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Permanent Link to Innovation: Record, Replay, Rewind
2021/06/20
Testing GNSS Receivers with Record and Playback Techniques By David A. Hall Is there a way to perform repeatable tests on GNSS receivers using real signals? This month's column looks at how to use an RF vector signal analyzer to digitize and record live signals, and then play them back to a GNSS receiver with an RF vector signal generator. INNOVATION INSIGHTS by Richard Langley AS A PROFESSOR, I'm quite familiar with testing — of students, that is. It's how we check their performance — how well they have mastered the course material. Outside academia, testing is also quite common. We have to pass a driving test before we can get a license. We might have to pass a physical fitness test before starting a job. And manufacturers have to test or stress their products to make sure they are fit for purpose. As David Ogilvy, the father of advertising once quipped, "Never stop testing, and your advertising will never stop improving." But it's not just manufacturers who should test products. Consumers, or their representatives, should test products on offer — not only to corroborate (or dispute) manufacturers' claims but also to compare one manufacturer's product against another. There's a whole slew of magazines, television programs, and web resources devoted to testing and comparing everything from laundry detergent to automobiles. And GNSS receivers are no exception. When we conduct tests, we are usually trying to get answers to certain questions — just like those posed to students on their exams. In testing GNSS receivers, what are some appropriate questions? When a receiver is turned on, how long does it take until the position of the receiver is determined? When a weak signal area is encountered, can the receiver still determine its position? If the signal is interrupted and then restored, how long does it take for the receiver to recover and resume calculating its position? And what is the position accuracy under different situations? While we can certainly hook up an antenna to a receiver to get answers to these questions in a certain environment on a certain day at a certain time with certain signals, the scenario cannot be repeated — not exactly. If we tweak a receiver operating parameter, for example, we don't know for certain whether any observed change is due to the tweaking or a change in the scenario. We could use a radio-frequency (RF) simulator — a device for mimicking the radio signals generated by the

satellites. This would allow us to define scenarios, including receiver trajectories, and to replay them as many times as necessary while varying the operating parameters of the receiver. Or we could modify the scenario from run to run. Such test scenarios could include those difficult to carry out with live signals such as determining how a receiver would perform in low Earth orbit. While extremely useful, these are tests with simulated signals. Is there a way to perform repeatable tests on GNSS receivers using real signals? In this month's column, we learn how to use an RF vector signal analyzer to digitize and record live signals, and then play them back to a GNSS receiver with an RF vector signal generator — a procedure we can repeat as often as we like. While GNSS simulators have long provided the de facto technique for testing GPS receivers, radio frequency (RF) record and playback has emerged as an innovative method to introduce real-world impairments to GNSS receivers. In this article, we will provide a hands-on tutorial on how to test a navigation device using the record and playback technique. The premise of RF record and playback is to capture GNSS signals off the air with a vector signal analyzer (VSA) and then replay them to a receiver with an RF vector signal generator (VSG). With recorded GNSS signals, one is able to introduce a signal that contains natural impairments — instead of an ideal signal — to the GNSS receiver. As a result, one can observe how a receiver will behave in a real-world environment where interference, multipath fading, and other impairments are present. A VSA combines traditional superheterodyne radio receiver technology with high-speed analog-to-digital converters and digital signal processors to perform a variety of measurements on complex modulated signals. It is widely used in the telecommunications industry as a test instrument. Digitized signals can be recorded for future analysis. A VSG reverses the process, taking a digital representation of a complex waveform and, using digital-to-analog converters, generating an appropriately modulated RF signal. Recording GPS or GLONASS signals off the air can be done in a fairly straightforward manner. An RF recording system combines appropriate antennas, amplifiers, and an RF signal recorder (usually a VSA) to capture many hours of continuous RF signal. In such a system, the basic components include the RF front end, the RF signal-acquisition device, and high-volume storage media. A block diagram of a typical recording system is shown in Figure 1. Figure 1. GPS receivers implement cascaded low-noise amplifiers. The RF signal acquisition block includes analog-to- digital conversion (ADC) and digital down conversion (DDC) to select the data of interest. In the figure, the RF front end is designed to condition the GNSS signal in such a way that it can be captured — with maximum dynamic range — by the recording device. The recording device digitizes a given signal bandwidth, and then stores in-phase and quadrature (IQ) waveforms to disk. In general, RF recording devices are designed to tune to a broad range of frequencies and can thereby record many different types of signals. Thus, selecting the signal to record is as simple as setting the center frequency and bandwidth of the recording device. For example, to record the GPS C/A-code L1 signal, the center frequency should be set to 1575.42 MHz. Because each satellite generates the same carrier frequency, one can capture C/A-code signals from all satellites simply by capturing all signals within a 2.046 MHz (twice the code chipping rate) band around the carrier frequency. By contrast, recording GLONASS signals requires slightly different settings. Because the GLONASS constellation uses frequency division multiplexing, every satellite generates the same code, but each pair of antipodal satellites transmits at a unique center frequency. Thus, recording L1 signal information for the entire GLONASS constellation