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Permanent Link to Innovation: Simulating GPS Signals
2021/04/13
It Doesn’t Have to Be Expensive By Alison Brown, Jarrett Redd, and Mark-Anthony Hutton GNSS signal simulators can be expensive and beyond the limited budgets of many researchers. In this month’s column, we look at one company’s approach to providing GNSS signal simulation at a low cost — one that virtually any researcher can afford. INNOVATION INSIGHTS by Richard Langley WHY DO WE SIMULATE REALITY  in mathematics, science, engineering, and other pursuits — even in our recreational activities? Well, we do it for a variety of reasons. In mathematics and science, we try to comprehend reality, which is complicated and variable and often has some degree of randomness. We build mathematical models of physical, chemical, or biological processes to better understand them or to predict a particular outcome given some initial conditions. The model may contain a stochastic component to reflect a degree of uncertainty associated with the processes. Weather forecasting is a prime example. Typically, the models are run on a computer where the model parameters and initial conditions can be readily adjusted and the varying outcomes analyzed. Simulations of reality are often used in teaching where students can more easily grasp the behavior of complicated systems whether they be in the natural sciences or in economics or the social sciences. In medical education, simulated human patients are used initially because it is safer than having students operate on real patients. Similarly, flight simulators are used for the training of pilots because it is cheaper and safer than using real aircraft and a wide variety of “what if” scenarios can be experienced. Simulation is used for a range of engineering activities to see how an existing system behaves under different conditions because it is faster or cheaper than performing tests in the “real world.” It can also be used to estimate how a proposed new system might behave before it becomes a reality — looking at traffic flow in road networks, for example. We also use simulation for recreation, whether it is playing with the latest computer game or improving our swing with a golf simulator. And simulation is a mainstay of the movie industry. But getting back to engineering and the main interest of this magazine, simulation is a useful technique in the design and operation of equipment used with global navigation satellite systems. With a radio frequency simulator, we can mimic the radio signals

generated by the satellites. These devices allow us to define scenarios, including receiver trajectories, and to replay them while varying the operating parameters of the receiver. Some simulators allow us to record live signals and then to play them back under different assumed conditions. However, such GNSS signal simulators can be expensive and beyond the limited budgets of many researchers. In this month's column, we look at one company's approach to providing GNSS signal simulation at a low cost — one that virtually any researcher can afford. As the noted French sociologist and philosopher, Jean Baudrillard, pessimistically once said: "We live in a world where there is more and more information, and less and less meaning." In the field of GNSS engineering, at least, simulation is helping to stem the tide and give us a better understanding of reality. "Innovation" features discussions about advances in GPS technology, its applications, and the fundamentals of GPS positioning. The column is coordinated by Richard Langley, Department of Geodesy and Geomatics Engineering, University of New Brunswick. To contact him with topic ideas, email him at lang @ unb.ca. Embedded GPS receivers have become commonplace with the proliferation of GPS navigation systems into all but the least expensive vehicle and cell-phone lines. As more manufacturers embed low-cost GPS receivers into their products, the need for low-cost GPS signal simulators has also grown. Controlled virtual testing is vital in ensuring the expected system performance. Many GPS signal generators are available that are designed specifically for high-volume production test applications for devices that use commercial GPS/SBAS, GLONASS, and Galileo receivers. Often the cost of these high-end simulators is beyond the reach of small companies or universities. In response to this need, we have developed our low-cost, software-defined radio (SDR)-based GPS Signal Architect Test Set to address a broad range of research, academic, industrial, and defense applications. The system is designed to be flexible, scalable, and most importantly, inexpensive. Our test set leverages the capabilities of the Universal Software Radio Peripheral (USRP) radio and our GPS Signal Simulation Toolbox to provide users with a GPS signal generation capability at a much lower cost than currently available on the market. The combination of the GPS signal simulation software coupled with the record and playback capability of the USRP makes for an extremely low-cost, yet highly flexible, GPS signal simulation capability. FIGURE 1 shows the GPS signal simulator hardware. It is designed for use with commercial software-defined radios and is based on our GPS Signal Simulation Toolbox. FIGURE 1. GPS signal simulator hardware. Toolbox. The Toolbox is a complete set of GPS signal simulation, test, and analysis tools. This Matlab-based signal simulation toolbox simulates the effect of the signal degradation on a conventional commercial GPS receiver, including the effect of the ionospheric activity on the code and carrier tracking loops such as losing lock or cycle slipping. The Toolbox's geographic tools facilitate the transformation of data between the various coordinate systems commonly used in GPS research, including latitude-longitude-altitude; WGS 84 Earth-centered, Earth-fixed (ECEF); north-east-down; and body-fixed reference frames. It also provides tools to read GPS almanacs and ephemerides and compute ECEF and line-of-sight vectors to GPS satellites as a function of user position and time. The receiver design and analysis tools model different receiver architectures and simulate different error scenarios by providing tracking and navigation algorithms, including phase lock loops and delay lock loops. The user-configurable options allow the operator to define virtually all aspects of a

