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Project Number 20070901

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Subject: Construction Bypass Traffic Routing System.

Dr Areibi,

Please find enclosed a copy of Altec Systems Inc's proposal to design and develop a Construction Bypass Traffic Routing System. We have illustrated in this proposal sensor and software analysis. A final report on Monday December 3, 2007. Thank you for your continued contribution in the matter.

Sincerely,

Jonathon Smith

Dan Ifrim

Stephen Turner

EXECUTIVE SUMMARY

This project looks at the issue of creating a device for dynamically routing traffic around road construction and repair. The device will use a pair of traffic lights to control the flow of traffic controlled by a central controller. This report outlines what has been accomplished in the month and a half since the initial proposal submittal. We have completed software and hardware design of the prototype and have begun implementation. We have also researched different possible sensors and powering options and presented our findings in this report. The design will consist of a master and slave unit each controlling a traffic light. Sensors will be used to determine the presence of cars on either side. The system will then attempt to dynamically route the traffic adjusting to minimize delay for both sides. A final report for the project will be submitted on Monday December 3, 2007.

BACKGROUND

The construction industry is responsible for re-routing traffic around work sites where there is no possibility of total road closure. The current system to manage traffic around road closures is dependent on a work team of two or more employees. Such being the case it can become quite the enduring task in extreme heat and cold conditions. Thus Altec Systems Inc has proposed an automated traffic management system. The proposed system will reduce the stress and workload of the employees at the work site allowing for the reallocation of manpower to various other tasks.

SENSOR ANALYSIS

The choice of which sensors the system will implement were decided based on the criteria and constraints of the system. That is the sensors were chosen based on their simplicity of interface, ease of deployment and low cost. Besides the primary sensor a backup system consisting of a different type of sensor was chosen to better detect false detections from the primary sensor.

The primary sensor was chosen to be a magnetic sensor. Magnetic sensors detect changes to the earth's magnetic field due to the proximity of ferromagnetic objects such as automobiles to the sensor. The sensors are non-contact and can detect numerous vehicles moving at high speeds. Figure 1.0 below shows the theory behind its operation.

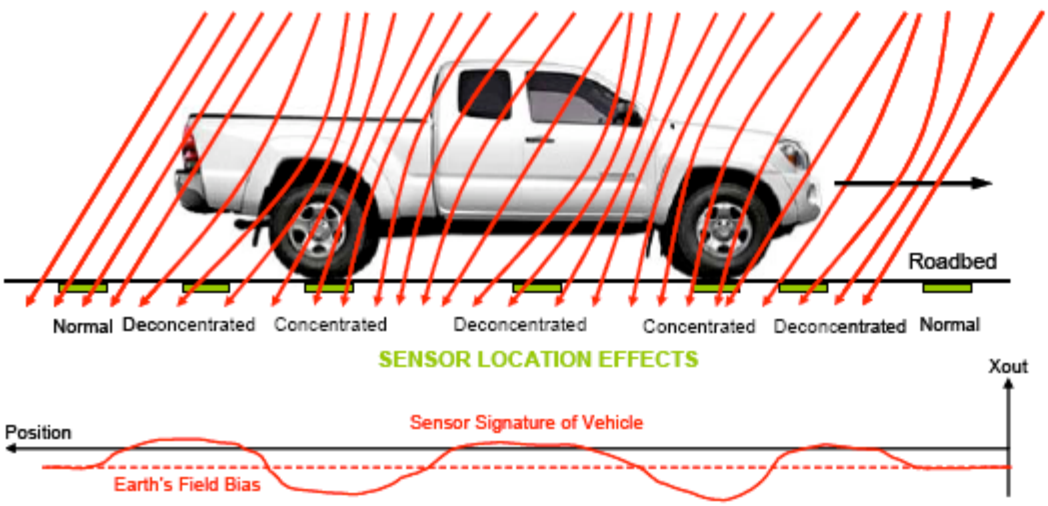

Figure 1.0: Magnetic Sensor Vehicle Detection

The secondary sensor chosen was the ultrasonic sensor. Ultrasonic sensors work by generating a high frequency sound wave and calculates the time it takes for that sound wave to reflect off an object and return to the sensor to calculate the distance between that object and the sensor. These sensors can be used to detect any object and have a range of around ten meters. . Figure 2.0 below shows the theory behind its operation.

