Automated Test System for Laser Designator and Laser Range Finder

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***Abstract*: Lasers and Electro-optics is a field of research leading to constant breakthroughs. Advances in optical components and systems are innumerable since the advent of lasers and electro optics. Using these cutting edge technologies, innovative solutions have been developed in the field of Thermal Imaging, Infrared optics and other Laser electronic systems. One of the uses of this is the laser designator and range finder. Hence to test this system, an automated test system is built using Xilinx Spartan-6.**

Keywords: Laser designator,range finder, Spartan-6, test system.

I INTRODUCTION

Technological advances in optics, optoelectronics leading to more rugged and efficient laser devices are largely responsible for making them indispensable in modern warfare. Lasers and Electro-optics is a field of research leading to constant breakthroughs. Advances in o-optical components and systems are innumerable since the advent of lasers and electro optics. Using these cutting edge technologies, innovative solutions have been developed in the field of Thermal Imaging, Infrared optics and other Laser electronic systems. Electro-optics is a technology based on the conversion of electricity into light. Army uses electro-optics for air defense systems, for airborne reconnaissance and surveillance using thermal imagers in Unmanned Aerial Vehicles (UAVs). The night vision devices, miniaturized Laser Range Finders (LRF), Laser Target Designators (LTD), laser warning sensors, fire control systems and Electro-optic (E-O) counter measure systems are used for military applications.[1]

There has been large scale proliferation of Lasers and Optoelectronic devices and systems for application like range finding, Target acquisition, Target tracking and designating. The unique characteristics of lasers offer significant improvements in the detection limits up to several kilometers. Unlike other forms of light, laser light has special properties which make it significantly more effective and dangerous than conventional light source of the same power. The laser light particles (photons) are usually Mono-chromatic meaning consisting of a single wavelength or color and Coherent meaning all the photons are in phase. Collimated photons are almost in parallel (aligned), with little divergence from the point of origin. It is this coherency that makes all the difference to make laser light so narrow and easy to focus on to a target. It is also associated with high directionality and monochromaticity that the photons in these waves are not only in the same phase but with same wavelength. The remarkable feature of laser is that it can be concentrated to very high energy and intensity over long distances.[2],[10]

The use of laser technology on the battlefield has developed in three primary areas: laser target ranging and designation systems, laser acquisition systems, and laser-guided munitions (LGMs).Laser designators and ranging devices are mostly used in civilian purpose like building surveys, search and rescue operation, hunting etc.

1.) Laser target ranging and designation systems provide accurate directional distance and vertical angle information for use in locating enemy targets. These systems may vary from hand-held to aircraft-mounted devices, but they all perform the same basic function. Once a target has been selected and accurately located, the laser designation capability is used to identify the specific target for laser-guided munitions.

2.) Laser acquisition devices are used to acquire reflected laser energy. These devices are used in conjunction with laser designation systems to pinpoint targets or other specific items. Normally, laser acquisition devices are mounted on fixed-wing aircraft or helicopters.

3.) Laser-guided munitions home in on reflected laser energy during the terminal portion of the attack to accurately hit the specific target. Such munitions are part of the precision guided munition (PGM) family.[3]

Key factors must be considered when employing laser systems. Adverse effects of these factors can often be overcome by planning and skillful employment of the designators.

A. GROUND MODE

Ground laser designators identify targets for artillery and aircraft delivered munitions. Equipped teams can designate for laser guided munitions as well as conventional ordnance delivered by Laser Spot Tracker (LST). Standard calls for fire are used except that the laser code must be exchanged between the ground designator and the firing unit or the aircraft.

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B. AIRBORNE MODE

Airborne laser target designators identify targets for all types of aircraft delivered munitions. Air borne designator systems operating in support of ground maneuver forces can employ all types of laser guided munitions. Standard calls for fire or request for air support are used, except that the code being used must be exchanged.

C. COMMUNICATIONS

Positive communications between the designator operator and the munition delivery means is required to coordinate the proper Pulse Repetitive Frequency (PRF) code, the seeker/laser designator alignment, and target designation timing.

D. COUNTERMEASURES

Judicious use of laser target designators limits the enemy's countermeasure capability. Designator vulnerability must be considered when designating point targets such as tanks, and guns that can detect radiation and suppress designators. Offset aim points reduce a target's ability to react.

