out below under G. GOALS.

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<u>C. THE SIGNAL STRENGTH METER</u>

There is a variety of signal strength meter makes and brands from simple to more elaborate. All of them are workable for amateur use. The more elaborate meters incorporate polarity switching, which is not of primary importance for amateur radio astronomy, although the effects of polarization in received signals can be observed by rotating the dish antenna 90 degrees and noting whether the signal gains or loses strength. The meter used with the DMAS radio telescope is a Channel Master 10041FD Signal Level Meter. This meter model is no longer in manufacture but can often be found on Amazon or other online sources. The signal strength meter must be located close to the dish antenna, not more than ten feet away, to prevent excessive signal loss between the antenna and the meter.

Channel Master Signal Strength Meter

The Channel Master serves the purpose of registering a radio frequency signal so that it can be observed and measured. It does this by means of needle movement on a meter and by change in pitch of an audible sound form the Channel Master's built-in speaker. As the dish antenna zeros in on a radio frequency source the meter needle will swing from left to right, and the sound from the speaker will rise in pitch. The strengths of different sources can be compared by noting and recording the different meter readings and sound pitches.

Inside the signal strength meter is a meter driver circuit, which amplifies the down-converted signal from the LNB and feeds it as a voltage varying signal to the meter. The Channel Master is powered from a power supply providing 12 to 18 VoltsDC. The power is connected through a bias T network which allows bias voltage from the power supply and signal from the LNB to pass through the same coaxial cable connecting the LNB and the signal strength meter.

D. THE COMPUTER AND RADIO SKY PIPE SOFTWARE

While this radio telescope as described thus far performs its task well, much more information can be garnered from a radio frequency signal if it can be displayed on a computer monitor screen. A moving graph, called a strip chart, visually6 indicates precise timing and strength of signal curves, peaks and bumps. Furthermore, the strip charts can be saved to the computer's memory for later review and analysis. For the sake of conservation of space the computer used for this radio telescope can be either a laptop or a tablet.

Special software must be loaded on the computer to enable it to display and save the charts. The specific software is Radio Sky Pipe, which can be downloaded free of charge on any computer by visiting www.radiosky.com. Once the software is downloaded the computer does not need to remain on line for telescope operation.

Computer attachment is made by connecting the Channel Master output via shielded cable with RCA plugs to the sound card (microphone) port of the computer. This cannot be done directly, however; the CM output is a coaxial F socket designated Rx. See further next Section.

E. THE INTERFACE

Inconveniently, neither the amplitude varying voltage to the meter nor the frequency (pitch) modulated signal to the meter speaker is compatible with the Sky Pipe software, which requires a sound card input signal that is a constant audio frequency which can be varied in amplitude. Thus an interface is required which converts the signal strength meter output into an audio signal of varying amplitude (loudness).

The following described interface was published by Mark Spencer in the June 2009 issue of QST, a publication of ARRL (

The basic operation of the interface consists in feeding the Channel Master output to a 9-bit analog-to-digital converter (ADC chip). The output from this chip is fed into a digitally controlled variable potentiometer chip. The potentiometer varies resistance in correspondence to the digital signal received from the ADC chip, which (going backward in the description of this process) produced a digital signal corresponding to the varying amplitude of the meter voltage. The potentiometer then controls the volume of an oscillator circuit, which produces an audio frequency of around 800 Hz (close to middle C). Thus a varying amplitude constant audio frequency signal is provided by the interface to the computer sound card, which the Sky Pipe software is able to accept. Below is the circuit schematic of the interface.

