D01 Digital Inputs and Stable Switch Circuits

Student worksheet | Prepare the hardware before microcontroller code

Technology Commons

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Student: _____ **Date:** _____

Use the evidence cycle in every activity: predict, calculate using GUESS, draw the schematic, simulate or verify, build or test where appropriate, compare evidence, diagnose a fault or limitation, and explain your conclusion.

Activity 1: Digital voltage levels

Required | Direct application

A 3.3 V GPIO input guarantees low at or below 0.8 V and high at or above 2.0 V. Classify 0.2, 1.2, 2.4, and 5.0 V. Identify any value that is invalid, indeterminate, or potentially damaging.

Applied voltage	Guaranteed logic interpretation	Safe?	Evidence
0.2 V			
1.2 V			
2.4 V			
5.0 V			

Activity 2: Floating input and pull-down

Required | Schematic and verification

Explain why the unconnected input is incorrect. Redraw the external pull-down circuit, then complete its state table.

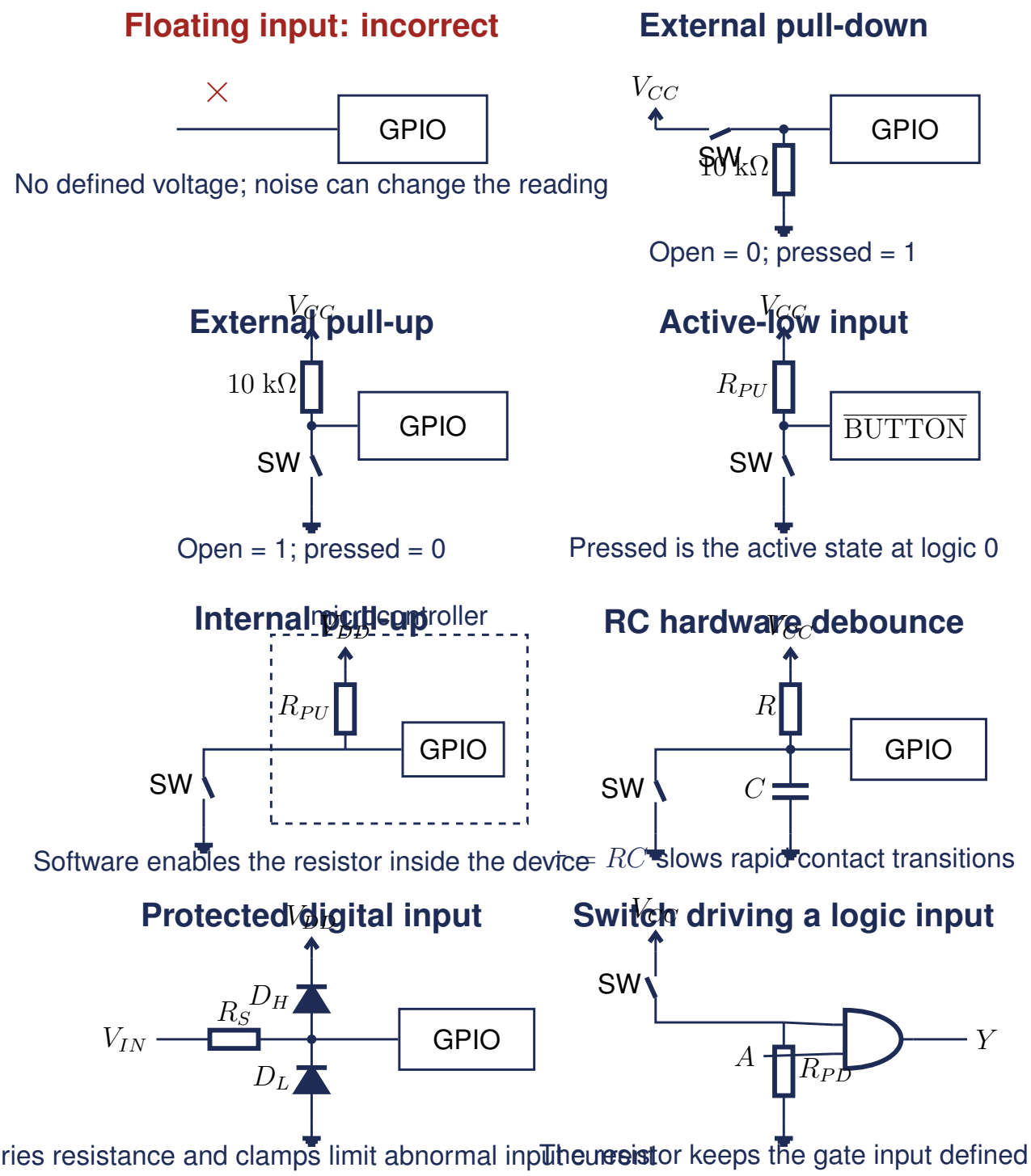


Figure 1: Floating input and pull-down reference circuits.

Switch position	Electrical connection	Pin voltage	Logic state	Active or inactive
open				
closed				

Verification evidence: _____

One limitation or likely fault: _____

Activity 3: Pull-up and active-low input

Required | GUESS and interpretation

Use a 10 kΩ external pull-up on a 5.0 V supply with a switch to ground.

1. Complete the state table.
2. Calculate resistor current while the switch is pressed.
3. Explain why the resistor prevents a source short.
4. Write a clear active-low signal name.

Switch position	Electrical connection	Pin voltage	Logic state	Active or inactive
open				
pressed				

GUESS work and exact calculator entry:

Activity 4: Internal pull-up and debounce

Required | Comparison and design decision

Compare an internal pull-up with an external pull-up. State two reasons an external resistor may still be appropriate. Then choose R and C for a starting debounce time constant between 1 and 10 ms.

$$\tau = RC$$

Decision	Choice	Evidence or trade-off
internal or external pull-up		
resistor value		
capacitor value		
calculated τ		
software or hardware debounce		

Activity 5: Protected input troubleshooting

Required | Design and diagnosis

