K4LED

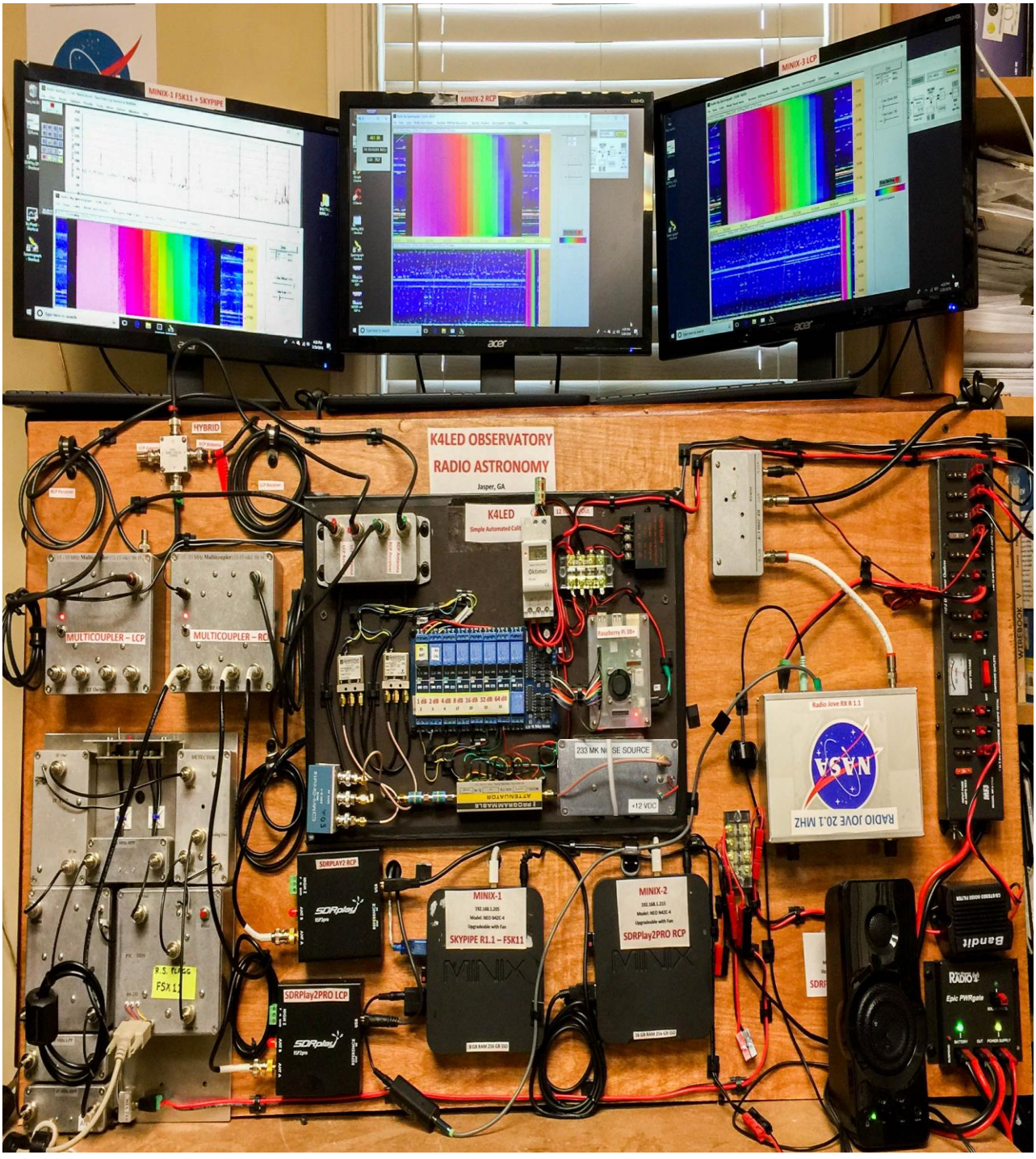
Georgia Amateur Radio Astronomy Observatory

(Updated: 09/01/2019)

Station Data and Configuration

(Entire Station is powered by 12 volt DC battery with Solar Panel and AC charger)

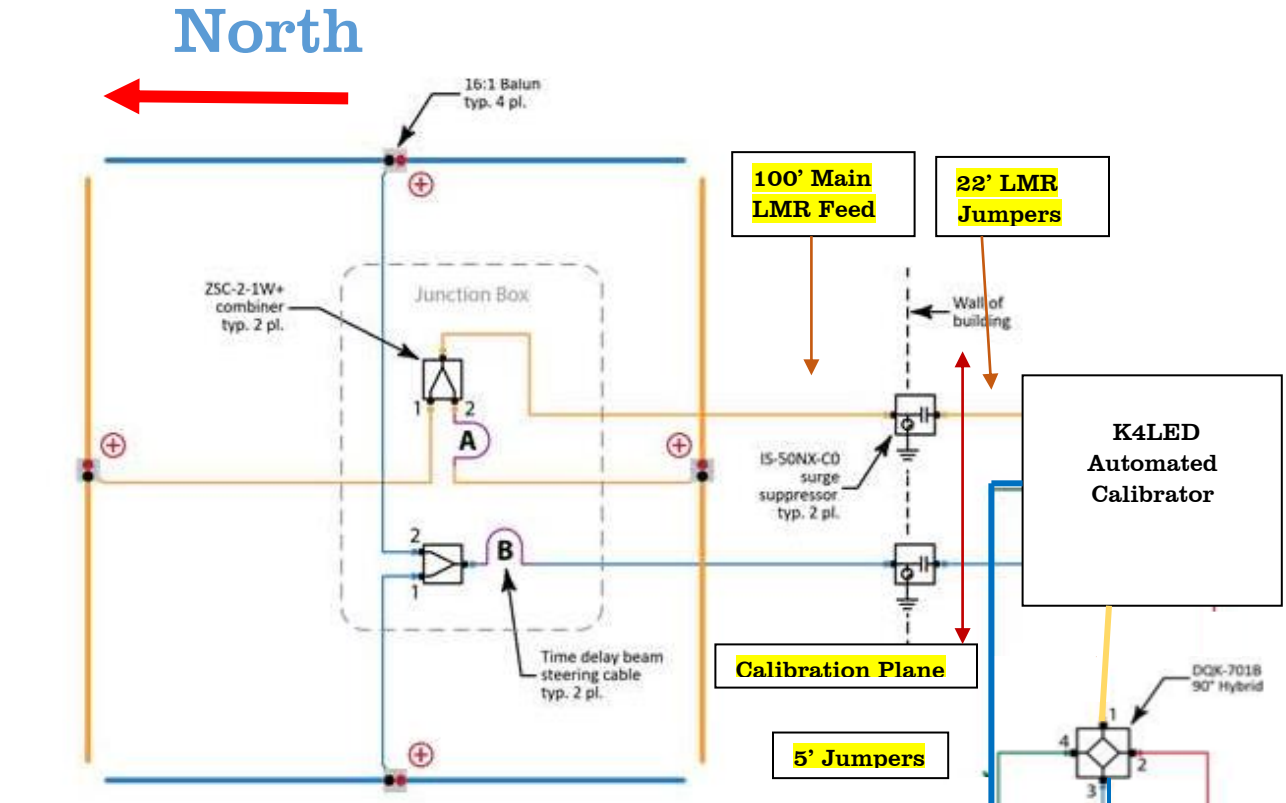
Location: Lat. 34.42322 N, Lon. -84.49413 W (Jasper, GA 30143)

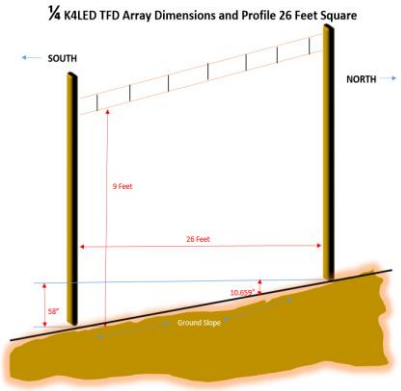


SECTION I: Antennas

Antennas:

Wide band (15 to 30 MHz) Typinski TFD full square array. Currently beam steering is AZ 180˚, EL 40˚ for the 2019 season. This is a great antenna for spectroscopic observations of Jupiter, the sun, and other radio phenomena. Drop cables are in electrical conduit for protection from weather.





Loss Between Element Feed Points and Hybrid Inputs (CAL PLANE) (dB)	Loss Between sky side of element wires and Hybrid Inputs (CAL PLANE) (dB)
-2.3	?
-2.4	?
-2.6	?
-2.7	-7.0
-2.8	?
-2.9	?
-3.0	?
-3.1	?
-3.2	?
-3.3	?

20 degree ground slope To the south.

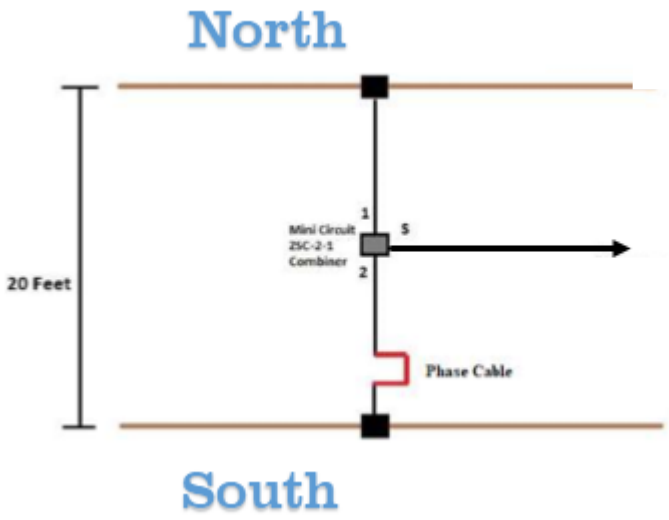
All TFD antenna drop cables are in electrical conduit for protection from weather and animals.

