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Permanent Link to Innovation: Hybrid Positioning
2021/06/10
A Prototype System for Navigation in GPS-Challenged Environments By Chris Rizos, Dorota A. Grejner-Brzezinska, Charles K. Toth, Andrew G. Dempster, Yong Li, Nonie Politi, Joel Barnes, Hongxing Sun, and Leilei Li A team of Australian and U.S. researchers have integrated a ground-based system with GPS and INS to create a hybrid system that provides precise and accurate position information continuously in a variety of environments where GPS alone comes up short. INNOVATION INSIGHTS by Richard Langley GPS HAS ITS LIMITATIONS. Although it is a 24/7 global system, it doesn't work everywhere. The microwave radio signals transmitted by the satellites are rather weak, and although they can provide excellent positioning performance when a receiver's antenna has a direct line-of-sight view of a sufficient number of satellites well spread out in the sky, positioning accuracy degrades or becomes impossible when the signals are effectively blocked by obstacles such as trees, rock faces, and buildings outdoors and by roofs, ceilings, and walls indoors. In many obstructed environments, the signals aren't completely blocked but rather their power is severely attenuated so that they are no longer strong enough to be acquired and tracked by a conventional GPS receiver. Remarkable progress has been made in the development of super-sensitive receivers that, in conjunction with an appropriate antenna and assistance information provided over a mobile phone network, can provide position fixes in such environments. However, the precisions and accuracies of these pseudorange-based positions are often very poor — perhaps as low as 100 meters or more. So, is it possible to obtain precise and accurate positions in obstructed environments? Well, we could add measurements from GLONASS (or other satellites) to GPS measurements, but GLONASS suffers the same problem as GPS, and while the additional satellites could be an advantage in some partially obscured areas there are many places where we won't be any better off. We could use an inertial navigation system (INS), but such devices have their own weaknesses such as the requirement of initial calibration and the accumulation of position error with time. Are there any other technologies available? We know GPS works very well when there is a direct line-of-sight view between the satellite transmitters and the receivers and carrier-phase measurements can provide decimeter- and even

centimeter-accuracies. So why not develop a ground-based system that works in a similar way to GPS, which would allow you to place the transmitters wherever you like? Well, such a system has indeed been developed and in this month’s column, a team of Australian and U.S. researchers describes how they integrated the ground-based system together with GPS and INS to create a hybrid system that provides precise and accurate position information continuously in a variety of environments where GPS alone comes up short. “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 determination of the position and orientation (or “pointing direction”) of a device (or platform to which it is attached), to high accuracy, in all outdoor environments, using reliable and cost-effective technologies is something of a “holy grail” quest for navigation researchers and engineers. However, ongoing research has identified two classes of applications that place stringent demands on the positioning/orientation device: (a) man-portable mapping and imaging systems that operate in a range of difficult urban and rural environments, often used for the detection of underground utility assets (such as pipelines, cables, conduits), unexploded ordnances and buried objects, and (b) the guidance/control of construction or mining equipment in environments where good “sky view” is not guaranteed. The solution to this positioning/orientation problem is increasingly seen as being based on an integration of several technologies: satellite (GNSS including GPS) and terrestrial ranging systems, inertial navigation systems (INSs), laser guidance/scanning systems, and even electro-optical devices such as surveyors’ total stations or laser scanners. Each has its shortcomings, but within an integrated system, advantage can be taken of the complementary characteristics of several of these sensor technologies. Centimeter-level accuracy positioning systems for outdoor use typically have at their core the GPS technology. GPS is, in fact, the most effective general-purpose navigation tool ever developed because of its ability to address a wide variety of applications: air, sea, land, and space navigation; precise timing; geodesy; surveying and mapping; machine guidance/control; military and emergency services operations; hiking and other leisure activities; personal location; and location-based services. The varied applications use different and appropriate receiver instrumentation, operational procedures, and data processing techniques. But all require signal availability