Kuwait National Radio Observatory
المرصد الراديوي الوطني الكويتي

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ABSTRACT

The Kuwait National Radio Observatory (KNRO) will provide unique and lasting benefits to Kuwaiti society. As the first research-grade radio telescope facility in the middle east, the KNRO will perform a long-term research program investigating the distribution and kinematics of Hydrogen gas in our Milky Way galaxy. At the same time, KNRO will fulfill a parallel educational mission, providing a unique and hands-on introduction to science, computers and mathematics to students at all levels.

Key Words

Radio, Astronomy, Antennas, Science Education

الملخص

هدف المشروع هو انشاء المرصد الوطني للفلك الراديوي. وسوف يقدم المرصد (KNRO) فوائد عديدة وجمة للمجتمع الكويتي. المرصد الراديوي المقترح سوف يكون اول مصدر ابحاث من نوعه في الشرق الاوسط وسوف يقوم المرصد بإجراء ابحاث علمية بعيدة المدى تتعلق بتوزيع وديناميكية سحب غاز الهيدروجين في مجرة درب التبانة. وبالاضافة الى الابحاث العلمية المتعددة , فإن المرصد سوف يقدم خدمات تعليمية فريدة تهدف الى اعداد الكوادر الوطنية في العديد من المراحل الدراسية وذلك للارتقاء بالتعليم العلمي والعملي في عدة محاور كالفيزياء والفلك والكمبيوتر.

المصطلحات

راديو ، فلك ، طبق ، التعليم العلمي.

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Introduction

Radio astronomy is a relatively new scientific discipline that employs radio waves to probe astrophysical phenomena from interstellar gas to extragalactic quasars. Since the dawn of radio astronomy in the 1930s, it has played a crucial role in developing our modern understanding of astrophysics. Most famously, the 2.725K cosmic microwave background (CMB) radiation was discovered by Penzias and Wilson at Bell Labs in 1965, using radio telecommunications equipment. Penzias and Wilson soon realized that the pervasive signal they were detecting in their antenna was the faint afterglow of the Big Bang, the very fires of creation. Radio telescopes are also responsible for the discovery of quasars (accreting black holes at the centers of distant galaxies) and pulsars (magnetized neutron stars, the remnants of exploded stars).

Perhaps even more significant than these famous discoveries of rare and exotic celestial objects, radio astronomy allows us to map out the distribution of cold hydrogen gas, the material from which all stars form. It is this area of research on which the KNRO will focus initially. Specifically, the Key Project of the observatory during its first year of operation will be to construct a detailed map of neutral hydrogen gas in the Milky Way galaxy.

In parallel with this scientific mission, the KNRO will pursue a complementary Education and Public Outreach mission in which students will learn about science, mathematics, astronomy, instrumentation, analysis, team work, and much more. This mission will be accomplished by offering customized training courses. The courses will not only cover theoretical aspects but they will also include lab and field work.

Furthermore, the KNRO community outreach team will visit public schools throughout Kuwait to present multimedia-driven lectures on popular topics in astronomy. The lectures are interactive and dynamic as students will actively participate in discussion workshops.

Finally, a dedicated and professional project website will be launched. The site will feature the projects news, updates, contacts, multimedia, and a special section devoted to education. The educational section will include trivia, exercises, proposed projects, and science-oriented games.

In conclusion, the KNRO project will provide valuable educational benefits to the community while presenting unique research opportunities for scientists and amateurs alike.

A simplified system block diagram is illustrated in Figure 1 below.

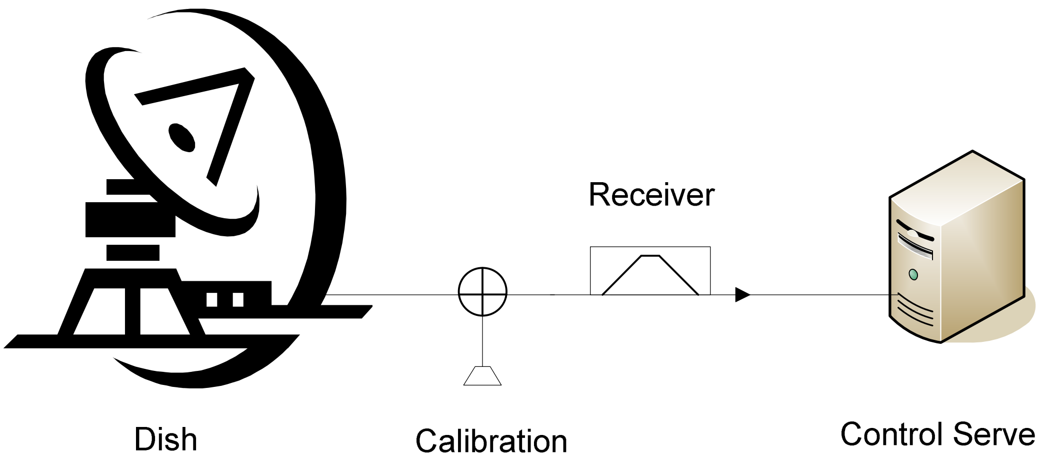

Figure 1. Simplified System Block Diagram

Objectives

The goals of this project are:

- To establish a dedicated research-grade radio telescope observatory in Kuwait.
- To provide the community with innovative and interactive educational opportunities in physics, astronomy, and mathematics via training courses, lectures, and a multimedia-driven website.

Justifications and Benefits

A. Scientific Justifications and Benefits

The most abundant element in the universe is hydrogen. Hydrogen makes up 75% of the mass of baryonic matter in the universe, followed by helium at 23% , and all other elements at 2%. Due to its abundance, hydrogen has been studied thoroughly at its natural harmonic frequency of 1420 Mhz.

By studying the kinematics and distributions of hydrogen clouds in the universe, we can gain a better understanding of the history and evolution of our galaxy and the universe overall.

Astronomical research has numerous long term practical benefits for society. For instance, radio astronomers developed low-noise amplifiers that made modern satellite communications possible. The heavy computational demands of astronomers drove the computer industry leaps forward. Imaging techniques developed by astronomers are now used in medical imaging devices.

The drive to research itself usually spawn a number of industries and technologies. Astronomers developed and perfected adaptive optics. Many of the modern high gain antennas used for microwave communication were initially developed by radio astronomers in order to conduct observations.

To best illustrate the benefits, it should be noted that the KNRO project will require a multitude of sensitive and high-tech instrumentation. For example, The telescope's L-Band wave guide will be designed and constructed in Kuwait. The wave guide design specifications can be released to the public domain where they can be employed in the construction of high-gain low-noise antennas suitable for the region.

Furthermore, the low-level and high-level drivers for control and data acquisition will be developed in Kuwait. Since the drivers are developed under an Open Source license, the community will benefit from the development of these control drivers and may customize them to suit their own applications.

B. Educational Justification and Benefits

Countries that invest in science education invest in their own prosperity. Currently, most of science education in Kuwait is focused on theory while neglecting how science and technology can affect and influence our lives.

Furthermore, most public educational institutes employ traditional teaching techniques where students are focused on solving a particular problem set without grasping the bigger framework.

Such traditional teaching methods not only limits the student's analytical scope, but they usually intimidate students away from science education. Subsequently, students conceive science as an inexplicable and tough realm only reserved for the elite.

In order to alleviate the barrier between students and science education, the KNRO team is developing a set of educational techniques that will put the student, not the teacher, at the center of attention.

These educational techniques are the focal point in our proposed training courses with the goal of developing critical and analytical thinking in students. They will also encourage students to pursue careers in science and technology.

For example, one technique is to balance theory and practice. Since theory is best accompanied by examples and practical implementations, the KNRO courses are designed such that students gain hands-on experience in many fields of research, including operation of radio telescopes, conducting attended and automated observations, and a lot more.

The students will not be *observers* of events, but they will be *active* participants, each developing their own techniques and conclusions. Students will learn about the scientific method by applying it to real world scenarios. This will help students build their technical and analytical skills and also their self esteem. The students will be involved in all phases from data collection to theory validation as illustrated in Figure 2.

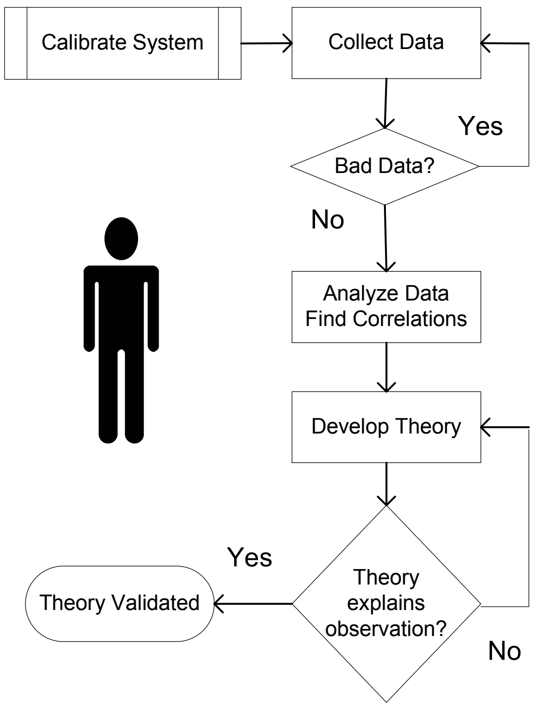

Figure 2. The scientific method process in the student-centric model

Finally, in order to reach the widest audience possible, the KNRO team will launch the KNRO website as part of the existing astronomy department site. The website will include up-to-date information on the KNRO project and several sections with trivia, "ask an astronomer", news, and images pertaining to science and astronomy.