Interface Schematic

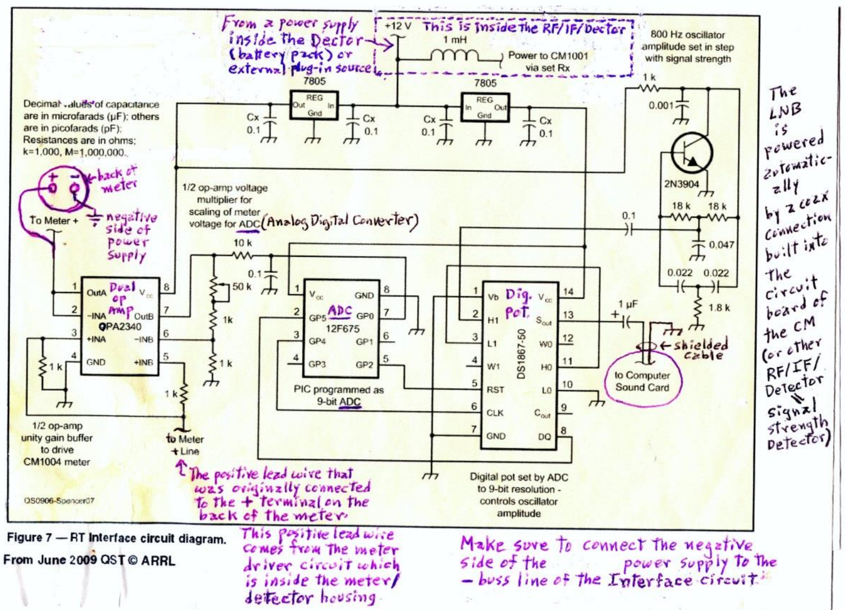

Figure 7 — RT Interface circuit diagram.
From June 2009 QST © ARRL

Coaxial connection is made from the Channel Master meter terminals (inside the Channel Master) to the interface. An RCA output from the interface makes connection via a shielded RCA cable to the sound card port of the computer.

F. THE POWER SUPPLIES

A 12 to 18 Volt DC power supply provides power to the LNB, the Channel Master and the interface. The interface component further reduces the voltage to 5 volts DC which is the required biasing for the chips. (See circuit schematics above). The computer has its own separate power supply.

G. GOALS

Even though the 10 GHz to 12 GHz range of frequencies is not utilized by professional astronomers, many experiments and observations can be made in that range by amateur radio astronomers.

1. The location of the Sun can be found even on a cloudy day by scanning the sky.

2. Solar periodicity can be observed and measured. This involves registering sunspot activity over a two or three month period. Not only can increase in solar activity be detected from radio frequency emissions, but it may also be possible to correlate the increased radio emissions with observations made with optical telescopes. Noting the periodicity of solar activity can aid in estimating the rotational rate of the Sun. Careful record keeping is necessary.

3. High Energy Pulses (HEPs) originating from the center of the Milky Way Galaxy can from time to time be picked up and correlated with the reception of these pulses by other radio astronomers. Detection of HEPs requires qccurate timing calibration, and altitude and azimuth tracking would increase the amount of time in which to observe the galactic center.

4. Mapping the plane of the Milky Way and collecting observational data over a sufficient period of time can achieved to determine the inclination of the galactic equator to the ecliptic.

5. The relation between radio energy and thermal radiation can be demonstrate by pointing the dish antenna to different objects, such as a building, the ground, a person, and even the Moon. Of course, the Sun would be an obvious object to target. From such observations it is learned that all objects emit radio waves even before they begin to radiate heat and light energy. An interesting project is to measure radio energy from a device with a heating element. As the element begins to warm up but before much heat can be felt, it will start emitting radio frequency energy. As the element continues to heat up, the amount of heat generated will become noticeable, but also the radio energy will increase. As the element becomes so hot as to glow (give off light), both the thermal readings and the radio energy reading will increase even more. The radio telescope will not pick up the heat or light energy, only the radio energy part of the electromagnetic spectrum. By conducting this experiment correlations can be made between thermal energy, measured with a thermometer, and radio energy measured with a radio telescope.

6. Drift scanning can be performed by which the dish antenna is fixed on its axes to point to some region of the sky. As the earth rotates the radio telescope automatically pans the sky. If a recording is made over a predetermined span of time, and if Right Ascension and Declination readings are recorded, it will be interesting to note radio emitting celestial objects that have been detected as well as the times and locations those objects were detected. Carrying out drift-scanning during the same time periods for a few days will also reveal the interesting

phenomenon of sidereal time progress (the same object will pass in and out of the beamwidth of the dish antenna with a four minute delay occurring each day). As before, careful record keeping is necessary. It will also be essential to know the RA (right ascension), the declination (Dec), the latitude and longitude of the location of the radio telescope, the calculated local sidereal time (LST), and the Greenwich Mean Sidereal Time (GMST) to which the local time is related. This is a pretty heavy set of requisites required for doing this kind of observing, but anyone who learns how to tackle this will be deepening their knowledge and experience in serious astronomy. A project that naturally arises out of making these observations is to explain or find out why this daily, same amount of time delay occurs.

7. By drift scanning of the Sun (for not more than three minutes or otherwise partially masking the dish) the beamwidth of the dish antenna can be determined, and the mathematical formula used to predict performance level of the dish antenna based on its beamwidth can be verified.

8. Satellites positioned in geosynchronous orbit along the Clarke belt, such as Hot Bird, Astra, and Sirius, can be located by this radio telescope. No surprise there; they transmit at the 12 GHz frequency. Content material from these satellites will remain encoded, (sorry, no TV watching with the radio telescope) but the carrier wave will be picked up by the radio telescope by which the satellites' locations can be found.

9. Undoubtedly other observations and experiments can be conducted with the 12GHz 32 inch dish radio telescope.