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A Graphical User Interface to Test Smart Antenna Device

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Abstract. Totrackgeolocationsofflightsareimportantwhentheconnectionbetweenthepilotandthebasestationislost.The pilot can be provided with a Smart Antenna device using which the pilot's location can be tracked. To capture and extract signals from the satellite, both antenna transmitters an dreceiversare required. In a Smart Antennadevice,boththereceiverantennaandtransmitterantennaareembeddedinthesamedevice.Usingthisdevice,GPS,GLONASSandIRNSSsignals can be captured and from the data that has been captured to track accurate geolocation of the device. To validatethe capturing rate of this device and its capability certain commands are given to the device. This paper discusses thecommands that are given to the device and the GUI that is developed to check if each command is given and the status ofthecommandis shownusingLabVIEW.

I. INTRODUCTION

The United States Air Force (USAF) operates a satellite-based radio navigation system which is owned by thegovernment of the United States called as GPS which provides geolocation and time information to the receiverantenna [1]. GLONASS is an alternative to GPS and is operated by the Russian satellite navigation system with notableprecision and global coverage [2]. IRNSS is operated by ISRO providing accurate timing and position information,covering India and its surrounding region extending 1,500 km. It provides services of two different levels, the"Standard Positioning Service" that is used for civil purposes and the "Restricted Service" is only for authorizedpurposes[3].

A Smart Antenna is a device that has been developed where both the receiver antenna as well as the transmitterantennaareembeddedonthesamedevice.ThisdevicecancaptureGPS,GLONASSandIRNSSsignalsandthe datathathasbeencaptured canbeanalyzed totrack geolocationofthe device.

ThefunctioningoftheSmartAntennadevicecanbecheckedusingdifferentparameters.Thedifferentparametersusedherearebycheckingthe TTFFmeasureforColdStartandHotStart,thenumberofsatelliteswithC/Nratioabove40,1PPSmonitoring,responseforthefactoryresetcommand,versioncommandandconfigurationcommands.The time taken for a navigation device to extract signals and navigation, and calculate the fix, that is, the positionsolutioniscalledTTFF[4].Tocalculatethesolutionfornavigation,atleastfoursatellitesaretrackedfromthesatellitesignalsthathavebeentrackedbythereceiverantenna.Thesignalsarethendecodedtoconveytheexactmessageinthesignal.TheinitialconditionsofthereceiverantennadeterminetheTTFF.Ifthereceiverantennahastrackedavalidmessage,thenthenavigationmessageneednotbedecoded.TheinitialconditionsofthereceiverantennaareColdStart,WarmStartandHotStart.IntheColdStartcondition,therewouldnotbeanyinformationatthereceiver'sendandsoitentailsafullsearchforsatellitesinthesky.IntheWarmStartcondition,thereceiverantennahasavalidsignalandthedeviceshallextractasignal fromeachsatellite withinformationoforbits.InHotStart,thedeviceisin astandbymode beingreadytoextractsignalsrapidly[5].

TheNationalMarineElectronicsAssociation(NMEA)hasdefinedastandardforcommunicationbetweenmarineinstrumentation [6]. The satellite signals are used using the NMEA standard. All characters that are used in thestandardareASCIItextwithcarriagereturnandlinefeed.Thedatathathasbeenreceivedfromthesatellitesaresent in "sentences". Each of these sentences begins with a “$” and ends with the carriage return or line feed. The "$" isfollowed by a “talker ID” and “sentence ID” and then number of data fields that are separated by commas and endsby an optional checksum and the carriage return or line feed. Each sentence may contain up to 82 characters. If dataforanyofthefieldisunavailable,thenthefieldisomittedwithonlycommaspresentandnospacebetweenthem.TheNMEAsentenceswillbe sentto the device intheformat asshowninFIGURE 1.

```
$GPGGA,171059.000,3749.9201,N,12228.4985,W,2,09,1.0,-6.1,M,-25.3,M,5.0,0000*6E
$GPGSA,M,3,17,19,28,13,15,24,30,06,48,,,,1.9,1.0,1.6*3D
$GPRMC,171059.000,A,3749.9201,N,12228.4985,W,3.1,168,310716,,*03
$GPVTG,167.62,T,,M,3.1,N,,K,D*10
$GPZDA,171059.000,31,07,2016,,*5D
$IIHDM,163,M*38
$IIHDT,177,T*3D
$IIXDR,A,4,D,ROLL,A,-2,D,PTCH,A*1A
$TIROT,-0.0,A*16
$PFEC,GPatt,177,-2,4*7C
$IIMDA,29.95,I,1.01,B,19.8,C,17.0,C,68.0,,16.7,C,,,,,,,,*3F
$IIXDR,P,1.01408,B,Barometer*2B
$IIXDR,C,19.8,C,AirTemp*26
$IIMMB,29.95,I,1.01408,B*42
$IIMTA,19.8,C*05
$SDDPT,0.9,0.50*6B
$SDDBT,3.2,f,0.9,M,0.5,F*0B
$VWVHW,177,T,,M,4.2,N,,K*4D
$IIVDR,20,T,,M,1.3,N*39
$VWVLW,0.0,N,0.0,N*4C
$YXMTW,17.0,C*14
```