In conclusion, the training courses, public lectures, and the website are very important tools to raise science awareness in a fun and innovative way in Kuwait.

Anticipated Outputs

A. The Scientific outputs of the project are:

- The erection of the first research grade radio observatory facility in the Middle East.
- Detailed energy distribution contours of hydrogen clouds in the Milky Way galactic disk.
- Galactic rotational curves.

B. The Educational outputs of the projects are:

- Three interactive courses in radio astronomy tailored to students in many levels and ages. Each course will last approximately 2-3 weeks.
- Twelve multimedia-driven public lectures across public schools in Kuwait. Each lecture will be followed by a discussion workshop.
- A website with sections devoted to science education and news.

Methodology

Scientific Method

To achieve the project's scientific goals, the Kuwait National Radio Observatory must be constructed, calibrated, and operated to conduct systematic scans of hydrogen clouds in the galactic disk.

System specifications for the radio observatory are illustrated in Table 1.

Property	Value
Center Frequency	1420 Mhz
Gain @ 1420 Mhz	34.6 dB
Beam Width @ 1420 Mhz	3 degrees
Antenna Diameter	4.8 m
F/D Ratio	0.4
Mechanical System	Alt-Az

Table 1. System Specifications

1420 Mhz is the natural harmonic frequency of neutral hydrogen gas and corresponds to a 21 cm wavelength. Under an unexcited state, both the electron and proton in the hydrogen atom spin in parallel. When the atom is excited, the spin direction of the electron changes to anti-parallel. Since atoms prefer unexcited low-energy states, the electrons flips back to its parallel state and releases a 21 cm photon. As such, observing the sky at 1420 Mhz is indicative of neutral hydrogen (H I) shells along low to medium latitudes of the galactic disk.

Planned observations shall fall under two prime categories:

- **Flux Measurements**

  Flux is defined as the rate of flow of energy in a unit area per second. If we consider the radio region of the electromagnetic spectrum, then we can employ the Rayleigh-Jeans radiation law which is an approximation for Plank's law, to calculate the flux (Kraus 1982).

$$S_0 = \frac{2kT_A}{A_e}$$

Where S_0 = observed flux density of source, watts m^{-2} Hz^{-1}
k = Boltzman's constant (= 1.38 * 10^{-23} joule K^{-1})
T_A = antenna temperature due to source, K
A_e = effective aperture of antenna, m^2

It is assumed that the source noise power is due to thermal emission and that the source is optically thick.

For a small parabolic radio telescope, the aperture efficiency is usually rated at 55% to 60%. If we calculate the effective aperture of the antenna, then the source thermal temperature can be obtained, at least in principle.

Since the first scientific objective is to construct a contour map detailing the flux readings, the antenna shall be locked in a drift scan mode, where the rotation of earth will enable the telescope to scan strips of the sky three degrees wide.

While the limiting resolution is only three degrees, this operation will require a scan area equivalent to 14,400 deg^2. Therefore, it will involve many successive observation runs before a usable contour map is created.

❖ Radial velocities vs. Distance

The second scientific objective of this project is to calculate the galactic rotational curve. By definition, the galactic rotational curve is the relation of stellar or gas rotational velocities as a function of distance from the galactic center.

Below is a schematic of the Milky Way galaxy illustrating face on and side views.

