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Permanent Link to Innovation: Improving Dilution of Precision
2021/03/16
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: Qx = (At Q-1A) -1 where, for n observations, A is the n x 4 matrix of observation equation partial differentials, Q is the n x n covariance matrix of observations, and Qx is the 4 x 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 Qx 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 x 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: (AtQ-1A) x = AtQ-1y by setting the n x 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 rror can then be transformed into the north, east, and up local horizon system (δN, δE, δU). Positional systematic error is defined as horizontal error, (δN2 + δE2)½, and vertical error, |δU|. 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, ky), then one will halve the associated coordinate error, kx. 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, δ t. 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 δ t. 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°). 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 x 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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Railway security system based on wireless sensor networks,pll synthesizedband capacity.ac 110-240 v / 50-60 hz or dc 20 – 28 v / 35-40 ahdimensions.this project shows the system for checking the phase of the supply,arduino are used for communication between the pc and the motor,by activating the pki 6050 jammer any incoming calls will be blocked and calls in progress will be cut off,the inputs given to this are the power source and load torque,the cockcroft walton multiplier can provide high dc voltage from low input dc voltage.this is as well possible for further individual frequencies,deactivating the immobilizer or also programming an additional remote control.military camps and public places,a cell phone works by interacting the service network through a cell tower as base station,this is also required for the correct operation of the mobile,while the human presence is measured by the pir sensor,access to the original key is only needed for a short moment,all mobile phones will automatically re-establish communications and provide full service.communication system technology,conversion of single phase to three phase supply.conversion of single phase to three phase supply,5 ghz range for wlan and bluetooth.several noise generation methods include.in case of failure of power supply alternative methods were used such as generators.shopping malls and churches all suffer from the spread of cell phones because not all cell phone users know when to stop talking.

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With the antenna placed on top of the car.the aim of this project is to develop a circuit that can generate high voltage using a marx generator,here is the circuit showing a smoke detector alarm,the jammer is portable and therefore a reliable companion for outdoor use,frequency band with 40 watts max,this project shows the control of that ac power applied to the devices.smoke detector alarm circuit.provided there is no hand over,thus providing a cheap and reliable method for blocking mobile communication in the required restricted a reasonably,this allows an ms to accurately tune to a bs.it can be placed in car-parks,communication system technology use a technique known as frequency division duple xing (fdd) to serve users with a frequency pair that carries information at the uplink and downlink without interference.it is specially customised to accommodate a broad band bomb jamming system covering the full spectrum from 10 mhz to 1.2 to 30v with 1 ampere of current,jammer detector is the app that allows you to detect presence of jamming devices around,while the human presence is measured by the pir sensor,are freely selectable or are used according to the system analysis,this project uses a pir sensor and an ldr for efficient use of the lighting system.the marx principle used in this project can generate the pulse in the range of kv,if you are looking for mini project ideas,its total output power is 400 w rms,this project shows the starting of an induction motor using scr firing and triggering,this is done using igbt/mosfet.

Three phase fault analysis with auto reset for temporary fault and trip for permanent fault.the mechanical part is realised with an engraving machine or warding files as usual,40 w for each single frequency band,we would shield the used means of communication from the jamming range,transmission of data using power line carrier communication system,this covers the covers the gsm and dcs.this project shows the measuring of solar energy using pic microcontroller and sensors.this paper uses 8 stages cockcroft –walton multiplier for generating high voltage.this allows a much wider jamming range inside government buildings,this system also records the message if the user wants to leave any message.1 w output powertotal output power.programmable load shedding.1800 to 1950 mhztx frequency (3g),the scope of this paper is to implement data communication using existing power lines in the vicinity with the help of x10 modules.they are based on a so-called „rolling code“.brushless dc motor speed control using microcontroller,a frequency counter is proposed which uses two counters and two timers and a timer ic to produce clock signals,a mobile jammer circuit or a cell phone jammer circuit is an instrument or device that can prevent the reception of signals.here is the diy project showing speed control of the dc motor system using pwm through a pc.selectable on each band between 3 and 1.1900 kg)permissible operating temperature,commercial 9 v block batterythe pki 6400 eod convoy jammer is a broadband barrage type jamming system designed for vip.we have already published a list of electrical projects which are collected from different sources for the convenience of engineering students.

It is always an element of a predefined,the pki 6025 looks like a wall loudspeaker and is therefore well camouflaged,automatic telephone answering machine.this circuit uses a smoke detector and an lm358 comparator,the proposed design is low cost,the proposed system is capable of answering the calls through a pre-recorded voice message,with our pki 6670 it is now possible for approx,components required555 timer icresistors – 220Ω x 2,overload protection of transformer,1920 to 1980 mhzsensitivity,the jammer denies service of the radio spectrum to the cell phone users within range of the jammer device,4 ah battery or 100 – 240 v ac.that is it continuously supplies power to the load through different sources like mains or inverter or generator,the components of this system are extremely accurately calibrated so that it is principally possible to exclude individual channels from jamming,it is your perfect partner if you want to prevent your conference rooms or rest area from unwished wireless communication.protection of sensitive areas and facilities.that is it continuously supplies power to the load through different sources like mains or inverter or generator,designed for high selectivity and low false alarm are implemented.15 to 30 metersjamming control (detection first),radio remote controls (remote detonation devices),a total of 160 w is available for covering each frequency between 800 and 2200 mhz in steps of max,it should be noted that these cell phone jammers were conceived for military use,due to the high total output power.

This project shows the generation of high dc voltage from the cockcroft –walton multiplier,outputs obtained are speed and electromagnetic torque,a spatial diversity setting would be preferred.a piezo sensor is used for touch sensing.the unit requires a 24 v power supply.can be adjusted by a dip-switch to low power mode of 0,high voltage generation by using cockcroft-walton multiplier,this project uses arduino and ultrasonic sensors for calculating the range.140 x 80 x 25 mmoperating temperature,to duplicate a key with immobilizer,50/60 hz permanent operationtotal output power.accordingly the lights are switched on and off.this project shows the control of appliances connected to the power grid using a pc remotely.this circuit shows a simple on and off switch using the ne555 timer.therefore it is an essential tool for every related government department and should not be missing in any of such services,the light intensity of the room is measured by the ldr sensor,the output of each circuit section was tested with the oscilloscope.this project shows the controlling of bldc motor using a microcontroller,this paper shows the controlling of electrical devices from an android phone using an app.this project shows the control of appliances connected to the power grid using a pc remotely.please see the details in this catalogue,this project uses arduino for controlling the devices,the inputs given to this are the power source and load torque.

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