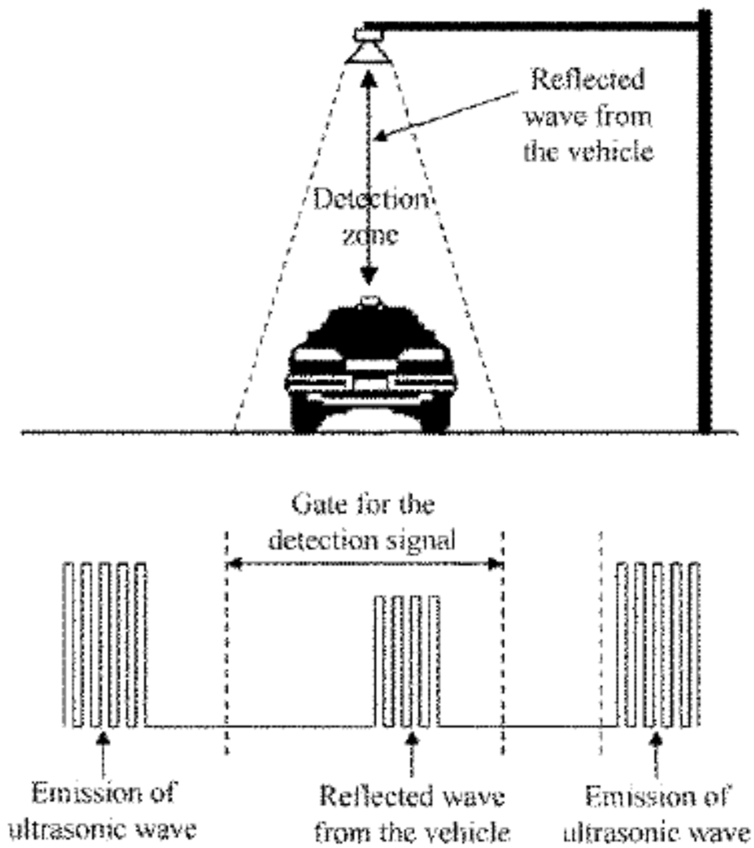

Figure 2.0: Ultrasonic Sensor Vehicle Detection

The magnetic and ultrasonic sensors were chosen based on the systems criteria and constraints and also a comparison of their advantages vs. their disadvantages. This comparison can be found in table 1.0 below where all the sensors considered for this system were evaluated. As you can see from the table, both the magnetic and ultrasonic sensors were found to be compact, easy to install and versatile. The magnetic sensor however was found to be prone to false vehicle detection to vehicles traveling in the adjacent lane. In this case the ultrasonic sensor would then verify that a vehicle was detected. Both sensors are sensitive to temperature changes, however the magnetic sensor is sensitive only to rapid temperature changes, which is relatively uncommon. The use of a backup sensor will be enough to offset this disadvantage.

	ADVANTAGES	DISADVANTAGES
MAGNETIC	• Compact size • Ease of installation • Multiple lane operation available.	• Adjacent lane vehicles could cause a false vehicle detection • Rapid temperature changes may cause false detection • Rapid changes in earths magnetic field amplitude may cause false detection
ULTRASONIC	• Compact size • Ease of installation • Multiple lane operation available.	• Sensitive to temperature and air turbulence • Large pulse repetition periods may degrade occupancy measurement on freeways with vehicles traveling at moderate to high speeds.
INDUCTIVE LOOP	• Provides basic traffic parameters (e.g., volume, presence, occupancy, speed, headway, and gap).	• Wire loops subject to stresses of traffic and temperature. • Multiple detectors required to instrument a location.
PHOTOELECTRIC	• Accurate measurement of vehicle position, speed, and class. • Multiple lane operation available.	• Potential degradation by heavy rain and heavy snow • Potential degradation by obscurants in atmosphere and by inclement weather

Table 1.0: sensor advantages vs. disadvantages

POWER ANALYSIS

Construction companies usually keep power generators around construction sites in order to power various machines and tools. These generators range in power from 4 000 to 8 000 watts and can power equipment for an average of 16 hours off 1 tank of gas. It is assumed that these generators will be the primary power source for the system. As an alternative backup power supply, modular solar polar was researched.