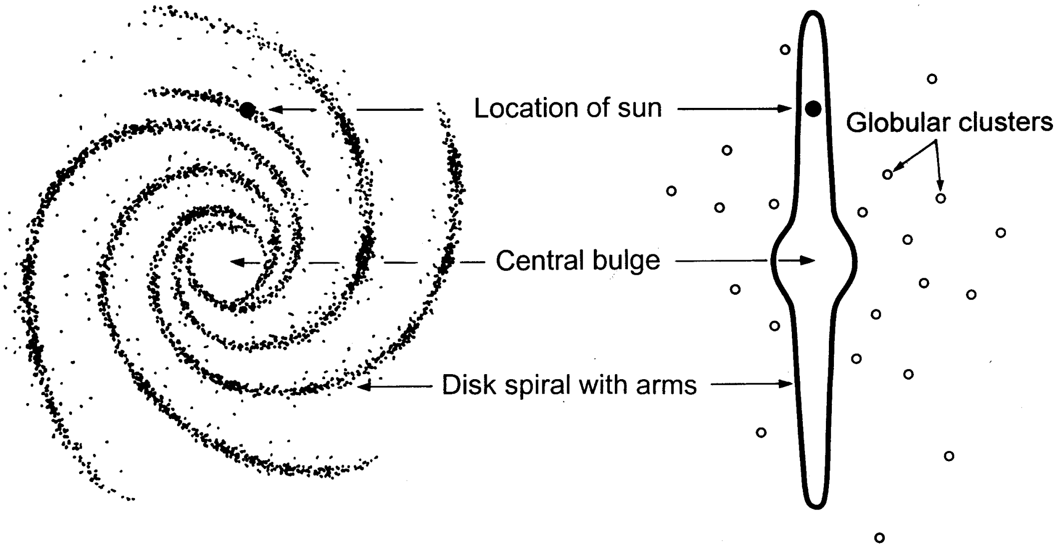

Figure 3. Simplified Model of the Milky Way Galaxy.

Consider the galactic arms beyond the bulge. The arms are either approaching us or moving way from us. We can detect and calculate this velocity by studying the Doppler Effect. Put simply, the Doppler Effect is the shift in frequency of objects moving to or from a stationary frame of reference. Mathematically, the equation is as follows:

$$\frac{v}{c} = \frac{\Delta\lambda}{\lambda}$$

Where v = velocity of object, m/s
c = velocity of light, $3 * 10^8$ m/s
$\Delta\lambda$ = different between rest wavelength and observed wavelength, m
λ = Rest wavelength, m

We can detect $\Delta\lambda$ from a multi-channel spectrometer, while we know the rest wavelength λ for hydrogen is 21 cm. Therefore, we can measure the velocity of the object under observation. A positive velocity indicate that the object is receding, while a negative velocity indicate that the object is approaching the observer.

The second required parameter is the distance scale. From galactic models, we know that the sun is located in the galactic arms 8 kpc from the center of the galaxy as illustrated in Figure 4.

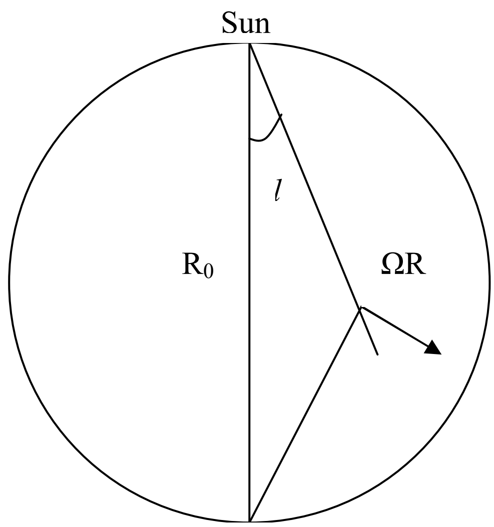

Figure 4. Trigonometric Method for Calculating Rotational Curves

The relationship between the observed radial velocities and the rotational curve is given in the following equation:

$V_r = R_0[\Omega(R) - \Omega_0] \sin(l) \cos(b)$

Where Ω_0 is the angular velocity of the solar neighborhood and *l*, *b* are the galactic longitude, and latitude respectively. This plot will indicate whether gas in the galaxy follows the expected behavior of Kepler's third law, where the velocity is inversely proportional to the square root of distance from the center of gravity.

Hardware

The KNRO project will employ a 4.8 m dish. Currently, there is no steering mechanism for the dish, and thus a reliable mechanical drive system must be constructed to permit automated and complete sky coverage. The drive mechanism is controlled via the Control Server in a closed loop configuration. This will alleviate any backslash in the drive system while slewing. Operators will be have two consoles in the science lab to control and monitor the telescope, in addition to performing data reduction and analysis tasks.

A laser printer will be available to enable print outs of data whenever required. All devices will be connected on internal LAN. To enable the remote control feature, the control server will have a secure connection to the internet.

A detail system block diagram is given in the next page.

