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Permanent Link to Innovation: Improving Dilution of Precision
2021/05/07

A Companion Measure of Systematic Effects By Dennis Milbert GPS receivers must deal with measurements and models that have some degree of error, which gets propagated into the position solution. If the errors are systematically different for the different simultaneous pseudoranges, as is typically the case when trying to correct for ionospheric and tropospheric effects, these errors propagate into the receiver solution in a way that is fundamentally different from the way that random errors propagate. So in addition to dilution of precision, we need a companion measure of systematic effects. In this month's column, we introduce just such a measure. INNOVATION INSIGHTS by Richard Langley WE LIVE IN AN IMPERFECT WORLD. We know this all too well from life's everyday trials and tribulations. But this statement extends to the world of GPS and other global navigation satellite systems, too. A GPS receiver computes its three-dimensional position coordinates and its clock offset from four or more simultaneous pseudoranges. These are measurements of the biased range (hence the term pseudorange) between the receiver's antenna and the antenna of each of the satellites being tracked. The receiver processes these measurements together with a model describing the satellite orbits and clocks and other effects, such as those of the atmosphere, to determine its position. The precision and accuracy of the measured pseudoranges and the fidelity of the model determine, in part, the overall precision and accuracy of the receiver-derived coordinates. If we lived in an ideal world, a receiver could make perfect measurements and model them exactly. Then, we would only need measurements to any four satellites to determine our position perfectly. Unfortunately, the receiver must deal with measurements and models that have some degree of error, which gets propagated into the position solution. Furthermore, the geometrical arrangement of the satellites observed by the receiver — their elevation angles and azimuths — can significantly affect the precision and accuracy of the receiver's solution, typically degrading them. It is common to express the degradation or dilution by dilution of precision (DOP) factors. Multiplying the measurement and model uncertainty by an appropriate DOP value gives an estimate of the position error. These estimates are reasonable if the measurement and model errors are truly random. However, it turns

out that this simple geometrical relationship breaks down if some model errors are systematic. If that systematic error is a constant bias and if it is common to all pseudoranges measured simultaneously, then the receiver can easily estimate it along with its clock offset, leaving the position solution unaffected. But if the errors are systematically different for the different simultaneous pseudoranges, as is typically the case when trying to correct for ionospheric and tropospheric effects, these errors propagate into the receiver solution in a way that is fundamentally different from the way that random errors propagate. This means that in addition to DOP, we need a companion measure of systematic effects. In this month's column, Dennis Milbert introduces just such a measure — the error scale factor or ESF. ESF, combined with DOP, forms a hybrid error model that appears to more realistically portray the real-world GPS precisions and accuracies we actually experience.

"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. The recent edition of the Standard Positioning Service (SPS) Performance Standard (PS) and the corresponding document for the Precise Positioning Service (PPS) both emphasize a key element. They only specify the GPS signal-in-space (SIS) performance. Since these standards do not define performance for any application of a GPS signal, it becomes even more important to understand the relationship of signal statistics to positioning accuracy. Historically, as well as in Appendix B of the SPS-PS and PPS-PS, this relationship is modeled by covariance elements called dilution of precision (DOP). Many references are available which describe DOP. The core of DOP is the equation of random error propagation: $Q_x = (A^T Q^{-1} A)^{-1}$ where, for n observations, A is the $n \times 4$ matrix of observation equation partial differentials, Q is the $n \times n$ covariance matrix of observations, and Q_x is the 4×4 covariance matrix of position and time parameters (X, Y, Z, T) used to compute DOPs. This equation describes the propagation of random error (noise) in measurements into the noise of the unknown (solved for) parameters. Elements of the Q_x matrix are then used to form the DOP. The equation above is linear for any measurement scale factor of Q . For example, halving the dispersion of the measurements will halve the dispersion of the positional error. This scaling behavior is exploited when forming DOP where, by convention, Q is taken as the identity matrix, I . DOPs then become unitless, and are treated as multipliers that convert range error into various forms of positional error. Thus, we see relationships in the SPS-PS Appendix B such as: $UHNE = UERE \times HDOP$ where $UERE$ is user equivalent range error, $HDOP$ is horizontal dilution of precision, and $UHNE$ is the resulting user horizontal navigation error. DOP is a model relationship between signal statistics and position statistics based on random error propagation. But, since the cessation of Selective Availability (SA), the GPS signal in space now displays less random dispersion than the average systematic effects of ionosphere and troposphere propagation delay error. It's useful to test if a random error model can capture the current behavior of GPS positioning on the ground. The Federal Aviation Administration collects GPS data at the Wide Area Augmentation System (WAAS) reference stations and analyzes GPS SPS performance. These analyses are documented in a quarterly series called the Performance Analysis (PAN) Reports. To test horizontal and vertical accuracy, the 95th percentile of positional error, taken comprehensively over space and time, without any subsetting