FIGURE1. NMEAsentencesextractedbythereceiverantenna

This paper presents an overview of a GUI that is developed to check if each command to validate the capabilityand functioning of the device is given to the Smart Antenna device and expected responses are received from thedevice.

II. LITERATURESURVEY

GNSSprovidessolutionsfor velocity,positionandtimingsolutionsfromanypointonorneartheEarth'ssurface.The main features of the system to be popularized are accuracy and global availability of solutions. Many global aswellasregionalsystemssuchas,GPS,Galileo,GLONASS,NavIC,BeidouandQZSSarecurrentlyoperational.TheGNSS users are concerned about the quality of solution that would be extracted by the receivers. Since most of thegeneric and high-cost geodetic receivers provide similar type of position solution, an attempt to review these effortsand discuss parameters that are used for geodetic coordinate system has been made. The utility to calculate accuracyparametersofsatellite-basedsolutionforpositionsaredevelopedandimplementedusingMATLABbyreviewingtheformulas. This utility would be useful in understanding the process of analyzing GNSS data for studies related toprecisionandaccuracy[7].

Veryaccurategeolocationservicesareimportantforawiderangeofapplicationsfromautonomousvehicles,civilinfrastructure system, sports and engineering to digitization of important historical structures. The advancement intechnology have seen the miniaturization of electronics and antennas, along with the increase in performance andnumber of GNSS by various nations and organizations and thus providing signal coverage globally. An economical,portable,low-cost,real-timekinematic(RTK)geolocationservicesfromreadilyavailablecomponentsfromcommercial suppliers are fabricated for applications related to engineering as well as research is demonstrated. Thissolution consists of a mobile RTK base station and RTK rover, providing centimeter-accuracy performance up to adistanceof15kmfromthebasestation.Thedatathathasto berevised istransmittedover internetusingopensource software solutions. Even small footprints of RTK base station and rover provides versatile applications in remotelocations as well. The geolocation service efficiency is validated using field experiments and measurements arecompared against state-of-the-art photogrammetry, digital level measurement technique and light detection andranging(LiDAR) [8].

The Indian region receives signals from many satellite navigation systems for hybrid operation of multi-GNSS.Even if GPS, GALILEO and GLONASS signals are present together, at some times of the day none of the GNSSsatellite is above 60° elevation angle from most parts of India thus causing issues in smooth navigation solutions inlocations where satellite visibility is also obstructed at lower elevation angles. In cases of lower GNSS satellitevisibility, the IRNSS/NavIC working with the GPS can increase these conditions of degraded visibility as a functionof time. The Indian satellite navigation system ensures that there is at least one satellite above 60° elevation for useovertheIndianregionandsupportstheoperationofmulti-GNSStowardssmoothsolutionandoptimizesthegeometryofsatellite [9].

Highly precise position information is provided by GPS. The GPS information of satellite data from multipleantennas is extracted for measuring altitude. The design for an embedded multi-antenna satellite data acquisitionsystem following the binary protocol of the GPS receiver. The binary protocol when compared to that of the NMEAprotocol can obtain more raw data, that is, pseudo range and signal-to-noise ratio for navigation of satellites. Thesystem hardware is based on AM335x ARM Cortex A8 microcontroller consisting four GPS receiver units (NV08C-CSM).ThesoftwaresystemisbasedontheembeddedLinuxoperatingsystemandthemulti-channeldataacquisitionprograms are designed. The results of this design depict that the system provide GPS raw data for measuring altitudemeeting the precision requirements. The hardware platform's size is small and can be applied in Unmanned surfacevehicles(USV), UnmannedAerial Vehicle(UAV), etc.[10].

