TECHNICAL DISCLOSURE

PLC-Based Controller for a Precision Laser Driller

Simulating a digital replacement for a twenty-year-old analog control system, validated in ladder logic before touching the real machine.

Central Manufacturing Technology Institute, Bangalore · with Amrita Vishwa Vidyapeetham

[Ladder Logic] [PLC Simulation] [Safety Interlocks] [Legacy System Migration]

10 Software: Zeliosoft2 v4.5 12 PLC: 6 DI / 4 DO 14 Status: Validated

01 — THE PROBLEM

Twenty years of analog control, running out of runway

The Raytheon precision laser driller/welder at CMTI Bangalore was built around analog controllers roughly two decades earlier. Sourcing components for maintenance and feature upgrades had become difficult — and the case for a digital controller kept getting stronger.

- 16 **Components scarce** — analog parts from that generation were no longer readily available.
- 18 **Not expansible** — adding capability meant redesigning around a fixed analog architecture.
- 20 **Bulky and expensive** — with a complex design that made troubleshooting slow.
- 22 **Hard to diagnose** — faults were difficult to trace through the analog signal chain.

A PLC/DSP-based digital controller offered a modular, user-friendly alternative — with no signal loss from A/D–D/A conversion, better noise immunity, and lower long-term cost.

02 — SYSTEM OVERVIEW

From three-phase supply to a single laser pulse

(10) THREE-PHASE SUPPLY → (12) HV CONTACTOR → (14) RESERVOIR / CAPACITOR BANK → (16) PFN (PULSE-FORMING) → (18) FLASHLAMP → (20) LASER ROD

The reservoir voltage is manually set and fed back to confirm it has built up to the target level before firing is armed. The Pulse Forming Network — seven identical inductor–capacitor loops — shapes that stored energy into a clean rectangular pulse for the flashlamp.

3 s
Reservoir charge time before FIRE is armed

7
Identical inductor–capacitor loops in the PFN

7 ms
Maximum pulse width — 1 ms per loop, full bank

03 — SIMULATION APPROACH

Every switch, sensor, and interlock, given an I/O tag

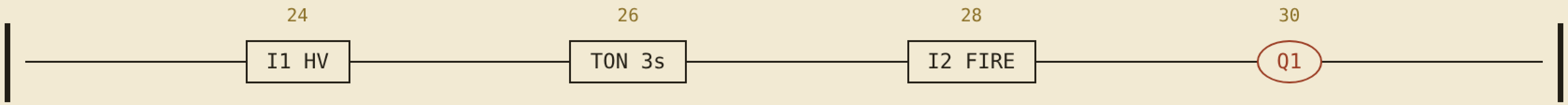
A PLC variant with six discrete inputs and four output relays was selected and programmed in ladder logic using Zeliosoft2 v4.5, mapping the analog system's switches, interlocks, and drive signals onto simulated I/O.

TABLE 1. SIMULATION I/O POINT LIST

INPUTS		OUTPUTS	
I1	HV switch	Q1	Charging SCR
I2	Trigger (FIRE) switch	Q2	Discharging SCR
I3–I9	Interlocks — overcurrent, overpower, overfrequency, cooling water low-flow / over-temp, water leak, misfire	Q3	PFN
IA	Emergency STOP	Q4	Laser rod
		Q5	Interlock activation indicator
		Q6	Emergency STOP indicator

04 — VALIDATED BEHAVIOR

Timing the pulse to the microsecond



Simplified rung — HV, then a 3-second timer, then FIRE, before the charging SCR can energize.

An asynchronous timer staggered the charging and discharging SCRs by 500 microseconds in each direction, so the two could never conduct at once — and any interlock trip cut power ahead of the HV contactor before it reached the rest of the system.

OVERCURRENT → TRIP | MISFIRE → TRIP | E-STOP → ISOLATE | NOMINAL → RUN

500 µs
Charge/discharge SCR stagger

7
Distinct interlocks reproduced in the ladder

6 DI / 4 DO
PLC variant used for the simulation

05 — CONCLUSION

Digital control, validated before the retrofit

The ladder-logic simulation reproduced every function and safety interlock of the original analog system — confirming that a modern digital controller could take over the Raytheon laser driller/welder without losing any of its safety behavior.

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FEASIBILITY CONFIRMED