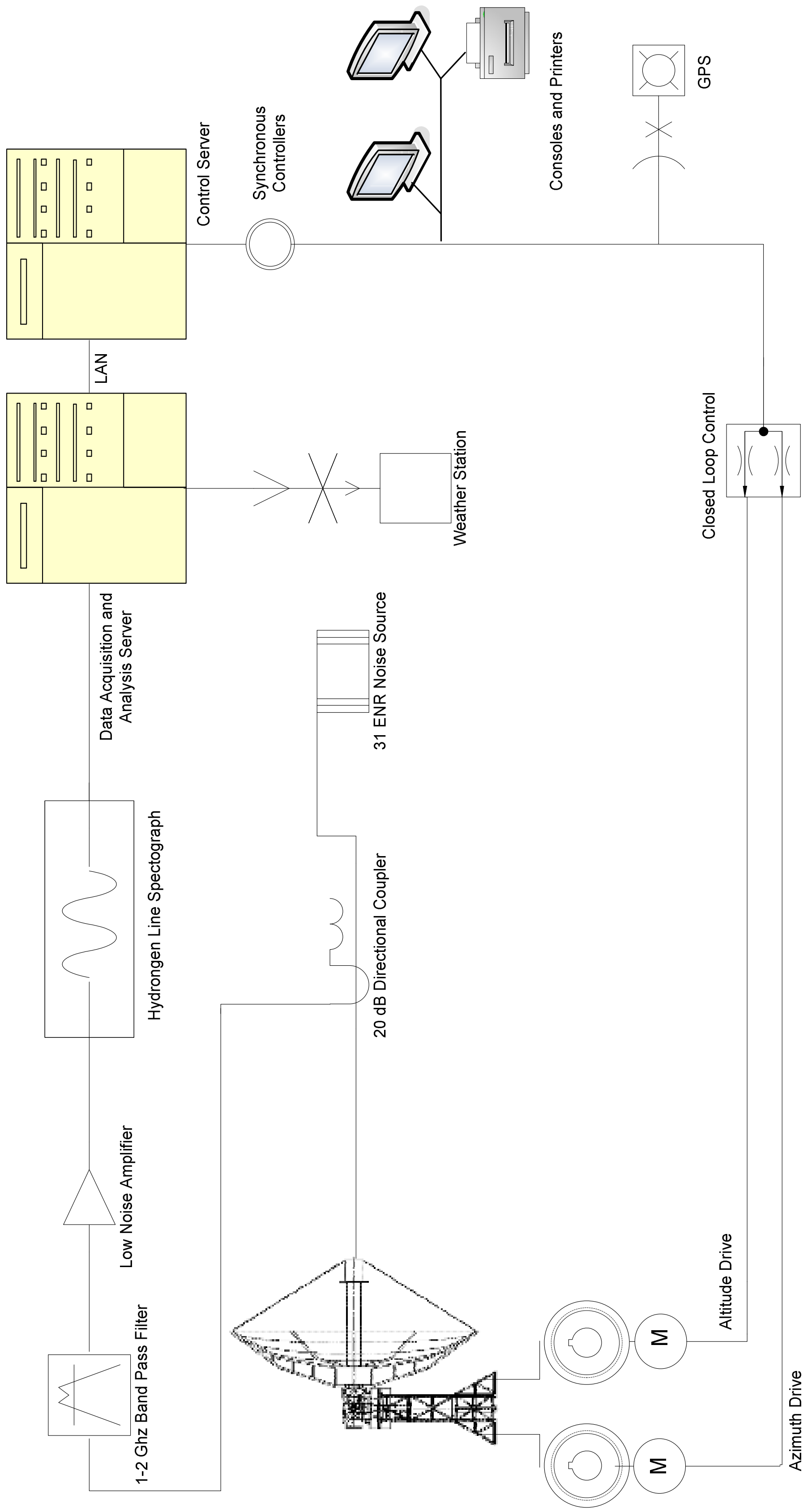

Figure 5. KNRO System Block Diagram

Signal Flow

In general terms, signal flow proceeds as following: Radio waves hit the parabolic dish and reflect to the focal point where the KNRO L-Band waveguide directs the signal to a monopole probe. A female coaxial connector is attached to probe and from this connection, a coaxial cable carries the signal to the band-pass filter via a 20 dB directional coupler.

It should be noted that the directional coupler and noise source are used exclusively for system calibration. For a detailed description of the use of these instruments, please refer to calibration section.

When the signal arrives at the band-pass filter, its frequency will be restricted to 1-2 Ghz as this will help to eliminate unwanted interference signals caused by communications and other man-made noise. The filtered signal will propagate next to the low noise amplifier which will boost the signal by 28 dB.