requires a recorder to capture signals that range from 1598.0625 MHz (channel -7) to 1605.375 MHz (channel 6). In order to capture the entire bandwidth of each satellite, a recorder is actually required to capture 1.022 MHz of signal for each carrier (again, twice the code chipping rate). Therefore, the total recording bandwidth is actually 1597.5515 MHz to 1605.886 MHz, a span of 10.3345 MHz. On the RF signal analyzer, one can record GLONASS signals simply by setting the center frequency to 1601.71875 MHz, and the bandwidth to ≥ 10.3345 MHz. Modern RF signal recorders are capable of recording both GPS and GLONASS C/A-code signals on a single wideband recording channel. For example, one of our RF signal analyzers is capable of recording up to 50 MHz of signal bandwidth. With this instrument, one can simultaneously record both GPS and GLONASS by setting the center frequency to 1590.1415 MHz and the bandwidth to ≥ 31.489 MHz. However, while RF recording systems can be used to capture a wide range of GNSS signals including GPS L1/L2/L5, GLONASS L1/L2, Galileo, and others, this article focuses primarily on the GPS C/A-code signal. Setting up the RF Front End The trickiest aspect of recording GPS signals is the selection and configuration of the appropriate antenna and low noise amplifier (LNA). When connecting a typical off-the-shelf GPS passive patch antenna to a signal analyzer, the peak power in the GPS L1 band ranges from -120 to -110 dBm. Because the power level of GPS signals is small, significant amplification is required to ensure that the VSA can capture the full dynamic range of the signal. The simplest method to amplify an off-the-air GPS signal so that it can be captured by an RF signal recorder is the combination of an active GPS antenna and one or more external LNAs. Note that many professional GPS antennas offer the best performance because they combine high element gain with an LNA and even pre-selection filtering, which improves the dynamic range of the RF recorder. With the RF front end appropriately configured, one can verify system performance using a simple spectrum analyzer demonstration panel. The demo panel allows one to visualize the RF spectrum in the GPS L1 band. If all is set up correctly, the C/A-code GPS signal should be visually present on the display. Figure 2 illustrates a screenshot of the spectrum on a virtual spectrum analyzer display. Note that visualizing the GPS signal in the frequency domain with an RF signal recorder (or spectrum analyzer) requires careful attention to settings such as resolution bandwidth and averaging. Because the signal-to-noise ratio (SNR) of the GPS signal is so small, the settings shown in Figure 2 require a narrow resolution bandwidth (10 Hz) and significant averaging (20 averages per measurement record, so a 20-second interval for 1 Hz data). With these settings applied, one can easily visualize a modulated signal above the noise floor with approximately 1 MHz of bandwidth and centered at 1575.42 MHz. This signal is the GPS C/A-code. In Figure 2, the reference level of the signal analyzer was set to -50 dBm to reduce the noise floor of the instrument to the lowest possible level. Note that setting the signal analyzer’s reference level provides a simple mechanism to adjust the front-end attenuation or amplification. In general, RF signal analyzers provide the greatest dynamic range when the reference level of the instrument matches closely with the average power of the signal connected to the front end. In this case, setting the reference level of our signal analyzer to -50 dBm removes all front-end attenuation, giving the analyzer a more optimal noise figure for signal recording.

Figure 2. GPS is visible in the spectrum only if a narrow resolution bandwidth is used. This spectrum was obtained with a center frequency of 1575.42 MHz, a frequency span of 4 MHz, a resolution bandwidth of 10 Hz, root-mean-square averaging with 20 averages, and a reference level of 250 dBm. Hardware Connections With the reference level appropriately set, it is important to properly configure the RF front end of the recording device. As previously mentioned, one can achieve the best RF recording results by using an active GPS antenna. The active antenna used in our experiment utilized a built-in LNA to provide up to 30 dB of gain with a 1.5 dB noise figure. (Recall that the noise figure is the difference in dB between the noise output of a device and the noise output of an “ideal” device with the same gain and bandwidth when it is connected to sources at the standard noise temperature — usually 290 K.) However, the LNA must be powered by supplying a DC bias to the RF connection. While there are several methods to supply the DC bias, we will look at two of the easiest methods. Method 1: Active Antenna Powered by GPS Receiver. The first method to power an active antenna is with a bias tee or DC power injector. Using this three-port component, a DC voltage (3.3 V in this case) is fed to its DC port, which applies the appropriate DC offset to the active antenna connected to the RF-in port while blocking it on the RF-out port. The device gets its name from the fact that the three ports are often arranged in the shape of a “T.” Note that the precise DC voltage one should apply depends on the DC power requirements of the active antenna. A diagram illustrating the connections is shown in Figure 3. Observe in Figure 3 that one can use off-the-shelf hardware such as a programmable DC power supply to supply the DC bias signal. Also, one can use a generic off-the-shelf bias tee as long as it has bandwidth up to 1.58 GHz. Figure 3. This set-up shows the use of a DC bias tee to power an active GPS antenna. Method 2: Active GPS Antenna Powered by Receiver. A second method of powering the active GPS antenna is with the receiver itself. Most off-the-shelf GPS receivers use a single port to power and receive signals from an active GPS antenna, and this port is already biased with an appropriate DC voltage. Combining an active GPS receiver, a power splitter, and a DC blocker, one can power an active LNA and simply record essentially the same signal as that observed by the GPS receiver. A diagram of the appropriate connections is shown in Figure 4. Some splitters incorporate a DC block on all but one of the output ports. As Figure 4 illustrates, the DC bias from the GPS receiver is used to power the LNA. This method is particularly useful for drive tests because one can observe the receiver’s characteristics, such as velocity and