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Review

Design of a novel control panel for 24-Volt automatic fish feeders

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This paper describes a novel control panel for programmable feeders in a production fish hatchery. This system used digital interval timers in electrical box to control three parallel rails of power outlets. Transformers were used to step down the voltage from 120 to 24-V for use by 24-V feeders. A photo-eye was incorporated into the system so that the feeder would only dispense during the daylight hours. The system functioned as designed, powering the feeders at programmed intervals during daylight hours and deactivating during the night. This panel was relatively simple to fabricate and very inexpensive, costing less the $500 USD to construct.

Key words: Fish feeder, feeder control panel, aquaculture.

INTRODUCTION

Automated feeders are a critical feature in fish hatcheries, reducing labor demands and providing feed to the fish at the necessary intervals (Piper et al., 1982; Aloisi, 1994; Carter, 2015). However, most electrically-powered automated feeders do not contain internal timers and will continuously dispense feed as long as electricity is supplied. Thus, control panels are needed to regulate the frequency and duration of feeder activity and subsequent food delivery. Historically, mechanical timers, such as timer switches using push pins, were often used to control feeders. These timers typically ran in 1 h cycles, and used pins inserted into the clock. These pins would push a metal plate to connect two wires, acting as a switch to allow power to run through the timer and into the outlets for the feeders at set intervals (DATAINTELO, 2023)

While relatively inexpensive, mechanical control panels for fish feeders can be problematic. They are unreliable, difficult to adjust, and limited in how often and how long power can be supplied to the feeders (Goddard, 1996). Digital control panels are easier to use and allow for more, and more precise, adjustments of feeding times and durations. These adjustments are critical to maximize feed utilization and feeding efficiencies (Volkoff and Peter, 2006; Craig et al., 2017). In addition, because digital control panels can be powered by solar cells, they can be used even in remote hatcheries (Susilawati et al., 2023). However, digital control panels are typically

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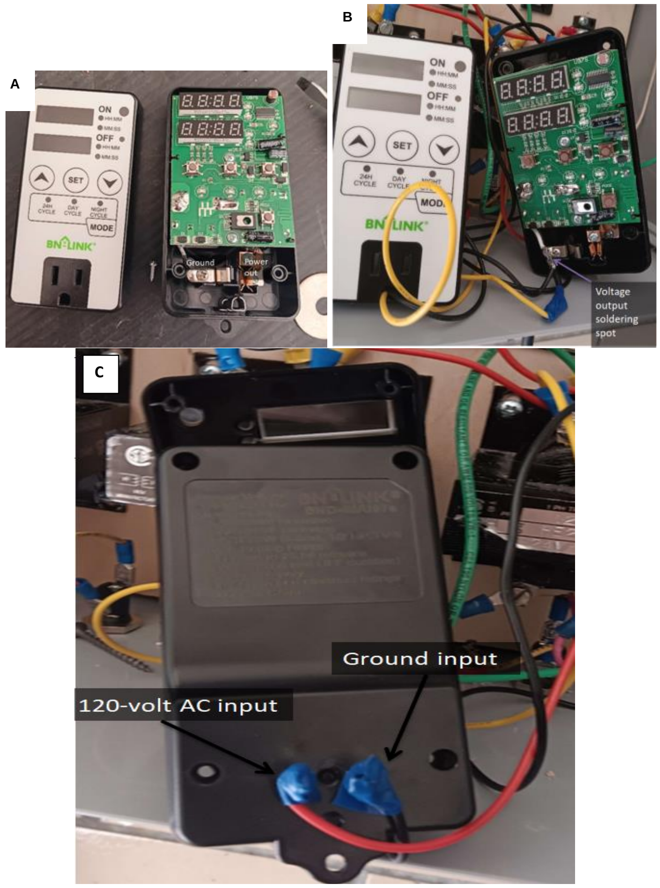

Figure 1. Circuity of the digital controller before changing input and output connectors (a), front view after changing input and output connectors (b), and back view back after changing input and output connectors (c).
Source**:** Author.

complex and expensive (Zhou et al., 2017; Meenakshi et al., 2020; Mohd et al., 2020). Thus, there is a need for less-expensive and less-complex, yet still effective and reliable, controllers for fish feeders. This paper describes the design of a low-cost, relatively-simple, digital control panel fabricated and installed at a production fish hatchery.

