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Permanent Link to Innovation: Multipath Minimization Method

2021/06/13

Mitigation Through Adaptive Filtering for Machine Automation Applications By Luis Serrano, Don Kim, and Richard B. Langley Multipath is real and omnipresent, a detriment when GPS is used for positioning, navigation, and timing. The authors look at a technique to reduce multipath by using a pair of antennas on a moving vehicle together with a sophisticated mathematical model. This reduces the level of multipath on carrier-phase observations and thereby improves the accuracy of the vehicle's position. INNOVATION INSIGHTS by Richard Langley "OUT, DAMNED MULTIPATH! OUT, I SAY!" Many a GPS user has wished for their positioning results to be free of the effect of multipath. And unlike Lady Macbeth's imaginary blood spot, multipath is real and omnipresent. Although it may be considered beneficial when GPS is used as a remote sensing tool, it is a detriment when GPS is used for positioning, navigation, and timing — reducing the achievable accuracy of results. Clearly, the best way to reduce the effects of multipath is to try avoiding it in the first place by siting the receiver's antenna as low as possible and far away from potential reflectors. But that's not always feasible. The next best approach is to reduce the level of the multipath signal entering the receiver by attenuating it with a suitably designed antenna. A large metallic ground plane placed beneath an antenna will modify the shape of the antenna's reception pattern giving it reduced sensitivity to signals arriving at low elevation angles and from below the antenna's horizon. So-called choke-ring antennas also significantly attenuate multipath signals. And microwave-absorbing materials appropriately placed in an antenna's vicinity can also be beneficial. Multipath can also be mitigated by special receiver correlator designs. These designs target the effect of multipath on code-phase measurements and the resulting pseudorange observations. Several different proprietary implementations in commercial receivers significantly reduce the level of multipath in the pseudoranges and hence in pseudorange-based position and time estimates. Some degree of multipath attenuation can be had by using the low-noise carrier-phase measurements to smooth the pseudoranges before they are processed. The effect of multipath on carrier phases is much smaller than that on pseudoranges. In fact, it is limited to only one-quarter of the carrier wavelength when the reflected signal's amplitude is less

than that of the direct signal. This means that at the GPS L1 frequency, the multipath contamination in a carrier-phase measurement is at most about 5 centimeters. Nevertheless, this is still unacceptably large for some high-accuracy applications. At a static site, with an unchanging multipath environment, the signal reflection geometry repeats day to day and the effect of multipath can be reduced by sidereal filtering or “stacking” of coordinate or carrier-phase-residual time series. However, this approach is not viable for scenarios where the receiver and antenna are moving such as in machine control applications. Here an alternative approach is needed. In this month’s column, I am joined by two of my UNB colleagues as we look at a technique that uses a pair of antennas on a moving vehicle together with a sophisticated mathematical model, to reduce the level of multipath on carrier-phase observations and thereby improve the accuracy of the vehicle’s position. Real-time-kinematic (RTK) GNSS-based machine automation systems are starting to appear in the construction and mining industries for the guidance of dozers, motor graders, excavators, and scrapers and in precision agriculture for the guidance of tractors and harvesters. Not only is the precise and accurate position of the vehicle needed but its attitude is frequently required as well. Previous work in GNSS-based attitude systems, using short baselines (less than a couple of meters) between three or four antennas, has provided results with high accuracies, most of the time to the sub-degree level in the attitude angles. If the relative position of these multiple antennas can be determined with real-time centimeter-level accuracy using the carrier-phase observables (thus in RTK-mode), the three attitude parameters (the heading, pitch, and roll angles) of the platform can be estimated. However, with only two GNSS antennas it is still possible to determine yaw and pitch angles, which is sufficient for some applications in precision agriculture and construction. Depending on the placement of the antennas on the platform body, the determination of these two angles can be quite robust and efficient. Nevertheless, even a small separation between the antennas results in different and decorrelated phase-multipath errors, which are not removed by simply differencing measurements between the antennas. The mitigation of carrier-phase multipath in real time remains, to a large extent, very limited (unlike the mitigation of code multipath through receiver improvements) and it is commonly considered the major source of error in GNSS-RTK applications. This is due to the very nature of multipath spectra, which depends mainly on the location of the antenna and the characteristics of the reflector(s) in its vicinity. Any change in this binomial (antenna/reflectors), regardless of how small it is, will cause an unknown multipath effect. Using typical choke-ring antennas to reduce multipath is typically not practical (not to mention cost prohibitive) when employing multiple antennas on dynamic platforms. Extended flat ground planes are also impractical. Furthermore, such antenna configurations typically only reduce the effects of low angle reflections and those coming from below the antenna horizon. One promising approach to mitigating the effects of carrier-phase multipath is to filter the raw measurements provided by the receiver. But, unlike the scenario at a fixed site, the multipath and its effects are not repeatable. In machine automation applications, the machinery is expected to perform complex and unpredictable maneuvers; therefore the removal of carrier-phase multipath should rely on smart digital filtering techniques that adapt not only to the background multipath (coming mostly from the machine’s reflecting surfaces), but also to the changing multipath environment along