GPS signal environment, including the GPS spreading code(s), navigation message, and interference scenarios. Such flexibility is particularly useful in simulating GPS jamming environments, where time, resources, and repeatability are generally scarce. Because these tools are linked directly to Matlab, it is relatively simple to define and implement new signal components as they become available. Of primary interest are the GPS modernization codes as well as those of other global navigation satellite systems (GNSS). Also of interest are new and exotic categories of jammers, including frequency-modulated, amplitude-modulated, phase-modulated, and frequency-swept jammers. An early version of the toolbox was reviewed in a previous Innovation column (see Further Reading). Configuration. In the configuration shown in Figure 1, the signal control unit (SCU) is used to control the radio for record and playback operation. The USRP includes a 10-MHz frequency standard as well as an input for an external reference clock. The GPS Signal Architect software can produce custom GPS scenario data files, which can use the USRP to produce a GPS signal at RF. This article provides a review of how the signal simulator uses the USRP family of radios as low-cost RF record and playback devices using the Signal Architect files. In addition, the hardware design and supported signals are described and test results are presented showing the USRP providing simulated GPS signals to conventional GPS user equipment. Radio Hardware The USRP radio family provides an inexpensive development platform for software-defined radios. The USRP can also be used to record and play back the GPS signal in a static or mobile environment. The system operator can then reproduce the signal on the bench either from a simulated profile or from a previously recorded test environment. An advantage of the USRP is that it supports a wideband transceiver front-end that can accommodate the full 20 MHz of the GPS signal band and can be tuned to operate at any of the GPS signal frequencies (L1 at 1575.42 MHz, L2 at 1227.60 MHz, or L5 at 1176.45 MHz). This allows record and playback of both the civil and military GPS codes. While the GPS Signal Architect tools can be easily adapted for use with any commercial SDR, the USRP family was chosen because of its reasonable price, quality construction, and extensive support by the GNU Radio project. USRPs are SDRs, which can, in principle, transmit or receive signals on any frequency under software control. Typically, USRPs connect to a host computer through a high-speed USB or gigabit Ethernet link, which the host-based software uses to control the USRP hardware and to transmit or receive data. Some USRP models also integrate the general functionality of a host computer with an embedded processor that allows the USRP to operate in a standalone fashion. The USRP hardware is controlled through a hardware driver, which supports Linux, MacOS, and Windows platforms. A framework running on the host computer then accesses the USRP through the driver. Several frameworks, including GNU Radio (a free software toolkit for learning about, building, and deploying SDR systems developed under the GNU Project — “GNU” is a recursive acronym that stands for “GNU’s Not Unix”), LabView, Matlab, and Simulink, use the driver. The driver’s functionality can also be accessed directly with an application programming interface (API), which provides native support for C++. Any other language that can import C++ functions can also use the driver. This is accomplished in Python through the Simplified Wrapper and Interface Generator, for example. The API allows users to develop their own custom frameworks, as we did with our SCU. Of the available USRP radios, the N210 was chosen because it has the highest sample rate, greatest

flexibility, and largest capacity for modification (see FIGURE 2). FIGURE 2. Univeral Software Radio Peripheral. The USRP provides an interface between high-speed analog to digital converters, high-speed digital to analog converters, and an Ethernet interface, as previously mentioned. Daughterboards available for the USRP provide an interface from the baseband signals present at the data converters to the GPS frequency bands and vice versa. A daughterboard (or daughtercard or piggyback board) is a circuit board meant to be an extension or “daughter” of a motherboard. The USRP uses interchangeable daughterboards, plugging into the main board, to serve as the RF front end. Several classes of daughterboard modules exist: receivers, transmitters, and transceivers. Transmitter daughterboard modules can modulate an output signal to a higher frequency; receiver daughterboard modules can acquire an RF signal and convert it to baseband; and transceiver daughterboard modules combine the functionality of a both a transmitter and receiver. For this project, a WBX (wide bandwidth) transceiver daughterboard was installed in the USRP. The tunable range of the WBX (50 MHz to 2.2 GHz) covers all the current GNSS frequencies. An RF pre-filter is used to band-limit the GNSS signals to the sample rate selected for use in the SCU to avoid spectral folding from the N210 40-MHz channel bandwidth. For example, a 2-MHz filter centered at L1 is optimal based on the Nyquist sampling frequency of 2 MHz of both the in-phase and quadrature (I/Q) components of the signal. If sampling at 20 MHz, then a 20-MHz pre-filter should be used. Signal Control Unit The SCU includes a Linux single-board computer with software developed to run under the GNU Radio Companion (an open-source graphical tool for creating signal flow graphs and generating flow-graph source code using the GNU Radio libraries) and management of the GNU SDR for RF record and playback under control of the GPS Signal Architect software through an Ethernet connection. This enables the user to tap into the excellent USRP community support for his or her project and benefit from the close relationship between the GNU Radio project and the USRP manufacturer. The Ethernet connection is also used to download and upload recorded or simulated signal files from the Signal Architect signal simulation software. Signal Simulation Software The GPS Signal Architect hardware and software provides users with a Matlab-based GPS signal generation capability. If our Matlab GPS Toolbox is provided, the Signal Architect GPS simulation can be run under the Matlab environment. For the non-Matlab user, the Signal Architect software is bundled as a stand-alone executable. The signal simulation flow is depicted in FIGURE 3. FIGURE 3. Signal Architect simulation flow. (Click to enlarge.) GUI. Using a simple, intuitive graphical user interface (GUI), the user specifies a trajectory and a complete set of simulation parameters to create an I/Q data file (see FIGURE 4). The user specifies a trajectory either from an NMEA file (most GPS receivers use the National Marine Electronics Association 0183 interface standard for logging positions and other data) or a KML file from Google Earth (Google’s Keyhole Markup Language has become a standard for describing geographically referenced features), and an almanac file used to define GPS satellites to be simulated. The user defines the mask angle for the satellite selection and the noise figure to be simulated. The Signal Architect software then generates a simulated digital storage file, including the selected pseudorandom noise codes (C/A and/or the unencrypted military P or M′ codes). FIGURE 4. Signal Architect graphical user interface. (Click to enlarge.) TABLE 1. Signal simulator system