Solar power via photovoltaic modules is a reliable and efficient power supply. These modules collect solar thermal energy and convert it directly into electrical energy. The decision to use solar power was based on the criteria and constraints of the system. It was found that the setup of solar panels was extremely modular and portable; being able to plug into the panel like it was a typical wall outlet. Since solar panels are available globally for businesses and consumers, prices of manufacturing have fallen a lot resulting in increased cost efficiency. Being water resistant and weather resistant makes solar panels ideal for implementing under the conditions found at construction sites. An example of a satellite solar panel setup is shown below in figure 3.0.

Figure 3.0: Satellite solar panel setup

Besides the solar panel as the backup power supply, there will also be a backup system of a storage battery implemented as a reserve power supply. The storage battery will provide the power required for the system to operate, whereas the solar panels will provide the power to recharge the battery. Therefore the solar panels must provide at least as much power to the battery over an interval as is required to power the system. Figure 4.0 below shows a block diagram outlining the design of such a system.

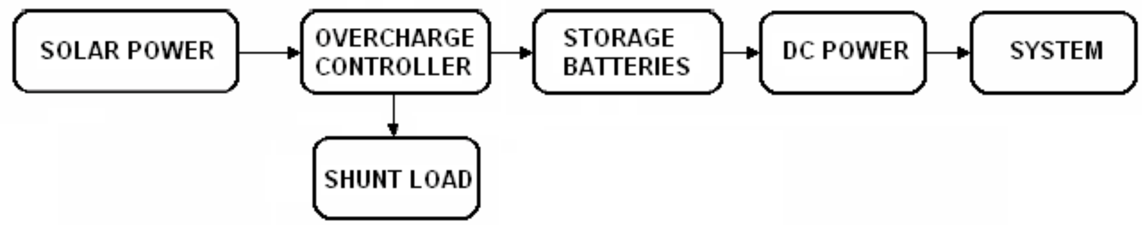

Figure 4.0: Block diagram of solar panel system

In order for the storage battery to efficiently and reliably provide power to the system, their charging must be governed by a charge controller or a charge regulator. The charge regulator ensures that the battery is not overcharged, undercharged or connected with reversed polarity, all of which would result in the permanent damage of the battery as well as decreased battery life.

SOFTWARE

At this stage in development of our project we have completed all of the logic design for the major components of our system and have started to implement the software. We have broken the software into 6 main program modules to be developed independently then combined into the two software programs for the master and slave. The project modules are:

- Program activation
- Manual mode logic
- Auto mode logic
- Communication
- Maximum Timer interrupt
- Car sensor interrupt

Each of these software modules will be coded individually as a series of normal and interrupt service subroutines.

The program activation subroutine will be responsible for starting the main software, initializing registers, timers and interrupts and establishing initial communication. Upon initialization the activation routine will first set the light red, then initialize the a/d, the timers, the serial interface then wait for the user to press the connect button, when the user does the program will establish the serial interface connection with the R/F module and through that the connection to the slave unit. The program will then hand off control to the main control loop. The slave's initialization routine will be identical to the masters, the software flowchart for the master initialization can be found in appendix A1.