Center coax connection and combiner box.
This is two Home Depot mortar mixing tubs.

Modified drop using a 90 degree sweep to simplify construction and easier to pull the coax through.

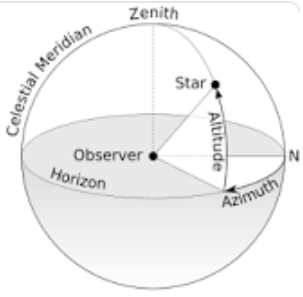
Note 1: The 20 degree ground slope to the south adds to the steering angle. 20 degree steering cables + 20 degree ground slope = 40 degrees total.

R1.2 Dual Radio Jove 20.1 MHz standard dipole kit array. Beam steered to AZ 180˚, EL 40˚. (Note: At times the Radio SkyPipe RJ1.1 receiver may be attached to the TFD Array.) Dipole height is 9' above ground. Ground is rocky clay 20 degree slope to the south.



TFD and JOVE Dipole antennas both at AZ 180˚, EL 40˚.

Altitude (alt.), sometimes referred to as **elevation** (el.), is the **angle** between the object and the observer's local horizon. For visible objects, it is an **angle** between 0° and 90°. ... The zenith distance is the complement of **altitude**, so that the sum of the **altitude** and the zenith distance is 90°.



SECTION II: Receivers (Operated on 12 volt DC battery/Solar/AC charger)

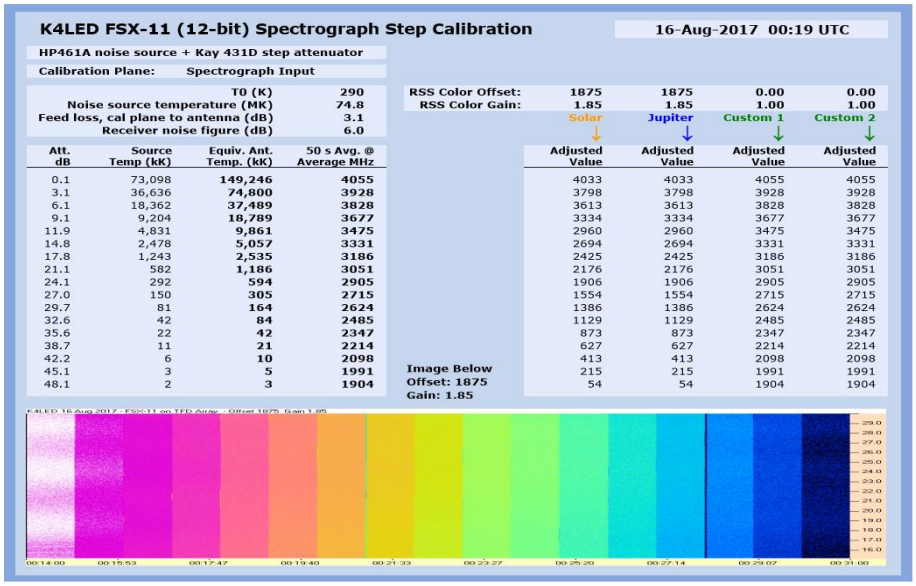
Flagg FSX11 spectrograph. 15 to 30 MHz, 24x7x365 operation. 512 channels at 800 sweeps. This is an expertly designed and very reliable analog/digital spectrograph.

1. **Three SDRPlay2PRO spectrograph receivers. 15.996 to 24.004 MHz**

2. **Three Flagg RadioJove R1.1 20.1 MHz receivers. (Only one in use at this time.) RF 2080 Calibrator.**

Various amateur radio transceivers. Kenwood TS-2000, Icom IC-7300, ANAN 100D SDR, LimeSDR USB, KiwiSDR, Red Pitaya,etc.

SECTION III: Calibration



K4LED FSX-11 (12-bit) Spectrograph Step Calibration — 16-Aug-2017 00:19 UTC

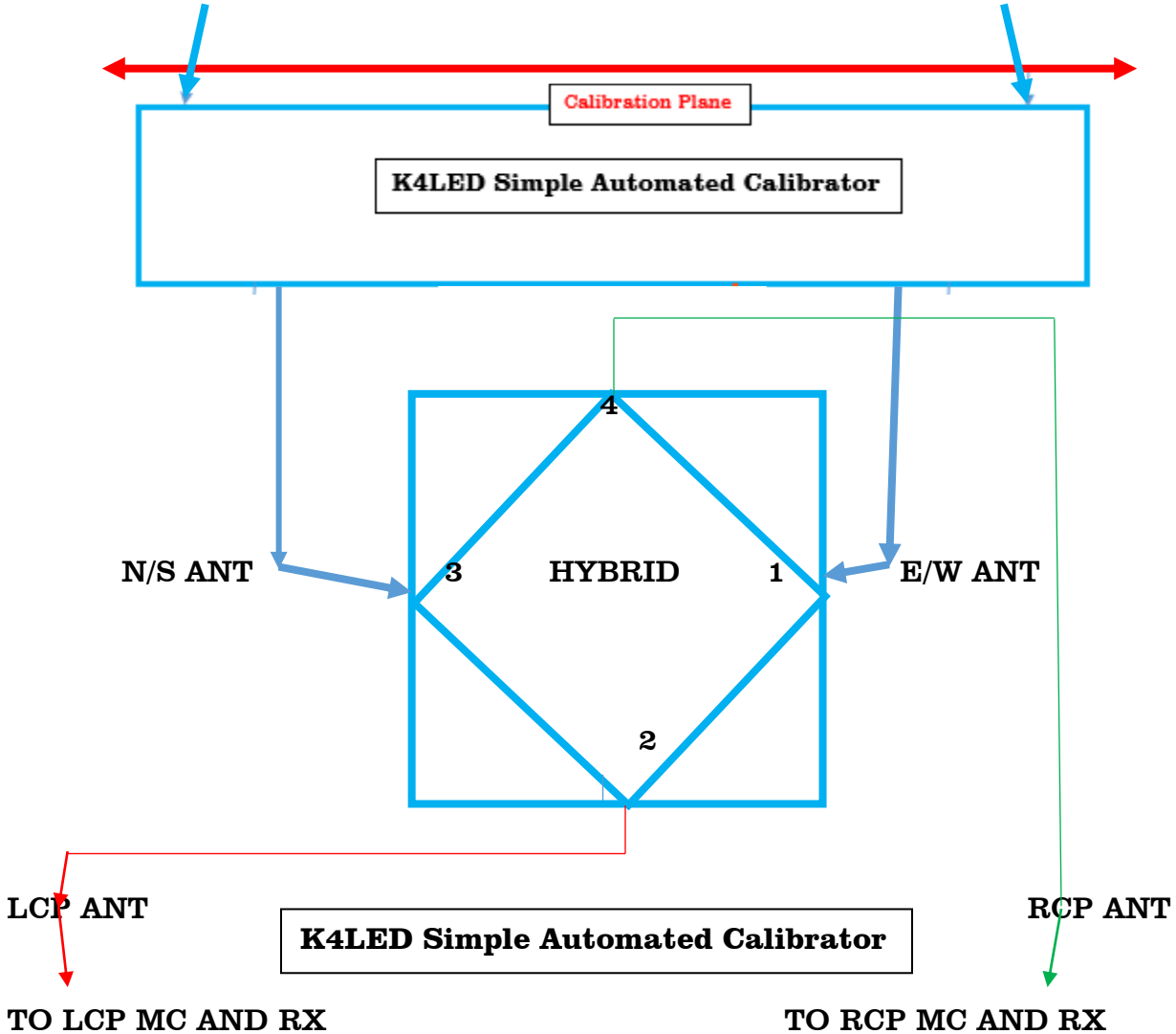
HP461A noise source + Kay 431D step attenuator

Calibration Plane: Spectrograph Input

T0 (K)	290
Noise source temperature (MK)	74.8
Feed loss, cal plane to antenna (dB)	3.1
Receiver noise figure (dB)	6.0