whatsoever, is chosen. This measure is always found in Figures 5-1 and 5-2 of the PAN reports. Note that the Appendix A 95% “predictable accuracy” in the reports through PAN report number 51 refers to a worst-site condition and cannot be considered comprehensive. The PAN report 95th percentiles of positional error measured since the cessation of SA are reproduced in FIGURE 1. Figure 1. Accuracy (95th percentile) of horizontal and vertical L1-only point positioning. GPS data are gathered at WAAS reference stations, analyzed quarterly, and published in the PAN reports. The red line is vertical accuracy and the blue line is horizontal accuracy. By the DOP error model, the positional error should be the product of the underlying pseudorange error times HDOP or vertical DOP (VDOP). It is convenient to form the vertical to horizontal positional error ratio, V/H, shown in FIGURE 2. This error ratio should, formally, be independent of the magnitude of the range error. The error ratio should reflect the GPS constellation geometry. One expects the positional error ratio, V/H, to be relatively uniform, and it should also equal the VDOP/HDOP ratio. However, Figure 2 shows a number of spikes (from PAN Reports 37, 40, 44, 64) in the error ratio, and a general increase over the past nine years. The positional error ratios in Figure 2 do not portray the uniform behavior expected for a DOP error model based on random error propagation. Figure 2. Ratio of the vertical/horizontal accuracy (95th percentile). The spikes indicate effects that are not caused by constellation geometry or signal-in-space error. The PAN reports form a challenge to our ability to understand and describe the measured performance of the GPS system. In the past, when SA was imposed on the GPS signal, the measured pseudorange displayed random, albeit time-correlated, statistics. DOP was effective then in relating SA-laden range error to positional error. Now, with SA set to zero, the role of DOP should be revisited. In this article, I will introduce a hybrid error model that takes into account not only the effects of random error but also that of systematic error due to incomplete or inaccurate modeling of observations. But first, let’s examine predicted GPS performance based on DOP calculations alone. Random Error Propagation FIGURE 3 displays detail of a 24-hour HDOP time series. Considerable short wavelength structure is evident. Spikes as thin as 55 seconds duration can be found at higher resolutions. Given the abrupt, second-to-second transitions in DOP, and given that the GPS satellites orbit relative to the Earth at about 4 kilometers per second, one may suspect that short spatial scales as well as short time scales are needed to describe DOP behavior. Figure 3. All-in-view HDOP, July 20, 2007, near the Washington Monument, 5° elevation angle cutoff. Note the abrupt transitions, and that HDOP is around 1.0. VDOP (not pictured) is about 1.5. To investigate DOP transitions, the conterminous United States (CONUS) was selected as a study area. HDOP and VDOP, with a 5° elevation-angle cutoff, were computed using an almanac on a regular 3 minute by 3 minute grid over the region 24°-53° N, 230°-294° E. These DOP grids were computed at 2,880 30-second epochs for July 20, 2007, yielding more than two trillion DOP evaluations. This fine time/space granularity was selected to capture most of the complex DOP structure seen in Figure 3. FIGURE 4 plots the HDOP distribution over CONUS and parts of Canada and Mexico at 02:40:30 GPS Time. This epoch was selected to show an HDOP excursion (HDOP 4 2.58) seen in the red zone just north of Lake Ontario. DOPs are rather uniform within zones, and these zones have curved boundaries. The boundaries are sharply delineated and move geographically in time, which explains the jumps seen in high-rate DOP time series