DESIGN

This control panel was designed for use at McNenny State Fish Hatchery, rural Spearfish, South Dakota, USA. The hatchery has 35 indoor circular tanks arranged in five rows of seven tanks, with each of the 35 tanks having its own electrically-powered automated feeder. Three separate circuits in parallel with each other supply power to the feeders. One of the circuits runs a power rail for one row of seven feeders, and the other two circuits each run a power rail for two rows of feeders. The feeders operate on 24-V alternating current (AC) while the power supply to the hatchery tankroom is 120-V AC. The existing feeder controller was a mechanical push-pin type.

To convert from 120-V AC to 24-V AC, a transformer using two inductors with a turns ratio of 5-to-1 was used. The changing flux in the inductor on the 120-V AC side created an induced current in the 24-V AC side of the transformer five times greater than the current on the 120-V AC side. Because there were three rows of 24-V AC outlet hookups, three transformers were used.

Short-period repeat-cycle digital timers were used (Timer Outlet Short Period Repeat Cycle Intermittent Digital Timer, Interval Timer, BN-LINK, Santa Fe Spring, California, USA). The timers had 120-V AC input from a wall outlet and outputted 120-V AC through an electrical socket. The electrical socket hookups on the back and front of the digital timer were soldered to end-stripped wires and covered with electrical tape (Figure 1).

A photoresistor, acting as the photo-eye, was placed in

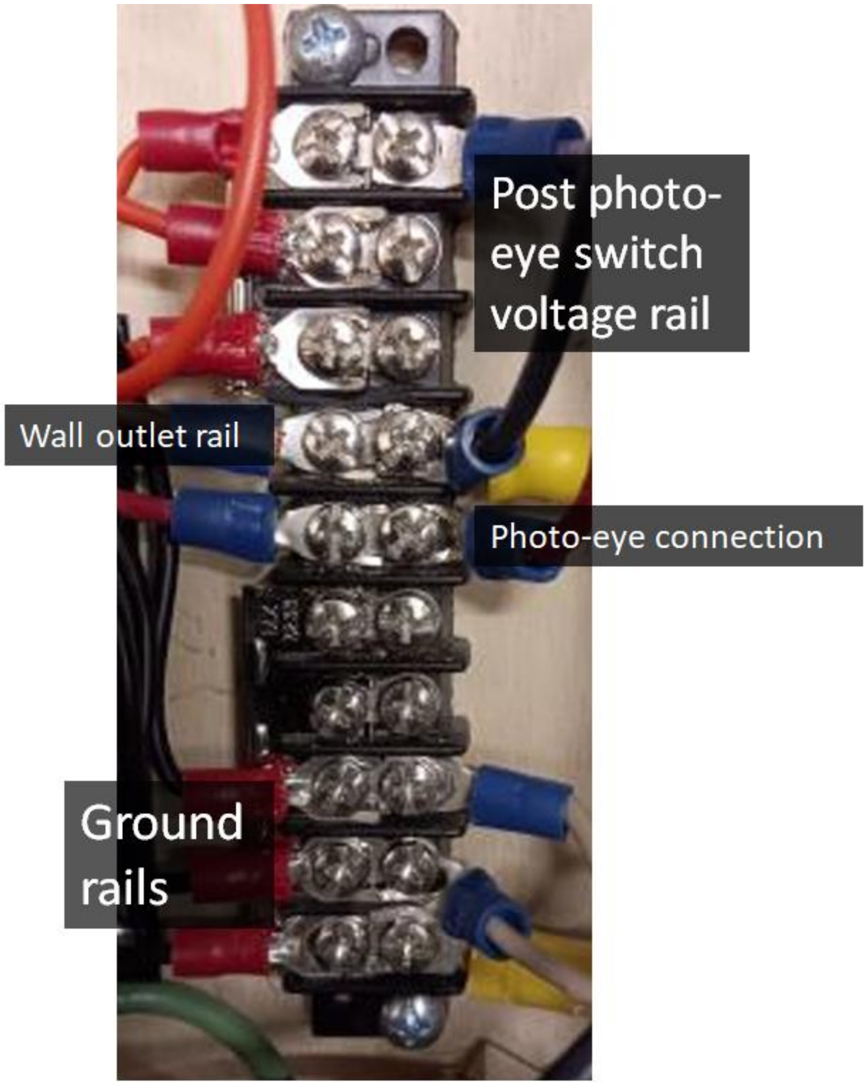

Figure 2. Screw terminal block for the feeder controller.
Source**:** Author.

series with the current switch on a single throw double pole (STDT) current activated switch. With adequate lighting, the incoming energy from the light reduces the resistance enough in the photoresistor to activate the switch to turn on the system.