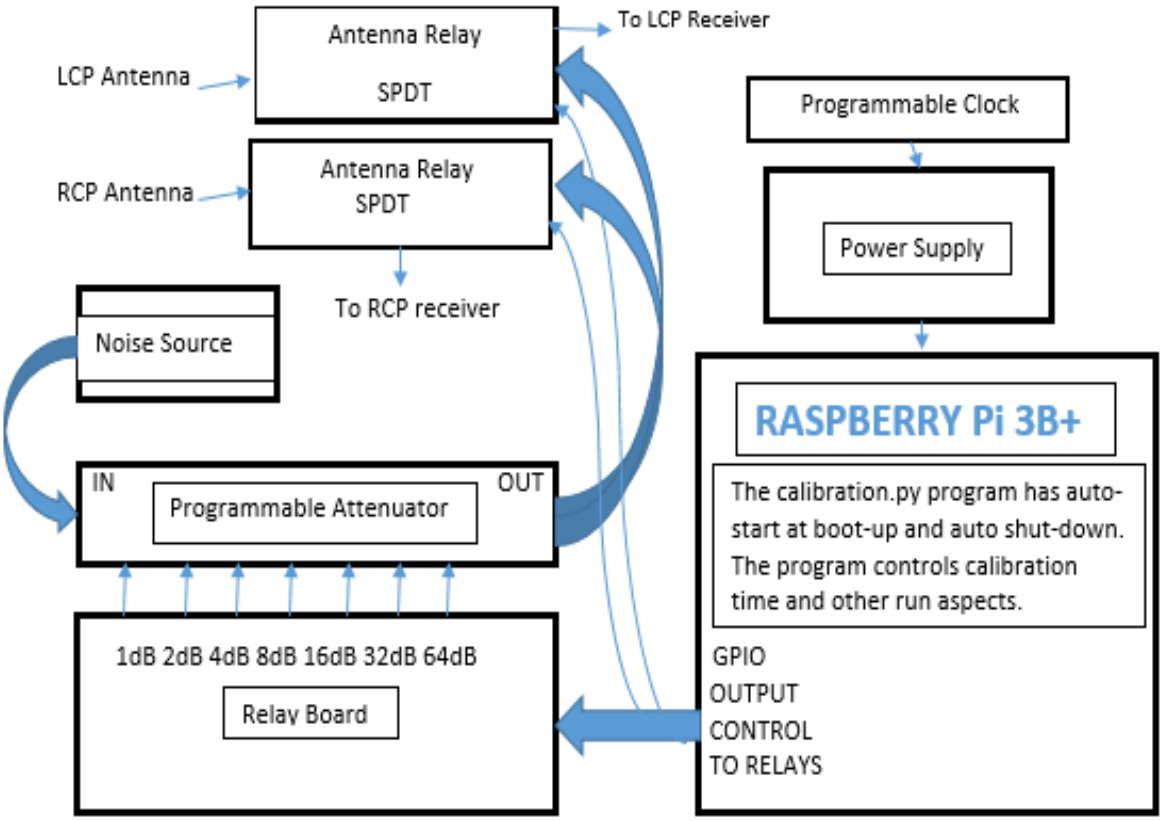
Att. dB	Source Temp (kK)	Equiv. Ant. Temp. (kK)	50 s Avg. @ Average MHz	Solar Adjusted Value	Jupiter Adjusted Value	Custom 1 Adjusted Value	Custom 2 Adjusted Value
				RSS Color Offset: 1875	1875	0.00	0.00
				RSS Color Gain: 1.85	1.85	1.00	1.00
0.1	73,098	149,246	4055	4033	4033	4055	4055
3.1	36,636	74,800	3928	3798	3798	3928	3928
6.1	18,362	37,489	3828	3613	3613	3828	3828
9.1	9,204	18,789	3677	3334	3334	3677	3677
11.9	4,831	9,861	3475	2960	2960	3475	3475
14.8	2,478	5,057	3331	2694	2694	3331	3331
17.8	1,243	2,535	3186	2425	2425	3186	3186
21.1	582	1,186	3051	2176	2176	3051	3051
24.1	292	594	2905	1906	1906	2905	2905
27.0	150	305	2715	1554	1554	2715	2715
29.7	81	164	2624	1386	1386	2624	2624
32.6	42	84	2485	1129	1129	2485	2485
35.6	22	42	2347	873	873	2347	2347
38.7	11	21	2214	627	627	2214	2214
42.2	6	10	2098	413	413	2098	2098
45.1	3	5	1991	215	215	1991	1991
48.1	2	3	1904	54	54	1904	1904

Image Below
Offset: 1875
Gain: 1.85



To Multicouplers

K4LED Simple Automated Calibrator



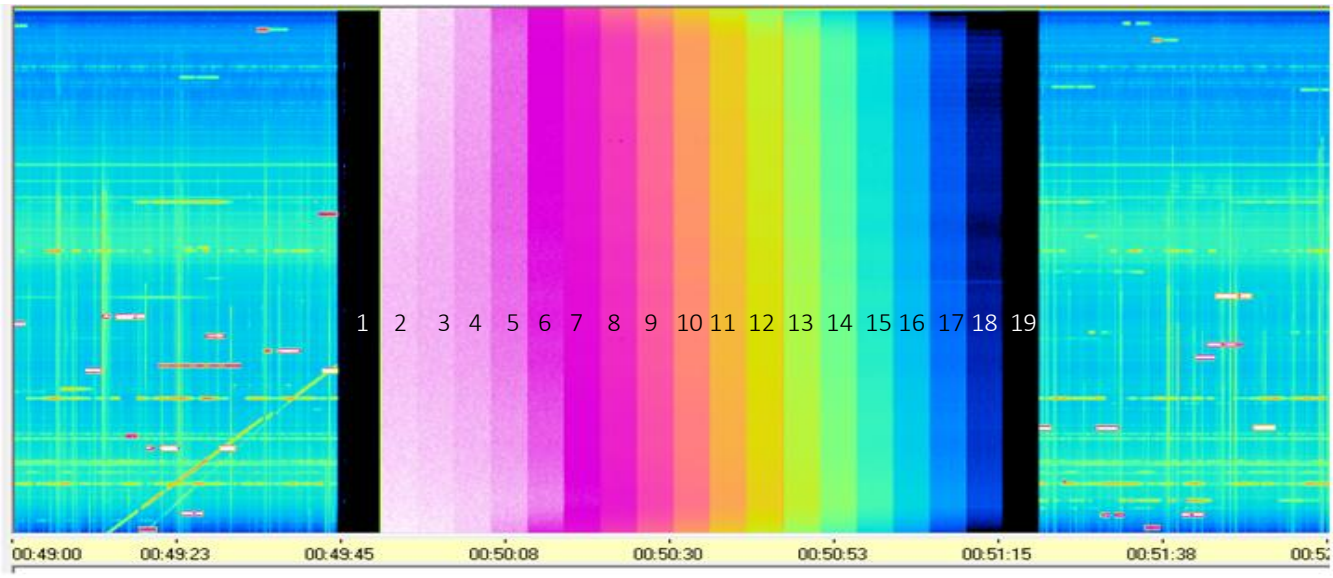
Notes: This automated calibrator was designed with off the shelf modules to keep it simple and facilitate replication by those with little electronics background. The Python control program is loaded into a Raspberry Pi computer. However almost any computer or controller with sufficient GPIO output pins that can utilize python software should work. The calibrator starts automatically with power on by the programmable clock. The antenna relays controlled by the computer program switches the receiver(s) from the antenna to the calibrator programmable attenuator output at the start of a calibration run. The noise source is attenuated in steps by the programmable attenuator from 0 dB to -127 dB controlled by the Python Calibration.py program running on the Raspberry Pi 3B+ computer. After the calibration run is complete the antenna relay is released returning the receiver(s) input to the antenna. All voltages needed are provided by the power supply package. After the calibration program has shut-down the programmable clock removes all power to the calibrator. The real time programmable clock has a battery back up in case of total power failures. The cost to replicate this simple automated calibrator should be around $265. The full python code is provided to facilitate replication of this calibrator designed primarily for Radio Jove Observatories. Fabrication and use is at your own risk.

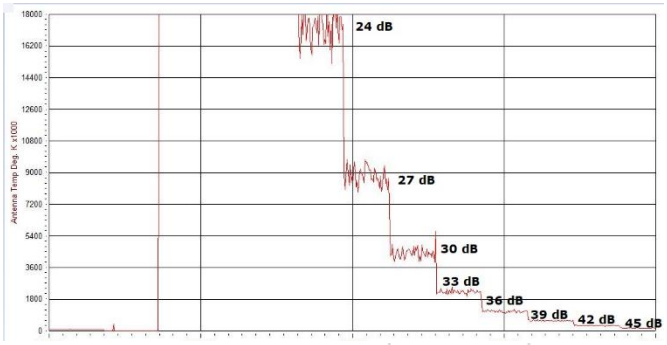
1@ Programmable Attenuator, Weinschel Engineering, 0-127 dB 12 volts DC (eBay) $100
2@ Antenna Relay, Ducommun Technologies, Model 2SE1T11JA 12 volt DC (eBay) $40
1@ Raspberry Pi, Model 3B+ (Amazon) $35
1@ Relay Module, 16 relays (Amazon) $29
1@ Noise generator, BG7TBL 2016-03-06 (eBay) $16
1@ Tobsun EA25-5v 12v to 5v converter (Amazon/eBay) $8
1@ OKTimer THC15A, 12 volt DC version (Amazon) $15
1@ Misc. wire, connectors, cables, etc. $20

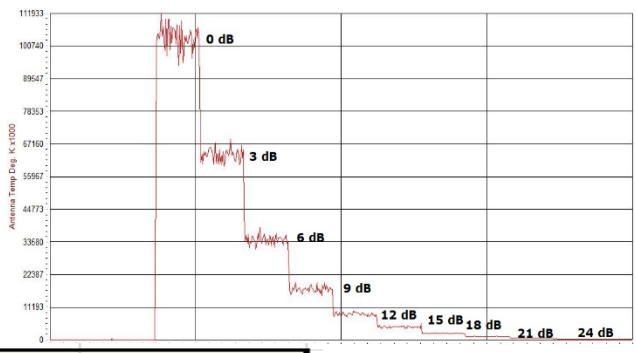
Notes: Currently the K4LED clock timer is set to run a calibration at 00:10 UT to 00:20 UT and also at 12:10 UT to 12:20 UT. Up to 17 calibrations per day are possible. If you use the OKTimer be sure to get the 12 Volt DC model. There are several different models with different voltage types. The timer/clock has a turn on glitch that was dampened with a 1000 uf electrolytic capacitor across the timer input. An on time of 10 minutes is set for a calibration run to make sure the Raspberry Pi has time to load at boot and shut-down after the program finishes. Buttons on the timer allow for a manual ON/OFF/AUTO modes. Otherwise the calibrator is totally powered down by the timer/clock except for calibration runs. The antenna relays are latching type so only a momentary pulse is needed to trip the relay to latch the receivers either to the calibrator or to the antenna. Therefore constant relay voltage is not required.