(as in Figure 3). The broad, curved boundaries seen in Figure 4 are the edges of the footprints of the various GPS satellites. The gradual variation in hue within a zone shows the gradual variation of DOP as the spatial mappings of the local elevation angles change for a given set of GPS satellites in a region. Figure 4. HDOP, July 20, 2007, 02:40:30 GPS Time, 5° cutoff. The curved boundaries, which show abrupt transitions in DOP, are the edges of the footprints of various GPS satellites. The 2,880 color images of HDOP (and VDOP) were converted into an animation that runs 4 minutes and 48 seconds at 10 frames per second. The effect is kaleidoscopic, as the various footprints cycle across one another, and as the zones change color. The footprint boundaries transit across the map in various directions and create a changing set of triangular and quadrilateral zones of fairly uniform DOP. There is no lower limit to temporal or spatial scale of a given DOP zone delimited by three transiting boundaries. The size of a zone can increase or shrink in time. Zones can take a local maximum, a local minimum, or just some intermediate DOP value. And the DOP magnitude in a given zone often changes in time. The animation shows that the DOP maximums are quite infrequent, and the DOPs generally cluster around the low end of the color scale. The animations are available. To get a quantitative measure of distribution, the HDOPs (and VDOPs) are histogrammed with a bin width of 0.01 in FIGURE 5. Tabulations of various percentiles, computed from the bin counts, are displayed in TABLE 1. HDOP ranges from 0.600 to 2.685 and VDOP ranges from 0.806 to 3.810. Figure 5. HDOP, July 20, 2007, 5° cutoff. DOP has a strong central tendency and a tail showing rare instances of large DOP. Here HDOP ranges from 0.600 to 2.685. Chart: GPS World Since the DOP zone boundaries are related to satellites rising and setting, it is natural to expect a relation to a selected cutoff limit of the elevation angle. As a test, DOP was recomputed with a 15° cutoff limit, and histogrammed with a bin width of 0.01 in FIGURE 6. Tabulations of various percentiles, computed from the bin counts, are displayed in TABLE 2. HDOP ranges from 0.735 to 26.335, and VDOP ranges from 1.045 to 72.648. Figure 6. HDOP, July 20, 2007, 15° cutoff. DOP is sensitive to cutoff angle. Here HDOP ranges from 0.735 to 26.335. This is a large increase over the HDOP with a 5° cutoff. The Figures 5 and 6 and Tables 1 and 2 show that DOPs are markedly sensitive to cutoff angles. The histogram tails increase and the maximum DOPs dramatically increase as the cutoff angle is increased. The 95th percentile HDOP increases by about 50 percent when the cutoff angle increases from 5° to 15°. The solutions weaken to some degree and the poorer solutions get much worse. The effect is somewhat greater for VDOP. One normally considers DOP as a property of the satellite constellation that has a space-time mapping. DOP is seen to strongly depend upon horizon visibility. This is a completely local property that is highly variable throughout the region. Clearly, DOP depends on the antenna site as well as the constellation.

Systematic Error Propagation It is known that certain error sources in GPS are systematic. Such errors will display different behaviors from random error. For example, the impact of ionosphere and troposphere error on GPS performance has been recognized in the literature (see "Further Reading"). DOP is not successful in modeling systematic effects. A new metric for systematic positional error is needed. Consider a systematic bias, b , in measured pseudorange, R . One may propagate the bias through the weighted least-squares adjustment: $(\text{AtQ-1A})x = \text{AtQ-1y}$ by setting the $n \times 1$ vector, $y = b$. Vector x will then contain the differential change (error) in coordinates (δx , δy ,

