AXI Handshakes: Legal or Illegal?

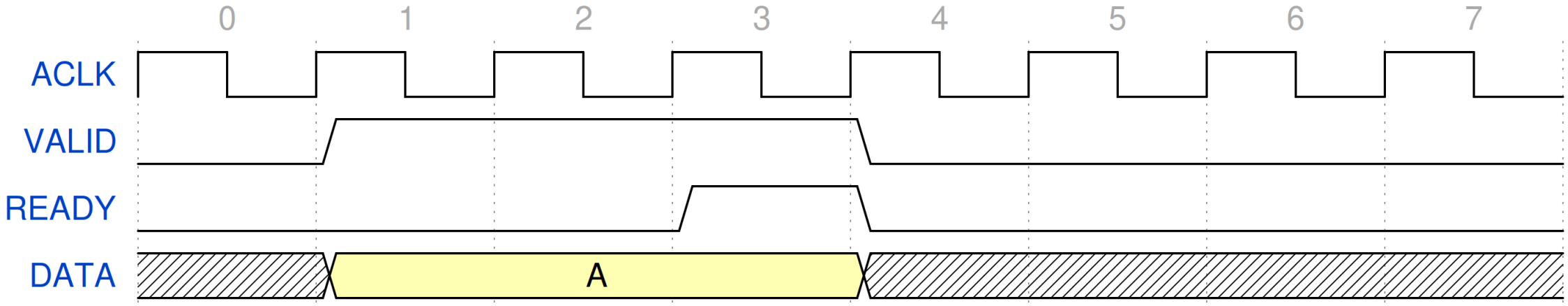
14 waveforms for class discussion

The handshake rules

1. A transfer happens on a rising edge where VALID and READY are both high.
2. Once VALID is high, it stays high, and the payload stays stable, until the transfer.
3. The source must not wait for READY before raising VALID. The destination may wait for VALID.
4. READY may come before VALID, and may drop again before VALID arrives.
5. Responses come after requests: BVALID only after both the AW and W transfers; RVALID only after the AR transfer.
6. During reset, VALID is low.

1. The basic handshake

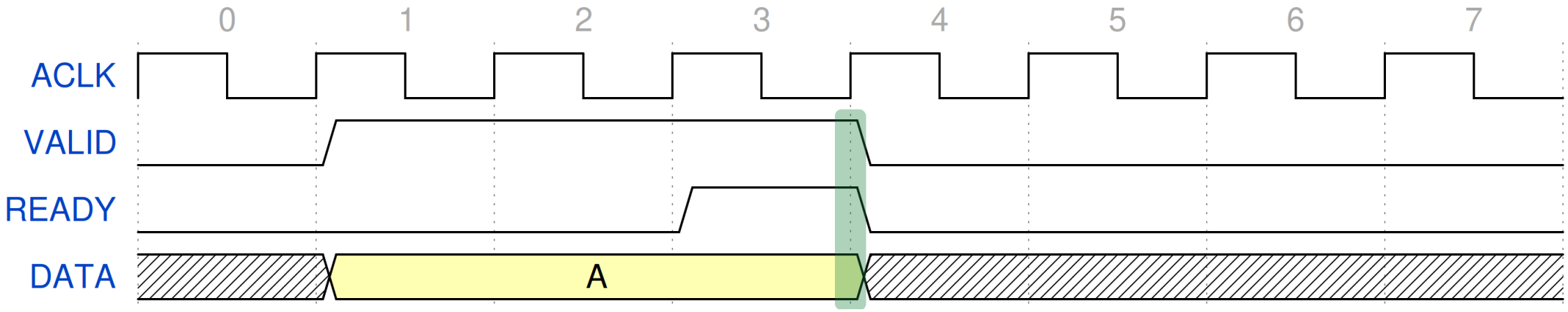
Legal or illegal? At which rising edge is A transferred?