Next, the signal will propagate to the spectrometer where it will be boosted again and down-shifted to 70 Mhz. The spectrometer gain, integration, and offset operational parameters can be controlled from the Data Acquisition Server (DAS) via RS-232 connection. Digital values from the spectrometer are continuously fed to DAS where they are time-stamped in accord with ISO 8601. Additional parameters like weather conditions, current celestial coordinates, and ephemeris data are also logged into the database.

Software

Software development consists of two main modules:

I. **Control:**

Complete steering capabilities in both Altitude and Azimuth modes can be accomplished via two orthogonal closed loop servo controllers. Each servo motor is connected to each axis shaft with gear ratios suitable for high accuracy tracking, on the order of 30 arc minutes. Furthermore, the drive system can turn 360° in azimuth under 3 minutes, and turn 90° in altitude under 2 minutes. A robust scalable and flexible control protocol is thus required for the mechanical system. The Instrument-Neutral-Distributed-Interface (INDI) protocol satisfies these requirement and adds native support for remote control and automation. The KNRO team shall develop an INDI driver to control and monitor the system's mechanical system. The control driver shall be designed with interlocks to insure safe steering. Additionally, the driver will supply real time coordinates to the Data Acquisition Server whenever it is required.

II. Data Acquisition

Data acquisition can be accomplished by developing an INDI driver for each data generator. There are three data generators in the KNRO system:

1. Spectrometer: Radio Telescope Data. This includes intensity, frequency, and time.
2. Weather Station: Temperature, Humidity, Wind.
3. GPS: Clock and Geographic Position.

Each generator will be connected to the Data Acquisition Server (DAS) via RS-232 connection. DAS will be running the INDI server which reroutes and broadcasts data packets to the desirable INDI drivers.

The GPS clock will synchronize all equipments upon initial system startup. Subsequent synchronization events will occur in one minute intervals as long as the system is active.

All incoming data are validated and checked for transmission errors before they are added to the database. Each database record will feature a unique snapshot of the observation run.

Calibration

I. Theory

In all practical instruments, there is always one or more noise sources that might interfere with the desirable input or output signal of an instrument. For radio telescopes, the noise includes losses due to the receiver electronics, thermal and electrical fluctuations, spillover due to ground radiation entering the radiation pattern minor lobes, and the transmission line.

In order to extract the radio source signal from the noise, we must account for all noise sources affecting the system. Generally, the noise power per unit bandwidth across the terminals of a resistor is defined by (Nyquist 1928):

$$w = kT$$

Where w = spectral power, watts Hz^{-1}

k = Boltzman's constant (= 1.38 * 10^{-23} joule K^{-1})

T = absolute temperature of resistors, K

while the total power is simply $W = kT\Delta\upsilon$, where $\Delta\upsilon$ is the bandwidth in Hz.

In principle, noise sources are associative. Therefore we can define the system noise power in terms of constituent noise sources:

$$W_{SYS} = W_{NR} + W_{NA} = k(T_R + T_A)\Delta\upsilon$$

Where W_{NR} is the noise power due to the receiver and transmission line, and W_{NA} is the noise power to the antenna.

When we are observing a celestial source, W_{SYS} becomes

$$W_{SYS} = W_{NR} + W_{NA} + W_{SRC} = k(T_R + T_A + T_{SRC})\Delta\upsilon$$

One popular method for removing the noise sources is known as the Y-factor and is described in the procedure section below.

II. Procedure

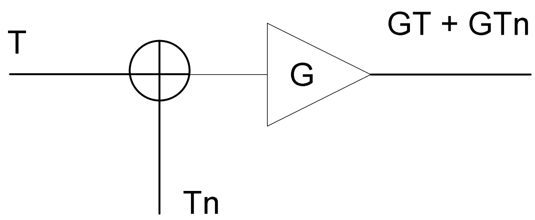

Figure 6. Noise Source in Amplifiers

As evident from figure 6, the KNRO receiver (spectrometer) will amplify and add both the actual source temperature T, and the noise temperature Tn. In order to account for the noise temperature, we need to conduct two measurements. The measurement includes an artificial noise source rated 31 ENR (Extra Noise Ratio).

First, we will inject the artificial noise source (hot) into the system and record the gain. Then, we turn off the artificial noise source (cold) and record the gain again. The ratio of "hot" gain over "cold" gain is called the Y factor:

$$Y = \frac{G(T_{HOT} + T_N)}{G(T_{COLD} + T_N)}$$

Where T_{HOT} refers to the artificial noise temperature, while T_{COLD} refers to room temperature (Typically 290 K). The Y factor is related to the noise figure F by:

$$F = \frac{ENR}{Y - 1}$$

Where ENR is the Extra Noise Ratio rating of the artificial noise source. Finally, the noise figure F is defined as:

$$F = \frac{T_N + 290}{290}$$

Therefore, we can determine the noise temperature of the receiver and remove its effect on the final signal pattern.