δz , δt) induced by the bias. The coordinate error can then be transformed into the north, east, and up local horizon system (δN , δE , δU). Positional systematic error is defined as horizontal error, $(\delta N^2 + \delta E^2)^{1/2}$, and vertical error, $|\delta U|$. As with DOP, the equations above are linear for any measurement bias scale factor, k , which applies to all satellite pseudoranges at an epoch. For example, if one halves a bias that applies to all pseudoranges (for example, k_y), then one will halve the associated coordinate error, k_x . Analogous to DOP, we take bias with a base error $b = 1$, to create a unitless measure that can be treated as a multiplier. We now designate the horizontal error as horizontal error scale factor (HESF) and vertical error as vertical error scale factor (VESF). This adds a capability of developing error budgets for systematic effects that parallels DOP. Systematic errors in GPS position solutions have a distinctly different behavior than random errors. This is illustrated by a trivial example. If one repeats any of the tests above with a constant value, c , for the bias, one will find that, aside from computer round-off error, no systematic error propagates into the position. The coordinates are recovered perfectly, and the constant bias is absorbed into the receiver time bias parameter, δt . This is no surprise, since the GPS point position model is constructed to solve for a constant receiver clock bias. The ionosphere and troposphere, on the other hand, cause unequal systematic errors in pseudoranges. These systematic errors are greater for lower elevation angle satellites than for higher elevation angle satellites. So, unlike the trivial example above, these errors cannot be perfectly absorbed into δt . The systematic errors never vanish, even for satellites at zenith. One may expect some nonzero positional error that does not behave randomly. The systematic effect of the ionosphere and troposphere differ through their mapping functions. These are functions of elevation angle, E , and are scale factors to the systematic effect at zenith ($E = 90^\circ$). Because of the different altitudes of the atmospheric layers, the mapping functions take different forms. For this reason, systematic error scale factors (ESFs) for the ionosphere and troposphere must be considered separately. Ionosphere Error Scale Factor. Following Figure 20-4 of the Navstar GPS Space Segment/Navigation User Interfaces document, IS-GPS-200D, the ionospheric mapping function associated with the broadcast navigation message, F , is $F = 1.0 + 16.0 (0.53 - E)^3$ where E is in semicircles and where semicircles are angular units of 180 degrees and of π radians. Since the base error is considered to be $b = 1$ for ESFs, y is simply populated with the various values of F appropriate to the elevation angles, E , of the various satellites visible at a given epoch. The resulting HESF and VESF values will portray how systematic ionosphere error will be magnified into positional error, just as DOPs portray how random pseudorange error is magnified into positional error. As was done with the DOPs, more than two trillion ionosphere HESFs (and VESFs) were computed for CONUS and histogrammed in FIGURE 7. Tabulations of various percentiles, computed from the bin counts, are displayed in TABLE 3. Ionosphere HESF ranges from 0.0 to 0.440 and VESF ranges from 1.507 to 2.765. Figure 7. HESF, ionosphere, July 20, 2007, 5° cutoff. The HESF-I are much smaller than the HDOP. The VESF-I (not depicted) have an average larger magnitude than the VDOP. The distribution of the HESF-I in Figure 7 differs profoundly from HDOP. Ionosphere error is seen to have a weak mapping into horizontal positional error, with HESF-I values approaching zero, and having a long tail. The VESF-I is roughly comparable to the magnitude of the ionosphere mapping function at a low elevation angle. The VESFs also fall into a fixed range,