Unmanned Aerial Systems that are mainly considered for applications in military and are currently becomingincreasingly popular in the civilian sector as well. Drones have been proven an effective force multiplier with round-the-clock, heavy-duty unmanned missions for long-range surveillance, search and rescue, act of reconnoitering andalso applications related to armed conflict. Emerging advancements in Internet of Things (IoT), drone deploymentscommercially are exponentially growing from taxi and cargo services to assessment of risks, disaster management,agriculture and infrastructure monitoring criticisms. Regardless of the area of application, drones are trusted withsafety,timeandcriticaltasks'liabilityandthereforerequiresafe,potentandtrustworthyoperations.Increasingdemandforunmannedaerialvehicleswiththepressureinthemarkettodecreaseitssize,weightandparametersrelatedtocostand power has resulted in vendors often ignoring security aspects leading to serious security threats and protection.As drones depend on GPS for navigation and position falling prey to attacks such as GPS jamming and spoofing.Using previously hardware for GPS spoofing, has been demonstrated in most of the academic researches that GPS'svulnerability to spoofing has severe conclusions for UAVs as the drones that are victim to this can be misdirected orhijackedcompletelyforviciousintents.TheseGPSspoofingattacksarenotonlyonUAVsbutalsotootherplatformsthat are dependent on GPS, such as ground vehicles, manned aircraft and cellular systems. GPS spoofing threats isreviewed focusing on the applications on UAVs and mobile platforms that are dependent on GPS presenting ataxonomyoftheattacksandanalyzingseveralmethodsbasedontheplacementofthespoofingdevice,methodologiesand goalsofthe hackers[11].

As it is difficult to deal with the illegal use of UAVs and lots of threats being increased in airports, restricted orunauthorized areas and military areas, a fix to this issue is necessary and therefore "hunting" trained firearms andhawks are used. Since drones are easily accessible by the common man and also improvement in their flight controlsystem,thesituationshaveturnedouttobeverydangerouscausingincreaseinthenumberofthreats.Onesolutionto this problem is the use of a Software Defined Radio (SDR) platforms that are available at low costs and can simulateGPS so that an error in the location can be shown up on the GPS receiver that is targeted. Here the targeted GPSreceiver will transfer invalid signals for this purpose. A system can be implemented that is defensive so as to distractor even take control of unauthorized UAVs whose trajectory depends on the information received from the GPS system[12].

III. METHODOLOGY

AGUIhastobedevelopedinLabVIEWforthegivenstepsthathastobeperformedtotestthecapabilityoftheSmart Antennadevice.Theflowchartforthestepsofthetests thathastobeperformedisas intheflowchartinFIGURE 2.Eachtesthastobeperformedinthesequentialorderasintheflowchartandacknowledgmentofeachtesthastobenoted.TheacknowledgmentofeachtestneedstobeshownintheGUI.