The system will have to function in both manual mode as well as automatic mode. The manual mode configuration will be activated by a manual/auto toggle switch. The main program loop will check this switch through every iteration and if it finds it is high it will start manual mode. Manual mode will be controlled by 2 switches, one for the master light (light 1) and one for the slave light (light 2). Toggling the switch high will indicate to the software that that light should be set to red, toggling the switch low will indicate to the software that the light should be green. For safety reasons it will be impossible to set both lights to green. If at any time both toggle switches are set low the software will automatically set light 2 to red and activate the error light. Under normal operating conditions toggling the light to red will produce a normal green to yellow to red transition in the light. There will be 3 appropriately colored indicator lights next to the switches so the operator can see the current state of the lights. The complete logic flow chart for the manual mode of the system can be found in appendix A2.

When the switch is toggled back to automatic mode the internal software logic will take over. The software tracks and estimate of how many cars are on each side and when the number of cars on the red side exceeds the car threshold as set by the car threshold knob the software should then switch the lights. The lights also switch when the max wait timer interrupt fires. The software flowchart illustrating the master control logic can be seen in appendix A3. The slave has less responsibility then the master in that it only watches traffic on it's side of the road. When the slave's light is red and the car threshold has been exceeded on the slave's side it sets it's light change request bit high in the slave state register, the count is then reset when the slave receives the light change from the master.

In order to facilitate the master/slave communication we are going to implement 2 memory buffers. One will be the command buffer, which the master will use to send commands to the slave, the other will be the slave state buffer which the slave will use to send it's state to the master. Various parts of the software will be able to write to and read from the buffers as necessary and the 2 buffers will synchronize between the master and slave every time the timer interrupt triggers, the master sending the command buffer to the slave and the slave sending the state buffer back. In this way the communication between master and slave will be transparent to the rest of the system. Both buffers will be 8 bits in size. The master command buffer will have the required slave light state as the 8th bit, the manual/auto state as the 7th bit and the light change threshold as the remaining 6 bits. The slave state register will have the 8th bit as the change request bit, the 7th bit will be a counter error bit, the 6th bit will be the emergency stop bit and the remain bits will be unused. The communication subroutine will also be set up in such a way that if communication is not successfully achieved every 10 seconds the software will assume there is a problem and force the light red and sound an alarm. A flowchart of the master communication software can be found in appendix A4.

To facilitate traffic moving the software will have a control knob, which will set the maximum time the lights can wait before they must change. This knob will control the time setting of the max wait time interrupt. This timer will reset when ever the light changes or when it expires. When the interrupt fires the light will change and the timer will reset. This flowchart can be found in appendix A5. The other interrupt the software will use will be binary interrupts slaved to the sensors. When the appropriate interrupt fires the software will increment or decrement the car counter as necessary.