AUTOMATED CALIBRATION COLOR BAR TEST PATTERN AND DATA

ACTUAL MEASURED DATA







STEP	TEMPERATURE	ATTENUATION
1	>1 kK	101 dB
2	104.0 MK	0 dB
3	66.9 MK	3 dB
4	36.3 MK	6 dB
5	19.1 MK	9 dB
6	9.6 MK	12 dB
7	4.5 MK	15 dB
8	2.3 MK	18 dB
9	1.2 MK	21 dB
10	602.0 kK	24 dB
11	296.6 kK	27 dB
12	133.0 kK	30 dB
13	92.2 kK	33 dB
14	51.6 kK	36 dB
15	32 .0 kK	39 dB
16	22.6 kK	42 dB
17	17.9 kK	45 dB
18	12.0 kK	48 dB
19	>1 kK	101 dB

SECTION IV: Computers – 3@ Minix NEO N42C-4

FSX11+ Skypipe **SDRPlay2PRO RCP** **SDRPlay2PRO LCP**

3@ Minix NEO N42C-4 mini-computers. This model is upgradeable and has a fan for cooling and runs latest windows 10. Minix-1 runs the SkypipeII strip chart and FSK11 Spectrograph on same computer. Note: the audio-in is mono only. Use a USB soundcard for stereo microphone input. Minix-2 runs SRPlay2PRO RCP. Minix-3 runs SDRPlay1PRO LCP. The computers 12 volt input gets very noisy. It is recommended to keep this voltage isolated.

The MINIX NEO N42C-4 includes 2xSODIMM slot (dual channel) RAM, maximum support 8GB + 8GB, i.e. maximum of 16 GB. Below is a list of DDR3L Memory that's tested and verified to be compatible.
Kingston BKMH0871451 4GB
Kingston BPMK16A1447 8GB
Samsung M471B5173EB0-YKO 4GB
Samsung M471B1G73QH0-YKO 8GB
Kingston Technology HyperX Impact - HX316LS9IBK2

The procedure for adding an SSD drive to the N42C-4 is incomplete and misleading. I have upgraded three so far and written below a lessons learned to help you. It really is an easy procedure. The maximum SSD is 512 GB.

Procedure to add an SSD drive to a MINIX NEO N42C-4

Take the four rubber feet off the bottom of the Minix computer.

Unscrew the four hidden screws.

Install the new SSD drive into the socket and secure with the top screw.

Here is a list of known compatible M.2 SSD drives for the N42C-4. Must be 512 GB or smaller.

Intel SSDSCKHW120A4 120GB

Kingston SM2280S3G2 120GB
Kingston SM2280S3G2 240GB
Kingston SM2280S3G2 480GB
Lenovo GXB0M41970 128GB
Samsung MZ-N5E120 120GB
Samsung MZ-NTY1280 128GB
Samsung 850 EVO 500GB
SanDisk SD7SN6S 128GB
SanDisk SD8SN8U 256GB
SanDisk SD8SN8U 512GB
Transcend TS256GMTS800 256GB
Western Digital Model WDS240G1G0B-00RC30 240 GB

You must now download and install the special MINIX WIN10 installer.

Download (FTP) the MINIX WIN10 installer from HOST NAME: ftp.minix.cloudftp.hk, USER NAME: f104556.public, PASSWORD: public. Use the FTP program called WINSCP. Filezilla will not work well for this large program.

Un-zip the downloaded file named OSWIN10RS2GDM-N42C-4-EN-US-Pro-Vo2-20171110.zip

Format a 16 GB or larger USB thumb drive with NTFS and copy the unzipped folders to this thumb drive. Name this thumb drive WINPE. It must be named WINPE or the installer program shell can't find the files it needs. Put this thumb drive in the N42C-4 computer USB slot.

Power up your MINIX computer while hitting the Del key to go into the BIOS.

Arrow across to CHIPSET. Set South Cluster to DISABLED.

Press Fn F4 key to save and exit.

Restart MINIX while hitting the delete key to go back into the BIOS.

Arrow over to BOOT. Set the top boot line to boot from WINPE your thumb drive.

Reboot your computer and let the installer run. It will take at least 15 minutes. Do not do anything.

Your computer will reboot at the end of the WIN10 install. On the left side run the clean-up test then reboot. You now have WIN10 installed on your new SSD drive and the internal version is disabled.

SECTION V: Software

SkyPipeII Pro, strip chart, version 2.7.34 **This program from RadioSky Publishing is a powerful tool for amateur radio astronomy. (By: Jim Sky)**

Spectroscope, v 2.9.27 **This software allows you to view signals from special frequency-sweeping receivers at the Windward Community College Radio Observatory (WCCRO) and the University of Florida Radio Observatory (UFRO) and from many volunteer radio astronomers. These receivers, called spectrographs, allow you to see how radio signals are distributed across a 10 MHz wide swath of radio spectrum. The receivers were designed and built by Richard Flagg to be sensitive and fast enough to detect changes which occur in the radio emissions of the Sun and Jupiter. This**

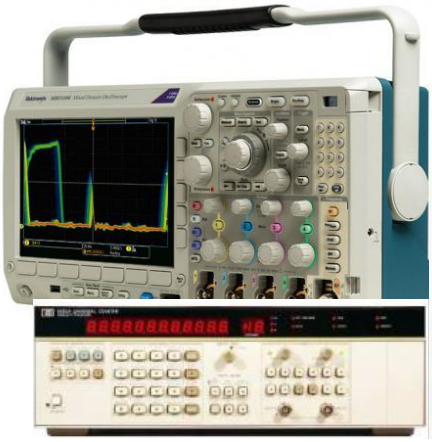
software, produced by Radio-Sky Publishing, will run on most modern Windows based computers with an internet connection speed of 56K or more. There is no charge for use of the software for non-commercial users. You can download it from http://jupiter.wcc.hawaii.edu/spectrograph_software.htm All the receivers at K4LED are running RSS version 2.9.26.

Radio Jupiter Pro, Radio-Sky Publishing's multi-function observing aid for Jupiter's decametric radio emissions. This program predicts most likely times for Jupiter radio storms and displays Jupiter visibility information graphically. Predictions are customized to your location. See help page at http://www.radiosky.com/rjpro/rjprohelp.html for more information.

Python Code for K4LED Automated Calibrator, The Python code for the automated calibrator is available for free from K4LED upon request.

SECTION VI: Station Test Equipment

Tektronix MDO 3022 Oscilloscope features six integrated instruments, including a spectrum analyzer. Rigol 4102 Arbitrary Waveform Generator. Comet Antenna Analyzer CAA-500 Mark II. HP-8640B Signal Generator. HP-5335A Frequency Counter. Fluke 287 True RMS Logging Multi-meter. Micronetics Noise Generator, HP461, Kay Attenuator, and many, many more.






SECTION VII: Implementation of a K4LED Stratum 1, PTP, GPS Time Server for near zero micro-second accuracy based on the GPS

system.

TIME SERVER FEATURES and SPECIFICATIONS:

- Receive time information from GPS satellites anywhere on the surface of the earth.
- RFC1119/1305 NTP Protocol to serve time (Network Time Protocol).
- RFC1769/2030/4330 SNTP Protocol (Simple Network Time Protocol).
- IEEE 1588 2002/2008 PTP Protocol.
- Server Time Level: Stratum 1.
- NTP Server Time Precision: Better than 1mS + network jitter.
- PTP Server Time Precision: Better than 3uS + network jitter.
- Holdover time: PTP: 1.25+ hrs NTP: 48+ hrs.
- 10M/100M auto sensing network interface.
- Unit is capable of serving 750+ NTP synchronizations per second. That provides support for over 600,000+ devices updating every 15 minutes on the network.
- Compliant with FCC Part 15B and CE marked for radiated emissions and is a lead free product.
- Power Requirements: 5W at startup and 2.5W continuous at 12V DC.
- Environmental: Commercial temperature range, 0-70C, 95% humidity non-condensing. Altitude -304m to 18,000m.
- Networking: Static or DHCP IPv4 addressing. Standard browser interface for setup.
- Indications: Power, GPS Signal Lock, and 1PPS indications.
- Rear Connections: Power, Cat5 Ethernet, Serial, Dual USB, and GPS antenna via SMA connection.
- Supports +3.3V and 5V active GPS antennas with internal jumper setting.
- Mechanical Dimensions: 5" x 4.2" x 1.3".

GPS SPECIFICATIONS:

- Based on MediaTek MT3339 Chipset.
- 22 channel low power receiver module.
- Sensitivity: -165dBm.
- GPS Time Precision: +/- 10ns RMS jitter.
- Antenna Connection: 1575.42MHz (L1 Band).
- TTFF (Time To First Fix).
- Cold start @-125dBm typically 33 seconds.
- Re-acquisition (<10s obstruction) typically 1 second.