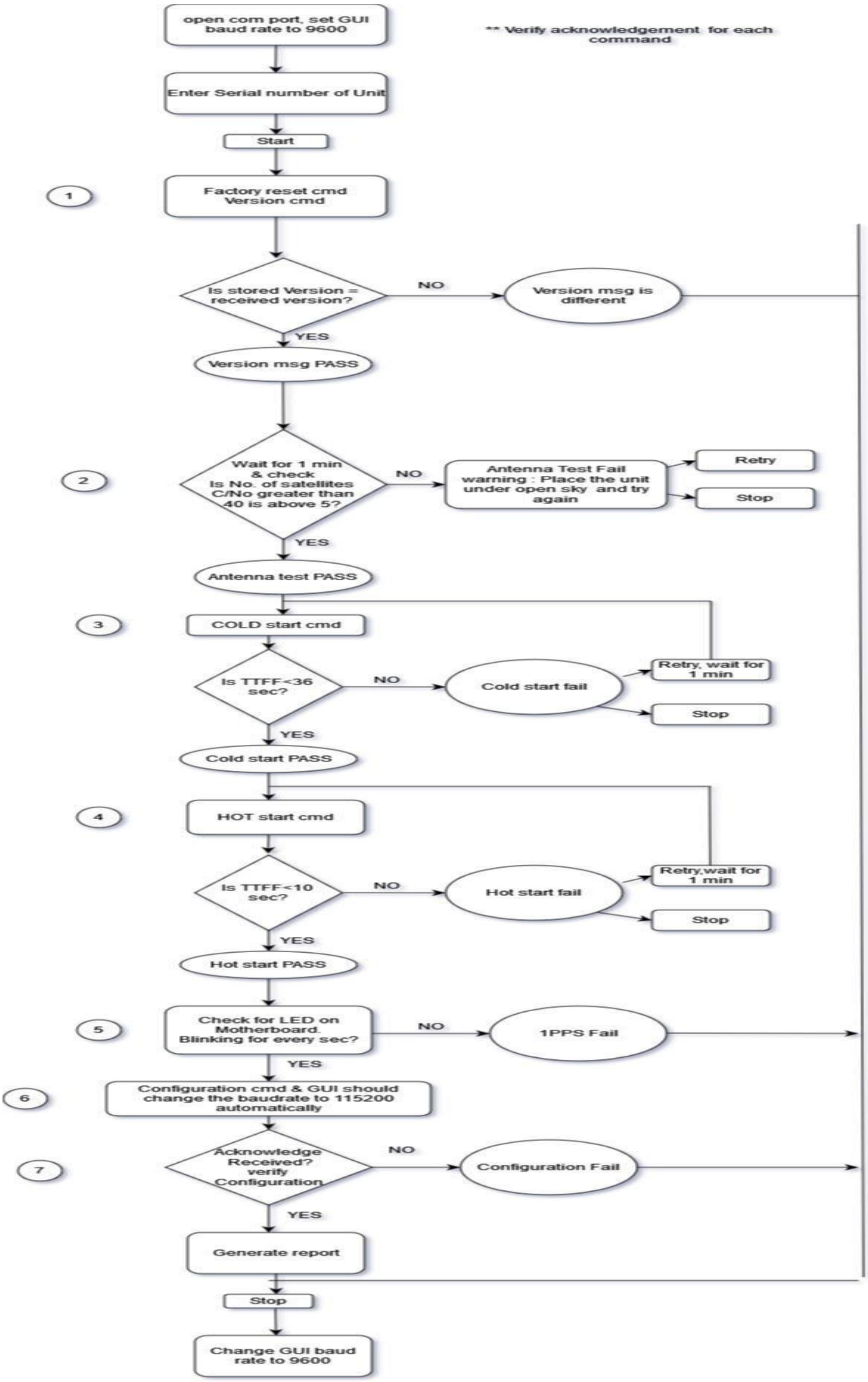

FIGURE2. Flowchartofthestepstobefollowed totesttheSmartAntennadevice

Initially, the COM port has to be initialized and set the baud rate to be 9600 and then the user can enter the serialnumber ofthe device thatisbeingvalidated.

The first step is to send the Factory Reset command and then the Version command and check for each of thesecommands the expected response is received. Once this step is successfully passed, then it needs to move to the nextstep.Otherwise,the validationhastobe stopped.

The second step is to check whether more than three GPS satellites and more than two IRNSS satellites have aC/N ratio of above 40. In case, this step fails it will provide a pop-up message to the user to check if the antenna hasbeen placed properly and will retry this step once again and if the step passes it will give a message to the user thatthistesthasbeenpassed andwillmove tothenextstep.

The third step is to give the cold start command and check if the time measure for TTFF is less than 36 seconds.If the test passes it will move to the next step otherwise, it will wait for one minute and retry this step once again. Ifthetestdoesn’tpassthenitwillstopthe validation.

The fourth step is to give the hot start command and check if the time measure for TTFF is less than 10 seconds.If the test passes it will move to the next step otherwise, it will wait for one minute and retry this step once again. Ifthetestdoesn’tpassthenitwillstopthe validation.

The fifth step is for the user to check if a light on the device is blinking for every second once they receive thepop-upmessagetocheckthedevice.TheusercanclickonYesorNodependingontheblinkinglightobserved.Iftheuser clicks on Yes, the test is passed and will move further to the next step and if the user clicks on No, the test willfailandvalidationwillbe stopped.