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Auto Mode Master

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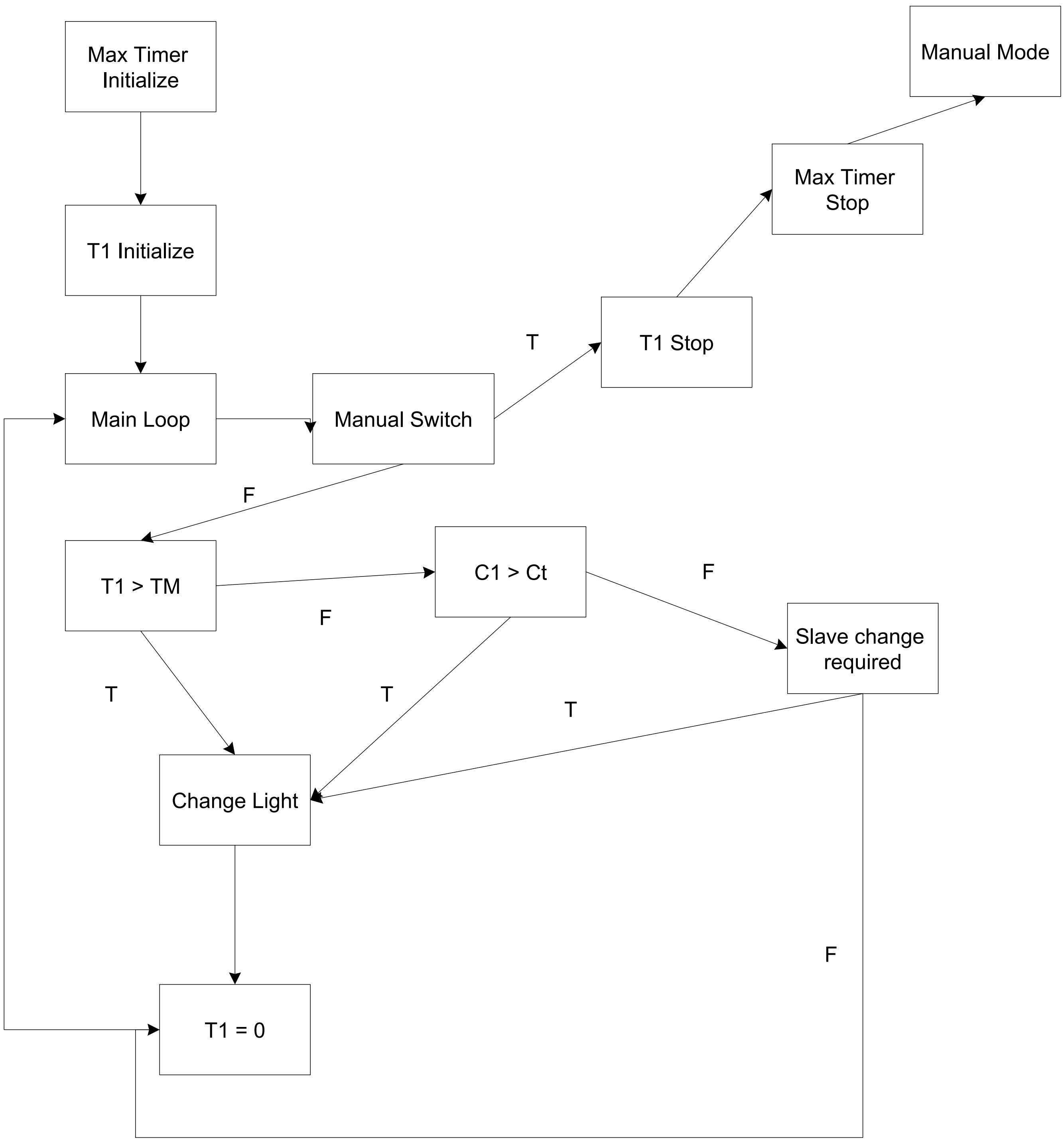
C1 = Cars Master Side
C2 = Cars Slave Side
TM = Min wait time
T1 = Timer One
Ct = Car Threshold