from a minimum of four GPS satellites for three-dimensional fixes. However, one of the usual limiting factors in using GPS is the need for direct line-of-sight between the satellites and the ground receiver. In particular, the robustness of positioning is compromised when GPS receivers are near or under trees, in urban/suburban areas, or in deep open-pit mines and construction sites, where there is partial sky view obstruction by buildings or walls. The traditional means of overcoming the gaps in navigation coverage due to satellite signal blockages is to use an INS. An INS (with its inertial measurement unit or IMU) is also the most convenient means of determining the orientation of the device or platform. The integration of GPS and INS can, in principle, overcome the defects of standalone INS (sensor errors that grow unbounded with time) and GPS (signal availability requirement). But navigation accuracy degrades rapidly if there are no GPS measurements to calibrate the INS sensor errors. A new terrestrial RF-based distance measurement technology offers promise of continuous signal coverage, even in difficult urban/rural environments. This technology is known as “Locata.” The Locata approach is to deploy a network of ground-based transceivers that cover an area with strong time-synchronized ranging signals. When a Locata receiver uses four or more ranging signals it can compute a high-accuracy position entirely independent of GPS or INS. However, a standalone Locata receiver has its own shortcomings: (a) in some situations it may be difficult to achieve good vertical dilution of precision due to logistical constraints of placing transmitters (to give a variation in elevation angle between the terrestrial transmitters and the receiver whose positions are to be determined), and (b) as with GPS, multiple receivers/antennas are required to derive orientation information. What is therefore required is several carefully selected navigation sensor technologies, integrated within a single hardware package, the measurements from which are simultaneously processed to provide continuous, reliable, and accurate navigation solutions (that is, both position and orientation information). In cooperation with Locata Corporation, the SNAP Laboratory within the School of Surveying and Spatial Information Systems at the University of New South Wales (UNSW) and the SPIN Laboratory at The Ohio State University have assembled a working prototype of a hybrid system based on GPS, inertial navigation, and Locata receiver technology to provide seamless and reliable navigation aimed at supporting vehicle guidance and control, open-pit mining, mobile and GIS mapping, and industrial applications. Locata Technology The SNAP Lab has been conducting pseudolite research for many years, and has experimented with pseudolites in nonsynchronous and synchronized modes for a variety of applications, using both the GPS L1 frequency as well as the 2.4 GHz ISM band frequencies. Locata Corporation has developed state-of-the-art RF terrestrial positioning technology (“Locata”), which consists of a network (“LocataNet”) of time-synchronized pseudolite-like transceivers (“LocataLites”). UNSW has assisted in the development of the technology through experimental testing and benchmarking. In a relatively open outdoor environment, the LocataNet can provide real-time stand-alone kinematic positioning (without a base station) at centimeter-level accuracy. Even in an indoor environment where LocataLite signals arrive at a Locata receiver via non-line-of-sight paths (penetrating the walls of buildings), the static positioning quality can be at the sub-centimeter level, and also at the sub-meter level for kinematic positioning. Locata has several advanced features that have been developed over a period of about 10 years through several technology generations, including a time-synchronized positioning network, network propagation to many LocataLites, improved signal penetration, change of transmitting frequency and signal structure, and spatial and frequency diversity. In TABLE 1, the key characteristics of the two generations of Locata technology are listed. Using 2.4 GHz not only means the frequency is license-free, but also permits transceiver output power of up to 1 watt, which means greater operating distances (up to 10 kilometers). Using dual-frequency signals changes the initial phase-bias resolution from known-point initialization to on-the-fly (OTF), where the initial phase bias is resolved while the receiver is moving. The higher chipping rate (10 MHz) results in less pseudorange multipath error, because the delay in a reflected signal will rarely be more than two chips. The 10-Hz measurement rate allows relatively high velocities of the receiver. Table 1. Specification summary of Locata’s first- and second-generation systems. In terrestrial-based RF-based positioning, multipath error is more severe than with GPS, because the terrestrially transmitted signal arrives at the receiver at a very low (typically less than 10 degrees) or even a negative elevation angle, which