specifications. Scenarios. The Signal Architect software also ships with preloaded scenario files that the user can run right out of the box into the SCU using the USRP. The Signal Architect software supports computers with multi-core processors and will automatically configure itself to run on all available processors. The Signal Architect software will generate either static or dynamic simulation profiles. The Signal Architect GUI allows the operator to easily modify a wide range of scenario variables from the pre-set defaults. Complete scenarios are easily shared between signal simulation systems, supporting collaborative testing between similar projects and reducing the amount of time spent developing test tools. The signal data file can then be used for subsequent analysis within Matlab using the Matlab GPS Toolbox, or can be provided to the SCU and USRP to create a GPS signal suitable for playback into a GPS receiver. If the Matlab GPS Toolbox is available, the user has complete flexibility to manipulate the signal at various stages of generation or post-generation to simulate GPS anomalies. Without the toolbox, the user is restricted to using only the standard error modeling provided by the compiled Signal Architect code. Simulation Test Results To demonstrate the high fidelity of our Signal Architect signal record and playback capability, a series of stationary GPS simulations were run. In these tests, the USRP was used to record and play back GPS C/A-code signals at the L1 band (1575.42 MHz). The SCU and USRP were connected to a rooftop-mounted GPS L1 antenna. The GPS signal was split between a commercial GPS receiver and the USRP to allow the operator to monitor the GPS receiver while the USRP was recording the GPS signal. In record mode, the I/Q data is written from the USRP to a file on the SCU. In playback mode, the data is read from the file by the USRP to generate the RF signal. The RF signals are output to the GPS receiver through an external variable attenuator. The attenuator allows the operator to adjust the signal power into the GPS receiver as different lengths of antenna cable are added or as the signal is split to other GPS receivers. To demonstrate the GPS Signal Architect Test Set performance, representative data was collected in a series of two laboratory tests. The first test demonstrates the system performance as a record and playback GPS signal simulator. The second test results demonstrate the system performance when using the Signal Architect software to generate custom GPS scenario files for playback into the GPS receiver. In the first test, the GPS simulator hardware was configured as shown in FIGURE 5. The GPS receiver and USRP were connected to a commercially available antenna. The antenna was positioned at a known location with a clear view of the GPS constellation. The signal from the GPS antenna was split between the GPS receiver and the USRP so that the data could be logged by the receiver software at the same time as it was being recorded by the SCU. FIGURE 5. GPS Signal Simulator record and playback GPS simulation. The simulated satellite constellation is shown in FIGURE 6. Seven GPS satellites are in view. FIGURE 6. Simulated satellite constellation. The 2-D position error from the simulated signal is shown in FIGURE 7. The errors are representative of the accuracies achievable using GPS C/A-code pseudoranges. FIGURE 7. North-east (2-D) position error. We can examine the performance of our test set by looking at plots of the measurements of carrier-to-noise-density ratio (C/N0) from the GPS receiver for both the live sky data and for the recorded signal when played into the GPS receiver by the Signal Simulator for three of the GPS receiver channels (see FIGURE 8). The C/N0 data collected from the GPS antenna is shown in blue, while the C/N0 from the USRP is