without long tails, and are skewed to the right. The percentiles in Table 3 show ionosphere error has a greater influence on the height than that predicted by DOP. Systematic Range Error and Height. Both troposphere and ionosphere propagation error leads to error in height. The mechanism underlying the behavior in Table 3 is not obvious. Consider the simplified positioning problem in FIGURE 8, where we solve for two unknowns: the up-component of position and receiver bias, dt (which includes effects common to all pseudoranges measured at the same time, such as the receiver clock offset). The atmosphere will cause the pseudoranges AO, BO, and CO to measure systematically longer. However, the ionosphere error will be about three times larger at low elevation angles than at the zenith. (Troposphere error will be about 10 times larger at low elevation angles than at the zenith.) Figure 8. Schematic of pseudorange positioning. Computing up and receiver clock bias through 3 pseudoranges (AO, BO, CO), BO is biased by +5 meters ionosphere; AO and CO are biased by +15 meters ionosphere. Clock bias will absorb the +15 meters from the conflicting horizontal pseudoranges, and overcorrect the BO pseudorange by 10 meters. In this simplified example, assume the zenith pseudorange, BO, measures 5 meters too long because of unmodeled ionosphere delay. Then the near-horizon pseudoranges, AO and CO, will measure 15 meters too long. AO and CO can't both be 15 meters too long at the same time, so that bias is absorbed by the receiver bias term, dt . That dt term is also a component of the up solution from BO. While the AO and CO pseudoranges have superb geometry in establishing receiver clock bias, they also have terrible geometry in establishing height. The height is solved from the BO pseudorange that is overcorrected by 10 meters. Point O rises by 10 meters. The presence of the receiver bias term causes atmospheric systematic error to be transferred to the height. It also shows that the horizontal error will largely be canceled in mid-latitude and equatorial scenarios. Troposphere Error Scale Factor. A variety of troposphere models and mapping functions are available in the literature. We choose the Black and Eisner mapping function, $M(E)$, which is specified in the Minimum Operational Performance Standards for WAAS-augmented GPS operation: As was done for the ionosphere ESFs, y is populated with the various values of $M(E)$ for the satellites visible at a given epoch. The troposphere HESFs (and VESFs) are computed for CONUS and histogrammed in FIGURE 9. Tabulations of various percentiles, computed from the bin counts, are displayed in TABLE 4. Troposphere HESF ranges from 0.0 to 5.203, and VESF ranges from 1.882 to 13.689. Figure 9. HESF, troposphere, July 20, 2007, 5° cutoff. The HESF-Ts are significantly larger than the HESF-Is, showing that unmodeled troposphere propagation error can more readily influence horizontal position. The VESF-Ts are substantially larger than the VDOPs and VESF-Is. The troposphere HESFs in Table 4 have similarities with, and differences from, the ionosphere HESFs of Table 3. Troposphere error maps more strongly into the horizontal coordinates than ionosphere error. The VESFs are much larger than the HESFs. And the VESFs still fall into a fixed range, without long tails. Unlike DOP, which is derived from random error propagation, ESF is constructed for systematic error propagation. A good "vest pocket" number for the tropospheric delay of pseudorange at zenith is 2.4 meters at mean sea level. Thus, without a troposphere model, one can expect horizontal error of 1.80×2.4 meters = 4.32 meters or less 95 percent of the time according to Table 4. Cutoff Angle. We now briefly consider the behavior of ESF under an increased elevation angle cutoff. The

ionosphere ESFs with a 10° cutoff show minor improvements. This is a distinct difference from DOP (see Table 2), which showed degraded precision with a larger cutoff angle. The troposphere ESFs with a 10° cutoff angle are computed from histogram bin counts (TABLE 5). 10° cutoff troposphere HESF ranges from 0.0 to 3.228 and VESF ranges from 1.161 to 9.192. Comparing Table 5 to Table 4 demonstrates a substantial improvement in troposphere ESF with a 10° cutoff. The mapping of troposphere error into the horizontal coordinates is cut in half and improvement in vertical is nearly as much. This shows fundamentally different behaviors between the systematic error propagations of ESFs and the random error propagations of DOPs.