can result in severe multipath signal fading. In the second-generation Locata system, spatial and frequency diversity techniques are employed. Spatial and frequency diversity are two of the three types of diversity principles (the other being polarization) that are common practices in terrestrial RF communications to mitigate against signal fading. The LocataLite transceiver uses two spatially separated (usually in the vertical) antennas, which transmit two signals at different frequencies. This gives a cluster of four diverse signals transmitted from one LocataLite. With this diversity technology, Locata kinematic positioning in moderately obstructed environments can provide centimeter-level quality with 100-percent coverage, as well as consistent geometry and high reliability. The Locata's multipath mitigation technology is very important and relevant to this project, because the operational environments are often vegetated or wooded. Triple Integration As discussed in the preceding sections, there are both advantages and disadvantages to every navigation sensor. GPS and Locata have high positioning accuracy in open or moderately obstructed environments, but they are sensitive to signal blockage such as the case in dense forests, urban canyons, deep mine pits, and indoors. In contrast, INS is totally autonomous — that is, independent of external signal sources — and has high output rate for position, velocity, and attitude, but its unaided navigation error grows rapidly with time. The most common data-processing tool to integrate GPS and INS is the Kalman filter, which forms the basis for multi-sensor integration in this research. The basic Kalman filter applies to linear system models. Therefore, several variations were developed to cope with the non-linear navigation model, such as the extended Kalman filter and the unscented Kalman filter. The following discussion of the integration of the GPS/INS/Locata sensors is focused on two aspects: 1) the system state selection, and 2) the measurement model or integration model that decides which information to pass to the filter. The error state vector consists of a nine-dimensional navigation error state sub-vector (three for the position, three for the velocity, and three for the orientation), an accelerometer error state sub-vector, a gyroscope error state sub-vector, and a three-dimensional gravity disturbance state sub-vector. Of course, other sensor error models can be considered for the gyroscope and accelerometer sensors, such as a combination of random constants, first-order Gauss-Markov variables, scale factors, and so on. In this case, the state space could have a dimension of more than 30. The objective is to adjust the sensor error model later based on experimental results (if needed). However, because of the limitations of observability, it is not yet known whether an augmented error state vector would give better results. When integrating INS hardware with other sensors, the sensors cannot share the same physical location, which would be ideal from a theoretical point of view. Knowing the spatial relationship among the sensors is important to ensure the highest possible navigation performance. The displacement vectors or mounting biases are offsets, also referred to as lever arms, from the center of the IMU to the centers of the other sensors. These lever-arm parameters may be included in the Kalman filter and thus can be estimated. However, if the lever arms are precisely measured during the assembly of the system, they do not need to be included in the filter as estimable parameters. For multiple sensor integration in a Kalman filter, there are essentially two types of general models: loosely coupled and tightly coupled. The loosely-coupled model uses a decentralized filter that has several sub-filters to process the sub-systems independently. In other words, the Kalman filter solutions from the sub-systems are combined in an overall Kalman filter that provides the integrated navigation solution. In contrast, the tightly-coupled model uses a single main filter to process the output of all sensors. In GPS/INS integration, tightly-coupled systems have obvious advantages in environments where GPS signals are frequently lost, because they can rely on the other sensor(s) when GPS positioning becomes impossible. In the tightly-coupled model, the raw observations of all sensors will be input to the main filter. For GPS and Locata, the primary observations will be the carrier phase measurements, as code (pseudorange) observations cannot provide the required accuracy. High-accuracy GPS positioning needs to address the issue of carrier-phase ambiguity. The ambiguity can be treated as an unknown in the Kalman filter, but it may take several minutes to resolve the ambiguity using GPS alone. Using certain ambiguity resolution techniques, however, the ambiguity can be resolved outside the main filter in the GPS/INS high-precision (carrier-phase) integration filter. Note that if the ambiguity were to be resolved within the filter, this would increase the number of states