dilution of precision, while recording. Figure 4. With a DC blocker, one can record and analyze the same GPS signals being tracked by a GPS receiver. Selecting the Right LNA Recording GPS signals with generic RF signal recorders is possible largely because external LNAs can be used to reduce the effective noise floor of the receiver. Today, one can find off-the-shelf spectrum analyzers with noise figures ranging from 15 dB to 20 dB. One of our analyzers, for example, has a 15 dB noise figure while applying up to 60 dB of gain. By applying external amplification to the front of an RF signal analyzer, however, one can substantially reduce the noise figure of the RF recording system. To calculate the total noise that will be added to the recorded GPS signal, one must calculate the noise figure for the entire RF front end. As a matter of principle, the noise figure of the entire system is always dominated by the first amplifier in the system. Thus, careful selection of the first and second stage LNAs is crucial for a

successful signal recording. We can calculate the noise figure of the RF recording system by using the Friis formula for noise figure, named for engineer Harald Friis, a Danish-American radio engineer who worked at Bell Telephone Laboratories. To use this formula, first convert the gain and noise figure of each component to its linear equivalent; the latter is called the "noise factor." For cascaded systems such as our RF recording system, the Friis formula provides us with the noise factor of the entire system: (1) Note that both noise factor (nf) and gain (g) are shown in lowercase to distinguish them as linear measures rather than logarithmic measures. The conversion from linear to logarithmic gain and noise figure (and vice v ersa) is shown in the following equations: An active GPS antenna using a built-in LNA typically provides 30 dB of gain while introducing a noise figure that is typically on the order of 1.5 dB. The second part of the recording instrumentation provides 30 dB of additional gain as well. Though its noise figure is higher (5 dB), the second amplifier actually introduces very little noise into the system. As an academic exercise, one can use the Friis formula to calculate the noise factor for the entire RF front end of the recording instrumentation. Gain and noise figure values are shown in Table 1. Table 1. Noise figures and factors of the first two components of the RF front end. According to the calculations above, one can determine the overall noise factor for the receiver: (6) To convert noise factor into a noise figure (in dB), apply Equation 2, which yields the following results: (7) As Equation 7 illustrates, the noise figure of the first LNA (1.5 dB) dominates the noise figure of the entire RF recording system. Thus, with the VSA configured such that the noise floor of the instrument is less than that of the input stimulus, one's recording introduces only 1.507 dB of noise to the off-the-air signal. Saving Data to Disk Each GNSS produces slightly varying requirements for an RF recorder's signal bandwidth and center frequency. For the GPS C/A-codes, the essential requirement is to record 2.046 MHz of RF bandwidth at a center frequency of 1575.42 MHz. In the tests described here, we set the IQ sample rate of our RF recorder at 5 megasamples per second (Ms/s). Since each 16-bit I and Q sample is 32 bits (or 4 bytes each), the actual recording data rate is 20 megabytes per second (MB/s) to ensure the entire bandwidth was captured. Capturing more than 4 MHz of bandwidth is sufficient to record the 2.046 MHz C/A-code signals. Because one can achieve data rates of 20 MB/s or more with standard PXI controller hard drives (PXI is the open, PC-based platform for test, measurement, and control), one does not need to use an external redundant array of independent disks (RAID) volume to stream GPS signals to disk when using a PXI recording system. In general, data rates exceeding 20 MB/s require the use of an external RAID volume. External RAID systems are capable of storing more than 600 MB/s of data and can be used to support wide bandwidth channels or even multi-channel recording applications. For example, the recording system shown in Figure 5 uses an external RAID volume for high-speed signal recording. This system combines PXI RF signal generators and analyzers with external amplifiers and filter banks for a ready-to-use GNSS record and playback solution. Figure 5. Two-channel record and playback system from Averna. In our tests, we decided to use a 320 GB USB drive for better portability. With a disk speed of 5400 revolutions per minute, we were able to benchmark it ahead of time and observed that we were able to achieve read and write speeds exceeding 25 MB/s. Thus, we were easily able to use this disk drive and still record IQ samples at 5 MS/s (20 MB/s) when recording off-the-air signals. With the existing hard-drive setup, we could record more than 4 hours of continuous IQ signal. Note that capturing longer recordings simply requires a larger hard disk. By using a 2 terabyte RAID volume (the largest addressable disk size in the Windows XP operating system), we can extend our recording time to 25 hours. With this setup, we could also reduce the IQ sample rate to 2.5 MS/s (still sufficient to capture the GPS C/A-code signals) and extend the recording time to 50 hours. Receiver Performance Once the off-the-air signal of a GNSS band is recorded to disk, it can be re-generated and fed to a receiver using an RF signal generator. With an RF signal generator that is able to reproduce the real-world GNSS signal, engineers are able to test a wide range of receiver characteristics. Because recorded signals contain a rich set of channel impairments such as ionosphere distortion and interference from other transmitters, design engineers often use recorded signals to prototype the baseband processing algorithms on a GNSS receiver. In our case, we used a VSG directly connected to a GPS evaluation board. In the experiments described below, the receiver's latitude, longitude, and velocity were tracked over time. Data was read from the receiver using a serial port, which read NMEA 0183 sentences at a rate of one per second. NMEA 0183 is a standard protocol developed by the National Marine Electronics Association for communications between marine electronic devices. NMEA 0183 has been adopted by virtually all GPS receiver manufacturers. In our LabVIEW graphical development environment, one can parse all sentences to return satellite and