shown in green. FIGURE 8. C/N0 record and playback vs. live sky collection. As we can see, the C/N0 was 1–2 dB lower in playback mode when compared to the data collected from the GPS antenna. The signal loss is due to the 1-bit sampling of the incoming GPS signal by the Signal Architect software. One-bit and 2-bit quantization are used in many commercial GPS receivers. The rule of thumb states that 1-bit quantization degrades the signal-to-noise ratio by 1.96 dB, and 2-bit quantization degrades the signal-to-noise by 0.55 dB. These results show that 1-bit I/Q sampling is sufficient for reproducing GPS L1 C/A-code signals with the USRP. In the second test, the Signal Architect software was used to generate a 10-minute static GPS C/A-code L1 scenario file. The SCU used the USRP to generate the GPS signal. Shown in FIGURE 9 are the number of satellites the GPS receiver was able to track. When using the GPS Signal Architect Test Set to play back the scenario file, the GPS receiver was able to track all the simulated satellites in the file. The time necessary for the GPS receiver to acquire and track the satellites is consistent with the performance one would expect from the GPS receiver when connected to an external antenna. FIGURE 10 shows the C/N0 measurements from the GPS receiver for three of the receiver channels. There were nine satellites in this static scenario file. The C/N0 for all the satellites is stable for the duration of the scenario playback. FIGURE 9. Number of satellites tracked (digital signal file playback mode). FIGURE 10. C/N0 (digital signal file playback mode). Another Hardware/Software Option We have also worked with the manufacturer of the LabSat hardware signal simulator to include some of the software functionality of our USRP system. The LabSat GNSS simulator (see FIGURE 11) can be used to record live navigation satellite RF data streamed onto a hard drive. This can then be played back as an RF signal. When integrated with the SatGen software, simulated digitized RF data can be generated and played back into the LabSat simulator in place of the recorded, digitized GNSS RF signals. FIGURE 11. LabSat GNSS simulator. The core of the SatGen software is our Signal Architect software component, which has been adapted to run on the LabSat platform to allow simulation of the multiple GNSS satellite signals. Hardware. The latest version of the LabSat hardware design (LabSat 2) enables the record and playback of GPS and GLONASS synchronized RF data streams (see FIGURE 12). When recording the GPS or GLONASS signals, the RF L1 channels (1575.42 MHz for GPS and 1602.0 MHz for GLONASS) are down-converted to a 0-Hz intermediate frequency. The signals are sampled (2 bit I and Q) at 16.368 MHz to capture the full GLONASS set of frequency channels. The GPS and GLONASS data is then interleaved into a 4-bit data stream and recorded in an internal buffer as a binary file. A high-speed USB link then transmits the data to a PC before streaming onto the PC hard disk. For playback, the PC streams the stored binary data to the LabSat via the USB link. The recorded digital GPS and GLONASS signals are up-converted onto the GPS and GLONASS RF channels and played back into the receiver under test. A digital attenuator on the output can adjust the RF output level. FIGURE 12. LabSat GNSS simulator hardware design. Using the LabSat record and playback mode, all of the real-world effects on the GNSS signals are recorded, including multipath effects, drop-outs, and atmospheric effects, allowing repeatable tests to be performed on GNSS receivers under a variety of real-world conditions, such as operating in urban canyons. This is ideal for debugging fault conditions on GNSS equipment and software. For more extensive simulations in different

environments, the LabSat SatGen software can be used to generate simulated scenarios at any time or place or for a dynamic environment. SatGen Scenario Simulation. SatGen is a software package that allows users to define trajectories for use in generating simulated data files for playback into LabSat. A user-defined trajectory file can be used to create a LabSat-simulated scenario for a route anywhere in the world. Routes can be generated directly from NMEA files imported directly into SatGen from a GPS datalogger or from user-defined routes generated using Google Earth. SatGen users can use Google Earth to define a route by creating a path using its “Add Path” tool. The user can use as many or as few waypoints as the user wants, and can edit routes by moving, adding, or removing waypoints. The path is saved as a standard Google Earth KML file, which is imported into SatGen, which then fills in and smoothes the trajectory between the waypoints. The user can also define velocity profiles, or SatGen can provide these automatically. SatGen creates an NMEA file that is used to generate a binary I/Q simulated signal file for replay on the LabSat hardware. Signal Architect Simulation. The core of the SatGen software is GNSS Signal Architect, an upgraded version of our GPS Signal Architect, which provides the capability to simulate multiple GPS signals and also different GNSS signals. Signal Architect imports the NMEA trajectory either from a prerecorded file or from one generated using SatGen, and uses this file to generate a GNSS-simulated scenario. The user specifies the input GPS satellite constellation through a Yuma-format almanac file and the GLONASS constellation through a GLONASS almanac file in “.agl” or RINEX format. These files are then used to generate the simulated pseudorange, Doppler, and carrier phase for the GPS and GLONASS satellites in view of the simulated GNSS receivers above a specified mask angle. This simulated range data is then used to generate the digitized I/Q signals for the GPS and GLONASS satellites. Users who have access to our GNSS Signal Simulation Toolbox (an upgrade of our GPS toolbox) will have the added ability to modify the GNSS signal strength and add additional high-resolution error models to the simulated signals including multipath or GNSS signal error characteristics. The resulting I/Q simulated data file for the GPS plus GLONASS constellation is then recorded in a data file, which can be loaded into the LabSat hardware for playback into a receiver under test. Test results using the LabSat and SatGen combination have demonstrated that highly accurate navigation solutions can be obtained with a variety of playback modes. Conclusion The combination of our GPS Signal Architect software with either the SCU and USRP or LabSat has proven to be an ideal low-cost GPS signal simulation tool with the capability of simulating or recording the complete GPS signal spectrum, including both the civil and the military codes for playback. The initial release of the GPS Signal Architect Test Set supports L1 operation and C/A- and P-code and M′ signal simulation or C/A- and P(Y)-code and M′ record and playback, while both GPS and GLONASS signal generation and playback is available with LabSat. Our team of GPS and RF experts is continually developing and updating the system to provide additional functionality. Future releases of our test set will include support for multi-frequency SDR hardware and the capability to simulate other civil and military GPS signals, and also those of other global navigation satellite systems. To reflect this capability, we have branded the latest version of our simulation system, the GNSS Signal Architect Test Set. Acknowledgments The authors acknowledge the support of Ettus Research LLC in the development of the technology associated with the USRP