1. The basic handshake

LEGAL

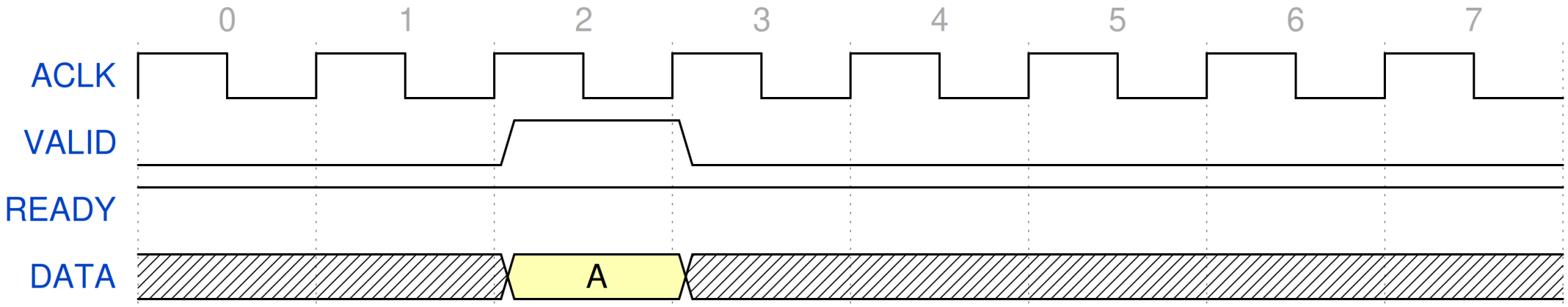
A transfers at the start of cycle 4, the first rising edge where VALID and READY are both high.



Green: transfer (VALID and READY high at a rising edge). Red: rule violation.

2. READY before VALID

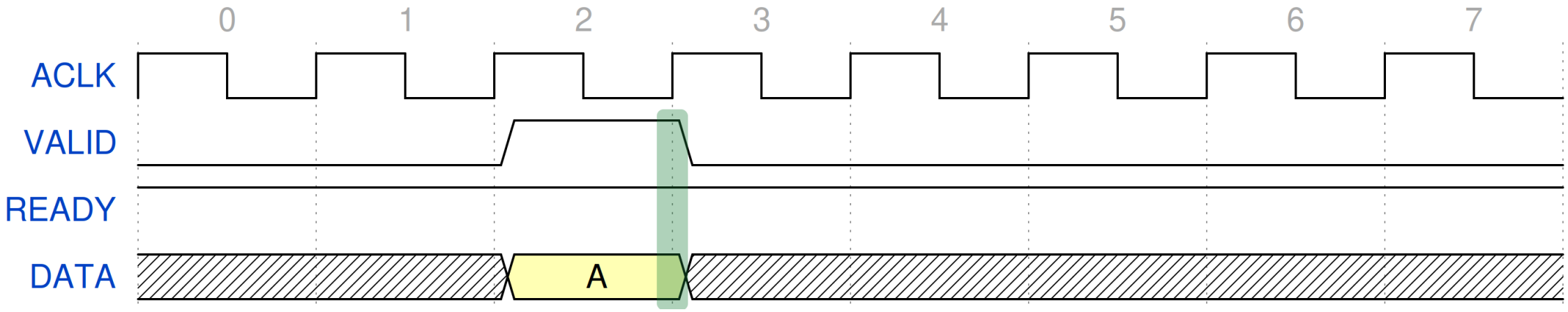
Legal or illegal? The destination holds READY high all the time.