Note: Max Timer Triggers Interupt

Manual Mode

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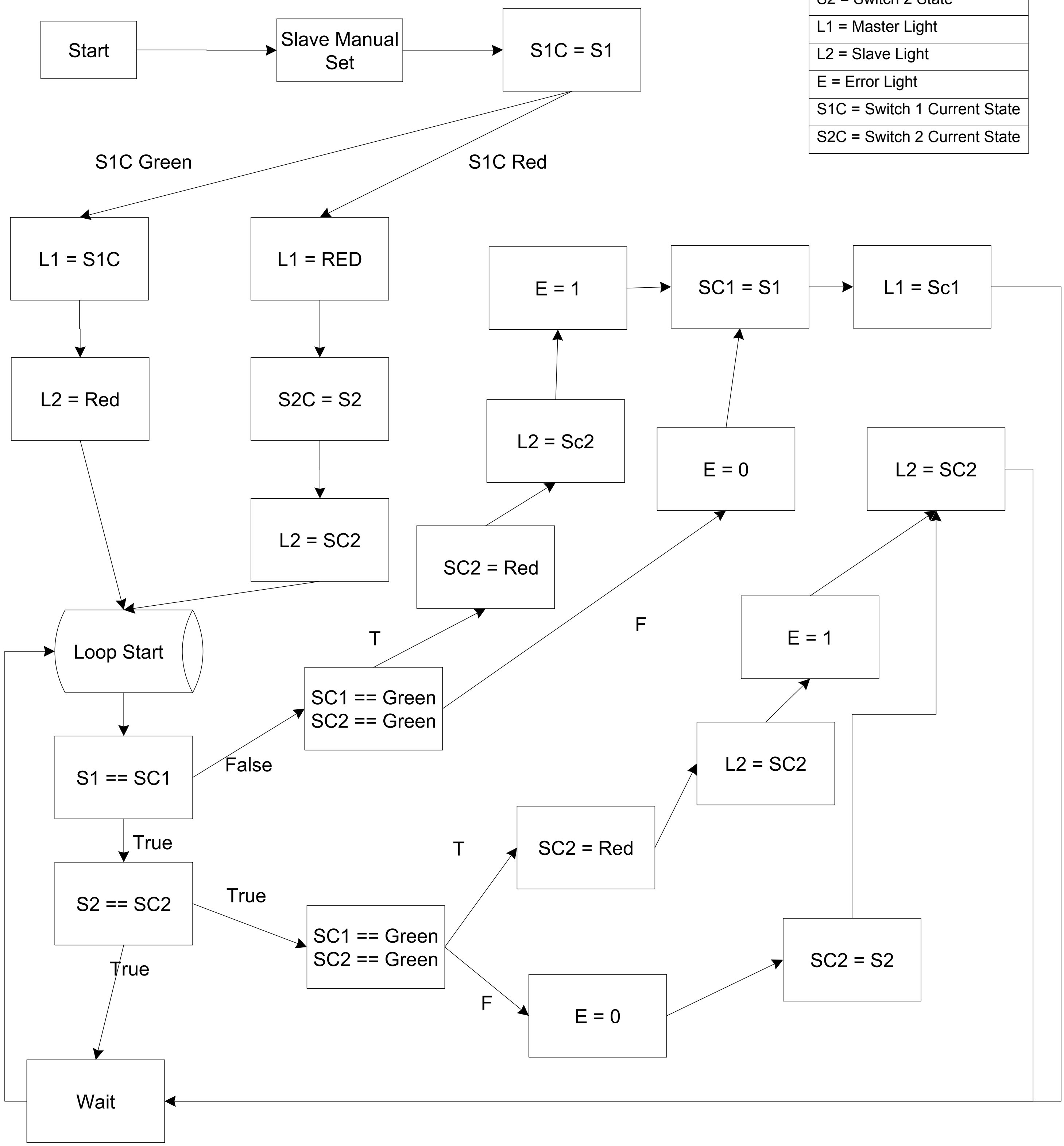
S1 = Switch 1 State	
S2 = Switch 2 State	
L1 = Master Light	
L2 = Slave Light	
E = Error Light	
S1C = Switch 1 Current State	
S2C = Switch 2 Current State	