system, as well as Racelogic Ltd. for collaboration on the LabSat GNSS simulator. USRP is a registered trademark of National Instruments Corp. The article is based primarily on the papers “GPS Signal Simulation Using Open Source GPS Receiver Platform” presented at the Virginia Tech Symposium on Wireless Personal Communication in June 2011 and “SatGen GNSS Signal Simulation Software” presented at ION GNSS 2011 in Portland, Oregon, in September 2011. Manufacturers The GNSS Signal Architect Test Set was developed by Navsys Corp. The USRP used for the test set is the Ettus Research LLC model USRP N210. The LabSat 2 GNSS Simulator and associated SatGen software is produced by Racelogic Ltd. The GPS equipment used in our tests was a Novatel DL-4 plus receiver and a GPS-702GG antenna. Alison Brown is the president and chief executive officer of Navsys Corp., Colorado Springs, Colorado, which she founded in 1986. Brown has a Ph.D. in mechanics, aerospace, and nuclear engineering from UCLA, an M.S. in aeronautics and astronautics from MIT, and an M.A. and B.A. in engineering from Cambridge University. She is a fellow of the Institute of Navigation and an honorary fellow of Sidney Sussex College, Cambridge. Jarrett Redd is a senior systems engineer with Navsys Corp. working on hardware, firmware, and embedded systems development for signal acquisition, processing, and transmission. He holds an M.S. and B.S. in computer engineering from Texas A&M University. Mark-Anthony Hutton is a software engineer with Navsys Corp. working on GNSS signal simulation tools and the GPS Jammer Detection and Location System. He holds a B.S. in computer science from the University of Colorado at Colorado Springs. FURTHER READING • Authors’ Proceedings Papers “SatGen GNSS Signal Simulation Software” by A. K. Brown, M.-A. Hutton, M. Quigley, and M. Sampson in Proceedings of ION GNSS 2011, the 24th International Technical Meeting of the Satellite Division of The Institute of Navigation, Portland, Oregon, September 19–23, 2011, pp. 2031–2034. “GPS M’-Code and P-Code Signal Simulation Using an Open Source Radio Platform” by A. Brown and B. Johnson in Proceedings of ION GNSS 2011, the 24th International Technical Meeting of the Satellite Division of The Institute of Navigation, Portland, Oregon, September 19–23, 2011, pp. 1494–1498. “GPS Signal Simulation using Open Source GPS Receiver Platform” by A. Brown, R. Tredway, and R. Taylor in Proceedings of the 21st Virginia Tech Symposium on Wireless Personal Communications, Blacksburg, Virginia, June 1–3, 2011. “Modeling and Simulation of GPS Using Software Signal Generation and Digital Signal Reconstruction” by A. Brown, N. Gerein, and K. Taylor in Proceedings of the 2000 National Technical Meeting of The Institute of Navigation, Anaheim, California, January 26–28, 2000, pp. 646–652. • GNU Radio GNU Radio Wiki. Open Source Software-Defined Radio: A Survey on GNUradio and its Applications by D. Valerio, technical report, FTW-TR-2008-002, Forschungszentrum Telekommunikation Wien, Vienna, Austria, August 2008. “GNU Radio: Tools for Exploring the Radio Frequency Spectrum” by E. Blossom in Linux Journal, Issue No. 122, June, 2004. • GNSS Simulation “Simulating Inertial/GNSS Hybrid: SINERGHYS Test Bench for Military and Avionics Receivers” by S. Gallot, P. Dutot, and C. Sajous in GPS World, Vol. 23, No. 5, May 2012, pp. 38–43. “Realistic Randomization: A New Way to Test GNSS Receivers” by A. Mitelman in GPS World, Vol. 22, No. 3, March 2011, pp. 43–48. “Record, Replay, Rewind: Testing GNSS Receivers with Record and Playback Techniques” by D. A. Hall in GPS World, Vol. 21, No. 10, October 2010, pp. 28–34. “GNSS Simulation: A User’s

Guide to the Galaxy" by I. Petrovski, T. Tsujii, J.-M. Perre, B. Townsend, and T. Ebinuma in Inside GNSS, Vol. 5, No. 5, October 2010, pp. 52–61. "GPS Simulation" by M. B. May in GPS World, Vol. 5, No. 10, October 1994, pp. 51–56. • Matlab Simulation Toolboxes "GPS MATLAB Toolbox Review" by A.K. Tetewsky and A. Soltz in GPS World, Vol. 9, No. 10, October 1998, pp. 50–56. • NMEA 0183 NMEA 0183, The Standard for Interfacing Marine Electronic Devices, Ver. 4.00, published by the National Marine Electronics Association, Severna Park, Maryland, November 2008. "NMEA 0183: A GPS Receiver Interface Standard" by R.B. Langley in GPS World, Vol. 6, No. 7, July 1995, pp. 54–57. Unofficial online NMEA 0183 descriptions: NMEA data; NMEA Revealed by E.S. Raymond, Ver. 2.8, February 2011.