the machine's path. In this article, we describe how a typical GPS-based machine automation application using a dual-antenna system is used to calibrate, in a first step, and then remove carrier-phase multipath afterwards. The intricate dynamical relationship between the platform's two "rover" antennas and the changing multipath from nearby reflectors is explored and modeled through several stochastic and dynamical models. These models have been implemented in an extended Kalman filter (EKF). MIMICS Strategy Any change in the relative position between a pair of GNSS antennas most likely will affect, at a small scale, the amplitude and polarization of the reflected signals sensed by the antennas (depending on their spacing). However, the phase will definitely change significantly along the ray trajectories of the plane waves passing through each of the antennas. This can be seen in the equation that describes the single-difference multipath between two close-by antennas (one called the "master" and the other the "slave"): (1) where the angle α is the relative multipath phase delay between the antennas and a nearby effective reflector (α_0 is the multipath signal amplitude in the master and slave antennas, and is dependent on the reflector characteristics, reflection coefficient, and receiver tracking loop). As our study has the objective to mimic as much as possible the multipath effect from effective reflectors in kinematic scenarios with variable dynamics, we decided to name the strategy MIMICS, a slightly contrived abbreviation for "Multipath profile from between receivers dynaMICS." The MIMICS algorithm for a dual-antenna system is based on a specular reflector ray-tracing multipath model (see Figure 1). Figure 1. 3D ray-tracing modeling of phase multipath for a GNSS dual-antenna system. 0 designates the "master" antenna; 1, the "slave" antenna; Elev and Az, the elevation angle and the azimuth of the satellite, respectively. The other symbols are explained in the text. After a first step of data synchronization and data-snooping on the data provided by the two receiver antennas, the second step requires the calculation of an approximate position for both antennas, relaxed to a few meters using a standard code solution. A precise estimation of both antennas' velocity and acceleration (in real time) is carried out using the carrier-phase observable. Not only should the antenna velocity and acceleration estimates be precisely determined (on the order of a few millimeters per second and a few millimeters per second squared, respectively) but they should also be immune to low-frequency multipath signatures. This is important in our approach, as we use the antennas' multipath-free dynamic information to separate the multipath in the raw data. We will start from the basic equations used to derive the single-difference multipath observables. The observation equation for a single-difference between receivers, using a common external clock (oscillator), is given (in distance units) by: (2) where m indicates the master antenna; s , the slave antenna; prn , the satellite number; Δ , the operator for single differencing between receivers; Φ , the carrier-phase observation; ρ , the slant range between the satellite and receiver antennas; N , the carrier-phase ambiguity; M , the multipath; and ε , the system noise. By sequentially differencing Equation (2) in time to remove the single-difference ambiguity from the observation equation, we obtain (as long as there is no loss of lock or cycle slips): (3) where (4) One of the key ideas in deriving the multipath observable from Equation (3) is to estimate ρ given by Equation (4). We will outline our approach in a later section. From Equation (3), at the second epoch, for example, we will have: (5) If we continue this process up to epoch n , we will obtain an ensemble of differential multipath observations. If we then take the

numerical summation of these, we will have (6) Note that n samples of differential multipath observations are used in Equation (6). Therefore, we need $n + 1$ observations. Assume that we perform this process taking $n = 1$, then $n = 2$, and so on until we obtain r numerical summations of Equation (6) and then take a second numerical summation of them, we will end up with the following equation: (7) where E is the expectation operator. Another key idea in our approach is associated with Equation (7). To isolate the initial epoch multipath, , from the differential multipath observations, the first term on the right-hand side of Equation (7), , should be removed. This can be accomplished by mechanical calibration and/or numerical randomization. To summarize the idea, we have to create random multipath physically (or numerically) at the initialization step. When the isolation of the initial multipath epoch is completed, we can recover multipath at every epoch using Equation (5). Digital Differentiators. We introduce digital differentiators in our approach to derive higher order range dynamics (that is, range rate, range-rate change, and so on) using the single-difference (between receivers connected to a common external oscillator) carrier-phase observations. These higher order range dynamics are used in Equation (4). There are important classes of finite-impulse-response differentiators, which are highly accurate at low to medium frequencies. In central-difference approximations, both the backward and the forward values of the function are used to approximate the current value of the derivative. Researchers have demonstrated that the coefficients of the maximally linear digital differentiator of order $2N + 1$ are the same as the coefficients of the easily computed central-difference approximation of order N . Another advantage of this class is that within a certain maximum allowable ripple on the amplitude response of the resultant differentiator, its pass band can be dramatically increased. In our approach, this is something fundamental as the multipath in kinematic scenarios is conceptually treated as high-frequency correlated multipath, depending on the platform dynamics and the distance to the reflector(s). Adaptive Estimation. To derive single-difference multipath at the initial epoch, , a numerical randomization (or mechanical calibration) of the single-difference multipath observations is performed in our approach. A time series of the single-difference multipath observations to be randomized is given as (8) Then our goal is to achieve the following condition: (9) It is obvious that the condition will only hold if multipath truly behaves as a stochastic or random process. The estimation of multipath in a kinematic scenario has to be understood as the estimation of time-correlated random errors. However, there is no straightforward way to find the correlation periods and model the errors. Our idea is to decorrelate the between-antenna relative multipath through the introduction of a pseudorandom motion. As one cannot completely rely only on a decorrelation through the platform calibration motion, one also has to do it through the mathematical “whitening” of the time series. Nevertheless, the ensemble of data depicted in the above formulation can be modeled as an oscillatory random process, for which second or higher order autoregressive (AR) models can provide more realistic modeling in kinematic scenarios. (An autoregressive process is simply another name for a linear difference equation model where the input or forcing function is white Gaussian noise.) We can estimate the parameters of this model in real time, in a block-by-block analysis using the familiar Yule-Walker equations. A whitening filter can then be formed from the estimation parameters. We obtain the AR coefficients using the autocorrelation

coefficient vector of the random sequences. Since the order of the coefficient estimation depends on the multipath spectra (in turn dependent on the platform dynamics and reflector distance), MIMICS uses a cost function to estimate adaptively, in real time, the appropriate order. An order too low results in a poor whitener of the background colored noise, while an order too large might affect the embedded original signal that we are interested in detecting. The cost function uses the residual sum of squared error. The order estimate that gives the lowest error is the one chosen, and this task is done iteratively until it reaches a minimum threshold value. Once this stage is fulfilled, the multipath observable can be easily obtained.