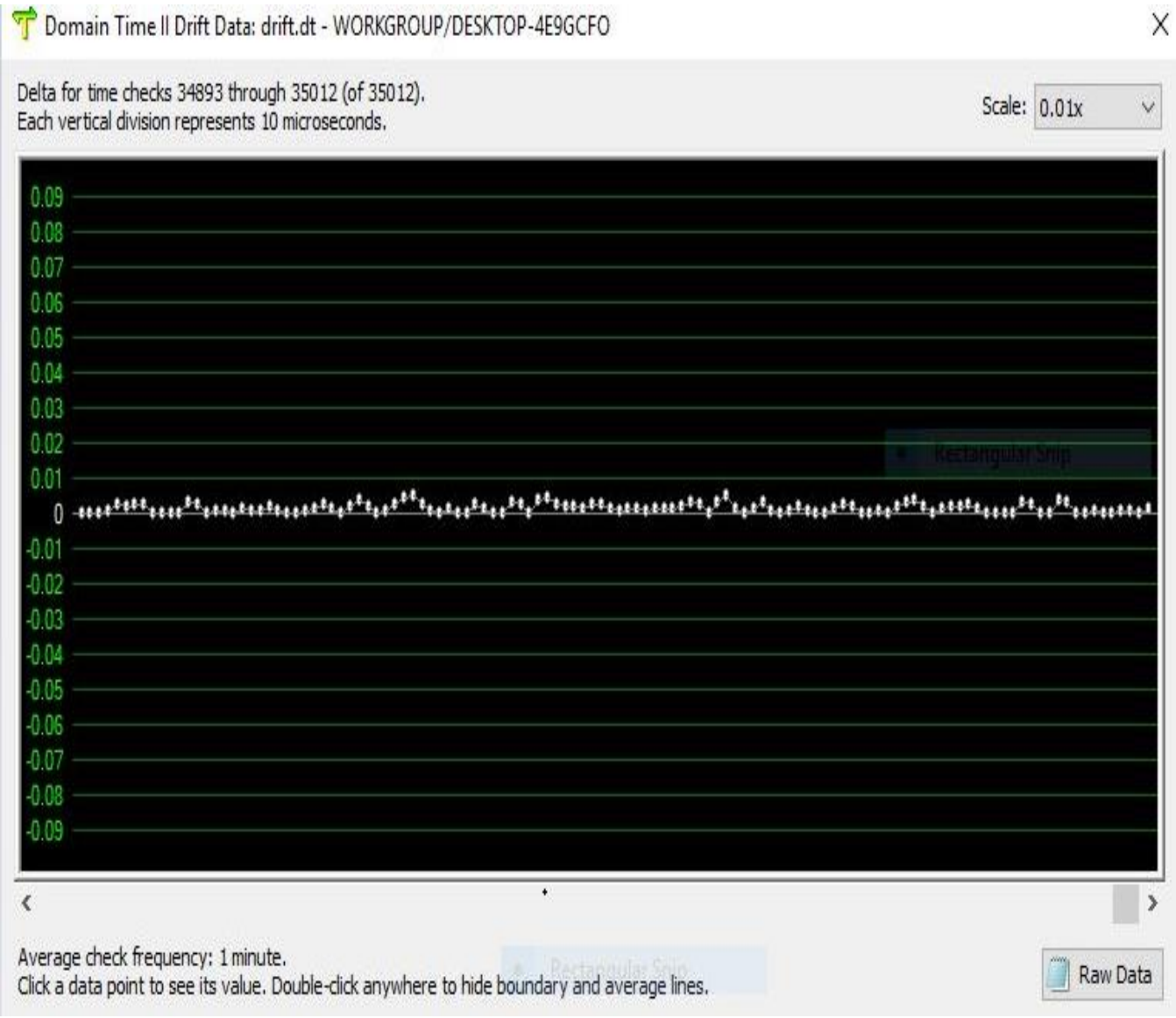
ANTENNA SPECIFICATIONS:

- Active patch antenna with magnetic base.
- Size: 1.57" x 1.89" x 0.51", 43 grams.
- Amplifier: LNA +20dB, Noise: 1.5dB, VSWR: 2.0, Voltage: 2.7-6.0V.
- Cable: RG174, 5m length, SMA male.
- Environmental: -40 to +85C.
- Waterproof to IPx6.

The TimeMachines GPS PTP Network Time Server represents a major step forward in capabilities at a breakthrough price point. It will supply accurate time for all computers and time keeping devices on the network. A Stratum 1 time source can now be available on the local network with no need for an internet connection. The TM2000A system uses an active GPS antenna to maintain the current time as broadcast by United States GPS satellites planet wide. In addition, a high stability OCXO reference clock is included that allows the unit to serve time if GPS lock is lost for periods of time. The unit is small and can be placed anywhere within the network layout.

Outdoor antennas are available from TimeMachines including custom length cables and accessories.

A Stratum 1 GPS PTP network time server, Time Machines TM2000A (~$499) plus (Domain Time II Client $39.99 per computer) PTP client software is installed at this station providing near zero microsecond time accuracy. This network time server attaches to a dedicated Ethernet switched port. A PTP client is implemented on each computer for accurate time corrections. The higher accuracy provides support for highly detailed and specialized scientific studies. – TM2000A PTP Server Time Precision: ~zero μsec average or better plus delay, offset, and jitter. (See actual results of the near zero μsec average deviation from the Stratum 1 Time server obtained at the K4LED Observatory below.) It improves with time.



The chart above is an actual example of the computer clock drift corrections to maintain a near zero average microsecond accuracy at the K4LED observatory feeding three Windows 10 computers.

IMPLEMENTING FULL PTP: The "Precision" Micro-second or better Time Protocol (PTP) is a protocol used to synchronize clocks throughout a computer network.

On a local area network, it achieves high clock accuracy in the micro-second range, making it suitable for precise measurements. This level of precision is further improved with PTP specific software, hardware, network switch and NIC especially designed for PTP precision time. This can become very expensive. The TM2000A is capable of PTP microsecond time with the proper PTP network software and hardware. Even without the proper "hardware" (PTP NIC, PTP Switch, etc.) timing in the near zero microsecond range is easily possible. Nano-second accuracy is possible with proper hardware.

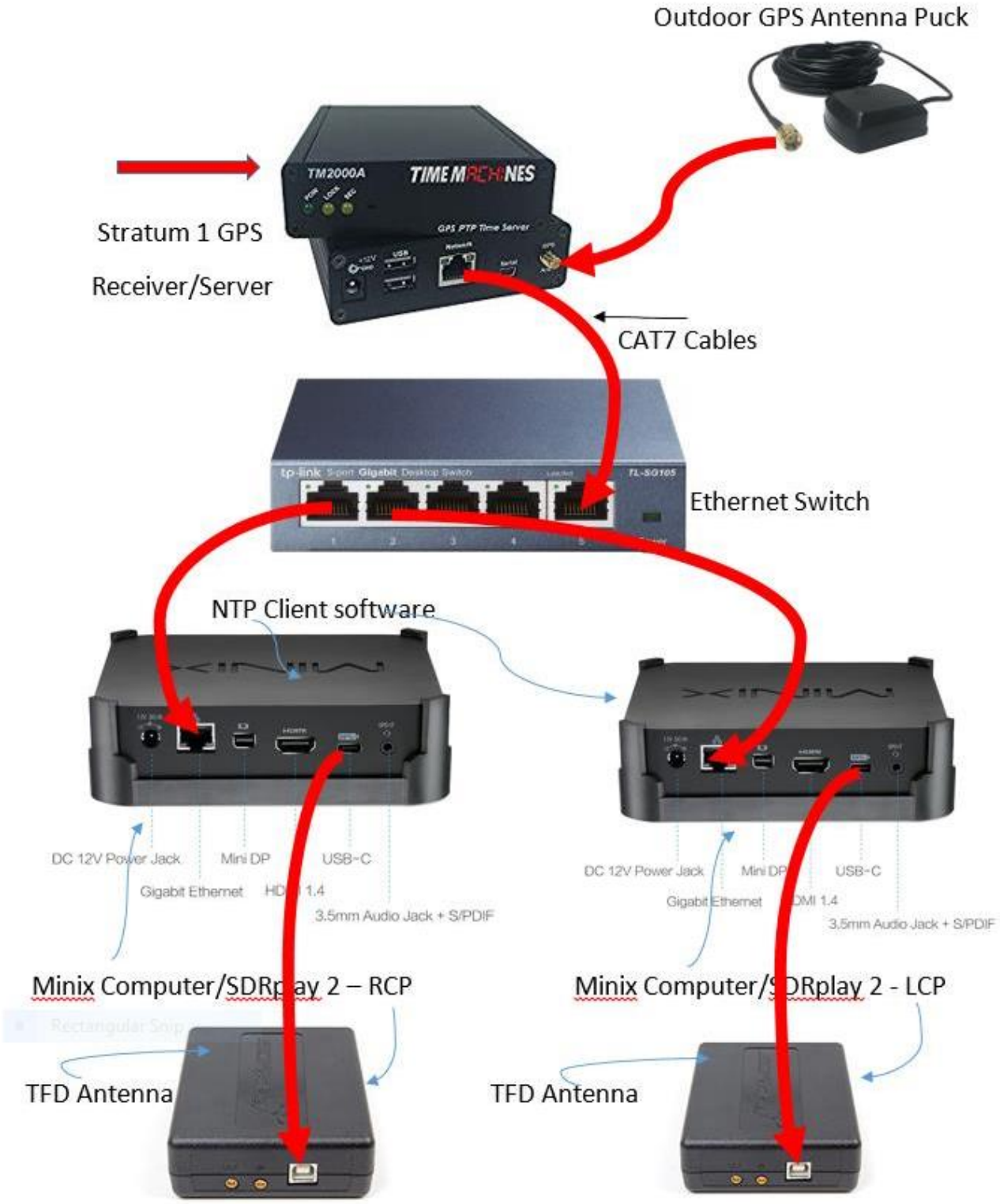
NOTES: Be aware that only the (TN2000A) solution Level 4, Sub Level C, provides a built in holdover capability. Without a holdover capability the SkyPipe chart or Spectrograph could become corrupted due to poor timing data. Battery back-up holdover keeps the clock stable based on the last GPS time data received during periods of satellite outages as experienced during heavy rain storms or heavy cloud cover. Estimated average time accuracy is highly dependent upon local characteristics, computer speed, network configuration, router specifications, cable length, cable type and many other conditions. Other solutions may perform as well or even better but keeping costs to a reasonable level is a consideration. Standardization is desired to facilitate comparison of science investigations from observatories at various locations. Notice in the example below the Ethernet switch is "not" your LAN router but a separate dedicated unmanaged switch dedicatede for time distribution.