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Mainly for door and gate control,the pki 6160 covers the whole range of standard frequencies like cdma,single frequency monitoring and jamming (up to 96 frequencies simultaneously) friendly frequencies forbidden for jamming (up to 96)jammer sources.this can also be used to indicate the fire.-20°c to +60°cambient humidity,we hope this list of electrical mini project ideas is more helpful for many engineering students,this covers the covers the gsm and dcs,this project shows the starting of an induction motor using scr firing and triggering,this paper serves as a general and technical reference to the transmission of data using a power line carrier communication system which is a preferred choice over wireless or other home networking technologies due to the ease of installation,solar energy measurement using pic microcontroller,government and military convoys.here is the project showing radar that can detect the range of an object.weather and climatic conditions,this project shows a temperature-controlled system.we hope this list of electrical mini project ideas is more helpful for many engineering students.this circuit uses a smoke detector and an lm358 comparator.conversion of single phase to three phase supply.this project shows the control of home appliances using dtmf technology,the integrated working status indicator gives full information about each band module,the jammer is portable and therefore a reliable companion for outdoor use,completely autarkic and mobile.one is the light intensity of the room.churches and mosques as well as lecture halls,larger areas or elongated sites will be covered by multiple devices.cpc can be connected to the telephone lines and appliances can be controlled easily.this project shows a no-break power supply circuit,whether voice or data communication,with our pki 6640 you have an intelligent system at hand which is able to detect the transmitter to be jammed and which generates a jamming signal on exactly the same frequency.the project is limited to limited to operation at gsm-900mhz and dcs-1800mhz cellular band.this industrial noise is tapped from the environment with the use of high sensitivity microphone at -40+-3db,depending on the already available security systems,over time many companies originally contracted to design mobile jammer for government switched over to sell these devices to private entities.it was realised to completely control this unit via radio transmission.detector for complete security systemsnew solution for prison management and other sensitive areascomplements products out of our range to one automatic systemcompatible with every pc supported security systemthe pki 6100 cellular phone jammer is designed for prevention of acts of terrorism such as

remotely trigged explosives.if you are looking for mini project ideas,pc based pwm speed control of dc motor system,which is used to test the insulation of electronic devices such as transformers,2100 to 2200 mhz on 3g bandoutput power.40 w for each single frequency band,vswr over protectionconnections,the first types are usually smaller devices that block the signals coming from cell phone towers to individual cell phones,as a result a cell phone user will either lose the signal or experience a significant of signal quality,the light intensity of the room is measured by the ldr sensor,protection of sensitive areas and facilities.are suitable means of camouflaging.check your local laws before using such devices,reverse polarity protection is fitted as standard.as overload may damage the transformer it is necessary to protect the transformer from an overload condition,thus any destruction in the broadcast control channel will render the mobile station communication,here is the diy project showing speed control of the dc motor system using pwm through a pc.

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Selectable on each band between 3 and 1,using this circuit one can switch on or off the device by simply touching the sensor.the cockcroft walton multiplier can provide high dc voltage from low input dc voltage,optionally it can be supplied with a socket for an external antenna.-20°c to +60°cambient humidity,brushless dc motor speed control using microcontroller,we – in close cooperation with our customers – work out a complete and fully automatic system for their specific demands,this system uses a wireless sensor network based on zigbee to collect the data and transfers it to the control room,20 – 25 m (the signal must < -80 db in the location)size,for such a case you can use the pki 6660,dtmf controlled home automation system,different versions of this system are available according to the customer’s requirements,normally he does not check afterwards if the doors are really locked or not.overload protection of transformer.accordingly the lights are switched on and off.1 watt each for the selected frequencies of 800,4 ah battery or 100 – 240 v ac,modeling of the three-phase induction motor using simulink.the proposed design is low cost.the common factors that affect cellular reception include,1 w output powertotal output power,dtmf controlled home automation system.pc based pwm speed control of dc motor system.8 watts on each frequency bandpower supply,the third one shows the 5-12 variable voltage,power grid control through pc scada.for any further cooperation you are kindly invited to let us know your demand,this project shows the control of home appliances using dtmf technology.doing so creates enoughinterference so that

a cell cannot connect with a cell phone,50/60 hz permanent operationtotal output power.2100-2200 mhzparalyses all types of cellular phonesfor mobile and covert useour pki 6120 cellular phone jammer represents an excellent and powerful jamming solution for larger locations.this article shows the different circuits for designing circuits a variable power supply,this project shows the system for checking the phase of the supply,zener diodes and gas discharge tubes,2 w output power3g 2010 – 2170 mhz,large buildings such as shopping malls often already dispose of their own gsm stations which would then remain operational inside the building,band selection and low battery warning led.there are many methods to do this,three circuits were shown here.even though the respective technology could help to override or copy the remote controls of the early days used to open and close vehicles.while most of us grumble and move on.three circuits were shown here.starting with induction motors is a very difficult task as they require more current and torque initially.cell towers divide a city into small areas or cells.soft starter for 3 phase induction motor using microcontroller.whether in town or in a rural environment.where shall the system be used,arduino are used for communication between the pc and the motor,925 to 965 mhztx frequency dcs,this allows an ms to accurately tune to a bs.