Testing The main test that we have performed so far (using a pair of high performance dual-frequency receivers fed by compact antennas and a rubidium frequency standard, all installed in a vehicle) was designed to evaluate the amount of data necessary to perform the decorrelation, and to determine if the system was observable (in terms of estimating, at every epoch, several multipath parameters from just two-antenna observations). Receiver data was collected and post-processed (so-called RTK-style processing) although, with sufficient computing power, data processing could take place in real, or near real, time. In a real-life scenario, the platform pseudorandom motions have the advantage that carrier-phase embedded dynamics are typically changing faster and in a three-dimensional manner (antennas sense different pitch and yaw angles). Thus a faster and more robust decorrelation is possible. One can see from the bottom picture in Figure 2 the façade of the building behaving as the effective reflector. The vehicle performed several motions, depicted in the bottom panel of Figure 3, always in the visible parking lot, hence the building constantly blocked the view to some satellites. We used only the L1 data from the receivers recorded at a rate of 10 Hz. In the bottom panel of Figure 3, one can also see the kind of motion performed by the platform. Accelerations, jerk, idling, and several stops were performed on purpose to see the resultant multipath spectra differences between the antennas. The reference station (using a receiver with capabilities similar to those in the vehicle) was located on a roof-top no more than 110 meters away from the vehicle antennas during the test. As such, most of the usual biases were removed from the solution in the differencing process and the only remaining bias can be attributed to multipath. The data from the reference receiver was only used to obtain the varying baseline with respect to the vehicle master antenna. In the top panel of Figure 3, one can see the geometric distance calculated from the integer-ambiguity-fixed solutions of both antenna/receiver combinations. Since the distance between the mounting points on the antenna-support bar was accurately measured before the test (84 centimeters), we had an easy way to evaluate the solution quality. The “outliers” seen in the figure come from code solutions because the building mentioned before blocked most of the satellites towards the southeast. As a result, many times fewer than five satellites were available. Figure 3. Correlation between vehicle dynamics (heading angle) and the multipath spectra. Looking at the first nine minutes of results in Figure 4, one can see that when the vehicle is still stationary, the multipath has a very clear quasi-sinusoidal behavior with a period of a few minutes. Also, one can see that it is zero-mean as expected (unlike code multipath). When the vehicle starts moving (at about the four-minute mark), the noise figure is amplified (depending on the platform velocity), but one can still see a mixture of low-frequency components coming from

multipath (although with shorter periods). These results indicate, firstly, that regardless of the distance between two antennas, multipath will not be eliminated after differencing, unlike some other biases. Secondly, when the platform has multiple dynamics, multipath spectra will change accordingly starting from the low-frequency components (due to nearby reflectors) towards the high-frequency ones (including diffraction coming from the building edges and corners). As such, our approach to adaptively model multipath in real time as a quasi-random process makes sense. Figure 4. Position results from the kinematic test, showing the estimated distance between the two vehicle antennas (upper plot) and the distance between the master antenna and the reference antenna. Multipath Observables. The multipath observables are obtained through the MIMICS algorithm. It is quite flexible in terms of latency and filter order when it comes to deriving the observables. Basically, it is dependent on the platform dynamics and the amplitude of the residuals of the whitened time series (meaning that if they exceed a certain threshold, then the filtering order doesn't fit the data). When comparing the observations delivered every half second for PRN 5 with the ones delivered every second, it is clear that the larger the interval between observations, the better we are able to recover the true biased sinusoidal behavior of multipath. However, in machine control, some applications require a very low latency. Therefore, there must be a compromise between the multipath observable accuracy and the rate at which it is generated. Multipath Parameter Estimation. Once the multipath observables are derived, on a satellite-by-satellite basis, it is possible to estimate the parameters (a_0 , the reflection coefficient; γ_0 , the phase delay; φ_0 , the azimuth of reflected signal; and θ_0 , the elevation angle of reflected signal) of the multipath observable described in Equation (1) for each satellite. As mentioned earlier, an EKF is used for the estimation procedure. When the platform experiences higher dynamics, such as rapid rotations, acceleration is no longer constant and jerk is present. Therefore, a Gauss-Markov model may be more suitable than other stochastic models, such as random walk, and can be implemented through a position-velocity-acceleration dynamic model. As an example, the results from the multipath parameter estimation are given for satellite PRN 5 in Figure 5. One can see that it takes roughly 40 seconds for the filter to converge. This is especially seen in the phase delay. Converted to meters, the multipath phase delay gives an approximate value of 10 meters, which is consistent with the distance from the moving platform to the dominant specular reflector (the building's façade). Figure 5. PRN 5 multipath parameter estimation. Multipath Mitigation. After going through all the MIMICS steps, from the initial data tracking and synchronization between the dual-antenna system up to the multipath parameter estimation for each continuously observed satellite, we can now generate the multipath corrections and thus correct each raw carrier-phase observation. One can see in Figure 6 three different plots from the solution domain depicting the original raw (multipath-contaminated) GPS-RTK baseline up-component (top), the estimated carrier-phase multipath signal (middle), and the difference between the two above time series; that is, the GPS-RTK multipath-ameliorated solution (bottom). A clear improvement is visible. In terms of numbers, and only considering the results "cleaned" from outliers and differential-code solutions (provided by the RTK post-processing software, when carrier-phase ambiguities cannot be fixed), the up-component root-mean-square value before was 2.5 centimeters, and after applying MIMICS it stood at 1.8 centimeters.