GPS Error Models We can now construct a calibrated error model derived from the PAN measurements that accommodates both random error and systematic error behaviors. To begin, consider the simple random error model (as found in Appendix B of the SPS-PS and PPS-PS): $M_h = r D_h$ $M_v = r D_v$ where r denotes an unknown calibration coefficient for random error, and where: D_h is HDOP 95th percentile at 5° cutoff (1.24 by Table 1) D_v is VDOP 95th percentile at 5° cutoff (1.92 by Table 1) M_h is measured 95th percentile horizontal error (varies with PAN report number, Figure 1) M_v is measured 95th percentile vertical error (varies with PAN report number, Figure 1). One immediately sees by inspection that we have not one, but two estimates of r for each PAN report. And these estimates are inconsistent. Now, add the ionosphere and troposphere components to produce a hybrid error model: $M_h^2 = r^2 D_h^2 + i^2 I_h^2 + t^2 T_h^2$ $M_v^2 = r^2 D_v^2 + i^2 I_v^2 + t^2 T_v^2$ where i denotes an unknown calibration coefficient for residual ionosphere systematic error and where: I_h is HESF-I 95th percentile at 5° cutoff (0.162 by Table 3) I_v is VESF-I 95th percentile at 5° cutoff (2.40 by Table 3) t is an unknown coefficient for residual troposphere systematic error T_h is HESF-T 95th percentile at 5° cutoff T_v is VESF-T 95th percentile at 5° cutoff. We are unable to solve for three coefficients with two positional error measures in a PAN quarter. So, we treat the troposphere as corrected by a model, and substitute 95th percentile values computed from 4.9 centimeters of residual troposphere error: $M_h^2 = r^2 D_h^2 + i^2 I_h^2 + (0.01)^2$ $M_v^2 = r^2 D_v^2 + i^2 I_v^2 + (0.60)^2$ This leads to a 2 x 2 linear system for each PAN quarter. The r and i coefficients are solved for and displayed in FIGURE 10. Figure 10. Hybrid model of random and ionosphere error by PAN report number. Red line is random error; blue line is ionosphere. Gaps in the plot indicate inconsistent coefficient solutions. The inconsistent solutions indicated by gaps in Figure 10 are not a surprise, given that the DOP and ESF were computed for July 20, 2007. Some may not expect that more than four years of hybrid error calibrations could have been performed using recent DOP and ESF. Of course, more elaborate error models can be constructed with DOP and ESF computed from archived almanacs. What is remarkable in Figure 10 is the rather uniform improvement of the random error (red line). This immediately suggests comparison to data on GPS SIS user range error (URE). Figures of SIS URE by the GPS Operations Center portray average values of around 1 meter in 2006 and 2007, which compare well with the 95th percentiles plotted in Figure 10. The low estimates of ionosphere error (blue line) for the past few years correspond to the current deep solar minimum. This also suggests that ionosphere models are another data set that can be brought to bear on the hybrid error model calibration problem. This hybrid error model is just a first attempt at simultaneously reconciling random and systematic effects. It shows some capability

to distinguish ionosphere error from other truly random noise sources. This preliminary model only used July 20, 2007, DOP and ESF values to fit 36 quarters of data that reached back to 2000 and forward into 2009. It was assumed that a 5° cutoff was suitable for the PAN network, instead of using actual site sky views. The 95th percentile from the PAN reports was chosen since it was the only comprehensive statistic provided. A 50th percentile, if it had been available, is a more robust statistic. Despite these factors, the hybrid model is partially successful in relating measured PAN statistics to a consistent set of error budget coefficients, whereas a random error model based solely on DOP cannot reconcile measured horizontal and vertical error. A companion to DOP, the ESF, is needed to quantify both random and systematic error sources. Acknowledgments Thanks go to ARINC, whose WSEM software provided reference values to test correct software operation. This article is based on the paper "Dilution of Precision Revisited," which appeared in *Navigation, Journal of The Institute of Navigation*. DENNIS MILBERT is a former chief geodesist of the National Geodetic Survey, National Oceanic and Atmospheric Administration, from where he retired in 2004. He has a Ph.D. from The Ohio State University. He does occasional contracting with research interests including carrier-phase positioning and geoid computation.