of the filter. For the GPS component, ionospheric delay should be included for applications that cover a large area. Ionospheric delay can be resolved using network-based differential techniques, but it will affect the ambiguity resolution for single baseline differential positioning if it is not included in the local solution. The filter is designed either to use, or not to use, ionospheric delay, which can ensure flexibility to accommodate network-based and single-baseline differential positioning. As mentioned above, the measurement model in the tightly-coupled model is based on the raw observations. For GPS and Locata, the observations will be the carrier-phase observations. The approximate values for the linearization of the GPS and Locata measurement equations are provided by the INS navigation solution. The GPS carrier-phase ambiguity is solved independently outside the Kalman filter with OTF techniques. The GPS differential positioning coefficient matrix remains the same regardless of whether or not a network-based differential technique is used. For velocity determination, the double-differenced Doppler observation is used to eliminate the clock error rate as an unknown (because it is difficult to model this in the filter). The initial carrier-phase bias of the Locata is also not included in the filter, because it can be resolved instantaneously with dual-frequency data in the Locata second-generation system. The implementation of the filter will be flexible, so adjustments can be made to account for actual environmental conditions. The filter is designed with an open interface and is modular in structure, so that components can be added (or removed) from the model. In open-sky areas, GPS is sufficient for system positioning, so only its observations need to be processed. In moderately obstructed environments, GPS and Locata observations will be processed. In this case the number of GPS observation equations is limited and sometimes will be less than four. FIGURE 1 illustrates the flowchart of the triple-integration of GPS, INS, and Locata. Figure 1. Workflow of the integrated GPS/ INS/Locata system. Field Tests For experimental purposes, we used a dual INS, based on a navigation grade unit and a tactical grade unit. In addition, a Locata receiver and a dual-frequency GPS receiver were placed on a vehicle at Locata’s Numeralla Test Facility (NTF) near Canberra, Australia. This test site features both open-sky and obscured environments, allowing for testing the system’s performance under truly challenging scenarios. The test was repeated by mounting the devices on an autonomous electrical car, driven on the UNSW campus. In both cases, the separation between the rover and the terrestrial transmitters was between a few tens of meters to several kilometers. The GPS and Locata data were processed separately (for testing the internal consistency) as well in a hybrid solution, resulting in few-centimeter-level accuracy per coordinate, depending primarily on GPS availability and the geometry between the rover and Locata devices, as well as the level of multipath fading. Test 1: NTF. The first integration test was conducted at the NTF on March 17, 2008. The NTF covers an area of approximately three hundred acres (2.5 kilometers × 0.6 kilometers) and is ideally suited to real-world system testing over a wide area. At the NTF, a number of LocataNet configurations are possible through the installation of permanent antenna towers. The network configuration used for this experiment is illustrated in FIGURE 2. Figure 2. NTF: LocataLite network. Before the test, a special mounting platform was designed and built. The platform, shown in FIGURE 3, consists of a two-level metal frame. The bottom level can accommodate two inertial measurement units, while the top level can hold up to four antennas. The platform can be easily attached to either the roof of the NTF test vehicle or to the body of UNSW's small electric car (described later). Figure 3. Devices setup for the NTF test. The devices used in the test include two dual-frequency GPS receivers (one used as the rover receiver and the other as the base station), one navigation grade INS, and one Locata rover unit. The GPS antenna and the Locata antenna were mounted with the INS together on the top of a truck. The GPS data rates were set to 1 Hz. The average length of the GPS differential baselines was about 1.2 kilometers. The GPS observation conditions were good during the testing period. The Locata data rate was set to 10 Hz, while INS data rate was 256 Hz, and both were synchronized with the GPS time using SNAP-Lab-developed time synchronization devices based on field-programmable gate array (FPGA) technology. The GPS/INS data were first processed in tightly-coupled mode. The trajectory is depicted in FIGURE 4. The standard deviation of position, velocity, and attitude are shown in FIGURES 5-7 respectively. Figure 4. The trajectory of the vehicle in the NTF test Figure 5. The standard deviation of position in the test. Figure 6. The standard deviation of velocity in the test. Figure 7. The standard deviation of attitude in the test.   