E. AIM POINTS

The nature of the target surface affects the aim point and varies the amount and direction of reflected radiation. Concave or poorly defined targets such as caves and tunnels may absorb the laser spots. Horizontal flat surfaces can refract or cause enough spillover to cause misses.

F. BATTLEFIELD OBSCURATION

Smoke, dust, and debris can impair the use of laser guided munitions. Reflective scattering of laser light by smoke particles may present false targets. The night sight, alternate positions on higher ground, and alternate designators can be useful in reducing smoke and dust effects.

G. DARKNESS

Targets are more difficult to locate, range, and designate during low illumination. The night sight on the designator will overcome the effects of darkness and can assist during periods of poor visibility and inclement weather.[4]

As these designators could be land based or airborne, depending on their uses there are varied functions which have to be verified before putting them to use to ensure that they work as desired at the time of requirement. Hence it is very important to test systems thoroughly for all their functionalities.

The objective is to design an automated test and clearance system for checking functionalities of a designator system and to certify with supporting data that the system is working satisfactorily meeting all requirements. The designator system being critical in its operations, it is essential that there be a system which completely tests the designator which is complex in its operation and at the same time due to its precision, laser measurements is very much preferred in defense

II LASER RANGE FINDER AND LASER DESIGNATOR

Laser Range Finder (LRF) is a device which uses a laser beam to determine the distance to an object from the aircraft. The most common form of laser operation is the time of flight principle by sending a laser pulse in a narrow beam towards the object and measuring the time taken by the pulse to be reflected off the target and returned to the sender. LRF is capable of measuring the distances up to 20 Km.[7]Laser designators are nothing but high power laser sources

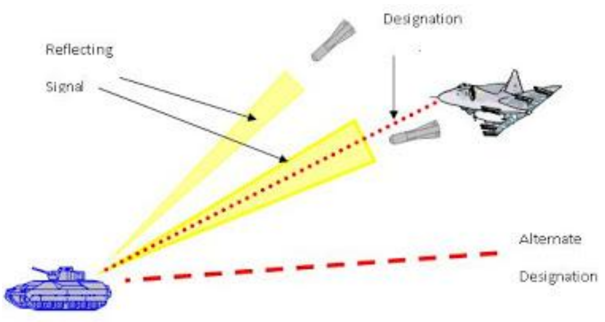

Fig 1 Application of LRF/LDR

with an optic system to get a narrow and parallel beam and high energy power supply and complex circuitry to help code the laser pulses generated for the designator. Coding becomes necessary to avoid jamming of laser. The principle behind laser ranging is that the delay between the designating LASER pulse and received laser pulse after reflection from target is measured and calculated in terms of distance. Laser-guided smart bombs work a little differently. Instead of a video camera sensor, the bomb has a laser seeker, an array of photo diodes.

The photo diodes are sensitive to a particular frequency of laser light. For the bomb to see its target, a separate human operator, either on the ground or in the air, has to "paint" the designated target with a high-intensity laser beam. The laser beam reflects off the target, and the laser seeker picks it up, as seen in the Fig 1. Airborne Laser designator is used to designate a target with the help of Infra-Red laser beam. Laser designators provide targeting for laser guided missiles or precision artillery munitions. [8]

III LITERATURE SURVEY

Laser technology is a well-established old branch of science. Though many applications were thought of with the expanding knowledge in the field of lasers, there was a limitation of matching electronics for processing the precise and minute time intervals involved in laser measurements.

With the advent of fast processing devices and large scale integration of circuits, very light, power efficient measurement equipments have become reality. In earlier times using parallel processing techniques measurements have been made but resulting in large power consuming

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and very heavy equipments. The case of automated test system for laser designators or ranging system was not much different. In the present approach the design of the system is around the Field Programmable Gate Array (FPGA).

Previously, the implementation of test system was done using microcontrollers and microprocessors which are time limited and take a long time to achieve the hard-real time limits.

- Intel's 8051 microcontroller: 8 bits wide, with only a clock speed of 12MHz. [5]
- Another automated test system was built using the 8088 or the iAPX 88 microprocessor. The processor has a clock speed of 10 MHz but is a 16 bit wide processor.