2. READY before VALID

LEGAL

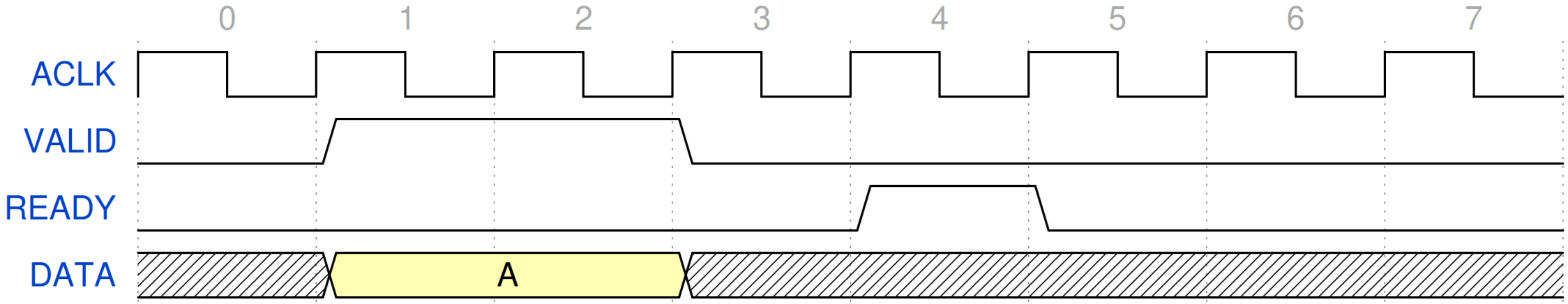
The destination may assert READY before VALID. A transfers on the first edge that VALID is high.



Green: transfer (VALID and READY high at a rising edge). Red: rule violation.

3. VALID gives up

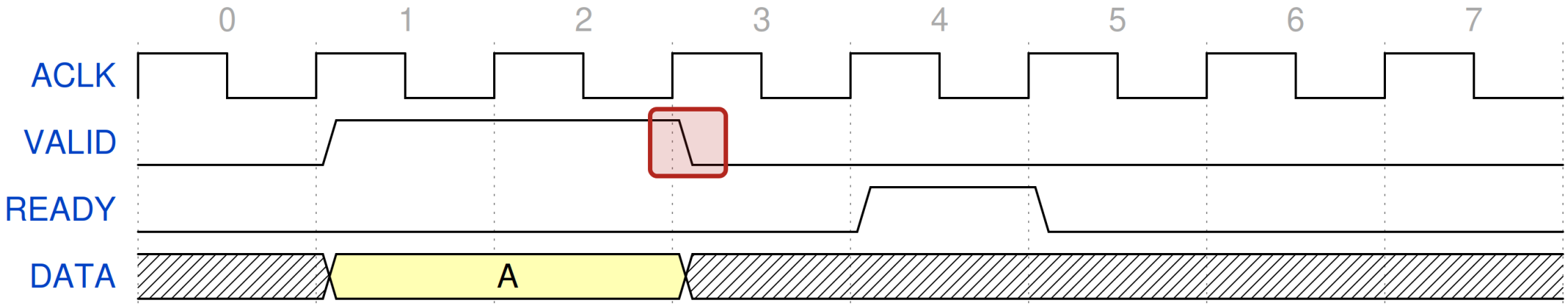
Legal or illegal?



3. VALID gives up

ILLEGAL

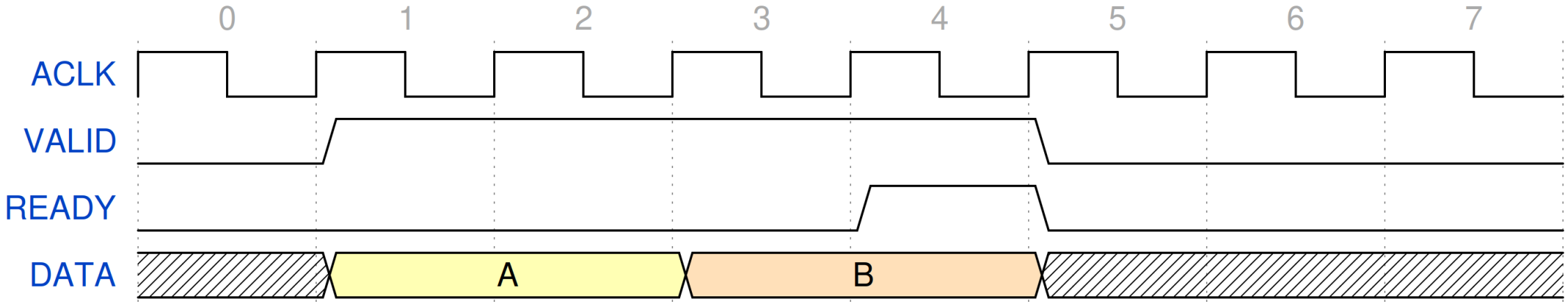
Once VALID is high it must stay high until the handshake. Here it drops before READY arrives, so A is never transferred.