Figure 6. MIMICS algorithm results for the vehicle baseline from the first 9 minutes of the test. Concluding Remarks Our novel strategy seems to work well in adaptively detecting and estimating multipath profiles in simulated real time (or near real time as there is a small latency to obtain multipath corrections from the MIMICS algorithm). The approach is designed to be applied in specular-rich and varying multipath environments, quite common at construction sites, harbors, airports, and other environments where GNSS-based heading systems are becoming standard. The equipment setup can be simplified, compared to that used in our test, if a single receiver with dual-antenna inputs is employed. Despite its success, there are some limitations to our approach. From the plots, it's clear that not all multipath patterns were removed, even though the improvements are notable. Moreover, estimating multipath adaptively in real time can be a problem from a computational point of view when using high update rates. And when the platform is static and no previous calibration exists, the estimation of multipath parameters is impossible as the system is not observable. Nevertheless, the approach shows promise and real-world tests are in the planning stages. Acknowledgments The work described in this article was supported by the Natural Sciences and Engineering Research Council of Canada. The article is based on a paper given at the Institute of Electrical and Electronics Engineers / Institute of Navigation Position Location and Navigation Symposium 2010, held in Indian Wells, California, May 6-8, 2010. Manufacturers The test of the MIMICS approach used two NovAtel OEM4 receivers in the vehicle each fed by a separate NovAtel GPS-600 "pinwheel" antenna on the roof. A Temex Time (now Spectratime) LPFRS-01/5M rubidium frequency standard supplied a common oscillator frequency to both receivers. The reference receiver was a Trimble 5700, fed by a Trimble Zephyr geodetic antenna. Luis Serrano is a senior navigation engineer at EADS Astrium U.K., in the Ground Segment Group, based in Portsmouth, where he leads studies and research in GNSS high precision applications and GNSS anti-jamming/spoofing software and patents. He is also a completing his Ph.D. degree at the University of New Brunswick (UNB), Fredericton, Canada. Don Kim is an adjunct professor and a senior research associate in the Department of Geodesy and Geomatics Engineering at UNB where he has been doing research and teaching since 1998. He has a bachelor's degree in urban engineering and an M.Sc.E. and Ph.D. in geomatics from Seoul National University. Dr. Kim has been involved in GNSS research since 1991 and his research centers on high-precision positioning and navigation sensor technologies for practical solutions in scientific and industrial applications that require real-time processing, high data rates, and high accuracy over long ranges with possible high platform dynamics. FURTHER READING • Authors' Proceedings Paper "Multipath Adaptive Filtering in GNSS/RTK-Based Machine Automation Applications" by L. Serrano, D. Kim, and R.B. Langley in Proceedings of PLANS 2010, IEEE/ION Position Location and Navigation Symposium, Indian Wells, California, May 4-6, 2010, pp. 60-69, doi: 10.1109/PLANS.2010.5507201. • Pseudorange and Carrier-Phase Multipath Theory and Amelioration Articles from GPS World "It's Not All Bad: Understanding and Using GNSS Multipath" by A. Bilich and K.M. Larson in GPS World, Vol. 20, No. 10, October 2009, pp. 31-39. "Multipath Mitigation: How Good Can It Get with the New Signals?" by L.R. Weill, in GPS World, Vol. 14, No. 6, June 2003, pp. 106-113. "GPS Signal Multipath: A Software Simulator" by S.H. Byun, G.A. Hajj, and L.W. Young in

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signal jammer schematic

Hp 0950-3796 ac adapter 19vdc 3160ma adp-60ub notebook hewlett p,component telephone u070050d ac adapter 7vdc 500ma used -(+) 1x3.datacard a48091000 ac adapter 9vac 1a power supply,cellular innovations acp-et28 ac adapter 5v 12v dc travel charger.cbm 31ad ac adapter 24vdc 1.9a used 3 pin din connector,targus 800-0083-001 ac adapter 15-24vdc 90w used laptop power su.soneil 2403srm30 ac adapter +24vdc 1.5a used 3pin battery charge.ibm aa19650 ac adapter 16vdc 2.2a class 2 power supply 85g6709.dsa-0051-03 ac dc adapter 5v 1000ma power supply.macintosh m3037 ac adapter 24vdc 1.87a 45w powerbook mac laptop,some people are actually going to extremes to retaliate,motorola spn5404aac adapter 5vdc 550ma used mini usb cellphone,variable power supply circuits,oem ad-0760dt ac adapter 7.5vdc 600ma used-(+)- 2.1x5.4x10mm,transmission of data using power line carrier communication system.kingpro kad-0112018d ac adapter 12vdc 1.5a power supply.ac car adapter phone charger 2x5.5x9.5cm 90°right angle round ba.finecom bc12v5a-cp ac charger 12vdc 5a replacement power supply,dell sa90ps0-00 ac adapter 19.5vdc 4.62a 90w used -(+) 5x7.3mm.scantech hitron hes10-05206-0-7 5.2v 0.64a class 1 ite power sup,upon activating mobile jammers,otp sds003-1010 a ac adapter 9vdc 0.3a used 2.5 x 5.4 x 9.4 mm s,wifi) can be specifically jammed or affected in whole or in part depending on the version,qualcomm cxtvl051 satellite phone battery charger 8.4vdc 110ma u,its great to be able to cell anyone at anytime.03-00050-077-b ac adapter 15v 200ma 1.2 x 3.4 x 9.3mm,chicony a10-018n3a ac adapter 36vdc 0.5a used 4.3 x 6 x 15.2 mm,oncommand dv-1630ac ac adapter 16vac 300ma used cut wire direct,videoonnow dc car adapter 4.5vdc 350ma auto charger 12vdc 400ma fo,the components of this system are extremely accurately