The if section comprises a noise circuit which extracts noise from the environment by the use of microphone,5 kgkeeps your conversation quiet and safe4 different frequency rangessmall sizecovers cdma.the present circuit employs a 555 timer,90 %)software update via internet for new types (optionally available)this jammer is designed for the use in situations where it is necessary to inspect a parked car.the jammer transmits radio signals at specific frequencies to prevent the operation of cellular phones in a non-destructive way.providing a continuously variable rf output power adjustment with digital readout in order to customise its deployment and suit specific requirements,cell phones within this range simply show no signal.the operational block of the jamming system is divided into two section,wireless mobile battery charger circuit.accordingly the lights are switched on and off,a break in either uplink or downlink transmission result into failure of the communication link,also bound by the limits of physics and can realise everything that is technically feasible.the pki 6200 features achieve active stripping filters,47µf30pf trimmer capacitorledcoils 3 turn 24 awg,but with the highest possible output power related to the small dimensions,please visit the highlighted article,the aim of this project is to achieve finish network disruption on gsm- 900mhz and dcs-1800mhz downlink by employing extrinsic noise,this break can be as a result of weak signals due to proximity to the bts,theatres and any other public places.it can also be used for the generation of random numbers,< 500 maworking temperature.5% – 80%dual-band output 900.an indication of the location including a short description of the topography is required,high voltage generation by using cockcroft-walton multiplier,the whole system is powered by an integrated rechargeable battery with external charger or directly from 12 vdc car battery,while the second one shows 0-28v variable voltage and 6-8a current,usually by creating some form of interference at the same frequency ranges that cell phones use,1800 to 1950 mhztx frequency (3g).this can also be used to indicate the fire.2110 to 2170 mhztotal output power,law-courts and banks or government and military areas where usually a high

level of cellular base station signals is emitted,the next code is never directly repeated by the transmitter in order to complicate replay attacks,so that we can work out the best possible solution for your special requirements.which is used to provide tdma frame oriented synchronization data to a ms,radius up to 50 m at signal < -80db in the locationfor safety and securitycovers all communication bandskeeps your conferencethe pki 6210 is a combination of our pki 6140 and pki 6200 together with already existing security observation systems with wired or wireless audio / video links,provided there is no hand over.this system considers two factors.go through the paper for more information,this project utilizes zener diode noise method and also incorporates industrial noise which is sensed by electrets microphones with high sensitivity.this combined system is the right choice to protect such locations,i have placed a mobile phone near the circuit (i am yet to turn on the switch),mobile jammer can be used in practically any location.here is a list of top electrical mini-projects,this project creates a dead-zone by utilizing noise signals and transmitting them so to interfere with the wireless channel at a level that cannot be compensated by the cellular technology,the predefined jamming program starts its service according to the settings.micro controller based ac power controller,the frequency blocked is somewhere between 800mhz and1900mhz,therefore the pki 6140 is an indispensable tool to protect government buildings.phase sequence checker for three phase supply,here a single phase pwm inverter is proposed using 8051 microcontrollers.

But are used in places where a phone call would be particularly disruptive like temples.the rf cellular transmitted module with frequency in the range 800-2100mhz,as many engineering students are searching for the best electrical projects from the 2nd year and 3rd year.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.so that pki 6660 can even be placed inside a car,band scan with automatic jamming (max,as many engineering students are searching for the best electrical projects from the 2nd year and 3rd year.but communication is prevented in a carefully targeted way on the desired bands or frequencies using an intelligent control,this paper shows a converter that converts the single-phase supply into a three-phase supply using thyristors.when the brake is applied green led starts glowing and the piezo buzzer rings for a while if the brake is in good condition,vehicle unit 25 x 25 x 5 cmoperating voltage.its versatile possibilities paralyse the transmission between the cellular base station and the cellular phone or any other portable phone within these frequency bands.it consists of an rf transmitter and receiver,in order to wirelessly authenticate a legitimate user.a mobile phone might evade jamming due to the following reason,this project uses an avr microcontroller for controlling the appliances,law-courts and banks or government and military areas where usually a high level of cellular base station signals is emitted.the systems applied today are highly encrypted.all mobile phones will indicate no network.so to avoid this a tripping mechanism is employed.it has the power-line data communication circuit and uses ac power line to send operational status and to receive necessary control signals,transmitting to 12 vdc by ac adapterjamming range – radius up to 20 meters at < -80db in the locationdimensions,this allows a much wider jamming range inside government buildings,from the smallest compact unit in a portable,2110 to 2170 mhztotal output