Due to large scale integration, FPGAs are more popular. FPGAs focus mainly on parallel execution. Unlike the long time taken by controllers and processors to execute the Interrupt Service Routine (ISR), FPGAs have many Finite State Machines that keep running all the time. They are like femto-controllers or like little clouds of control logic. They run simultaneously so there is not missing interrupts. FPGAs have the more relied upon or desired digital clock manager. One input clock signal is fed and it can derive 4 or more from it using a wide variety of frequency multipliers and dividers. [6], [9]

The current work involves use of XILINX FPGA board, Spartan-6. The features of Spartan 6 are

- has a 42% less power consumption and 12% increase in performance over its predecessors
- has up to 150k logic cells
- advanced memory support at 320MHz
- and 3.2Gbps low-power transceivers

IV IMPLEMENTATION

The implementation of the system is done as shown below. The communication between the Enhanced Laser Designator (ELDR) and the FPGA kit is done through the RS232 port.

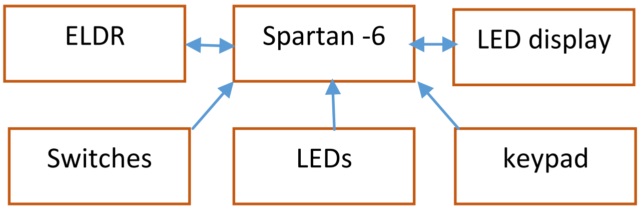

Fig 2 over view of the system

As seen in Fig 2, the inputs are given through the keypad and/or the switches. The given command is displayed on the LED display. The answer awaited from the ELDR is then decoded and displayed on the LED display. To show the start and stop of the operation required, say range finding, the LED is turned on and when the range is detected, another LED is turned on to denote it.

To monitor the signals, a controller is required and hence, Xilinx embedded development platform is used to customize the required controller; Microblaze. The controller designed here is a 32-bit RISC architecture controller running at a clock rate of 100MHz with program memory of 64Kb.

A RANGE FINDER TEST IMPLEMENTATION

The system overview for the test of range finder is as shown in Fig 3. It consists of the laser designator enclosed in a partially reflective glass casing, receivers, Spartan 6 kit, range display i.e. LED display and serial interface.

The ELDR transmits the laser at the target. Simultaneously, a glass casing placed around the ELDR reflects the light towards the test system and these acts as a start pulse for a counter in the FPGA kit. The laser beam is reflected by the target and once the beam is received, this acts as a stop pulse for the gate.

The delayed laser pulses received are sent to the automated test system. The automated system computes the delay between the fired laser signal and received laser signal by implementing a high speed counter in the FPGA kit and the information is available on the automated system for verification. This delay is converted into distance and hence the range of the target from the designator can be displayed on the display devices.

The main parameters checked during the testing are the Pulse Repetitive Frequency (PRF), range, modes and wavelength. The range denotes the distance between the designator and the target. The wavelength is used to check against the received signal and validate it. Also wavelength sent is set around the value of 1064nm or 1557nm which is eye-safe. Hence the desired wavelength can be set and also the seeker is tuned to the same frequency. The pulse sent by the designator is actually encoded such that no signal is intercepted and hence it is not jammed. To do this, the PRF is used so that the frequency is a unique value. This is transmitted repeatedly and can only be detected by a seeker tuned to the same frequency. The modes used here can be continuous mode or burst mode of transmitting the laser to designate the target.

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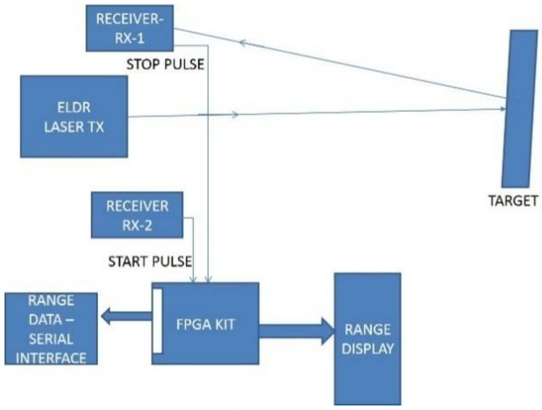

Fig 3 test setup for laser range finder

The flow chart for the working of the module can be seen in Fig 4. The counter must be initialized at the beginning. The counter starts only if the start pulse is high and stops when the stop pulse is enabled. If the value in counter corresponds to 200m, an error message is displayed. If the value is well within the counter limit, the