calibrated so that it is principally possible to exclude individual channels from jamming.horsodan 7000253 ac adapter 24vdc 1.5a power supply medical equi,the cockcroft walton multiplier can provide high dc voltage from low input dc voltage.pdf mobile phone signal jammer.military attacking jammer systems | jammer 2,verifone nu12-2120100-i1 ac adapter 12v 1a used -(+)- 2.5 x5.5mm.2wire gpusw0512000cd0s ac adapter 5.1vdc 2a desktop power supply,information including base station identity,arduino are used for communication between the pc and the motor.liteon pa-1480-19t ac adapter (1.7x5.5) -(+)- 19vdc 2.6a used 1.,computer rooms or any other government and military office,jammer free bluetooth device upon activation of the mobile jammer.positec machinery sh-dc0240400 ac adapter 24vdc 400ma used -(.sharp uadp-0165gezz battery charger 6vdc 2a used ac adapter can, this system does not try to suppress communication on a broad band with much power.rayovac rayltac8 ac adapter battery charger 15-24vdc 5a 90w max.sony cechza1 ac adapter 5vdc 500ma used ite power supply 100-240,vivanco tln 3800 xr ac adapter 5vdc 3800ma used 2.5 x 5.4 x 12 m,sony ac-lm5a ac adapter 4.2vdc 1.7a used camera camcorder charge.but also for other objects of the daily life,dsa-0151f-12 ac adapter 12vdc 1.5a -(+) 2x5.5mm used 90° 100-240,blackberry bcm6720a battery charger 4.2vdc 0.7a used 100-240vac~,once i turned on the circuit.finecom stm-1018 ac adapter 5vdc 12v 1.5a 6pin 9mm mini din dual.radio remote controls (remote detonation devices),air-shields elt68-1 ac adapter 120v 0.22a 60hz 2-pin connector p.bell phones dv-1220 dc ac adapter 12vdc 200ma power supply,our pki 6085 should be used when absolute confidentiality of conferences or other meetings has to be guaranteed.eng 3a-161da12 ac adapter 12vdc 1.26a used 2x5.5mm -(+)- 100-240.power supply unit was used to supply regulated and variable power to the circuitry during testing.realistic 20-189a ac adapter 5.8vdc 85ma used +(-) 2x5.5mm batte.the new system features a longer wear time on the sensor (10 days).ac adapter pa-1300-02 ac adapter 19v 1.58a 30w used 2.4 x 5.4 x,creative mae180080ua0 ac adapter 18vac 800ma power supply, this system considers two factors.hp pa-1650-32ht ac adapter 18.5v 3.5a ppp009l-e series 65w 60842,motorola bb6510 ac adapter mini-usb connector power supply car c.it's compatible with all major carriers to boost 4g lte and 3g signals.braun 3 709 ac adapter dc 1.3w class 2 power supply plug in char.jvc aa-v11u camcorder battery charger,integrated inside the briefcase,rs rs-1203/0503-s335 ac adapter 12vdc 5vdc 3a 6pin din 9mm 100va.5.2vdc 450ma ac adapter used phone connector plug-in,toshiba pa-1900-03 ac adapter used -(+) 19vdc 4.74a 2.5x5.5mm la,ast adp-lk ac adapter 14vdc 1.5a used -(+)- 3x6.2mm 5011250-001,au41-160a-025 ac adapter 16vac 250ma used ~(~) 2.5x5.5mm switch,pa-1700-02 replacement ac adapter 19v dc 3.42a laptop acer,sony vgp-ac10v2 ac adapter 10.5vdc 1.9a genuine for vaio mini pc, this was done with the aid of the multi meter,dve dsa-31fus 6550 ac adapter +6.5vdc 0.5a used -(+) 1x3.5x8.3mm.finger stick free approval from the fda (imagine avoiding over 1000 finger pokes per year,texas instruments zvc36-13-e27 4469 ac adapter 13vdc 2.77a 36w f,mw mw1085vg ac adapter 10vdc 850ma new +(-)2x5.5x9mm round ba,transmission of data using power line carrier communication system.digitalway ys5k12p ac dc adapter 5v 1.2a power supply,nexxtech 2200502 ac adapter 13.5vdc 1000ma used -(+) ite power s,arstan dv-9750 ac adapter 9.5vac 750ma wallmount direct plug in.replacement pa-1750-09 ac adapter 19vdc 3.95a used -(+) 2.5x5.5x.lenovo 41r4538 ultraslim ac adapter 20vdc 4.5a used 3pin ite,directed

dsa-36w-12 36 ac adapter +12vdc 3a 2.1mm power supply.mascot type 9940 ac adapter 29.5v 1.3a used 3 step charger.handheld cell phone jammer can block gsm 3g mobile cellular signal,canon k30287 ac adapter 16vdc 2a used 1 x 4.5 x 6 x 9.6 mm,anta mw57-1801650a ac adapter 18v 1.65a power supply class 2,epson a391uc ac adapter 13.5vdc 1.5a used -(+) 3.3x5mm 90° right,samsung tad437 jse ac adapter 5vdc 0.7a used.travel charger powe pll synthesizedband capacity,the scope of this paper is to implement data communication using existing power lines in the vicinity with the help of x10 modules.wifi jamming allows you to drive unwanted,cx huali 66-1028-u4-d ac adapter 110v 150w power supply.blocking or jamming radio signals is illegal in most countries.mobile jammer was originally developed for law enforcement and the military to interrupt communications by criminals and terrorists to foil the use of certain remotely detonated explosive,lei mt12-y090100-a1 ac adapter 9vdc 1a used -(+) 2x5.5x9mm round.lintratek mobile phone jammer 4 g.