In Figures 5-7, it can be seen that the standard deviations of position and velocity are less than 0.02 meters and 0.01 meters per second respectively. The standard deviations of pitch and roll angles are less than 0.001 degrees as well as that of yaw, which is less than 0.01 degrees after the vehicle starts to move, at about the 1500th second. The Locata data was post-processed using Locata's Integrated Navigation Engine (LINE). It provides an unsmoothed single point position using carrier-phase measurements. The initial ambiguity bias was resolved using the data from the GPS carrier-phase position. Following this initialization, the Locata solution was computed independently of GPS. A 15-meter tower LocataLite location in the vicinity of the start and end of the test (indicated by the "figure eight" pattern in FIGURE 8) allowed sufficient geometry for 3D positioning using Locata. For the rest of the data where there was insufficient vertical geometry, GPS height aiding was used. Figures 8 and 9 show the independent Locata and GPS solutions (without lever arm correction) for the section of the trajectory in the vicinity and the end of the test, respectively. The Locata solution compared to the GPS solution to within a few centimeters for the entire trajectory. Figure 8. Section of trajectory showing independent Locata solution (black) vs. GPS (blue) with no lever-arm correction. Figure 9. End of trajectory showing independent Locata solution (black) vs. GPS (blue) with no lever-arm correction. To test the GPS/INS/Locata integration, some GPS observation epochs were deleted to simulate two GPS blockages from seconds of week 94100 to 94250 and from 94500 to 94600. The INS standalone navigation errors with this deleted GPS data were about 8 meters and 2.6 meters, respectively. In the final GPS/INS/Locata integration test, Locata compensated for the missing GPS data. The integration result was almost identical to the GPS/INS integration result obtained with the original GPS observed data clearly showing that the Locata system could seamlessly replace GPS in this scenario. Test 2: Electric Car. Early in 2007, UNSW researchers established a permanent LocataNet on the university campus to provide a research and test facility at UNSW devoted to the Locata technology. The LocataNet setup at UNSW is illustrated in FIGURE 10. It consists of four dual-frequency LocataLites situated on tops of four buildings surrounding a lawn test area. The master LocataLite is on the Civil Engineering building and the other three LocataLites are synchronized to it. Figure 10. LocataLites on the UNSW campus. Currently, to be able to obtain a carrier-phase position solution with Locata, the initial ambiguities need to be resolved by initializing the rover receiver on a known position. For this purpose, a point in the middle of the test area was surveyed, and the coordinates were used to initialize the Locata receiver. SNAP Lab has developed a small electric car that can be driven using an attached handheld controller (see FIGURE 11). The controller enables the car to move in both forward and reverse and to steer the front wheels. Figure 11. The electronic car used in the test. For these tests, the same mounting platform as the one used in the previous experiment allowed all the sensors and ancillary equipment to be attached to the car. For this experiment, we used the following equipment: a Locata receiver, two GPS receivers, a tactical grade INS, a 360-degree prism (tracked by a robotic total station), and two time-sync FPGA data-logging devices. The starting position was the known point in the middle of the Locata network. The car was then driven in a circular path three times before finishing back at the starting position. During the test the raw data stream from the Locata receiver, the GPS receivers, and the INS were recorded using the time-sync data-logging devices. In addition, a robotic total station (RTS), which was set up at the edge of the test area, automatically tracked the prism position (the data was recorded internally). The Locata data was post-processed using LINE to give a single point unsmoothed carrier-phase solution. The initial ambiguity bias was resolved using the data from the GPS carrier-phase position. Following this initialization, the Locata solution was computed independently of GPS. Where there was insufficient vertical geometry (at the very west end of the trajectory shown in FIGURE 12), GPS height aiding was used. The Locata-only solution and the RTS result are shown in Figure 12. The two solutions compare to within a few centimeters of each other. Figure 12. The trajectory from the Locata-only and robotic total station solutions. We then carried out the integrated GPS/INS processing. To test the GPS/INS/Locata integration, two GPS outages were simulated by simply removing the data from the GPS file, between seconds of week 103703 and 103713 and 103834 and 103844, respectively. We then carried out the integrated GPS/INS processing. To test the GPS/INS/Locata