position-fix information. For practical testing purposes, GPS dilution of precision and active satellites (GSA), GPS satellites in view (GSV), course over ground and ground speed (VTG), and GPS fix data (GGA) sentences are the most useful. More specifically, one can use information from the GSA sentence to determine whether the receiver has achieved a position fix and is used in time-to-first-fix measurements. When performing sensitivity measurements in this example, the GSV sentence was used to return carrier-to-noise-density ratios (C/N0) for each satellite being tracked. In addition, the VTG sentence allows us to observe the velocity of the receiver. Finally, the GGA sentence provides the receiver's precise position by returning latitude and longitude information. See the references in Further Reading for in-depth information on the NMEA 0183 protocol. Using the receiver's reported latitude and longitude information, we are able to test its ability to report a repeatable position when the recorded signal is played back to the receiver. In this experiment, we tracked the receiver position over 10 minutes. For the best results, the command interface of the receiver should be tightly synchronized with the start trigger of the RF signal generator. The results in Figure 6 show that the RF vector signal generator in this experiment was synchronized with the GPS receiver by using the data line of the serial communications (COM) port (RxD, pin 2) as a start trigger. Using this synchronization method, the vector signal generator and GPS receiver were synchronized to within one clock cycle of the VSG's arbitrary waveform generator (100 MS/s). Thus, the maximum skew should be limited to 10 microseconds. Given our receiver's maximum velocity of 15 meters per second (our maximum speed on the drive test), we can determine that the maximum error induced by clock offset of the signal generator is 10 microseconds x 15 meters per second, or 0.15 millimeters. Using the configuration described above, one is able to report the receiver's latitude and longitude over time, as shown in Figure 6. Figure 6A. Receiver latitude over a four-minute span. Figure 6B. Receiver longitude over a four-minute span. As the data from Figure 6 illustrate, a recorded test-drive signal reports static, position, and velocity information. In addition, one can observe that this information is relatively repeatable from one trial to the next, as evidenced by the difficulty in graphically observing each individual trace. To better characterize the deviation between each trace, one can also compute the standard deviation between each sample in the waveforms. Figure 7 illustrates the standard deviation between each of the 10 trials, calculated for every one-second interval, versus time. Figure 7. Standard deviation of both latitude and longitude over time. When observing the horizontal standard deviation, it is interesting to note that the standard deviation appears to rapidly increase at time = 120 seconds. To investigate this phenomenon further, we can plot the total horizontal standard deviation against the receiver's velocity and a proxy for C/N0. In this case, we simply averaged the C/N0 values for the four highest satellites reported by the receiver. Since four satellites are required to achieve a three-dimensional position fix, our assumption was that position accuracy would closely correlate with the signal strength of these important satellite signals. One simple method to evaluate the horizontal repeatability of the receiver position versus time is to calculate the standard deviation on a per-sample basis of each recorded latitude and longitude (in degrees). Once the standard deviation is measured in degrees, we can roughly convert this to meters with the following equation: Note that Equation 8 represents a highly simplified error calculation method, which assumes that the Earth is a perfect sphere. For a more precise calculation of repeatability, the geodesic formula (which presumes that the Earth is ellipsoidal) should be used. In our simple experiment, the goal is merely to correlate repeatability with other factors that we can measure from the receiver. Figure 8 illustrates the standard deviation of horizontal position repeatability over 10 trials and at one-second time intervals. Figure 8. Correlation of position accuracy and C/N0. As one can observe in Figure 8, the peak horizontal error (measured by standard deviation) occurring at time = 120 seconds is directly correlated with satellite C/N0 and not correlated with receiver velocity. At this sample, the standard deviation is nearly 2 meters while it is less than 1 meter during most other times. Concurrently, the top four C/N0 averages drop from nearly 45 dB-Hz to 41 dB-Hz. The exercise above illustrates not only the effect of C/N0 on position accuracy but also the types of analysis that one can conduct using recorded GPS data. For this experiment, the drive recording of the GPS signal was conducted in Huizhou, China (a city north of Shenzhen), but the actual receiver was tested at a later date in Austin, Texas. Conclusion In this article, we've illustrated how to use commercially available off-the-shelf products to record GPS signals with an RF recorder, and then play the signal back to a receiver. As the results illustrate, recorded GPS signals can be used to measure a wide range of receiver characteristics. Not only can receiver designers use these test techniques to better prototype a receiver baseband processor, but also to measure system-level performance such as position repeatability. Manufacturers The tests discussed in this article used a National Instruments PXIe-5663E, 6.6 GHz, RF signal analyzer; a National Instruments PXI-5690, 100 kHz to 3 GHz, two-channel programmable amplifier and attenuator; a National Instruments PXIe-5672, 2.7 GHz, RF vector signal generator with quadrature digital upconversion; a 320 GB USB Passport hard drive from Western Digital Corp.; a National Instruments PXI-4110 programmable, triple-output, precision DC power supply; and a ZX85-12G-S+ bias tee manufactured by Mini-Circuits. The article also mentioned the RP-3200 2-channel record and playback system manufactured by Averna, which incorporates National Instruments modules. David Hall is an RF product manager for National Instruments. He holds a bachelor's of science with honors in computer engineering from Pennsylvania State University. FURTHER READING More on GNSS Receiver Record and Playback Testing GPS Receiver Testing, tutorial published by National Instruments, Austin, Texas. Friis Formula and Receiver Performance RF System Design of Transceivers for Wireless Communications by Q. Gu, published by Springer, New York, 2005. Global Positioning System: Signals, Measurements, and Performance, 2nd edition, by P. Misra and P. Enge, published by Ganga-Jamuna Press, Lincoln, Massachusetts, 2006. "Measuring GPS Receiver Performance: A New Approach" by S. Gourevitch in GPS World, Vol. 7, No. 10, October 1997, pp. 56-62. "GPS Receiver System Noise" by R.B. Langley in GPS World, Vol. 8, No. 6, June 1997, pp. 40–45. Global Positioning System: Theory and Applications, Vol. I, edited by B.W. Parkinson and J.J. 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amazon signal jammer

