

PROJECT ABSTRACT

PLC-Based Pneumatic Paper Cutting Machine

An industrial-automation trainer built around a real Siemens SIMATIC S7-1200 PLC: pneumatic clamp and guillotine blade, dual-hand safety start, latching e-stop, retentive cut counter with presets, and ladder logic written in TIA Portal. Delivered built-to-order with the machine, PLC program, diagrams, report, PPT and viva kit.

01. Title

PLC-Based Pneumatic Paper Cutting Machine

02. Introduction / Background

Paper cutting sounds simple until it is done by hand: a stack of sheets drifts during the cut, edges come out ragged, and every stroke puts the operator's fingers near the blade. Commercial print shops solved this decades ago with PLC-controlled guillotine cutters — programmable cut sequences, pneumatic clamping that holds the stack still, and safety interlocks that refuse to cycle unless the operator's hands are provably on the buttons. This project rebuilds that industrial machine at student scale: a steel frame carrying a pneumatic cylinder and guillotine blade, a paper stack table, and a genuine Siemens SIMATIC S7-1200 PLC running ladder logic written in TIA Portal. It is an automation trainer as much as a machine — every wire, every rung of logic and every pressure setting is something the student built, programmed and tuned.

03. Problem Statement

Manual paper cutting in print shops, binderies and college reprographic rooms is slow, inconsistent and hazardous: stacks shift mid-cut, edge quality varies with the operator, and hands work close to an exposed blade. Industrial guillotines solve all three problems but are far beyond a classroom budget and are closed black boxes — students never see the control logic. The project addresses this by building a student-scale PLC-controlled cutter that demonstrates the real industrial solution: pneumatic clamping for stack registration, a sequenced clamp-then-cut cycle in ladder logic, dual-hand anti-tie-down starting, a latching emergency stop, and a retentive counter with cut-count presets — all inspectable, programmable and tunable by the student.

04. Objectives

- Design and fabricate the machine: steel frame, guillotine blade with guide, paper stack table with adjustable back gauge.

- Build the pneumatic circuit: double-acting cylinders for clamp and blade drive, 5/2 solenoid valves, FRL unit, flow-control valves and pressure switches (design target ~4-6 bar shop air).
- Wire all 24 V industrial I/O to a Siemens SIMATIC S7-1200: palm buttons, mushroom-head e-stop, reed switches, selector switch, indicator lamps.
- Program the clamp-and-cut sequence in TIA Portal ladder logic with dual-hand start timing, fault latching and manual/auto modes.
- Implement retentive cycle counting with cut-count presets on the operator panel.
- Deliver the complete student kit: machine, PLC program, diagrams, tuning guide, report, PPT and viva Q&A.

05. Proposed Methodology

The build proceeds in four stages. (1) Mechanical: the frame, blade guide, paper table and back gauge are fabricated from steel sections; the blade is aligned to the table with adjustable gibs. (2) Pneumatic: cylinders, valves, the FRL unit and flow controls are plumbed per the circuit diagram; pressure is set at the regulator and cut speed tuned with the flow-control valves. (3) Electrical: 24 V I/O — palm buttons, e-stop, reed switches, selector — are wired to the S7-1200 per the wiring diagram, with the safety chain hardwired to drop outputs. (4) Software: the sequence is programmed in TIA Portal as ladder logic — input validation, dual-hand timing window, clamp confirm, blade stroke with end-switch feedback, retract, counter increment, fault latching — then commissioned step by step in manual jog mode before automatic cycling.

06. System Architecture / Working

The operator places a paper stack against the back gauge and selects auto mode. Pressing both palm buttons inside the timing window starts the cycle: the PLC first validates clamp-home, blade-home and guard inputs, then extends the clamp cylinder; a pressure switch confirms the stack is held. The main valve then drives the guillotine blade down through the stack, reed switches report stroke end, the blade retracts, the clamp releases, and the retentive counter increments; the cycle repeats for the preset count. Any e-stop press, guard fault or pressure loss freezes the sequence mid-cycle and latches the fault, requiring a deliberate reset sequence before restart. In manual mode the selector enables jog operation of each cylinder for setup and tuning.

07. Hardware / Software Requirements

- Siemens SIMATIC S7-1200 PLC; TIA Portal for ladder-logic programming
- Double-acting pneumatic cylinders (clamp + blade), 5/2 solenoid valves
- FRL unit, flow-control valves, pressure switches, pneumatic fittings and tubing
- 24 V DC I/O: dual palm buttons, mushroom-head e-stop, reed switches, selector switch, indicator lamps, 24 V power supply

- Steel fabrication: frame, blade guide, paper table, back gauge
- Shop-air supply at ~4-6 bar (lab air line or small compressor; prerequisite, not included)

08. Expected Outcomes

- Working machine performing sequenced clamp-and-cut cycles on paper stacks (design target: stacks up to ~50 mm; cut quality verified at the buyer's build).
- TIA Portal ladder-logic project implementing the full sequence with safety interlocks, readable and modifiable by the student.
- Tuned pneumatic circuit: set pressure, adjusted cut speed, confirmed clamp force.
- Operator panel with retentive cycle counter, presets and mode selection.
- Complete documentation: report, PPT, diagrams, tuning guide and viva Q&A.

09. Applications

- Industrial-automation training: real PLC, real pneumatics, real safety practice.
- Teaching platform for ladder logic, sequential control and machine interlocking.
- Demonstrator for print/bindery automation concepts at student scale.
- Base for extensions: HMI panel, light curtain, servo-driven back gauge.

10. Future Scope

- Touchscreen HMI replacing the discrete panel with recipe management.
- Light curtain for presence-sensing safeguarding.
- Servo-driven programmable back gauge for variable cut sizes.
- Production data logging: cuts per shift, downtime events, OEE-style metrics.

11. References

- Siemens — SIMATIC S7-1200 Programmable Controller, System Manual.
- Siemens — TIA Portal programming documentation (LAD/FBD).
- Festo/standard pneumatic component documentation — cylinders, valves, FRL units.
- General machinery-safety practice: dual-hand controls and e-stop categories (instructional reference; the demonstrator is not a certified industrial machine).