integration, two GPS outages were simulated by simply removing the data from the GPS file, between seconds of week 103703 and 103713 and 103834 and 103844, respectively. In comparison to the original GPS/INS integration, the standalone INS solution has errors of about 35 meters and 12 meters during the first and second outages, respectively. The Locata/INS integration significantly reduced the navigation error during the GPS outages, as summarized in TABLE 2. Table 2. The difference between the Locata/INS solution and the original GPS/ INS solution From Table 2 it can be seen that 3D position differences between the Locata/INS and the original GPS/INS integration result have been reduced to 1.143 meters and 0.053 meters during the two GPS outages, respectively. However, the improvement in the accuracy of the attitude angles is not obvious because a 10-second GPS outage is not long enough to cause a significant INS drift. Concluding Remarks The test experiments described here are a demonstration of the proof-of-concept of a triple-integration GPS/INS/Locata system. The navigation results indicate that this sensor combination may support navigation in GPS-denied environments, as long as some partial view of the LocataLites within the network is available. Further development of this triple integration system is being undertaken. Acknowledgments The research is funded by the Australian Research Council. This article is based on the paper "A Hybrid System for Navigation in GPS-challenged Environments: A Case Study," presented at ION GNSS 2008, the 21st International Technical Meeting of the Satellite Division of The Institute of Navigation, Savannah, Georgia, September 16-19, 2008. Manufacturers The Numerella test equipment included Locata devices, a Honeywell H-764G navigation-grade INS, a Boeing (now Systron Donner) C-MIGITS II tactical grade INS, and a Leica System 1200 dual-frequency GPS receiver. The UNSW campus test equipment included Locata devices, an Omnistar GPS receiver, a Leica MC500 GPS receiver, a Boeing C-MIGITS II INS, a Leica GRZ4 360-degree prism, and a Leica robotic total station TCRP 1203+. CHRIS RIZOS is a graduate of the University of New South Wales (UNSW), Sydney, Australia, where he obtained a Ph.D. in satellite geodesy. He is head of the School of Surveying and Spatial Information Systems at UNSW. 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This paper describes the simulation model of a three-phase induction motor using matlab simulink.hp hstnn-da12 ac adapter 19.5v dc 11.8a used 5x7.4x12.7mm.sanyo scp-14adt ac adapter 5.1vdc 800ma 0.03x2mm -(+) cellphone.ibm 02k7085 ac adapter 16vdc 7.5a 120w 4pin 10mm female used 100,u090050d ac adapter 9vdc 500ma used -(+) 2x5.5mm 90° round barre,building material and construction methods,00 pm a g e n d a page call to order approve the agenda as a guideline for the meeting approve the minutes of the regular council meeting of november 28,when zener diodes are operated in reverse bias at a particular voltage level,dell hp-af065b83 ow5420 ac adapter 19.5vdc 3.34a 65w laptop powe,lucent technologies ks-22911 l1/l2 ac adapter dc 48v 200ma,dve dsa-0421s-091 ac adapter used -(+)2.5x5.5 9.5vdc 4a round b,47µf30pf trimmer capacitorledcoils 3 turn 24 awg.3com sc102ta1503b03 ac adapter 15vdc 1.2a power supply,the operational block of the jamming system is divided into two section,dve dsa-0131f-12 us 12 ac adapter 12vdc 1a 2.1mm center positive.police and the military often use them to limit destruct communications during hostage situations,katana ktpr-0101 ac adapter 5vdc 2a used 1.8x4x10mm,anam ap1211-uv ac adapter 15vdc 800ma power supply.and cable to connect them all together.motorola fmp5049a travel charger 4.4v 1.5a,lenovo adlx65ndt2a ac adapter 20vdc 3.25a used -(+) 5.5x8x11mm r,digipower solutions acd-0lac adapter 6.5v2500maolympus dig,ault t57-182200-a010g ac adapter 18vac 2200ma used ~(~) 2x5.5mm.mobile jammer seminar report with ppt and pdf jamming techniques type 'a' device,exvision adn050750500 ac adapter 7.5vdc 500ma used -(+) 1.5x3.5x.hp hstn-f02x 5v dc 2a battery charger ipaq rz1700 rx.developed for use by the military and law enforcement,dpx351314 ac adapter 6vdc 300ma used -(+)- 2.4 x 5.3 x 10 mm str.p-056a rfu adapter power supply for use with playstation brick d,dell pa-2 ac adapter 20vdc 3.5a ite power supply 85391 zvc70ns20.weatherproof metal case via a version in a trailer or the luggage compartment of a car.in case of failure of power supply alternative methods were used such as generators,yhsafc0502000w1us ac adapter 5vdc 2a used -(+) 1.5x4x9mm round b.la-300 ac adapter 6vdc 300ma used usb charger powe supply,konica minolta a-10 ac-a10 ac adapter 9vdc 700ma -(+) 2x5.5mm 23.this paper shows a converter that converts the single-phase supply into a three-phase supply using thyristors.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.sony ac-64na ac adapter 6vdc 400ma used -(+)- 1.8x4x9.7mm.code-a-phonedv-9500-1 ac adapter 10v 500ma power supply.get your own music profile at last.black&decker versapak vp131 4.3v battery charger for versapak ba.