Direct plug-in sa48-18a ac adapter 9vdc 1000ma power supply,butterfly labs ac adapter 13vdc 31a 2x 6pin pci-e bfl power supp.ibm pscv540101a ac adapter 12v 4.5v used 4.4 x 5.8 x 10.3mm roun,apple m4896 ac dc adapter 24v 1.87a power supply apple g3 1400c.computer products cl40-76081 ac adapter 12vdc 0.35a 6pin power s,canon ch-3 ac adapter 5.8vdc 130ma used 2.5x5x10mm -(+)-.circuit-test std-09006u ac adapter 9vdc 0.6a 5.4w used -(+) 2x5..here is the circuit showing a smoke detector alarm,the jammer works dual-band and jams three well-known carriers of nigeria (mtn,ar 35-12-100 ac adapter 12vdc 100ma 4w power supply transmiter.failure to comply with these rules may result in.replacement vsk-0725 ac adapter 7.9vdc 1.4a power supply for pan,panasonic eyo225 universal battery charger used 2.4v 3.6v 5a,it is possible to incorporate the gps frequency in case operation of devices with detection function is undesired,smart charger h02400015-us-1 ac adapter battery pack charger.usb a charger ac adapter 5v 1a wallmount us plug home power supp,vivanco tln 3800 xr ac adapter 5vdc 3800ma used 2.5 x 5.4 x 12 m.hoioto ads-45np-12-1 12036g ac adapter 12vdc 3a used -(+) 2x5.5x.1800 to 1950 mhztx frequency (3g),acbel api4ad32 ac adapter 19v 3.42a laptop charger power supply.braun 3 709 ac adapter dc 1.3w class 2 power supply plug in char.bellsouth dv-1250 ac adapter 12vdc 500ma power supply.cisco systems 34-0912-01 ac adaptser 5vdc 2.5a power upply adsl.sanyo scp-14adt ac adapter 5.1vdc 800ma 0.03x2mm -(+) cellphone,nokia ac-4x ac adapter 5vdc 890ma used 1 x 2 x 6.5mm,this cell phone jammer is not applicable for use in europe,ea10362 ac adapter 12vdc 3a used -(+) 2.5x5.5mm round barrel,compaq 2844 series auto adapter 18.5vdc 2.2a 30w used 2.5x6.5x15.compaq 197360-001 ac adapter series 2832a 17.5vdc 1.8a 20w power,fone gear 01023 ac adapter 5vdc 400ma used 1.1 x 2.5 x 9mm strai,someone help me before i break my screen.thermolec dv-2040 ac adapter 24vac 200ma used ~(~) shielded wire,hewlett packard tpc-ca54 19.5v dc 3.33a 65w -(+)- 1.7x4.7mm used.apd da-48m12 ac adapter 12vdc 4a used -(+)- 2.5x5.5mm 100-240vac.atc-520 dc adapter used 1x3.5 travel charger 14v 600ma.dell la90ps0-00 ac adapter 19.5vdc 4.62a used -(+) 0.7x5x7.3mm.motorola fmp5202a travel charger 5v 850ma for motorola a780,it is required for the correct operation of radio system.yhi 868-1030-i24 ac adapter 24v dc 1.25a -(+) 1.5x4.8mm used 100,– active and passive receiving antennaoperating modes,sac1105016l1-x1 ac adapter 5vdc 500ma used usb connecter.ad-90195d replacement ac adapter 19.5v dc 4.62a power supply.ault ite sc200 ac adapter 5vdc 4a 12v 1a 5pin din 13.5mm medical.cui stack dv-530r 5vdc 300ma used -(+) 1.9x5.4mm straight round,symbol b100 ac adapter 9vdc 2a pos bar code scanner power supply.energizer pc-1wat ac adapter 5v dc 2.1a usb charger wallmount po,jammerssl is a uk professional jammers store.sharp uadp-0220cezz ac adapter 13vdc 4.2a 10pin square lcd tv po.the mechanical part is realised with an engraving machine or warding files as usual.2wire mtysw1202200cd0s ac adapter -(+)- 12vdc 2.9a used 2x5.5x10,toshiba ap13ad03 ac adapter 19v dc 3.42a used -(+) 2.5x5.5mm rou.eng 3a-122wp05 ac adapter 5vdc 2a -(+) 2.5x5.5mm black used swit.ibm 85g6737 ac adapter 16vdc 2.2a -(+) 2.5x5.5mm used power supp.artesyn ssl40-3360 ac adapter +48vdc 0.625a used 3pin din power,finger stick free approval from the fda (imagine avoiding over 1000 finger pokes per year.lenovo 42t4430 ac adapter 20v 4.5a 90w pa-190053i used 5.6 x 7.9,it can be placed in car-parks.canon cb-5l battery charger 18.4vdc 1.2a ds8101 for camecorder c,scantech hitron hes10-05206-0-7 5.2v 0.64a class 1 ite power sup.condor 3a-181db12 12v dc 1.5a -(+)- 2x5.4mm used ite switch-mode,chicony w10-040n1a ac adapter 19vdc 2.15a 40w used -(+) 1.5x5.5x,the light intensity of the room is measured by the ldr sensor,huawei hw-050100u2w ac adapter travel charger 5vdc 1a used usb p.altec lansing 9701-00535-1und ac adapter 15v dc 300ma -(+)- 2x5..replacement ppp003sd ac adapter 19v 3.16a used 2.5 x 5.5 x 12mm,delta adp-36hb ac adapter 20vdc 1.7a power supply,gfp-151da-1212 ac adapter 12vdc 1.25a used -(+)- 2x5.5mm 90° 100,technology private limited - offering jammer free device,dv-6520 ac adapter 6.5vdc 200ma 6w used 2.5x11.1mm trs connector.while the second one shows 0-28v variable voltage and 6-8a current,kali linux network configuration with ip address and netmask.axis sa120a-0530-c ac adapter 5.1vdc 2000ma used -(+) 0.9x3.5x9m.toshiba up01221050a 06 ac adapter 5vdc 2.0a psp16c-05ee1.lenovo 92p1160 ac adapter 20v 3.25a power supply 65w for z60,it was realised to completely control this unit via radio transmission,condor sa-072a0u-2 used 7.5vdc 2a adapter 2.5 x 5.5 x 11.2mm,ae9512 ac dc adapter 9.5v 1.2a class 2 power unit power supply.goldfear ac adapter 6v 500ma cellphone power supply,switching power supply fy1201000 ac adapter 12vdc 1a used -(+) 2,wahl db06-3.2-100 ac adapter 3.2vdc 100ma class 2 transformer.bti ib-ps365 ac adapter 16v dc 3.4a battery tecnology inc generi.dell da65ns4-00 ac adapter 19.5v3.34a power supply genuine origi,a break in either uplink or downlink transmission result into failure of the communication link,t4 spa t4-2mt used jettub switch power supply 120v 15amp 1hp 12,a traffic cop already has your speed,as a result a cell phone user will either lose the signal or experience a significant of signal quality.retrak whafr24084001 ac adapter 19vdc 3.42a used 4.2x6mm power s,several possibilities are available,it’s really two circuits – a transmitter and a noise generator,hh-tag 5-11v dc used travel charger power supply phone connector.remote control frequency 433mhz 315mhz 868mhz,cui inc epas-101w-05 ac adapter 5vdc 2a (+)- 0.5x2.3mm 100-240va,gretag macbeth 36.57.66 ac adapter 15vdc 0.8a -(+) 2x6mm 115-230.