Thesixthstepistosendtheconfigurationcommandstothedeviceandcheckifexpectedresponseisreceived.

The final step is to receive the acknowledgment message for the sixth step if the test has been passed or failed. Ifthe test passes, it will move to the next step and if not then it will stop the validation. Report has to be generateddepictingtheserialnumber ofthedevicethathasbeentestedwiththemeasured valuesofthetests.

IV. RESULTS AND DISCUSSIONS

A GUI to validate the functioning of the device has been developed. The GUI will be as shown in FIGURE 3. Itwill show which step is currently being performed and the status of each step will be shown at the sidebar where theblock withred colourwillchangetogreencolour once thetestispassed.

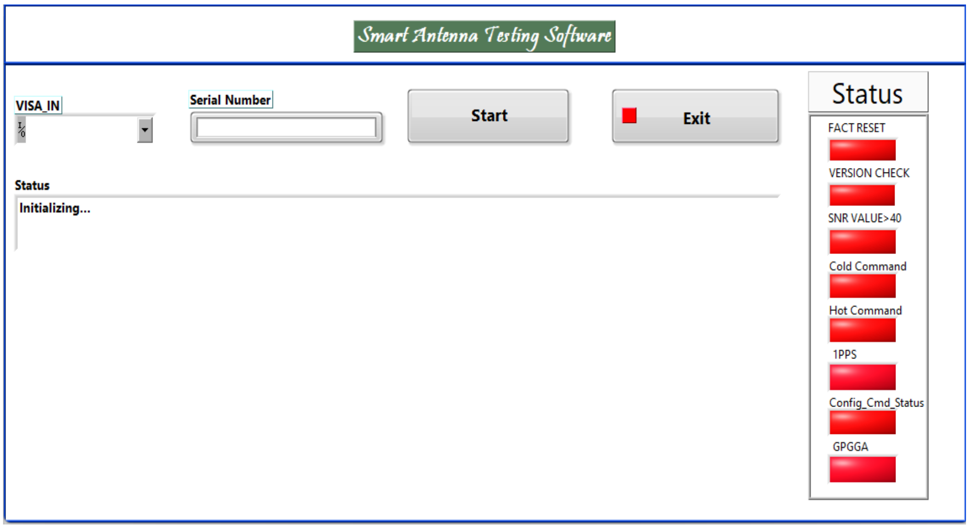

FIGURE3. GUIdeveloped totesttheSmartAntennadevice

The report for the tests performed will also be generated. The report will contain information such as ProductName, Part Name and Serial Number of the device that is being tested, the date and time of the test completed, theTTFFmeasureforColdStartandHotStart,thenumberofGPSsatelliteswithC/Nratiogreaterthan40dBHz,the numberofIRNSSsatelliteswithC/Nratiogreaterthan40dBHz,1PPSmonitoring,VersionNumber,Factory Resetand ReceiverConfigurationasshowninFIGURE4.

Smart Antenna Test Report

Product Name	Smart Antenna
Part Number	123
Serial Number	123111
Date and Time	17-05-2022 15:24:02

Test Report

Cold Start(s)	33.422000
Hot Start(s)	0.203000
No. of GPS Satellites C/No >40dBHz is >=5	Pass
No. of IRNSS Satellites C/No >40dBHz is >=2	Pass
1PPS	YES
Version No.	$GPTXT,Telit V34-0.0.4-NVC-4.5.12.4-N96-003210*49
Factory Reset	DONE
Receiver Configuration	Pass

FIGURE4. Reportforthetestsperformed

V. CONCLUSION

A GUI was developed to validate the functioning and capability of the Smart Antenna device by various stepsusingLabVIEW.Eachstepdepictsdifferentteststhatareperformedusingdifferentparametersthatareusedtocheckthe device's caliber. The different parameters that are used here are the factory reset command, version checkcommand, configuration commands, cold start command, hot start command, checking the number of satellites withC/N ratio greater than 40dBHz for both GPS satellites and IRNSS satellites that have been tracked and 1 PPSmonitoring.ThestatusofeachtestperformedisindicatedintheGUI.TheGUIisdevelopedinLabVIEWsoastotestfor multiple Smart Antenna devices at once then that can be achieved effectively. The Smart Antenna devices can beused formilitaryapplications.

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