An electrical box (40.6 cm tall by 35.6 cm wide by 15.2 cm deep; Hammond PCJ-SL - Type 4X Polycarbonate Junction Box (Solid and Clear Cover), Metal Latch Cover, TEquipment, Long Branch, New Jersey USA) was used to prevent exposure of the electronic components to the high-moisture hatchery environment (National Fire Protection Association, 2008). A 40.6 cm by 35.6 cm wooden board was screwed into the back of the electrical box for component attachment. To facilitate the connections between the different components and the power input, a screw terminal block was attached to the wooden board (Figure 2).

A fuse was added in series after each of the transformers in the system to provide power surge protection for the entire system. The fuses act as small resistors that absorb a small amount of power. When the current become excessive, the resistive component in the fuse burns up and breaks the circuit connection, preventing damage to the motors (Wright and Newbery, 2004). Nine, 1.27 cm diameter access holes were drilled in the electrical box for the wires from three transformers and their fuses, and two, 2.22 cm holes were drilled for the power supply and the photo-eye (Figure 3).

Two solder spade through attachments were used to thread the wires through the electrical box for each transformer. One double spade connector fuse holder was used on each transformer to enable changing the fuses without opening the electrical box. Halex conduit and halex connectors were used for the power and the

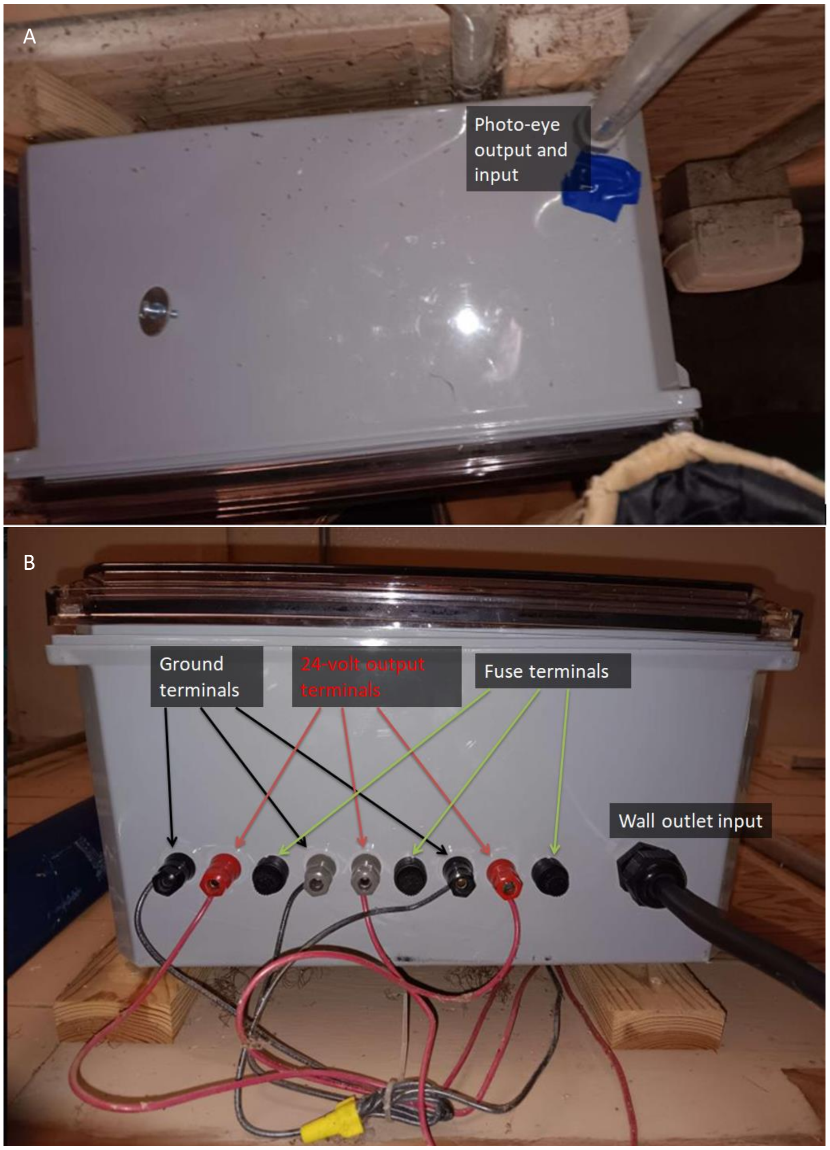

Figure 3. Electrical box containing the feeder controller with a top view (a) and bottom view (b) of access holes.
Source**:** Author.