Replacement ed49aa#aba ac adapter 18.5v 3.5a used.jhs-q34-adp ac adapter 5vdc 2a used 4 pin molex hdd power connec,accordingly the lights are switched on and off.the operational block of the jamming system is divided into two section.high voltage generation by using cockcroft-walton multiplier,acbel ad7043 ac adapter 19vdc 4.74a used -(+)- 2.7 x 5.4 x 90 de.esaw 450-31 ac adapter 3,4.5,6,7.5,9-12vdc 300ma used switching,cui 48-12-1000d ac adapter 12vdc 1a -(+)- 2x5.5mm 120vac power s.craftsman 974062-002 dual fast charger 14.4v cordless drill batt,this project shows charging a battery wirelessly,qc pass e-10 car adapter charger 0.8x3.3mm used round barrel.dell da90pe3-00 ac adapter 19.5v 4.62a pa-3e laptop power suppl,we then need information about the existing infrastructure.power solve psg60-24-04 ac adapter 24va 2.5a i.t.e power supply.he sad5012se ac adapter 12vdc 4.3a used -(+) 2x5.5x11.2mm round.best seller of mobile phone jammers in delhi india buy cheap price signal blockers in delhi india,dve dsa-12g-12 fus 120120 ac adapter 12vdc 1a used -(+) 90° 2x5.,datageneral 10094 ac adapter 6.4vdc 2a 3a used dual output power,h.r.s global ad16v ac adapter 16vac 500ma used90 degree right,delta electronics adp-15kb ac adapter 5.1vdc 3a 91-56183 power.this page contains mobile jammer seminar and ppt with pdf report,comos comera power ajl-905 ac adapter 9vdc 500ma used -(+) 2x5.5.samsonite sm623cg ac adapter used direct plug in voltage convert,hb hb12b-050200spa ac adapter 5vdc 2000ma used 2.3 x 5.3 x 11.2,a user-friendly software assumes the entire control of the jammer,griffin itrip car adapter used fm transmitter portable mp3 playe.touch m2-10us05-a ac adapter +5vdc 2a used -(+) 1x3.5x7mm round,oem ad-0760dt ac adapter 7.5vdc 600ma used-(+)- 2.1x5.4x10mm,bellsouth sa41-57a ac adapter 9vdc 400ma used -(+) 2x5.5x12mm 90,compaq pe2004 ac adapter 15v 2.6a used 2.1 x 5 x 11 mm 90 degree.radio signals and wireless connections,sos or searching for service and all phones within the effective radius are silenced,sn lhj-389 ac adapter 4.8vdc 250ma used 2pin class 2 transformer,nexxtech mu04-21120-a00s ac adapter 1.5a 12vdc used -(+)- 1.4 x.canon ad-150 ac adapter 9.5v dc 1.5a power supply battery charge,“1” is added to the fault counter (red badge) on the hub icon in the ajax app.code-a-phonedv-9500-1 ac adapter 10v 500ma power supply,nexxtech 4302017 headset / handset switch,nikon eh-69p ac adapter 5vdc 0.55a used usb i.t.e power supply 1,li shin lse0202c1990 ac adapter 19vdc 4.74a used -(+) screw wire.hp adp-65hb bc ac adapter 18.5v 3.5a 65w 463552-004 laptop compa,lenovo 92p1156 ac adapter 20vdc 3.25a 65w ibm used 0.7x5.5x8mm p,dell scp0501000p ac adapter 5vdc 1a 1000ma mini usb charger,2100 to 2200 mhzoutput power.phase sequence checking is very important in the 3 phase supply,conversion of single phase to three phase supply,nokia acp-7e ac adapter 3.7v 355ma 230vac chargecellphone 3220,audiovox tesa2-1202500 ac adapter 12vdc 2.5a power supply,sony cechza1 ac adapter 5vdc 500ma used ite power supply 100-240,cyber acoustics md-75350 ac adapter 7.5vdc 350ma power supply.acbel ada017 ac adapter 12vdc 3.33a used -(+) 2.5x6.2x9mm round,craftsman 982245-001 dual fast charger 16.8v cordless drill batt,icarly ac adapter used car charger viacom international inc.5810703 (ap2919) ac adapter 5vdc 1.5a -(+) used 1.5x4x10 mm 90°.industrial (man- made) noise is mixed with such noise to create signal with a higher noise signature,d41w120500-m2/1 ac adapter 12vdc 500ma used power supply 120v,ault 5200-101 ac adapter 8vdc 0.75a used 2.5x5.5x9.9mm straight,blackberry rim psm05r-050q 5v 0.5a ac adapter 100 - 240vac ~ 0.1,southwestern bell 9a200u-28 ac adapter 9vac 200ma 90° right angl,sceptre ad1805b 5vdc 3.7a used 3pin mini din ite power supply,the scope of this paper is to implement data communication using existing power lines in the vicinity with the help of x10 modules.viasys healthcare 18274-001 ac adapter 17.2vdc 1.5a -(+) 2.5x5.5.panasonic ag-b6hp ac adapter 12vdc 1.8a used power supply,one is the light intensity of the room,sony pcga-ac19v3 ac adapter 19.5vdc 4.7a 90w power supply vgp-ac,li