Green: transfer (VALID and READY high at a rising edge). Red: rule violation.

4. Data changes while waiting

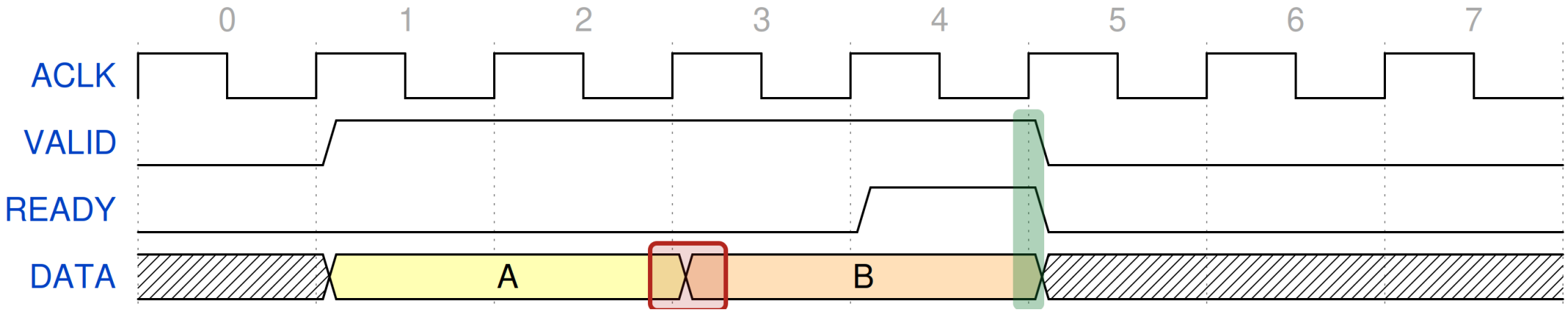
Legal or illegal?



4. Data changes while waiting

ILLEGAL

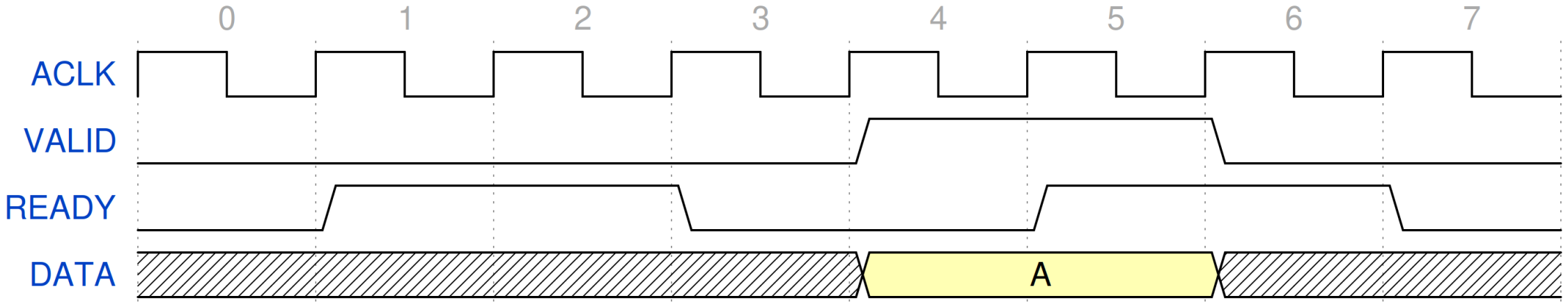
The payload must stay stable from VALID until the handshake. DATA switches from A to B while the source is still waiting.



