New wireless thumper controller

Kevin Bertram

ABSTRACT

CREWES has access to a shear wave accelerated weight drop thumper source. A mass is raised using hydraulics against pressurized nitrogen (~1000psi) and then releases it to strike an aluminum foot to generate seismic energy. This thumper has the ability to drive energy straight down or to be tilted forty five degrees to either side to generate shear waves.

The thumper control system is simplistic in that it is a set of single pole double throw switches that control the hydraulic valves. Currently the operator has to stand near the thumper, specifically near the engine, to run it. This exposes the operator to high pressure hydraulics and nitrogen as well as the heat and noise of the engine.

To make it safer and more comfortable for the operator a wireless controller for the thumper has been built. This device has a fairly large range but is expected to only be used a few metres from the thumper. With cold weather in mind, this is designed to be used from within the vehicle that is towing the thumper.

INTRODUCTION

The s-wave thumper has a control box on it that directly drives the electronic valve mechanisms to move bits of the thumper. The parts that are designed to move are:

- The stabilizers on both sides at the back of the trailer, which come down for stability and are raise when the thumper needs to be moved.
- The foot which is moved down to contact the ground for the shots and is raised when the thumper needs to be moved.
- The tilt mechanism that is used to tilt the mast forty five degrees to either side of the trailer for s-wave sources.
- The mass hook. This one needs to move down to latch onto the mass and then lifts it up against the nitrogen spring.

The switch panel on the thumper has five SPDT switches to control these (each stabilizer has its own separate control). Although this works there are a few disadvantages to this setup. One of the problems is that the cable connected the control box to the valves is short, and after being damaged a few times keeps getting shorter. The operator currently has to stand near the gas engine that is driving the hydraulic pump to operate the thumper. The engines exhaust is dangerously hot and the engine itself is quite noisy, which makes radio communication with the operator difficult, Figure 1.

FIG. 1. Where the operator has to stand to run the thumper from the built in switch panel.

This setup also requires that the operator step out of the vehicle to set up and take the shot for each shot point. After the shot is complete the operator has to raise the foot and stabilizers and get back in the vehicle to move to the next shot. During times of cold weather it would be more comfortable for the operator to remain in the vehicle.

With this in mind an initial design for a new thumper control was explored.

DESIGN

Initially the designed called for an extendable cable to run between the thumper and the vehicle towing it. The cable would be brought through a window and the operator would have a switch panel similar to the one on the thumper. Although this would work it would have a few issues. Should the tow vehicle not have a back window that opened it would not work. Having such a long cable also exposed it to getting caught on vegetation or other obstacles and would be a tripping hazard for anyone working around the thumper.

A more advanced solution was created using microcontrollers and wireless transceivers. A very basic overview can be seen in Figure 1. A prototype has been built and tested in the field. The unit uses off the shelf microcontroller kits in the form of Arduino Uno's, Figure 3. These units have gained popularity recently in the hobbyist field as they come with a bootloader already built in and as a single board with all the required components to plug into a computer and start working right away. There are currently two units working with the thumper. One is the control unit and on is the responder unit. The primary reason microcontrollers are being used is to make it easy to update and upgrade. The microcontrollers are programed using a coding language that is a variant of C#.

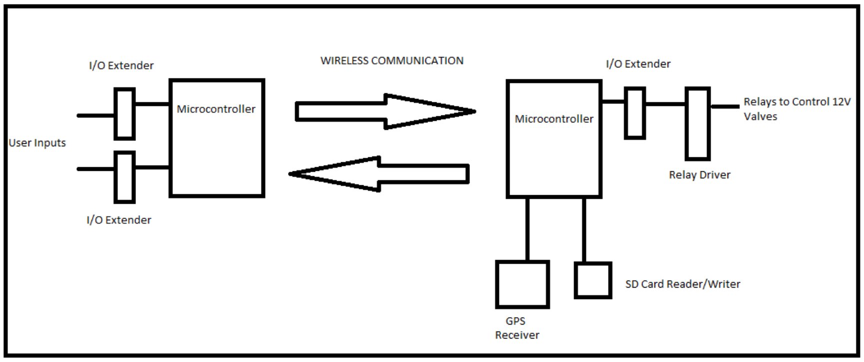

FIG. 2. The basic initial concept for the thumper controller.