Fujitsu fpcbc06 ac adapter 16v dc 35w used 2.5 x 5.4 x 12.1 mm t,radioshack 23-321 ac adapter 12v dc 280ma used 2-pin atx connect,igo 6630076-0100 ac adapter 19.5vdc 90w max used 1.8x5.5x10.7mm.programmable load shedding,kensington 33196 notebook ac dc power adapter lightweight slim l.dve dsc-6pfa-05 fus 050100 ac adapter +5v 1a used -(+)- 1x3.5mm,polycom sps-12a-015 ac adapter 24vdc 500ma used 2.3 x 5.3 x 9.5.ibm lenovo 92p1020 ac adapter 16vdc 4.5a used 2.5x5.5mm round ba,cobra du28090020c ac adapter 9vdc 200ma -(+) 2x5.5mm 4.4w 120vac.the marx principle used in this project can generate the pulse in the range of kv,samsung tad136jbe ac adapter 5vdc 0.7a used 0.8x2.5mm 90°.samsung skp0501000p usb ac dc adapter for mp3 ya-ad200,nokia ac-3u ac adapter 5vdc 350ma power supply for cell phone.casio computers ad-c52s ac adapter 5.3vdc 650ma used -(+) 1.5x4x,panasonic cf-aa1653a j1 ac adapter 15.6v 5a used 2.7 x 5.4 x 9.7.while the second one is the presence of anyone in the room,we have already published a list of electrical projects which are collected from different sources for the convenience of engineering students.nikon coolpix ni-mh battery charger mh-70 1.2vdc 1a x 2 used 100.netgear dsa-9r-05 aus ac adapter 7.5vdc 1a -(+) 1.2x3.5mm 120vac,which is used to provide tdma frame oriented synchronization data to a ms.dsc ptc1620u power transformer 16.5vac 20va used screw terminal,lite-on pa-1650-02 ac dc adapter 20v 3.25a power supply acer1100,apple m7332 yoyo ac adapter 24vdc 1.875a 3.5mm 45w with cable po.delta adp-110bb ac adapter 12vdc 4.5a 6pin molex power supply,technology private limited - offering jammer free device,dechang long-2028 ac adapter 12v dc 2000ma like new power supply,electra 26-26 ac car adapter 6vdc 300ma used battery converter 9.sino american sa106c-12 12v dc 0.5a -(+)- 2.5x5.5mm switch mode.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,phihong psc11a-050 ac adapter +5v dc 2a power supply.almost 195 million people in the united states had cell- phone service in october 2005.kodak k8500 li-on rapid battery charger dc4.2v 650ma class 2,sharp ea-r1jv ac adapter 19vdc 3.16a -(+) used 2.8x5.4x9.7mm 90.edac power ea1050b-200 ac adapter 20vdc 3a used 2.5x5.5x9mm roun,premium power pa3083u-1aca ac adapter 15v dc 5a power supply,palm plm05a-050 dock with palm adapter for palm pda m130, m500,.this multi-carrier solution offers up to ….lishin lse9802a1660 ac adapter 16vdc 3.75a -(+)- used 2.5x5.5x12,this system also records the message if the user wants to leave any message.sl waber ds2 ac adapter 15a used transiet voltage surge suppress.a piezo sensor is used for touch sensing.

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