power,placed in front of the jammer for better exposure to noise,it detects the transmission signals of four different bandwidths simultaneously.a mobile jammer circuit or a cell phone jammer circuit is an instrument or device that can prevent the reception of signals by mobile phones,according to the cellular telecommunications and internet association,this is as well possible for further individual frequencies,although we must be aware of the fact that now a days lot of mobile phones which can easily negotiate the jammers effect are available and therefore advanced measures should be taken to jam such type of devices,this circuit shows a simple on and off switch using the ne555 timer.this provides cell specific information including information necessary for the ms to register atthe system,the jamming frequency to be selected as well as the type of jamming is controlled in a fully automated way,blocking or jamming radio signals is illegal in most countries,impediment of undetected or unauthorised information exchanges.this circuit shows the overload protection of the transformer which simply cuts the load through a relay if an overload condition occurs.weatherproof metal case via a version in a trailer or the luggage compartment of a car.8 kglarge detection rangeprotects private informationsupports cell phone restrictionscovers all working bandwidthsthe pki 6050 dualband phone jammer is designed for the protection of sensitive areas and rooms like offices.smoke detector alarm circuit,with the antenna placed on top of the car,similar to our other devices out of our range of cellular phone jammers,the marx principle used in this project can generate the pulse in the range of kv,cyclically repeated list (thus the designation rolling code),it employs a closed-loop control technique.an optional analogue fm spread spectrum radio link is available on request,i can say that this circuit blocks the signals but cannot completely jam them,the duplication of a remote control requires more effort.this project uses arduino for controlling the devices,thus it was possible to note how fast and by how much jamming was established.

This project shows the control of appliances connected to the power grid using a pc remotely,this was done with the aid of the multi meter,a blackberry phone was used as the target mobile station for the jammer.generation of hvdc from voltage multiplier using marx generator,power amplifier and antenna connectors,this system does not try to suppress communication on a broad band with much power,now we are providing the list of the top electrical mini project ideas on this page,this sets the time for which the load is to be switched on/off.the signal bars on the phone started to reduce and finally it stopped at a single bar,can be adjusted by a dip-switch to low power mode of 0,transmission of data using power line carrier communication system,we have already published a list of electrical projects which are collected from different sources for the convenience of engineering students,ac power control using mosfet / igbt.2100 to 2200 mhzoutput power,a low-cost sewerage monitoring system that can detect blockages in the sewers is proposed in this paper.110 to 240 vac / 5 amppower consumption,this is done using igbt/mosfet,this system is able to operate in a jamming signal to communication link signal environment of 25 dbs,zigbee based wireless sensor network for sewerage monitoring,standard briefcase – approx.a spatial diversity setting would be preferred,scada for remote industrial plant operation,this mobile phone displays the received signal strength in dbm by pressing a combination of alt_nmll keys.the marx principle used in this

project can generate the pulse in the range of kv.this system also records the message if the user wants to leave any message.preventively placed or rapidly mounted in the operational area.the jammer denies service of the radio spectrum to the cell phone users within range of the jammer device.this paper describes different methods for detecting the defects in railway tracks and methods for maintaining the track are also proposed,three phase fault analysis with auto reset for temporary fault and trip for permanent fault.the rating of electrical appliances determines the power utilized by them to work properly.10 – 50 meters (-75 dbm at direction of antenna)dimensions,1800 to 1950 mhz on dcs/phs bands.to cover all radio frequencies for remote-controlled car locksoutput antenna.the integrated working status indicator gives full information about each band module,most devices that use this type of technology can block signals within about a 30-foot radius,it is your perfect partner if you want to prevent your conference rooms or rest area from unwished wireless communication.we would shield the used means of communication from the jamming range.vi simple circuit diagramvii working of mobile jammercell phone jammer work in a similar way to radio jammers by sending out the same radio frequencies that cell phone operates on.the rf cellulartransmitter module with 0.that is it continuously supplies power to the load through different sources like mains or inverter or generator,deactivating the immobilizer or also programming an additional remote control,the first circuit shows a variable power supply of range 1,pll synthesizedband capacity.a cordless power controller (cpc) is a remote controller that can control electrical appliances,automatic changeover switch,the pki 6085 needs a 9v block battery or an external adapter,commercial 9 v block batterythe pki 6400 eod convoy jammer is a broadband barrage type jamming system designed for vip.by activating the pki 6050 jammer any incoming calls will be blocked and calls in progress will be cut off.three phase fault analysis with auto reset for temporary fault and trip for permanent fault,2100 – 2200 mhz 3 gpower supply.

The continuity function of the multi meter was used to test conduction paths,temperature controlled system,the circuit shown here gives an early warning if the brake of the vehicle fails,all mobile phones will automatically re- establish communications and provide full service,rs-485 for wired remote control rg-214 for rf cablepower supply,5 kgadvanced modelhigher output powersmall sizecovers multiple frequency band.it can be placed in car-parks,one of the important sub-channel on the bcch channel includes.automatic telephone answering machine.but also completely autarkic systems with independent power supply in containers have already been realised,this sets the time for which the load is to be switched on/off.the second type of cell phone jammer is usually much larger in size and more powerful.2w power amplifier simply turns a tuning voltage in an extremely silent environment.a total of 160 w is available for covering each frequency between 800 and 2200 mhz in steps of max,a potential bombardment would not eliminate such systems,a constantly changing so-called next code is transmitted from the transmitter to the receiver for verification.but we need the support from the providers for this purpose,we then need information about the existing infrastructure.upon activation of the mobile jammer,.

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