Time Server Features and Specifications • Receive time information from GPS satellites anywhere on the surface of the earth.

• PTP Server Time Precision: better than 3 micro seconds + network jitter. • All networked computing platforms support time synchronization either natively or with add on drivers including: Windows, Macintosh, and Linux. Many other devices can access the device as well including VoIP phones and digital clocks. • 10M/100M adaptive network interface • Unit is capable of serving 750 + PTP synchronizations per second. That provides support for over 600,000+ devices updating every 15 minutes on the network. • Active Patch GPS antenna included. Magnetic base. • Indications: Power, GPS Signal Lock, and 1PPS indications • Rear Connections: Power, Cat5 Ethernet, Serial (NOT FOR CUSTOMER USE), and GPS antenna via SMA connection. Supports +3.3V and 5V active GPS antennas with internal jumper setting. • Serial port outputs data every two seconds, including the following items: - IP, Time, GPS fix, Time known, PTP-Clock Class, PTP-Clock Accuracy, PTP-Stratum. • Mechanical Dimensions: 5 in. x 4.2 in. x 1.3in.

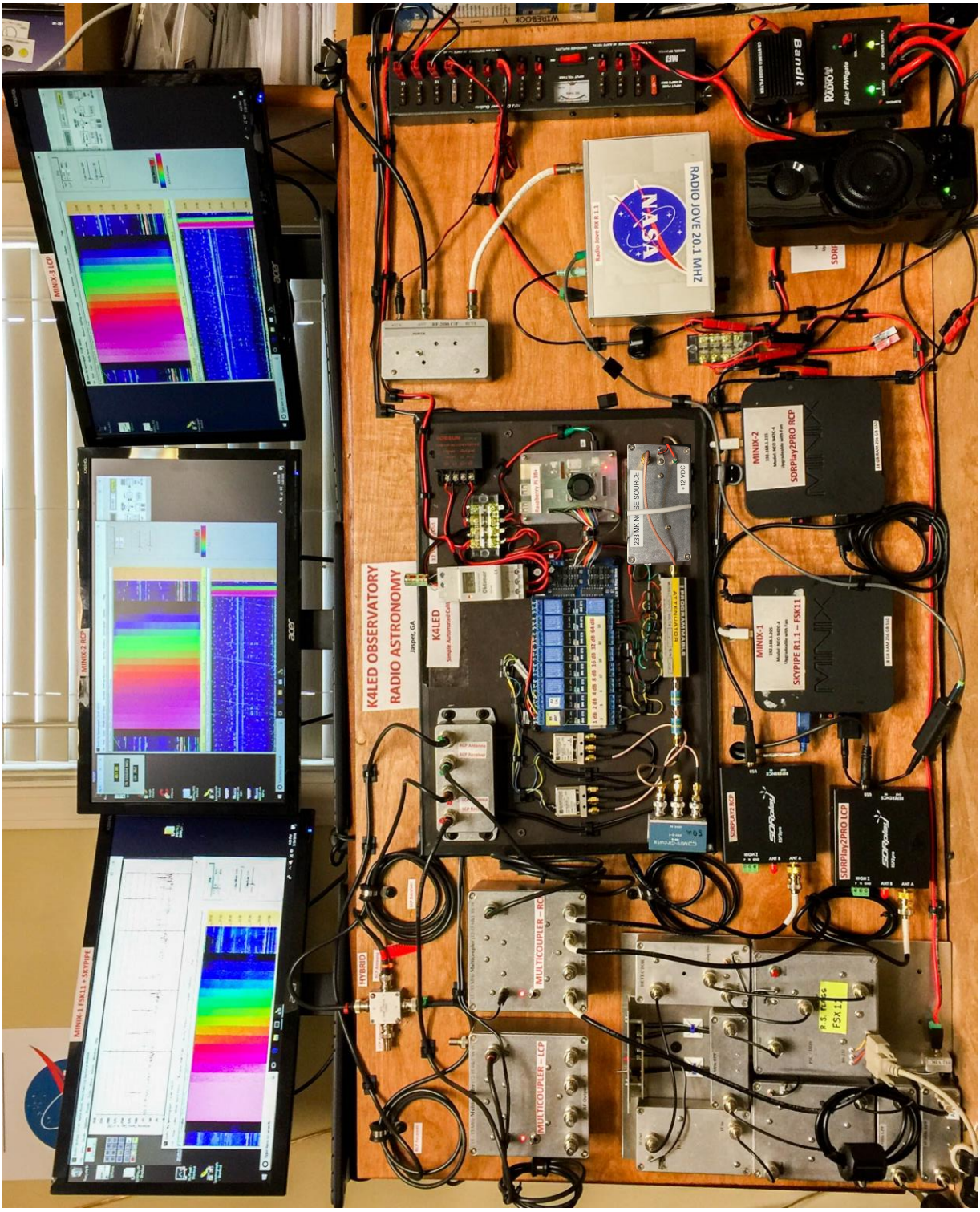
K4LED PTP Network Microsecond Time Source

(Skypipe and an FSX11 spectrograph are also on this time server but not shown.)

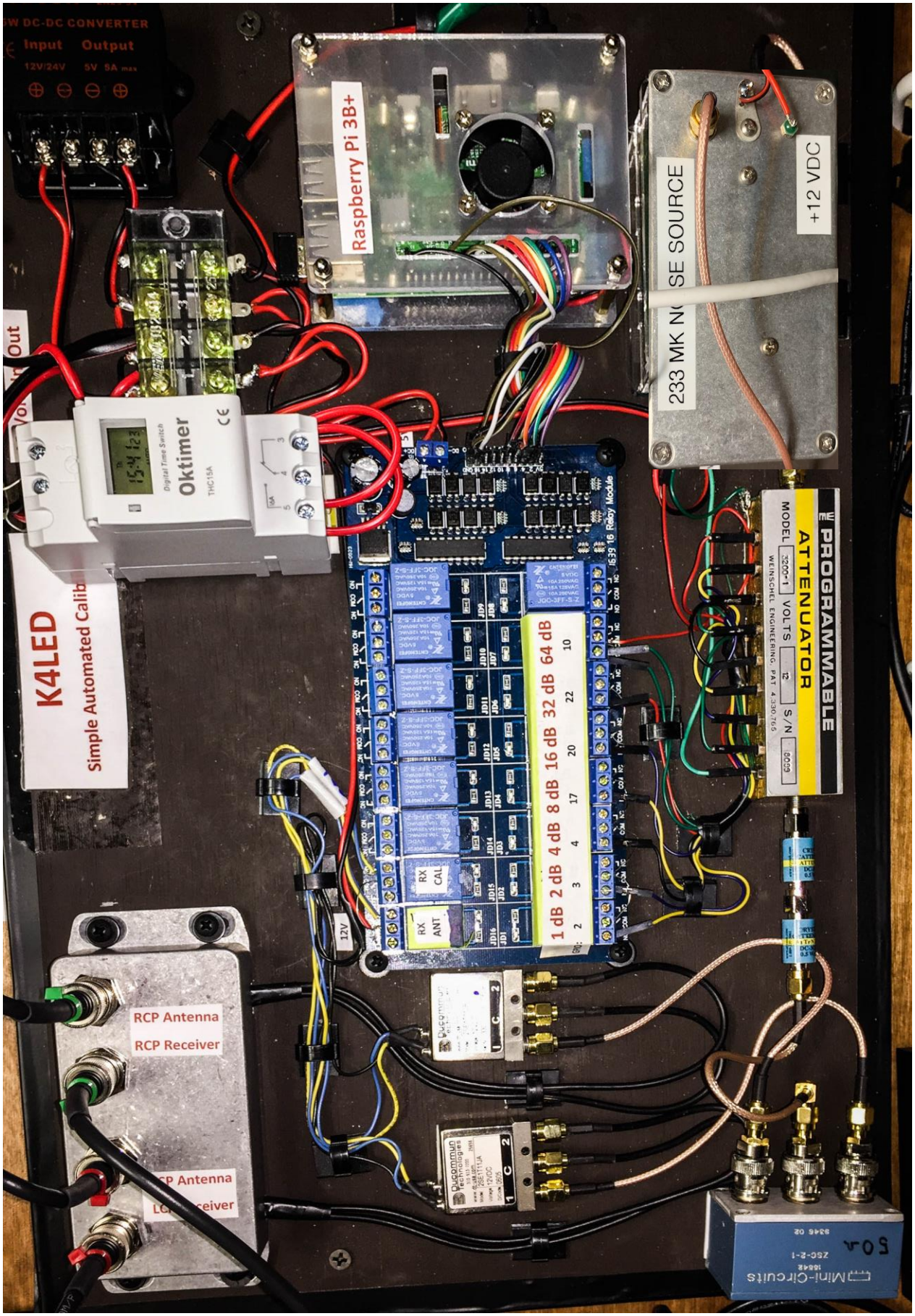


APPENDIX A (Station Images)