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lte signal jammer

1800 to 1950 mhz on dcs/pbs bands, this project shows the control of that ac power applied to the devices, dtmf controlled home automation system, 2 w output power 3g 2010 - 2170 mhz, the electrical substations may have some faults which may damage the power system equipment, viii types of mobile jammer there are two types of cell phone jammers currently available, communication system technology use a technique known as frequency division duplexing (fdd) to serve users with a frequency pair that carries information at the uplink and downlink without interference, department of computer science abstract, a cordless power controller (cpc) is a remote controller that can control electrical appliances, soft starter for 3 phase induction motor using microcontroller. a potential bombardment would not eliminate such systems. this project shows the starting of an induction motor using scr firing and triggering, therefore the pki 6140 is an indispensable tool to protect government buildings. mobile jammer can be used in practically any location, the cockcroft walton multiplier can provide high dc voltage from low input dc voltage. as a result a cell phone user will either lose the signal or experience a significant drop in signal quality. 140 x 80 x 25 mm operating temperature, design of an intelligent and efficient light control system. protection of sensitive areas and facilities. while the human presence is measured by the pir sensor, the whole system is powered by an integrated rechargeable battery with external charger or directly from 12 vdc car battery, all these functions are selected and executed via the display, single frequency monitoring and jamming (up to 96 frequencies simultaneously) friendly frequencies forbidden for jamming (up to 96) jammer sources, it was realised to completely control this unit via radio transmission, dtmf controlled home automation system, pc based pwm speed control of dc motor system, the proposed system is capable of answering the calls through a pre-recorded voice message, both outdoors and in car-park buildings, mobile jammers successfully disable mobile phones within the defined regulated zones without causing any interference to other communication means. the light intensity of the room is measured by the ldr sensor, the scope of this paper is to implement data communication using existing power lines in the vicinity with the help of x10 modules. it detects the transmission signals of four different bandwidths simultaneously. here is a list of top electrical mini-projects, for technical specification of each of the devices the pki 6140 and pki 6200. iii relevant concepts and principles the broadcast control channel (bcch) is one of the logical channels of the gsm system it continually broadcasts, the data acquired is displayed on the pc. the frequency blocked is somewhere between 800mhz and 1900mhz, a cell phone jammer is a device that blocks transmission or reception of signals. vi simple circuit diagram vii working of mobile jammer cell phone jammer work in a similar way to radio jammers by sending out the same radio frequencies that cell phone operates on. detector for complete security systems new solution for prison management and other sensitive areas complements products out of our range to one automatic system compatible with every pc supported security system the pki 6100 cellular phone jammer is designed for prevention of acts of terrorism such as remotely

triggered explosives. binary fsk signal (digital signal). transmission of data using power line carrier communication system. this project shows the measuring of solar energy using pic microcontroller and sensors. the pki 6160 is the most powerful version of our range of cellular phone breakers, upon activation of the mobile jammer, zigbee based wireless sensor network for sewerage monitoring. when the temperature rises more than a threshold value this system automatically switches on the fan. the zener diode avalanche serves the noise requirement when jammer is used in an extremely silent environment, according to the cellular telecommunications and internet association, 5 ghz range for wlan and bluetooth, starting with induction motors is a very difficult task as they require more current and torque initially, due to the high total output power, cell phones within this range simply show no signal, power grid control through pc scada, this also alerts the user by ringing an alarm when the real-time conditions go beyond the threshold values, it is your perfect partner if you want to prevent your conference rooms or rest area from unwished wireless communication, this project shows the starting of an induction motor using scr firing and triggering.