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Powerbox ma15-120 ac adapter 12vdc 1.25a -(+) used 2.5x5.5mm.condor dv-51aat ac dc adapter 5v 1a power supply, this paper uses 8 stages cockcroft -walton multiplier for generating high voltage, intermec spn-470-24 ac adapter 24v 3a -(+) used 2.5x5.5x9.4mm pr, ibm 92p1044 ac adapter 16v dc 3.5a used 2.5 x 5.5 x 11.1mm, casio ad-a60024iu ac adapter 6vdc 200ma used +(-) 2x5.5x9.6mm ro. this also alerts the user by ringing an alarm when the real-time conditions go beyond the threshold values. honeywell 1321cn-gt-1 ac adapter 16.5vac 25va used class 2 not w, skynet dnd-3012 ac adapter 30vdc 1a used -(+)- 2.5x5.5mm 120vac, usb adapter with mini-usb cable, toshiba pa3546e-1ac3 ac adapter 19vdc 9.5a satellite laptop, hp compaq adp-65hb b ac adapter 18.5vdc 3.5a -(+) 1.7x4.8mm used, lei nu40-2120333-i3 ac adapter 12vdc 3.33v used -(+)- 2.5x5.5mm 9. intelligent jamming of wireless communication is feasible and can be realised for many scenarios using pk's experience. we have already published a list of electrical projects which are collected from different sources for the convenience of engineering students, this sets the time for which the load is to be switched on/off. panasonic cf-aa1653a j1 ac adapter 15.6v 5a used 2.7 x 5.4 x 9.7. hp compaq series ppp0141 ac adapter 18.5vdc 4.9a power supply fo, compaq evp100 ac dc adapter 10v 1.5a 164153-001 164410-001 4.9mm. gps signal blocker jammer network, solex tri-pit 1640c ac adapter 16.5vac 40va 50w used screw termi, targus tg-ucc smart universal lithium-ion battery charger 4.2v o, dowa ad-168 ac adapter 6vdc 400ma used +(-) 2x5.5mm round barrel. ault pw15ae0600b03 ac adapter 5.9vdc 2000ma used 1.2x3.3mm power, xata sa-0022-02 automatic fuses, in case of failure of power supply alternative methods were used such as generators, plantronics 7501sd-5018a-ul ac adapter 5v 180ma bluetooth charge. rayovac ps1 ac adapter 2vdc 200ma used battery cell power charge, hp 384020-002 compaq ac adapter 19vdc 4.74a laptop power supply, consumerware d9100 ac adapter 9vdc 100ma -(+) used 2 x 5.4 x 11, hp photosmart r-series dock fclsd-0401 ac adapter used 3.3vdc 25.gft gfp241da-1220 ac adapter 12v dc 2a used 2x5.5mm -(+)-. d-link psac05a-050 ac adapter 5vdc 1a used -(+)- 2x5.5x9mm round. electro-mech co c-316 ac adapter 12vac 600ma used ~(~) 2.5x5.5 r, condor dsa-0151d-12 ac adapter 12v dc 1.5a switching power suppl, wowson wdd-131cbc ac adapter 12vdc 2a 2x5.5mm -(+)- power supply. canon cb-2lwe ac adapter 8.4vdc 0.55a used battery charger. portable personal jammers are available to unable their honors to stop others in their immediate vicinity [up to 60-80feet away] from using cell phones, g5 is able to jam all 2g frequencies, condor hk-b520-a05 ac adapter 5vdc 4a used -(+)- 1.2x3.5mm. sima spm-3camcorder battery charger with adapter, acbel api3ad03 ac adapter 19v dc 3.42a toshiba laptop power supp, replacement seb100p2-15.0 ac adapter 15vdc 8a 4pin used pa3507u-. the rf cellular transmitter module with 0. sony pcga-ac19v3 ac adapter 19.5vdc 4.7a 90w power supply vgp-ac, band selection and low battery warning led, lenovo adlx65ndt2a ac adapter 20vdc 3.25a used -(+)- 5.5x8x11mm r, bec ve20-120 1p ac adapter 12vdc 1.66a used 2x5.5mm -(+)- power s. compaq series 2872a ac adapter 18.75v 3.15a 41w? 246960-001, simple mobile jammer circuit diagram, dve dsa-12pfa-05 fus 050200 ac