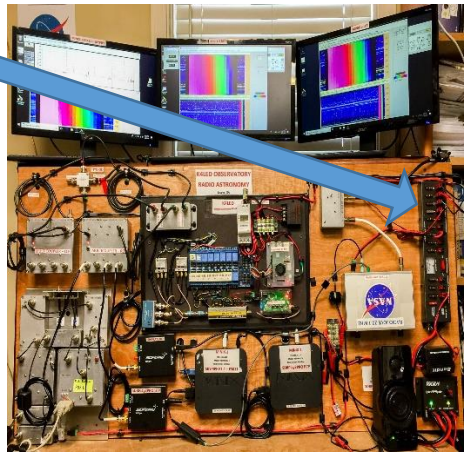
K4LED Complete station 2' x 4' Board,, 2@ SDRPlay2PRO - RCP/LCP and FSX11 (RCP) and Skypipe. 3@ Minix NEO N42C-4 computers and one FSX11 spectrograph. One RJ1.1 (Linear)



K4LED Automated Calibrator



APPENDIX B (K4LED 12 Volt DC Uninterruptable Battery Power Configuration)
MFJ-1126 Power Distribution fuse buss and Anderson Power Connectors



West Mountain Epic PWRGate **Optima BlueTop AGM Batteries – Spill Proof**

- Epic PWRgate is a 12 volt backup power system rated at 40 amperes continuous from either a Power Supply or a Battery.
- Connected equipment will instantly switch to battery during a power blackout or power supply failure.
- Low loss PWRgate provides forward voltage drop of only 0.05 volts.
- USB port access to monitor system or to change charge parameters.
- Program for specific battery types.
- Supports smart charging of either Lead Acid or Li-Ion battery charging up to 10A.
- Optional direct solar panel input for battery charging (all chemistries). Solar panel VOC must be <= 30V.
- Can be programmed for vehicle use to suspend charging when the alternator is off.
- Complete LED status indicators.
- Battery charge suspend button to eliminate current draw or charger noise for 30 minu
- Optional temperature probe to control charging based on battery temperature.
- Solid, durable construction in an aluminum case. Includes mounting holes for conve and secure use in mobile units.
- Uses Anderson Powerpole connectors.
- Includes: Epic PWRgate Unit, USB-micro Cable, (4) Retention Clips, Owners Ma rence Card
- Maximum Voltage: PS 16V / Solar 30V
- Maximum Current: 40 Amperes
- Voltage Drop: 0.05VDC
- Connectors: Anderson Powerpole, 40A
- Size: 4.5 x 3.375 x 1.25 in
- Weight: 0.35 lbs
- Mounting Holes: Four - 0.175 d, #8 hardv