Operation

In order to accomplish the project's scientific goals, the operation of the telescope must conform to a set of procedures and policies to insure the most efficient use of the equipments and related facilities.

The KNRO team shall develop the proper procedures to conduct observations taking into consideration the security, safety, and vitality of such observations. Since the KNRO project is publicly funded, observation lots will be allocated to the public and interested researchers. An electronic form may be submitted detailing the purpose and details of the observation request. The KNRO team will asses all request 72 hours after their reception and shall notify contact persons about the result.

In addition to operating the telescope locally, authorized users may remotely control the telescope any where around the globe. A custom software tool will be developed in order to facilitate scheduling and cross-coordination overhead.

Projects Tasks and Work Plan

Task 1: Site Preparation

The term "site" refers to physical location where the telescope, labs, and related facilities are situated. The site must conform to the specifications outlined in Attachment II (Site Specifications Document).

All enclosed facilities will be furnished with the required instruments as illustrated in the KNRO System Block Diagram.

The site shall abide by all relevant regulations in Kuwait where applicable.

Task 2: Telescope Construction

Once Task 1 is accomplished, the construction works of the radio telescope will proceed as following:

1. Foundation Works: Leveling, Casting, Pier.
2. Mechanical Works: Assembly of gears, rotors, encoders, limit switches, and pulleys for the Altitude-Azimuth drive system.
3. Electrical Works: Installing Uninterruptible Power Supply (UPS) system, common earth ground, and cabling.
4. Software development: Developing control and data acquisition system.
5. System integration: Integrating the telescope's primary and auxiliary modules with the control server.

Task 3: System Calibration

Radio observations are not feasible without proper and regular system wide calibration. The system calibration task involves the following operations:

1. Minimizing Standing Wave Ratio (SWR) values for all interconnected modules.
2. Determining the noise temperature for the antenna, transmission line, and the receiver.
3. Determining the *cold* sky temperature.

Task 4: Operation

Operational tasks involves conducting manned and automated observation sessions in accord to a set of procedures and policies. Real time data are continuously fed to the Control and Data Acquisition server where they are automatically tagged and archived until further processing.

To satisfy the projects objectives, the telescope's primary dish will be systematically scanning selected regions of the galactic disk between galactic latitudes -20° and +20°.

Task 5: Data Reduction and Analysis

The observational data stored in the server will be checked and inspected for validity and quality. A collection of reduction tools will be employed to simplify and extract relevant data.

Using a set of professional analytical tools designed for Radio Astronomy, the KNRO team will calculate and plot galactic rotational curve where observational data exists. Two dimensional flux density contour maps will be constructed for the observed hydrogen clouds distributions in the Milky Way disk.

Task 6: Training Courses

The KNRO team will offer the public with the opportunity to enroll in training courses designed to present astronomical facts and concepts in a unique and entertaining manner.

Each course will take in consideration the target audience age and background. All students will participate in lab and field work in order to tie theory with practice. The KNRO project will advertise these training courses in the daily newspapers four weeks before they start.

Task 7: Public Lectures

As part of KNRO community outreach commitment, we will coordinate with the Ministry of Education public relations department to arrange for scientific lectures to be presented in a number of public schools in Kuwait.

The lectures will be held regularly and will focus on stimulating the student's interest in science and mathematics, in addition to fostering critical and analytical skills.

Task 8: KNRO Website

The KNRO website will be launched early in the project and is planned to grow spatially as the project progresses. The design of the site will conform to W3C standards and shall feature a bilingual interface. The website is intended to be part of the main department of astronomy website located at astronomy.ksclub.org

The content of the site will reflect the project news, FAQ, multimedia with videos and images about current and past events, and much more. The educational sections are designed for children and adults alike with varying levels of depths and challenges.

CLASSIFIED

Project Budget

CLASSIFIED

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Attachment I. Glossary

Directional Coupler
A directional coupler is a transmission coupling device for separately sampling (through a known coupling loss) either the forward (incident) or the backward (reflected) wave in a transmission line.

GPS
The Global Positioning System, usually called GPS (the US military refers to it as NAVSTAR GPS), is a satellite navigation system used for determining one's precise location and providing a highly accurate time reference almost anywhere on Earth or in Earth orbit. It uses an intermediate circular orbit (ICO) satellite constellation of at least 24 satellites.