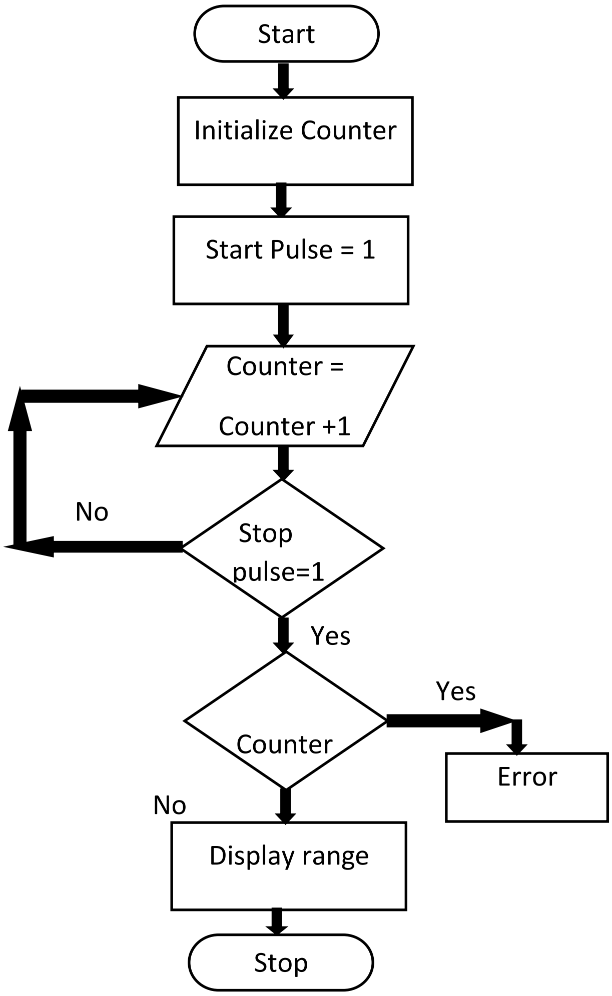

Fig 4 flow chart for the operation of range finder

range is displayed on the LED display.

B LASER DESIGNATOR TEST IMPLEMENTATION

The test setup for the designator can be seen in the fig 5. The inputs set on the panel of the automatic test system containing the information like the PRF, wavelengths and mode are read by the FPGA and the control circuitry and a serial stream compatible with the ELDR is sent to the ELDR which, on reception will fire the laser and designates the target.

The reflected signals received by the receiver/ seeker in the ELDR are processed by the ELDR and a serial stream of data containing a confirmation of the action is displayed on the set of displays in a suitable format.

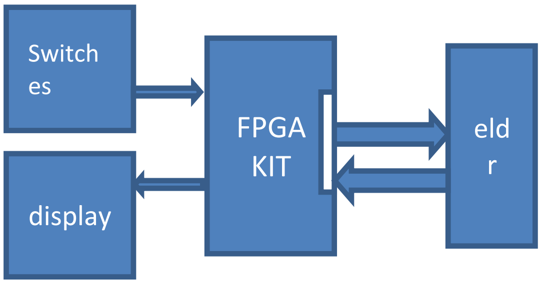

Fig 5 designator test setup.

The algorithm stated below explains the working of the test setup for designator. On power on, the condition of the designator must be known. Hence tests must be run on the designator. The appropriate command is given by the command panel to the ELDR. The commands to be sent are formed into packets by the FPGA and sent to the ELDR through serial communication port. The ELDR decodes the commands and runs the necessary checks and hence sends an appropriate reply. This reply received is decoded by the FPGA and then displayed on the LED character display.

Algorithm

1. The laser designator is powered on
2. A command is sent from the command panel to run certain checks
3. The command is sent in the form of 20 byte packet.
4. Replies about the checks are received
5. The data is received in serial stream is decoded
6. The range is displayed

V CONCLUSION

The designator system being critical in its operations, it is essential that there be a system which completely tests the designator which is complex in its operation and at the same time due to its precision, laser measurements is very much preferred in defense. As the work is ongoing, the above solution of using an FPGA will be an accurate and cost effective method to test a laser designator and range finder.

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