Master Communication

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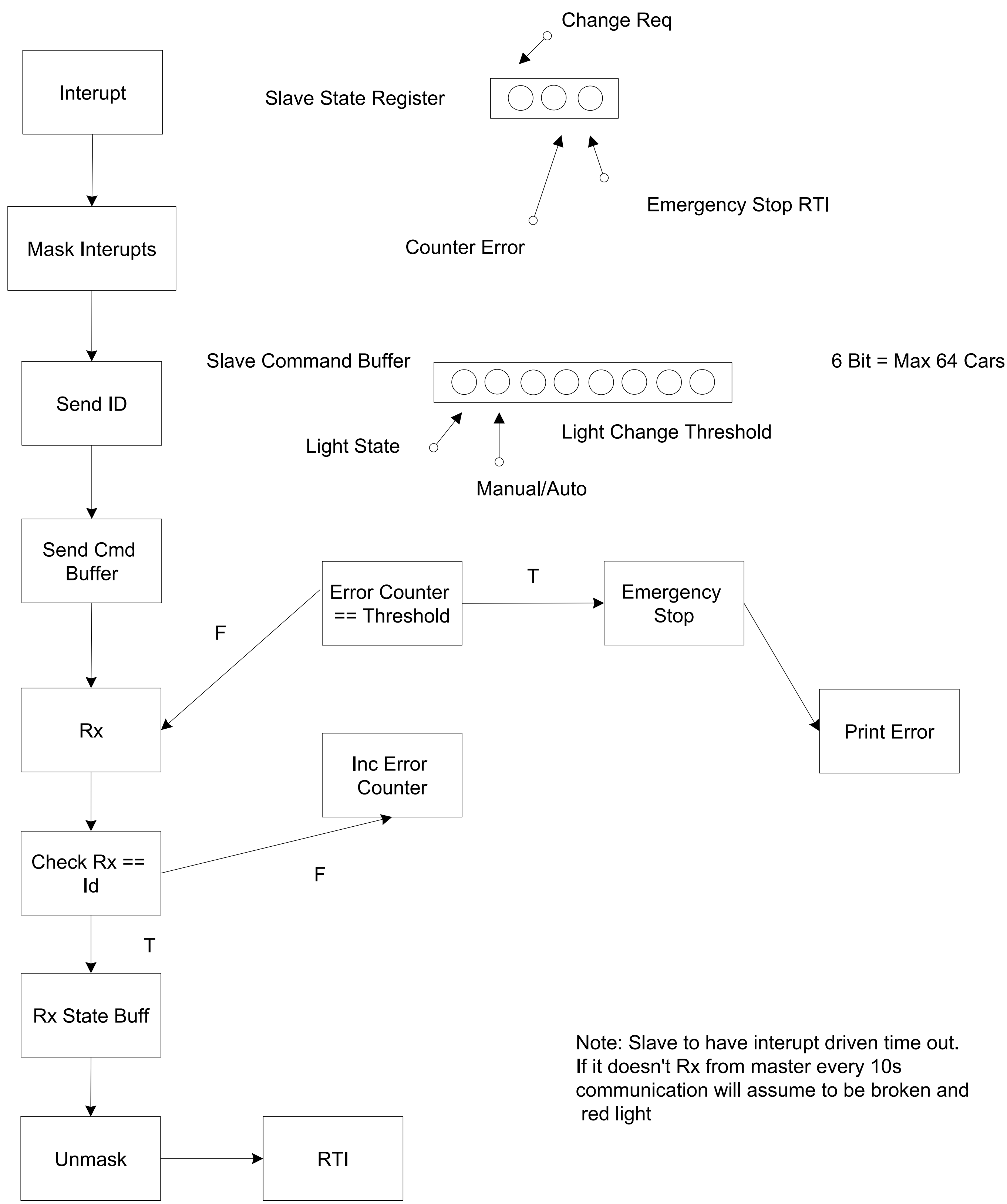

Note: Slave to have interupt driven time out.
If it doesn't Rx from master every 10s
communication will assume to be broken and
red light