LNA
A low noise signal booster used to amplify the weak signals received on a satellite antenna. Usually found in the receiver front ends.

Noise Source
A device designed to emit specific electromagnetic noise in a wide range of frequencies. It is often used in calibration and test systems.

Parsec
The parsec (pc) is a unit of length used in astronomy. It stands for "parallax of one arc second", and is approximately $3.08567758 \times 10^{16}$ meters.

Pulsars
Pulsars are rotating neutron stars that are observable as sources of electromagnetic radiation. The radiation intensity varies at a regular period, believed to result from the rotation of the star.

Quasars
A quasar (acronym for QUASi-stellAR radio sources) is an astronomical object that looks like a star in optical telescopes (i.e. it is a point source), and has a very high redshift. The general consensus is that this high redshift is cosmological, the result of Hubble's law, which implies that quasars must be very distant and must emit more energy than dozens of normal galaxies.

Spectrometer
Instrument used to determine the distribution of energy within a spectrum of wavelengths.

SWR
Standing Wave Ratio (SWR) is the ratio of the amplitude of a partial standing wave at an anti-node (maximum) to the amplitude at an adjacent node (minimum).

UPS
Uninterruptible Power Supply. A power supply that will continue to operate after the loss of AC input power. A UPS normally uses some type of automatic battery backup system.

Attachment II. Site Specification Document

❖ Kuwait Climatic Conditions

Kuwait is a small arid desert country with scarse fresh water resources, long hot and dry summers, and relataively short warm winters. The average rainfall is less than 130 mm and mainly occurs during the winter season. Dust storms are most common in April-May due to northwestern winds.

The annual average wind speed is 22.2 km/h. The maximum recorded temperature was 51 °C in 1978 while the lowest recorded temperature was -6.1 °C in 1974.

The average temperature in the summer is 45 °C while the average temperature in winter is 7.8 °C.

❖ System Operating Parameters

Parameter	Units	Minimum	Maximum	Optimal
Internal Temperature	°C	5	25	20
External Temperature	°C	-5	45	25
Internal Humidity	%	10%	100%	50%
External Humidity	%	10%	100%	50%
Wind Speed	km/h	-	30	0
Rainfall	mm	-	500	0
Altitude clearance*	°	60	90	70

* The altitude clearance refers to unobstructed sky coverage area required for proper operation of the telescope from 0° to 360° azimuth.

❖ Required Facilities

Facility	Count	Description
Parking	1x	Parking for 20-30 cars.
Meeting Hall	1x	
Class Room	1x	Class room suitable for 20 students.
Lab	1x	Science Lab and Control Room
Lab	1x	Computer Lab
Kitchen	1x	Kitchen with water fountain and vending machine.
Toilet	2x	1x for men, 1x for women.

Attachment III. Website Specification Document

I. Introduction

The KNRO team is responsible for designing and deplyoing the KNRO Website which will be part of the astronomy's department website in order to meet the project's objectives.

Launch of the website is expected only one month after the project startup. This is due to the modularity of the website design that permits seamless spital expansion of the site whenever desirable.

Careful attention is paid to cater for both local and international audiences, and thus the decision was to feature a bilingual interface in Arabic and English. The default language is Arabic.

II. Website Goals

The goals of the website are:

- To provide up to date coverage on the KNRO Project.
- To provide coverage on community related activities and events.
- To provide a section devoted to science education and awareness.

III. Audience Profile

The targeted audience consists of the following groups:

- Students: Ages 12-18.
- General Public.
- Researchers and Scientists.

IV. Site Structure

Item	Description	Language	
		Arabic	English
Search	Search box with simple and advanced search capabitlies to perform cross-site search function.	✔	✔
Site Map	A hierchal list containing a structured layout for the site's pages and services.	✔	✔
FAQ	A collection of frequenly asked questions and answers.	✔	✔
News	A section to cover project and community news.	✔	
Media	A modular gallary consisting of image, audio, and video materials related to the site. The content are searchable.	✔	✔
Ask An Astronomer	An electronic form that enables users to submit astronomy related queries.	✔	
Contact Information	A page containing emails, phone numbres, map and location details.	✔	✔
Trivia	A set of questions to test scientific and astronomical knowledge. There are 5 levels of difficulty.	✔	
Games	Educational Flash Based games	✔	
Person of the Month	A section featuring an overview of people who made contributions to science and astronomy.	✔	
Project Describtion	Displays history and purpose of the project and its current status.	✔	✔
Privacy Notes	What kind of information the website collects in order to provide services.	✔	
Radio Astronomy Tutorial	Basic introduction to Radio Astronomy.	✔	