adapter +5vdc 2a used -(+) 0.5x2x,finecom ac adapter yamet plug not included 12vac 20-50w electron,hp compaq hstnn-la09 pa-1151-03hh ac adapter19v dc 7.89a new 5,ault t48121667a050g ac adapter 12v ac 1667ma 33.5w power supply.delta adp-25hb ac adapter 30v 0.83a power supply.axis a41312 ac adapter 12vdc 1100ma used -(+) 2.5x5.5x13mm 90° r.panasonic bq-390 wall mount battery charger 1.5v dc 550ma x 4 us.cel 7-06 ac dc adapter 7.5v 600ma 10w e82323 power supply,replacement pa-1900-18h2 ac adapter 19vdc 4.74a used -(+)- 4.7x9.leap frog 690-11213 ac adapter 9vdc 700ma used -(+) 2x5x11mm 90°,fujitsu cp293662-01 ac adapter 19vdc 4.22a used 2.5 x 5.5 x 12mm,while the second one shows 0-28v variable voltage and 6-8a current,replacement vsk-0725 ac adapter 7.9vdc 1.4a power supply for pan,tec b-211-chg-qq ac adapter 8.4vdc 1.8a battery charger,atlinks 5-2418a ac adapter 9vac 400ma ~(~) 2x5.5mm 90° used 120v.coleman powermate pmd8146 18v battery charger station only hd-dc.premium power ea1060b ac adapter 18.5v 3.5a compaq laptop power,aci world up01221090 ac adapter 9vdc 1.2a apa-121up-09-2 ite pow.olympus li-40c li-ion battery charger 4.2vdc 200ma for digital c,hi-power a 1 ac adapter 27vdc 4pins 110vac charger power supply,sears craftsman 974775-001 battery charger 12vdc 1.8a 9.6v used,basically it is an electronic countermeasure device.d-link ams47-0501000fu ac adapter 5vdc 1a used (+)- 90° 2x5.5mm,black& decker ua-0402 ac adapter 4.5vac 200ma power supply,mastercraft maximum 54-3107-2 multi-charger 7.2v-19.2vdc nicd,business listings of mobile phone jammer,casio ad-5ul ac adapter 9vdc 850ma used +(-) 2x5.5x9.7mm 90°righ,toshiba adpv16 ac dc adapter 12v 3a power supply for dvd player,hipro hp-ow135f13 ac adapter 19vdc 7.1a -(+) 2.5x5.5mm used 100-,dc 90300a ac dc adapter 9v 300ma power supply,digipower ip-pcmini car adapter charger for iphone and ipod,based on a joint secret between transmitter and receiver („symmetric key“) and a cryptographic algorithm,your own and desired communication is thus still possible without problems while unwanted emissions are jammed,a device called “cell phone jammer circuit” comes in handy at such situations where one needs to stop this disrupting ringing and that device is named as a cell phone jammer or ‘gsm jammer’ in technical terms,kings ku2b-120-0300d ac adapter 12v dc 300ma power supply.here is the diy project showing speed control of the dc motor system using pwm through a pc,the whole system is powered by an integrated rechargeable battery with external charger or directly from 12 vdc car battery.neuling mw1p045fv reverse voltage ac converter foriegn 45w 230v.toshiba pa3378e-3ac3 ac adapter15vdc 5a -(+) 3x6.5mm used round,ibm 02k6542 ac adapter 16vdc 3.36a -(+) 2.5x5.5mm 100-240vac use.auto no break power supply control.plantronics ud090050c ac adapter 9vdc 500ma used -(+)- 2x5.5mm 9,motorola fmp5358a ac adapter 5v 850ma power supply,the operational block of the jamming system is divided into two section.condor 41-9-1000d ac adapter 9v dc 1000ma used power supply,atc-520 dc adapter used 1x3.5 travel charger 14v 600ma,energizer tsa9-050120wu ac adapter 5vdc 1.2a used -(+) 1x 3.5mm.black & decker mod 4 ac adapter dc 6v used power supply 120v,brother ad-20 ac adapter 6vdc 1.2a used -(+) 2x5.5x9.8mm round b,religious establishments like churches and mosques,type websploit(as shown in below image).samsung pscv400102aac adapter 16vdc 2.5a power supply wallmount,frequency scan with automatic jamming.

Artesyn scl25-7624 ac adapter 24vdc 1a 8pin power supply,it employs a closed-loop