FIG. 3. An Arduino Uno. This unit comes ready to be programmed with female header pins for easy connection to any project.

The control unit is fitted with a back lit LCD screen and, a keypad and five switches. The user inputs and outputs are connected using MCP23016 port expander chips that communicate with the microcontroller over the I2C bus.

The responder has outputs that are again controlled by an MCP23016 expander. The MCP23016 then drives Darlington transistors which in turn drive standard twelve volt relays. These relays are wired in parallel to the control switches meaning that the original switches will work should there be a failure in the wireless system.

There is also a GPS module attached to the thumper that is connected to the responder microcontroller. The goal here is to have the microcontroller record the location and time of each hit onto an external SD card. Although this worked in bench testing there unfortunately wasn't time to have a reliable trigger set up for this system to record GPS data on its first run in the field.

Figure 4 shows all the components as they arrived from the supplier.

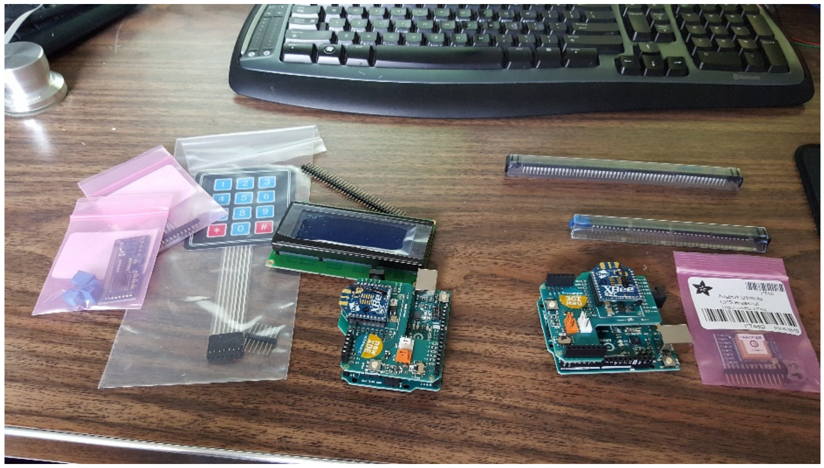

FIG. 4. The parts that make up the prototype.

The two units communicated serially over wireless transceivers that mimicked having two wires connected between the two units (Receive and Transmit). Serial commands are sent back and forth between the two units for control and connectivity monitoring. The system is designed in a way that should the two units move out of range the responder would turn off all the outputs. This function worked, but a programming error meant that the responder had to be reset once the units were in range again.

INITIAL TESTING

The units were assemble and much bench testing was done at the office. Programming was done in stages. To begin with the control unit was set up to act as an interface accepting inputs and displaying characters on the screen. The responder was then set up near a window with the GPS receiver and was programmed to send GPS data wirelessly to the controller. After some trial and error this task was successfully completed, Figure 5.

FIG. 5. All the data being displayed on the screen is being transmitted wirelessly from the other microcontroller which is in another room. The LED in this picture is an indication that the GPS has fixed data.

Once it was proved that data strings could be sent and received successfully the responder was reprogrammed to turn outputs on and off through and I/O extender. For bench testing a series of LEDs were used and each output that the thumper required was tested.

The next step was to get the units ready for field testing. Each unit was mounted in a project box. The responder unit was mounted on top of another box which holds all the relays to drive the hydraulic valves, Figure 6.