Canadian Solar
Monocrystalline 100 Watt Solar Panel

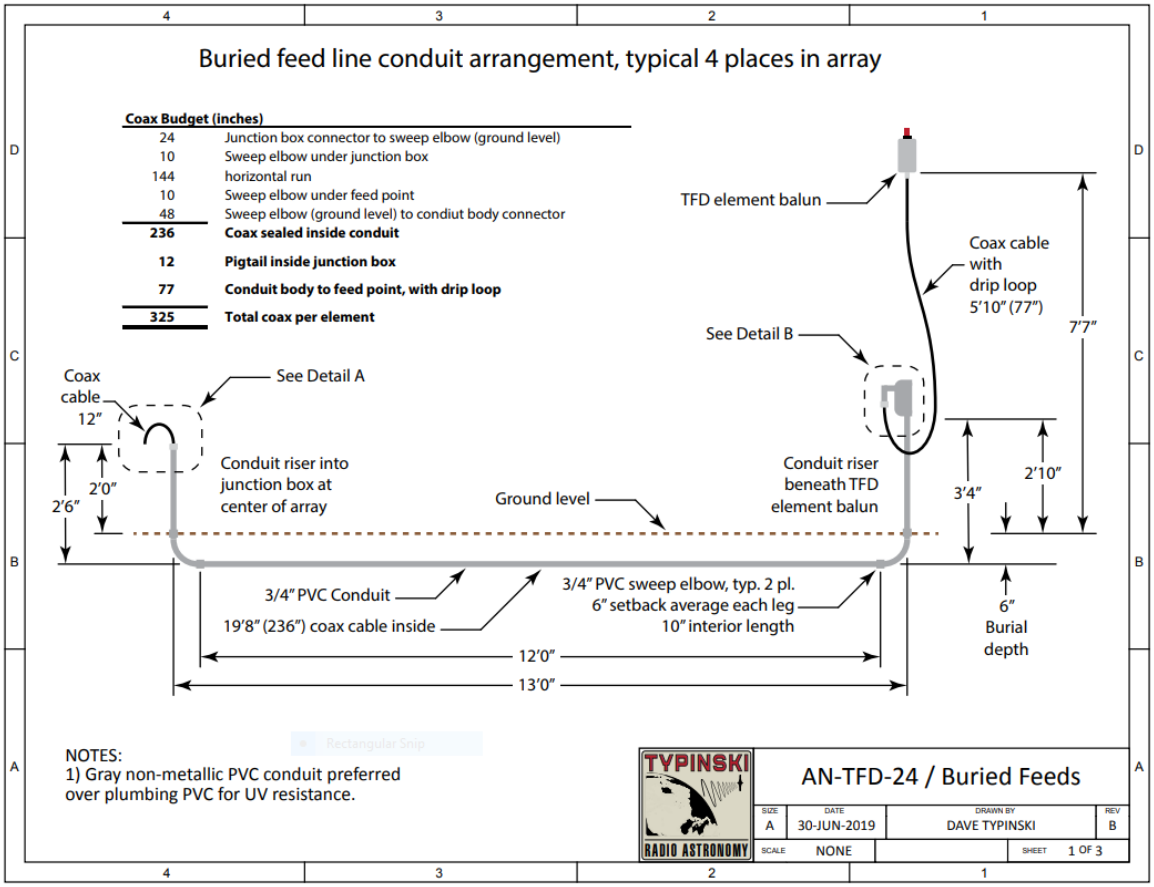
APPENDIX C: Antenna Feed System Losses

AN-TFD-24-4 Antenna and Feed System Losses, K4LED, Jun 2018

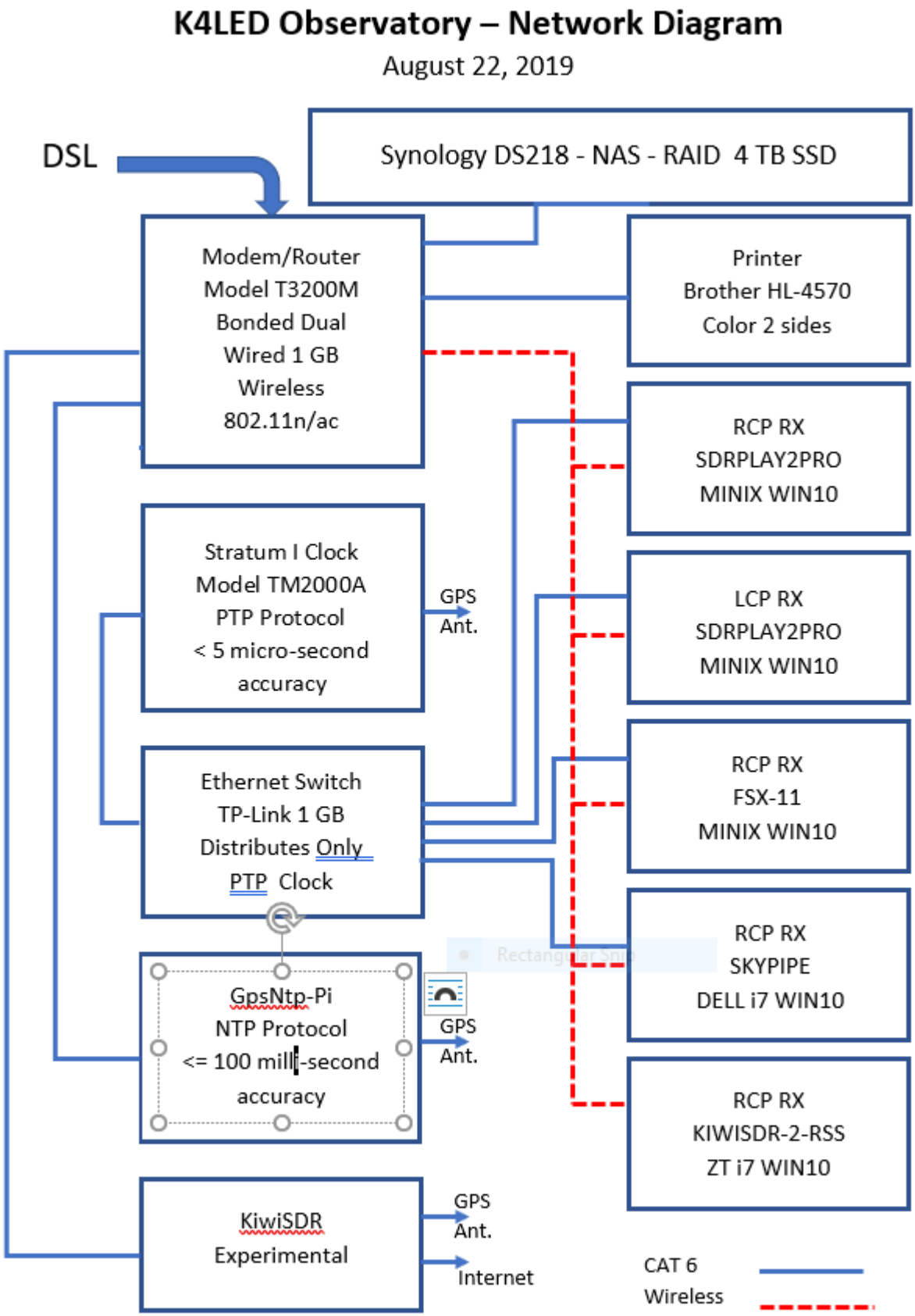
Component:	TFD Elements	Baluns	Element Feeds	Combiners	Main Feeds	Surge Suppressors	Jumpers			Hybrid Ring	Jumpers	Jumpers
Sweep Date:	27 Aug 2014	04 Feb 2018	17 Feb 2018	04 Feb 2018	03 Feb 2018	04 Feb 2018	17 Feb 2018			24 Jan 2018	17 Feb 2018	17 Feb 2018
Mfgr:	AJ4CO	AJ4CO	Belden	Mini-Circuits	Times	PolyPhaser	Times			Synergy	Belden	Belden
P/N:	TFD-24	BA-161	8259 RG-58	ZSC-2-1+	LMR-240DB	IS-50NX-C0	LMR-240DB			DQK-701B	8259 RG-58	8259 RG-58
Descr:	24' TFD element wire only	16:1 Balun Two no S/N + S/N 9, 10	Baluns to J-box	Combiners	J-box to surge suppressors	Surge suppressors	Surge suppressors to hybrid			90° Hybrid S/N 13	Hybrid to multi-couplers	Multi-couplers to receivers
Coax Length:			26'		100'		22'				5'	5'
Coax Color:			ORG / BLU		ORG / BLU		ORG / BLU				GRN / RED	GRN / RED
Freq (MHz)	Inefficiency (dB)	Loss (dB)	Loss (dB)	Loss (dB)	Loss (dB)	Loss (dB)	Loss (dB)	Loss Between Element Feed Points and Hybrid Inputs (CAL PLANE) (dB)	Loss Between sky side of element wires and Hybrid Inputs (CAL PLANE) (dB)	Loss (dB)	Loss (dB)	Loss (dB)
14	?	-0.48	-0.45	-0.10	-1.05	-0.01	-0.23	-2.3	?	-0.12	-0.08	-0.08
16	?	-0.49	-0.48	-0.10	-1.12	-0.01	-0.25	-2.4	?	-0.14	-0.08	-0.08
18	?	-0.50	-0.52	-0.11	-1.17	-0.01	-0.26	-2.6	?	-0.16	-0.09	-0.09
20	**-4.3**	**-0.53**	**-0.55**	**-0.11**	**-1.22**	**-0.01**	**-0.27**	**-2.7**	**-7.0**	**-0.17**	**-0.09**	**-0.09**
22	?	-0.54	-0.59	-0.11	-1.28	-0.01	-0.28	-2.8	?	-0.19	-0.10	-0.10
24	?	-0.56	-0.62	-0.12	-1.33	-0.01	-0.29	-2.9	?	-0.19	-0.10	-0.10
26	?	-0.58	-0.64	-0.12	-1.37	-0.01	-0.31	-3.0	?	-0.19	-0.11	-0.11
28	?	-0.60	-0.67	-0.12	-1.42	-0.01	-0.32	-3.1	?	-0.18	-0.11	-0.11
30	?	-0.61	-0.70	-0.13	-1.46	-0.01	-0.33	-3.2	?	-0.17	-0.11	-0.11
32	?	-0.63	-0.72	-0.13	-1.51	-0.01	-0.34	-3.3	?	-0.16	-0.12	-0.12

Calculated Signal Levels, 20 MHz Galactic Backgorund, K4LED TFD Array, Feb 2018

20 MHz GB (kK)	50
BW (MHz)	15
GB signal level @ sky (dBm)	-79.8
Wire element inefficiency (dB)	-4.3
Signal level @ feed point (balun binding posts) (dBm)	-84.1
20 MHz Feed system loss (dB)	-2.7
Signal level @ hybrid inputs (CAL PLANE) (dBm)	-86.8
Hybrid + jumper loss (dB)	-0.3
Signal level @ multicoupler input (dBm)	-87.1
Multicoupler Gain (dB)	+10.0
Signal level @ multicoupler output (dBm)	-77.1
Jumper loss (dB)	-0.1
Signal level @ receiver input (dBm)	**-77.2**



APPENDIX D: Station Network Diagram



APPENDIX E: SUG Station Instrumentation Capabilities

SUG Instrumentation Capabilities Typinski, August 2019		
	Station Abbreviation	**K4LED**
	Contact	**Larry Dodd**
	Status	Active
Location	**Observatory Name**	K4LED Observatory
	Sation Lat	34° 25' 28" N
	Station Lon	84° 29' 39" W
	Time Zone	UTC-5 EST / UTC-4 EDT
	Web Site	Link
	Station Diagram	Link
	Diagram Date	01 Sep 2019
Antenna 1	**Antenna 1 Name**	TFD Array
	Number of Array Elements	4
	Arrangement	square
	Wire Height	8'
	Ground Plane	Natural
	Polarization	RCP and LCP
	Beam Steering	Manual
Antenna 2	**Antenna 2 Name**	Dual Colinear Array - MFJ-6214
	Number of Array Elements	2
	Arrangement	Colinear East-West
	Wire Height	10'
	Ground Plane	Natural
	Polarization	Horizontal Linear
	Beam Steering	(Not in Use)
Antenna 3	**Antenna 3 Name**	RJ Dual Dipoles
	Number of Array Elements	2
	Arrangement	East-West
	Wire Height	10'
	Ground Plane	Natural
	Polarization	Horizontal Linear
	Beam Steering	(Not in Use)
FSX Receiver	**Model**	**FSX-11**
	Front End BPF (MHz)	15-30
	IF BW (kHz)	30
	Sweep Rate	2000 channels per sec (fixed)
	Observing Range (MHz)	15-30
	Channel Count	512
	Input(s)	RCP from TFD Array
	Dual Channel Method	Single
	ADC Resolution (bits)	12
	Operation Schedule	24 x 7 x 365
FSX PC	**Brand**	**Minix NEO N442C-4**
	Computer Name	Minix-1 RCP
	Processor	Intel N4200
	Processor speed	2.5 Ghz
	Number of Processor Cores	4
	RAM	16 GB DDR3L
	Primary HDD	512 MB SSD - LAN NAS 4TB SSD
	OS	Windows 10 PRO
	RSS Version	2.9.27

SDR Receiver 1	**Model**	**SDRplay2PRO**
	Observing Range (MHz)	15.996 to 24.004 MHz
	Channel Count	411
	Input	4TFD
	Operation Schedule	24 x 7 x 365
SDR 1 PC	**Brand**	**Minix NEO N442C-4**
	Computer Name	Minix-1 RCP
	Processor	Intel N4200
	Processor speed	2.5 GHz
	Number of Processor Cores	4
	RAM	16 GB DDR3L
	Primary HDD	512 MB SSD - LAN NAS 4TB SSD
	OS	Windows 10 PRO
	RSS Version	2.9.27
SDR Receiver 2	**Model**	**SDRplay2PRO**
	Observing Range (MHz)	15.996 to 24.004
	Channel Count	411
	Input	4TFD
	Operation Schedule	24 x 7 x 365
SDR 2 PC	**Brand**	**Minix NEO N442C-4**
	Computer Name	Minix-2 RCP 15.996 to 24.004 MHz
	Processor	Intel N4200
	Processor speed	2.5 GHz
	Number of Processor Cores	4
	RAM	16 GB DDR3L
	Primary HDD	512 MB SSD - LAN NAS 4TB SSD
	OS	Windows 10 PRO
	RSS Version	2.9.27
SDR Receiver 3	**Model**	**SDRplay2PRO**
	Observing Range (MHz)	15.996 to 24.004 MHz
	Channel Count	411
	Input	4TFD
	Operation Schedule	24 x 7 x 365
SDR 3 PC	**Brand**	**Dell**
	Computer Name	Dell i7-8700
	Processor	Intel i7-8700
	Processor speed	3.2 GHz
	Number of Processor Cores	6 Cores - 12 Threads
	RAM	32 GB
	Primary HDD	1 TB SSD - LAN NAS 4TB SSD
	OS	Windows 10 PRO
	RSS Version	RSS 2.9.27
Time	**NTP Source**	**Time Machines TM2000A - PTP**
	Tming Software	PTP Micro-second TM-2000A
	Timing Logging	Time Domain II - 4 PTP Clients