Master Overview

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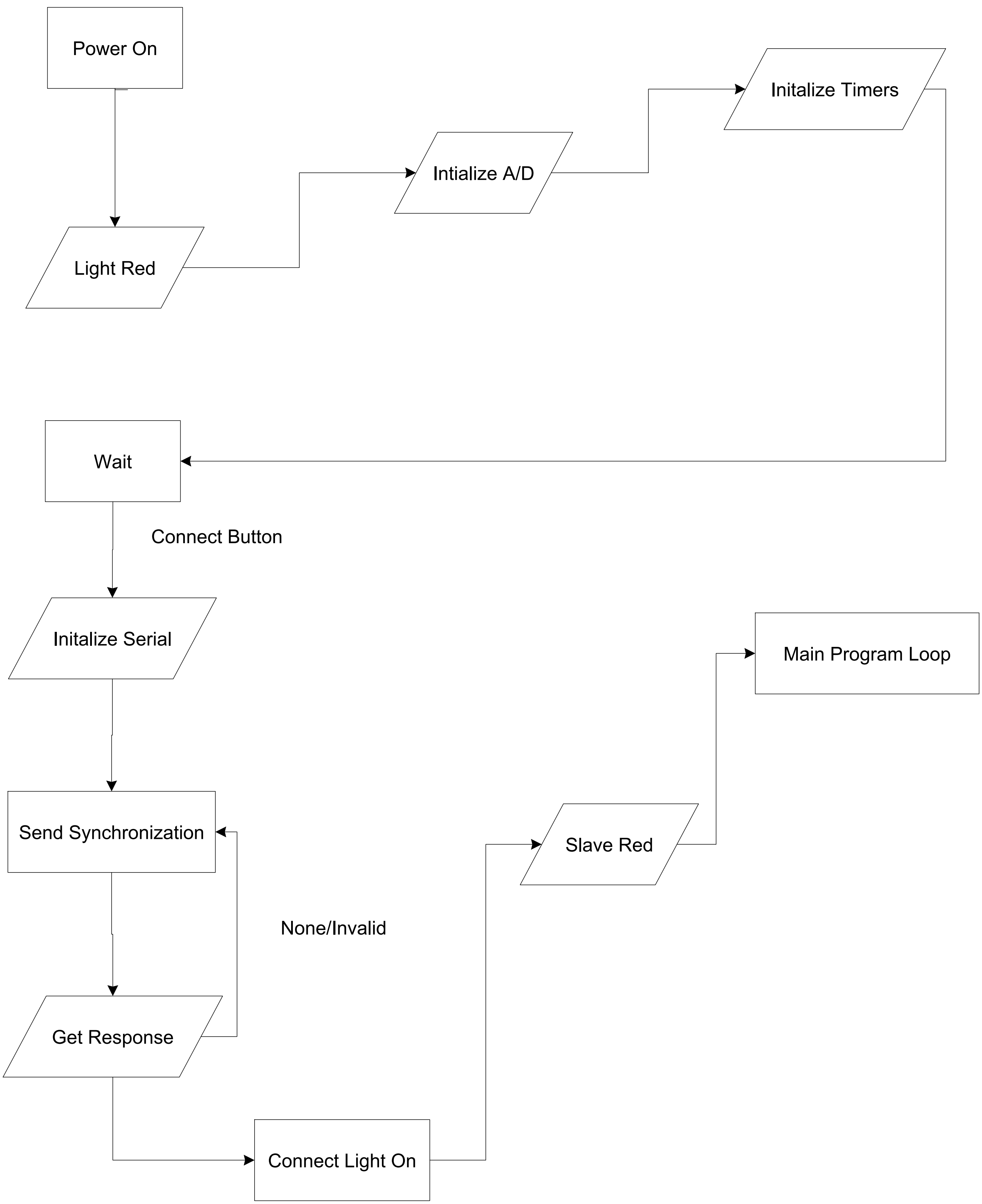

Max Time Out

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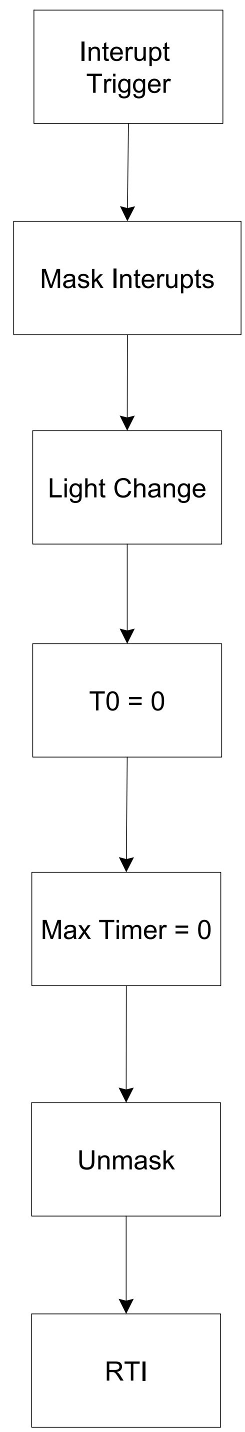

Sensor Schematic

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