A student connects a 5.0 V sensor output directly to a Raspberry Pi input. The input behaves unpredictably after the test.

1. Identify the compatibility mistake.
2. Draw an approved interface concept for review.
3. Name the data needed before selecting resistor or level-shifter values.
4. Give a safe test sequence that does not risk a second GPIO pin.
5. Write a one-paragraph engineering conclusion.

Optional Level 4 extensions

Extension A: Logic-gate input system

Design a two-input logic circuit in which a stable switch input enables an indicator only when a second condition is true. Include the truth table, pull resistor, LED resistor, and transistor driver if the load exceeds the gate output rating.

Extension B: Microcontroller transfer

Implement the same switch as an internal pull-up input. Record the released and pressed readings, demonstrate software debounce, and explain why the code uses `LOW` for the active state.

Common assessment rubric

Category	Level 1	Level 2	Level 3	Level 4
Mathematical reasoning and GUESS	limited setup or unit use	partly correct method	correct method and units	precise, efficient reasoning with independent checks
Schematic quality and conventions	major symbol or connection errors	mostly readable with some errors	correct, labelled, and readable	exceptionally clear with purposeful layout and complete references
Simulation or verification evidence	limited or incomplete evidence	some valid evidence and comparison	complete evidence with comparison	well-chosen evidence that tests assumptions and limitations
Physical construction and safe practice	frequent prompting required	generally safe with some prompting	safe, organized, and approved work	consistently anticipates hazards and supports team safety
Testing and troubleshooting	guesses without a test plan	partial plan using some evidence	logical tests identify the likely cause	efficient tests distinguish alternatives and verify the repair
Design decisions	choice has limited justification	some criteria support the choice	clear criteria and trade-offs support the choice	constraints, evidence, and iteration produce a strong decision
Documentation and communication	incomplete or difficult to follow	understandable with gaps	clear tables, labels, results, and conclusion	concise, polished communication makes the evidence easy to audit

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