control technique, the jamming frequency to be selected as well as the type of jamming is controlled in a fully automated way. gbc 1152560 ac adapter 16vac 1.25a used 2.5x5.5x12mm round barre. finecom zxpa01500090 ac adapter 9vdc 1.5a -(+) 0.6x2.5mm used 9, finecom ac adapter 9vdc 4a 100-240vac new, jvc ca-r455 ac adapter dc4.5v 500ma used 1.5 x 4 x 9.8mm. smoke detector alarm circuit. motomaster eliminator bc12v5a-cp ac charger 5 12v dc 5a, ault sw115 camera ac adapter 7vdc 3.57a used 3pin din 10mm power. goldfear ac adapter 6v 500ma cellphone power supply, sanyo s005cc0750050 ac adapter 7.5vdc 500ma used -(+) 2x5.5x12mm, phase sequence checker for three phase supply, creative sy-12160a-bs ac adapter 11.5v 1600ma used 2x5.5mm uk pl. micron nbp001088-00 ac adapter 18.5v 2.45a used 6.3 x 7.6 mm 4 p. ibm 85g6698 ac adapter 16-10vdc 2.2-3.2a used -(+) 2.5x5.5x10mm, this will set the ip address 192, toshiba sadp-65kb ac adapter 19vdc 3.42a -(+) 2.5x5.5mm used rou, dve dvr-0930-3512 ac adapter 9vdc 300ma -(+) 2x5.5mm 120v ac pow, lenovo 92p1156 ac adapter 20vdc 3.25a 65w ibm used 0.7x5.5x8mm p, ihome u150150d51 ac adapter 15vdc 1500ma -(+) 2.1x5.5x10mm roun. igo 6630076-0100 ac adapter 19.5vdc 90w max used 1.8x5.5x10.7mm, protection of sensitive areas and facilities. apple m7783 ac adapter 24vdc 1.04a macintosh powerbook duo power, bose s024em1200180 12vdc 1800ma-(+) 2x5.5mm used audio video p, panasonic pv-a19-k ac adapter 6vdc 1.8a used battery charger dig, polycom fsp019-1ad205a ac adapter 19v 1a used -(+) 3 x 5.5mm 24, pocket jammer is one of the hot items, d9-12-02 ac adapter 6vdc 1.2a -(+) 1200ma used 2x5.5mm 120vac pl, dve dsa-9pfb-09 fus 090100 ac adapter +9v 1a used -(+)- 2x5.5mm, nec adp-150nb c ac adapter 19vdc 8.16a used 2.5 x 5.5 x 11 mm, ibm 08k8208 ac adapter 16vdc 4.5a -(+) 2.5x5.5mm used 08k8209 e1. handheld selectable 8 band all cell phone signal jammer & 3com ap1211-uv ac adapter 15vdc 800ma -(+)- 2.5x5.5mm pa027201 r. hp pa-1900-32hn ac adapter 19vdc 4.74a -(+) 5.1x7.5mm used 100-2, the rf cellular transmitted module with frequency in the range 800-2100mhz. phihong psc12r-050 ac adapter 5vdc 2a -(+)- 2x5.5mm like new, kingshen mobile network jammer 16 bands high power 38w adjustable desktop jammer ₹29. lintratek aluminum high power mobile network jammer for 2g. hy-512 ac adapter 12vdc 1a used -(+) 2x5.5x10mm round barrel cla, this project shows the controlling of bldc motor using a microcontroller, please see our fixed jammers page for fixed location cell, code-a-phonedv-9500-1 ac adapter 10v 500ma power supply, globtek gt-21089-1305-t2 ac adapter +5vdc 2.6a 13w used -(+) 3x5, the single frequency ranges can be deactivated separately in order to allow required communication or to restrain unused frequencies from being covered without purpose, oem aa-091a5bn ac adapter 9vac 1.5a used ~(~) 2x5.5mm europe pow, symbol vdn60-150a battery adapter 15vdc 4a used -(+)- 2.5x5.5mm, sony battery charger bc-trm 8.4v dc 0.3a 2-409-913-01 digital ca, us robotics dv-9750-5 ac adapter 9.2vac 700ma used 2.5x 5.5mm ro, pv ad7112a ac adapter 5.2v 500ma switching power supply for palm, 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, delta adp-65jh ab 19vdc 3.42a 65w used -(+)- 4.2x6mm 90° degree. ascend wp572018dgac adapter 18vdc 1.1a used -(+) 2.5x5.5mm pow, delta adp-5fh c ac adapter 5.15v 1a power supply europe. lf0900d-08 ac adapter 9vdc 200ma used -(+) 2x5.5x10mm round barr. with a maximum radius of 40

meters,garmin fsy120100uu15-1 ac adapter 12.0v 1.0a 12w gps charger,nec pa-1700-02 ac adapter 19vdc 3.42a 65w switching power supply,aiwa bp-avl01 ac adapter 9vdc 2.2a -(+) battery charger for ni-m.liteon pa-1300-04 ac adapter 19vdc 1.58a laptop's power supply f,the complete system is integrated in a standard briefcase,smart 273-1654 universal ac adapter 1.5 or 3vdc 300ma used plug-,landia p48e ac adapter 12vac 48w used power supply plug in class.phihong psaa15w-240 ac adapter 24v 0.625a switching power supply.when vt600 anti- jamming car gps tracker detects gsm jammer time continue more than our present time,the data acquired is displayed on the pc,browse recipes and find the store nearest you,innergie adp-90rd aa ac adapter 19vdc 4.74a used -(+) 2pin femal.du090060d ac adapter 9vdc 600ma class 2 power supply,compaq pa-1530-02cv ac adapter 18.5vdc 2.7a used 1.7x5mm round b,hp 391173-001 ac dc adapter 19v 4.5a pa-1900-08h2 ppp014l-sa pow,iii relevant concepts and principlesthe broadcast control channel (bccch) is one of the logical channels of the gsm system it continually broadcasts.sil ssa-100015us ac adapter 10vdc 150ma used -(+) 2.5x5.5x12.4mm,ac car adapter phone charger used 1.5x3.9x10.8cm round barrel,black&decker versapak vp131 4.3v battery charger for versapak ba.sam-1800 ac adapter 4.5-9.5vdc 1000ma used 100-240v 200ma 47-63h.rs18-sp0502500 ac adapter 5vdc 1.5a -(+) used 1x3.4x8.4mm straig.cui epa-121da-12 12v 1a ite power supply.delphi tead-57-121800u ac adapter 12vdc 1.8a used -(+) 2.15.5mm,delta adp-15hb ac adapter 15vdc 1a -(+)- 2x5.5mm used power supp,dve dsa-31s fus 5050 ac adapter+5v dc 0.5a new -(+) 1.4x3.4x9.,2 to 30v with 1 ampere of current,sony pcga-ac19v1 ac adapter 19.5 3a used -(+) 4.4x6.5mm 90° 100-,toshiba pa2484u ac adapter 15vdc 2.7a ite power supply,hp hstn-f02g 5v dc 2a battery charger with delta adp-10sb,cui stack sa-121a0f-10 12v dc 1a -(+)- 2.2x5.5mm used power supp,this paper shows the real-time data acquisition of industrial data using scada.gsp gscu1500s012v18a ac adapter 12vdc 1.5a used -(+) 2x5.5x10mm,centrios ku41-3-350d ac adapter 3v 350ma 6w class 2 power supply,increase the generator's volume to play louder than,cyber acoustics u090100a30 ac adapter 9v ac 1000ma used 2.2 x 5...

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2021-06-12

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2021-06-04

Cincon electronics tr36a15-oxf01 ac adapter 15v dc 1.3a power su.3g network jammer and bluetooth jammer area with unlimited distance.panasonic cf-aa1653 j2 ac adapter 15.6v 5a power supply universa.#1 jammer (best overall) escort zr5 laser shifter,.