photo-eye external connections. The digital timers, transformers, and the current-controlled switch were secured onto the wooden board inside of the electrical box. The components were all connected according to the wiring diagram (Figure 4). The completed digital control panel is as shown in Figure 5. Total cost for the components of this feeder controller was less than $500 USD.

DISCUSSION

The digital control panel provided 24-V AC voltage to the automatic feeders at the desired times and for the desired intervals for three months without any issues. It allowed for more feedings and the timing of feedings to be more precise, along with increased precision in the amount of feed fed by automatic feeders. This was important to maximize fish rearing performance and feeding efficiencies (Volkoff and Peter, 2006; Craig et al., 2017). The photo-eye and current controlled switch also functioned properly by only providing power to the digital controller during daylight hours. Feeder timing and intervals were easy for hatchery staff to change, allowing for considerable flexibility with automatic feeder operations during fish rearing. Although the control panel has only been in use for a relatively short time period of 120 days, it is anticipated that it will be reliable in the long

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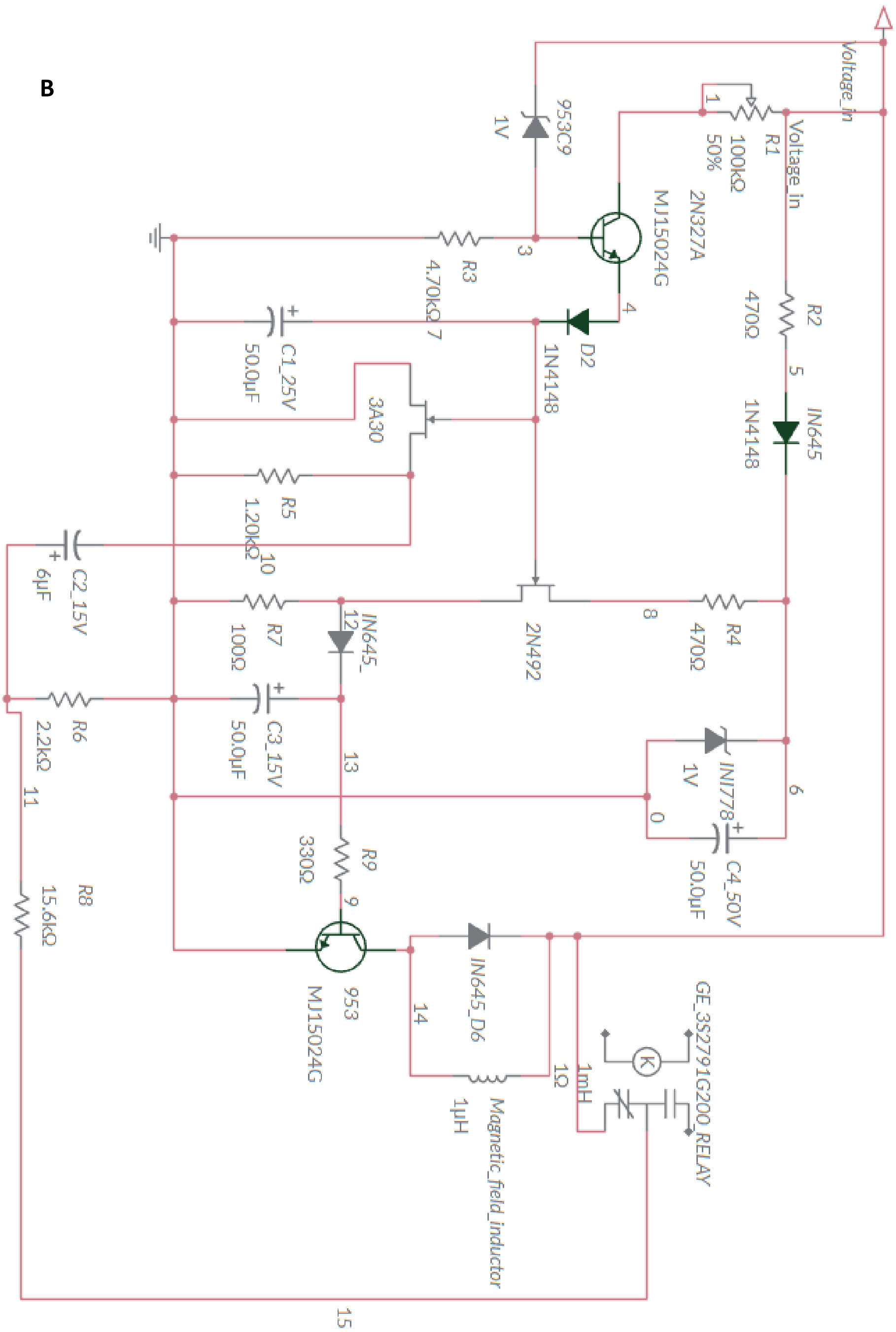