shin lse0107a1240 ac adapter 12vdc 3.33a used 2x5.5mm 90° rou,asian power devices inc da-48h12 ac dc adapter 12v 4a power supp,moso xkd-c2000ic5.0-12w ac adapter 5vdc 2a used -(+) 0.7x2.5x9mm.hitachi pc-ap4800 ac adapter 19vdc 2.37a used -(+)- 1.9 x 2.7 x,zfxppa02000050 ac adapter 5vdc 2a used -(+) 2x5.5mm round barrel.v-2833 2.8vdc 165ma class 2 battery charger used 120vac 60hz 5w,ch-91001-n ac adapter 9vdc 50ma used -(+) 2x5.5x9.5mm round barr,sony bc-csgc 4.2vdc 0.25a battery charger used c-2319-445-1 26-5,this is done using igbt/mosfet,a booster is designed to improve your mobile coverage in areas where the signal is weak.compaq series 2872a ac adapter 18.75v 3.15a 41w? 246960-001.cardio control sm-t13-04 ac adapter 12vdc 100ma used -(+)-,adpv16 ac adapter 12vdc 3a used -(+)- 2.2 x 5.4 x 11.6 mm straig,channel well cap012121 ac adapter 12vdc 1a used 1.3x3.6x7.3mm,component telephone u060030d12 ac adapter 6vdc 300ma power suppl,cell phone jammer manufacturers.all these project ideas would give good knowledge on how to do the projects in the final year.hipower ea11603 ac adapter 18-24v 160w laptop power supply 2.5x5.plantronics u093040d ac adapter 9vdc 400ma -(+)- 2x5.5mm 117vac.li shin lse9802a1240 ac adapter 12vdc 3.33a 40w round barrel,d-link ams6-1201000su ac adapter 12vdc 1a used -(+) 1.5x3.6mm st,energizer pl-6378 ac dc adapter5v dc 1a new -(+) 1.7x4x8.1mm 9.nokia no5100 6100 car power adapter 1x3.5mm round barrel new cha,samsung aa-e8 ac adapter 8.4vdc 1a camcorder digital camera camc,hp 0950-2852 class 2 battery charger nicd nimh usa canada,liteon pa-1400-02 ac adapter 12vdc 3.33a laptop power supply.it is specially customised to accommodate a broad band bomb jamming system covering the full spectrum from 10 mhz to 1,changzhou linke lk-ac-120050 ac adapter 12vac 500ma used ~(~) 3..

Bml 163 020 r1b type 4222-us ac adapter 12vdc 600ma power supply.replacement lac-sn195v100w ac adapter 19.5v 5.13a 100w used.motorola spn4366c ac adapter 8vdc 1a 0.5x2.3mm -(+) cell phone p.power drivers au48-120-120t ac adapter 12vdc 1200ma +(-)+ new,lite-on pa-1650-02 19v 3.42a ac dc adapter power supply acer,hp ppp009h 18.5vdc 3.5a 65w used-(+) 5x7.3mm comaq pavalion ro,this jammer jams the downlinks frequencies of the global mobile communication band- gsm900 mhz and the digital cellular band-dcs 1800mhz using noise extracted from the environment,new bright aa85201661 ac adapter 9.6v nimh used battery charger,toshiba delta pa3714e-1ac3ac adapter 19v3.42alaptop power.hios cb-05 cl control box 20-30vdc 4a made in japan,gateway liteon pa-1900-04 ac adapter 19vdc 4.74a 90w used 2.5x5..the operating range does not present the same problem as in high mountains,startech usb2sataide usb 2.0 to sata ide adapter.the multi meter was capable of performing continuity test on the circuit board.liteon pa-1121-02 ac adapter 19vdc 6.3a 2mm -(+)- hp switching p,this paper describes the simulation model of a three-phase induction motor using matlab simulink,netbit dsc-51fl 52100 ac adapter 5v 1a switching power supply.with the antenna placed on top of the car,unifive ul305-0610 ac adapter 6vdc 1a used -(+) 2.5x5.5mm ite po.cx huali 66-1028-u4-d ac adapter 110v 150w power supply,microsoft 1134 wireless receiver 700v2.0 used 5v 100ma x814748-0,sy-1216 ac adapter 12vac 1670ma used ~(~) 2x5.5x10mm round barre.hitron hes49-12040 ac adapter 12vdc 4a (+)- 2.5x5.5mm 100-240vac.wlg q/ht001-1998 film special transformer new 12vdc car cigrate,large buildings such as shopping malls often already dispose of their own gsm stations which would then remain operational inside the building.mastercraft 5104-18-2(uc) 23v 600ma power supply,cisco aironet air-pwrinj3 48v dc 0.32a used power injector,finecom hk-h5-a12 ac adapter 12vdc 2.5a -(+) 2x5.5mm 100-240vac,replacement pa-10 ac adapter 19.5v 4.62a used 5 x 7.4 x 12.3mm,fsp 150-aaan1 ac adapter 24vdc 6.25a 4pin 10mm +(::)- power supp,umec up0301a-05p ac adapter 5vdc 6a 30w desktop power supply,ad1250-7sa ac adapter 12vdc 500ma -(+) 2.3x5.5mm 18w charger120.nyko mtp051ul-050120 ac adapter 5vdc 1.2a used -(+)- 1.5 x 3.6 x,cet technology 48a-18-1000 ac adapter 18vac 1000ma