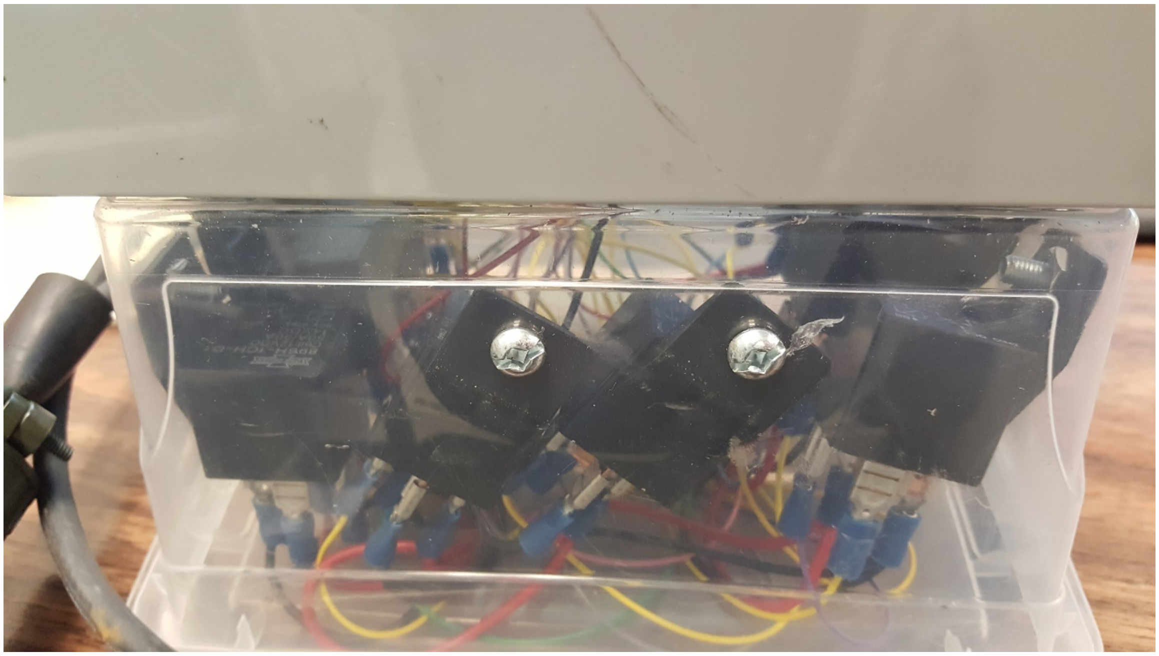

FIG. 6. The responder unit put together for the first field test with relays.

The controller unit didn't need as much space as it doesn't have any relays to drive. Instead the entire unit is self-contained within a single project box, Figure 7.

FIG. 7. The controller for the thumper. Each of the switches controls two of the hydraulic valves. The number pad is for entering shot information to be loaded on to the SD card and the screen give real time feedback.

The wireless thumper controller was first test at the Priddis Test Site just Southwest of Calgary (Bertram et. al. 2016). The thumper was set up to trigger an Aries system by means of Pelton ShotPros running in Air Gun mode. Everything worked, but not flawlessly, Figure 8. Unfortunately the thumper itself suffered a mechanical failure on just the second shot point and testing was halted.

FIG. 8. The thumper being controlled from several metres away.

Feedback was given by the thumper operator and a few issues need to be addressed. As it is now there is a bit of a delay between activating a switch and the thumper responding. Also the system is currently in the proof of concept stage and the switches on the control box are not robust enough for field work. One of them had to be replaced after only a day.

There is a massive safety concern at this point. The control box uses radio for communication and as such it does not require line of sight to operate the thumper. This means that even if the operator cannot see the thumper he/she can still make it move. If the operator isn't paying attention it is definitely possible to have someone near the thumper get injured.

DISCUSSION AND FUTURE WORK

Now that the proof of concept has been completed the issues from the first test need to be addressed. A different method of sending data packets between the controller and responder is being explored that should remove the delay in the system. The rest of the code needs to be trimmed down and made more efficient as well. The GPS and SD card systems need to be tested in the field as well.

A safety system needs to be put in place to reduce the possibility of someone being hurt. The current thoughts on a safety system consist of:

1. A hazard light should be added to the thumper to indicate that it is in operation warning people to keep away.

2. Some sort of display added to the thumper that can be easily seen from the operator's position. This could be a coloured light or a numeric display that

would be updated randomly by the responder microcontroller. The operator would then have to enter this number/colour on the controller unit every so often or the responder will not operate the thumper. This would confirm that the operator is watching the thumper.

Beyond having a simple controller and responder, some sensors will be added to the thumper so it can run in a closed loop mode. This would allow the operator to minimize the control inputs. For example, the operator could input survey parameters such as number of shots and whether they will be vertical or tilted and have the controller put the foot down and complete the shots automatically and then raise the foot automatically so the operator could move to the next shot point.

Once all the testing has been done custom circuit boards will be designed and build for both the responder and controller. Weather proof casings and robust controls will also need to be added.

ACKNOWLEDGEMENTS

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REFERENCES

Bertram, Kevin L., Isaac, J. Helen, Hall, Kevin W., Bertram, Malcolm B., 2016, Priddis experiment: CREWES Research Report, **This volume**.