Figure 4. Digital controller circuit diagram circuit diagram (created by Multism Live Online Circuit Simulator 2023) with black box switches for the digital controller (a) and black box internal circuitry (b).
Source**:** Author.

term. If any of the components do fail, they can be easily, quickly, and inexpensively replaced.

The digital control panel described in this paper performed well while controlling three rows of electrical outlets for automated feeders at McNenny State Fish Hatchery. At less than $500 USD to construct, it was very low cost and similar in price to mechanical control panels that are less reliable, more difficult to adjust, and that limit the feeding precision required to maximize fish feeding efficiencies (Goddard, 1996). This digital control panel for fish feeders could be assembled by individuals with only a small amount of electrical experience. It is much

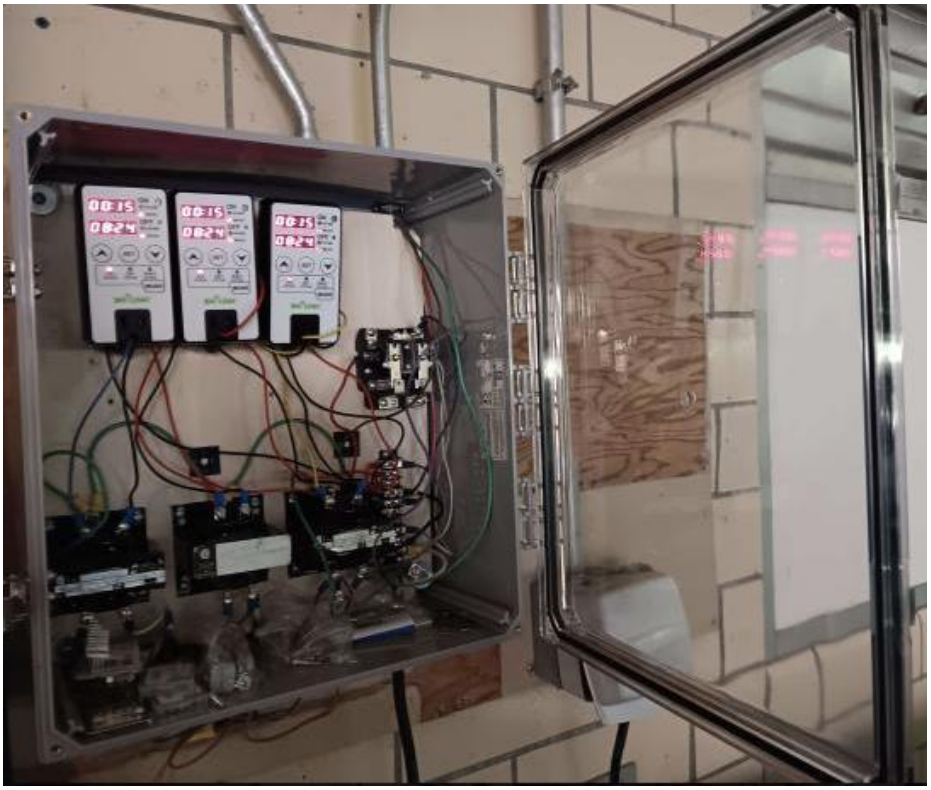

Figure 5. View of the electrical box with the digital control panel installed and in operation.
Source**:** Author.

simpler, and much less expensive than other fish feeder digital control panels commercially-available or described in the literature (Zhou et al., 2017; Meenaskshi et al., 2020; Mohd et al., 2020). In brief, this feeder control panel design is a simple and easy-to-use solution for use in fish hatcheries.

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