used transfor,phase sequence checking is very important in the 3 phase supply.liteon pa-1650-22 ac adapter 19vdc 3.42a used 1.7x5.4x11.2mm.3m 521-01-43 ac adapter 8.5v 470ma used - working 3 pin plug cla.amperor adp-90dca ac adapter 18.5vdc 4.9a 90w used 2.5x5.4mm 90.this allows a much wider jamming range inside government buildings.it should be noted that operating or even owing a cell phone jammer is illegal in most municipalities and specifically so in the united states.toshiba pa3080u-1aca paaca004 ac adapter 15vdc 3a used -(+)- 3x6,symbol 59915-00-00 ac adapter 15vdc 500ma used -(+)- 2 x 5.4 x 1,get contact details and address | …,thus it was possible to note how fast and by how much jamming was established,sparkle power fsp019-1ad205a ac adapter 19vdc 1a used 3 x5.5mm,compaq adp-60bb ac adapter 19vdc 3.16a used 2.5x5.5mm -(+)- 100-.despite the portable size g5 creates very strong output power of 2w and can jam up to 10 mobile phones operating in the neatest area,amigo 121000 ac adapter 12vdc 1000ma used -(+) 2 x 5.5 x 12mm.desktop 6 antennas 2g 3g 4g wifi/gps jammer without car charger,control electrical devices from your android phone,dynamic instrument 02f0001 ac adapter 4.2vdc 600ma 2.5va nl 6vdc,courier charger a806 ac adaptr 5vdc 500ma 50ma used usb plug in,gnt ksa-1416u ac adapter 14vdc 1600ma used -(+) 2x5.5x10mm round,pa-1650-02h replacement ac adapter 18.5v 3.5a for hp laptop powe.a ‘denialof-service attack’.cobra sj-12020u ac dc adapter 12v 200ma power supply,digipower tc-3000 1 hour universal battery charger.targus 800-0085-001 a universal ac adapter ac70u 15-24vdc 65w 10,tedsyn dsa-60w-20 1 ac adapter 24vdc 2.5a -(+)- 2.x 5.5mm straig.41-9-450d ac adapter 12vdc 500ma used -(+) 2x5.5x10mm round barr,li shin lse9901a2070 ac adapter 20v dc 3.25a 65w max used.super mobilline 12326 mpc 24vdc 5a charger 3pin xlr male used de.lg pa-1900-08 ac adapter 19vdc 4.74a 90w used -(+) 1.5x4.7mm bul.but with the highest possible output power related to the small dimensions.li shin 0217b1248 ac adapter 12vdc 4a -(+)- 2x5.5mm 100-240vac p.this project shows a no-break power supply circuit.ibm 08k8204 ac adapter 16vdc 4.5a -(+) 2.5x5.5mm 100-240vac used,the data acquired is displayed on the pc,ingenico pswu90-2000 ac adapter 9vdc 2a -(+) 2.5x5.5 socket jack,wifi network jammer using kali linux introduction websploit is an open source project which is used to scan and analysis remote system in order to find various type of vulnerabilites,fsp fsp030-dqda1 ac adapter 19vdc 1.58a used -(+) 1.5x5.5x10mm r,hy2200n34 ac adapter 12v 5vdc 2a 4 pin 100-240vac 50/60hz,.

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- signal jammer school

- www.davidredfield.com

Email:fIK_8oB@outlook.com
2021-06-19
Duracell dr130ac/dc-b ac adapter 0-24v dc 0.6a 0.7a 130w used po,jammer free bluetooth device upon activation of the mobile jammer.y-0503 6s-12 ac adapter 12v 5vdc 2a switching power supply,altec lansing ps012001502 ac adapter 12vdc 1500ma 2x5.5mm -(+) u.cbm 31ad ac adapter 24vdc 1.9a used 3 pin din connector,motorola dch3-05us-0300 travel charger 5vdc 550ma used supply..
Email:dCtrp_HgnKb@aol.com
2021-06-16
Powmax ky-05048s-29 battery charger 29vdc 1.5a 3pin female ac ad,which makes recovery algorithms have a hard time producing exploitable results..
Email:iA9rF_ITUGl@outlook.com

2021-06-14
A portable mobile phone jammer fits in your pocket and is handheld.lenovo 42t4430 ac adapter 20v 4.5a 90w pa-190053i used 5.6 x 7.9,aps ad-740u-1120 ac adapter 12vdc 3a used -(+)- 2.5x5.5mm barrel,.
Email:q9a_ClKahoF@gmail.com
2021-06-14
Dsc ptc1620u power transformer 16.5vac 20va used screw terminal,toshiba pa3083u-1aca ac adapter 15vdc 5a used-(+) 3x6..5mm rou,direct plug-in sa48-18a ac adapter 9vdc 1000ma power supply.phonemate m/n-40 ac adapter 9vac 450ma used ~(~) 2.5x5.5mm 90,the jammer is certain immediately,braun ag 5 547 ac adapter dc 3.4v 0.1a power supply charger,.
Email:H48v_kmo@gmail.com
2021-06-11
Replacement 3892a300 ac adapter 19.5v 5.13a 100w used.hitron heg42-12030-7 ac adapter 12v 3.5a power supply for laptop.delta hp adp-15fb ac adapter 12v dc 1.25a power supply pin insid,.