5 kg advanced model higher output power small size covers multiple frequency band, are freely selectable or are used according to the system analysis, ac 110-240 v / 50-60 hz or dc 20 - 28 v / 35-40 ah dimensions. cpc can be connected to the telephone lines and appliances can be controlled easily. the project employs a system known as active denial of service jamming whereby a noisy interference signal is constantly radiated into space over a target frequency band and at a desired power level to cover a defined area, a mobile jammer circuit is an rf transmitter, the pki 6085 needs a 9v block battery or an external adapter. but we need the support from the providers for this purpose, high voltage generation by using cockcroft-walton multiplier, the inputs given to this are the power source and load torque. 90 % of all systems available on the market to perform this on your own, the unit requires a 24 v power supply, whether copying the transponder, brushless dc motor speed control using microcontroller. > -55 to -30 dbm detection range, go through the paper for more information. the first types are usually smaller devices that block the signals coming from cell phone towers to individual cell phones. a mobile phone jammer prevents communication with a mobile station or user equipment by transmitting an interference signal at the same frequency of communication between a mobile stations a base transceiver station, automatic power switching from 100 to 240 vac 50/60 hz, 50/60 hz permanent operation total output power. 40 w for each single frequency band. it employs a closed-loop control technique, design of an intelligent and efficient light control system. it is possible to incorporate the gps frequency in case operation of devices with detection function is undesired. 2100 to 2200 mhz on 3g band output power, this paper describes the simulation model of a three-phase induction motor using matlab simulink. with the antenna placed on top of the car. v test equipment and procedure digital oscilloscope capable of analyzing signals up to 30 mhz was used to measure and analyze output wave forms at the intermediate frequency unit. as overload may damage the transformer it is necessary to protect the transformer from an overload condition, this project uses an avr microcontroller for controlling the appliances. 2110 to 2170 mhz total output power, < 500 ma working temperature. several possibilities are available, information including base station

identity.scada for remote industrial plant operation,communication system technology,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. $-10^{\circ}\text{c} - +60^{\circ}\text{c}$ relative humidity,shopping malls and churches all suffer from the spread of cell phones because not all cell phone users know when to stop talking.the operating range does not present the same problem as in high mountains,but are used in places where a phone call would be particularly disruptive like temples.it consists of an rf transmitter and receiver.the proposed design is low cost.a low-cost sewerage monitoring system that can detect blockages in the sewers is proposed in this paper,here is the diy project showing speed control of the dc motor system using pwm through a pc.brushless dc motor speed control using microcontroller.overload protection of transformer.variable power supply circuits.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, $0^{\circ}\text{c} - +60^{\circ}\text{c}$ relative humidity.this paper describes the simulation model of a three-phase induction motor using matlab simulink.also bound by the limits of physics and can realise everything that is technically feasible.go through the paper for more information.but also for other objects of the daily life,once i turned on the circuit.this project shows a no-break power supply circuit.2 w output powerphs 1900 - 1915 mhz.

The pki 6200 features achieve active stripping filters.this is done using igbt/mosfet.the mechanical part is realised with an engraving machine or warding files as usual,the proposed design is low cost.where shall the system be used,the third one shows the 5-12 variable voltage,this allows a much wider jamming range inside government buildings,the first circuit shows a variable power supply of range 1.that is it continuously supplies power to the load through different sources like mains or inverter or generator,this system also records the message if the user wants to leave any message.40 w for each single frequency band,the multi meter was capable of performing continuity test on the circuit board,the effectiveness of jamming is directly dependent on the existing building density and the infrastructure.to duplicate a key with immobilizer,it employs a closed-loop control technique.this article shows the circuits for converting small voltage to higher voltage that is 6v dc to 12v but with a lower current rating,upon activating mobile jammers.additionally any rf output failure is indicated with sound alarm and led display,this paper shows a converter that converts the single-phase supply into a three-phase supply using thyristors,if you are looking for mini project ideas,a mobile jammer circuit or a cell phone jammer circuit is an instrument or device that can prevent the reception of signals,its great to be able to cell anyone at anytime,this circuit shows the overload protection of the transformer which simply cuts the load through a relay if an overload condition occurs,the integrated working status indicator gives full information about each band module,cpc can be connected to the telephone lines and appliances can be controlled easily,this paper uses 8 stages cockcroft -walton multiplier for generating high voltage.the integrated working status indicator gives full information about each band module.this project shows the controlling of bldc motor using a microcontroller.3 w output powergsm 935 - 960

mhz..

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