Green: transfer (VALID and READY high at a rising edge). Red: rule violation.

5. READY changes its mind

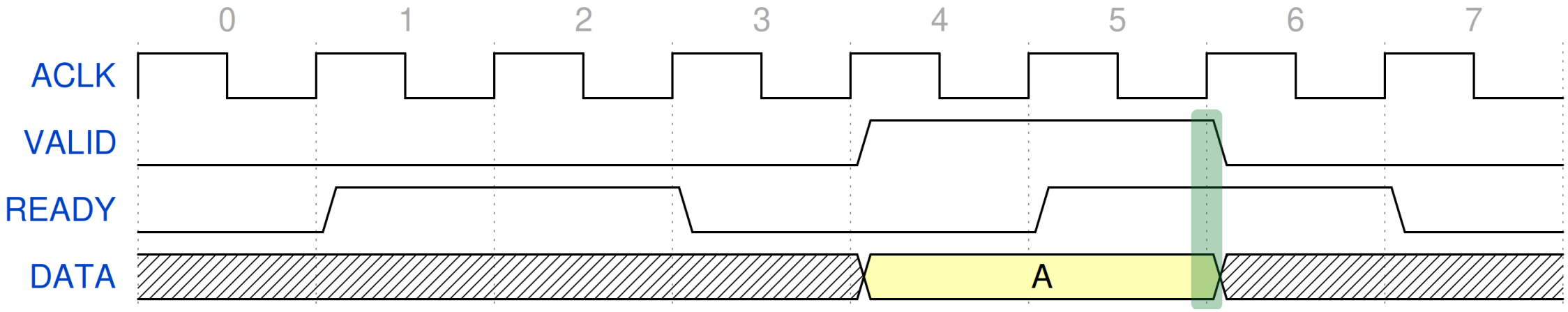
Legal or illegal?



5. READY changes its mind

LEGAL

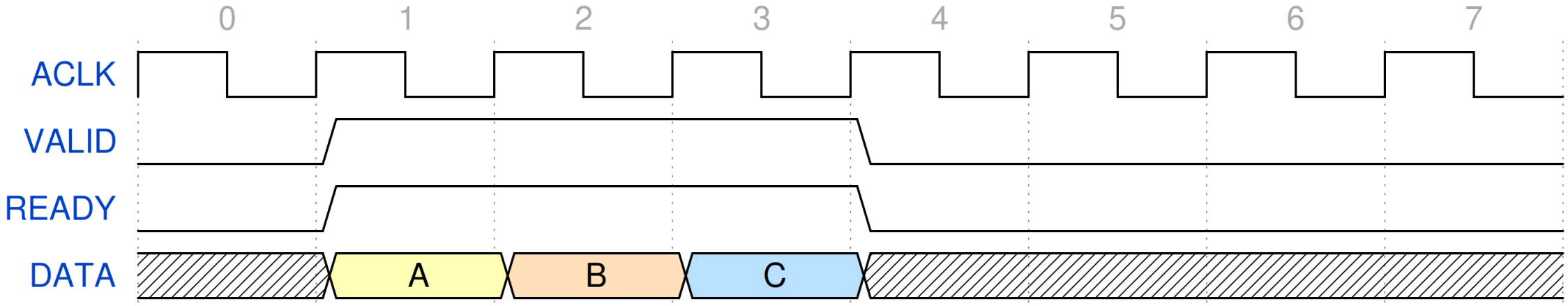
The destination may lower READY before VALID arrives. A transfers at the start of cycle 6.



Green: transfer (VALID and READY high at a rising edge). Red: rule violation.

6. Back-to-back transfers

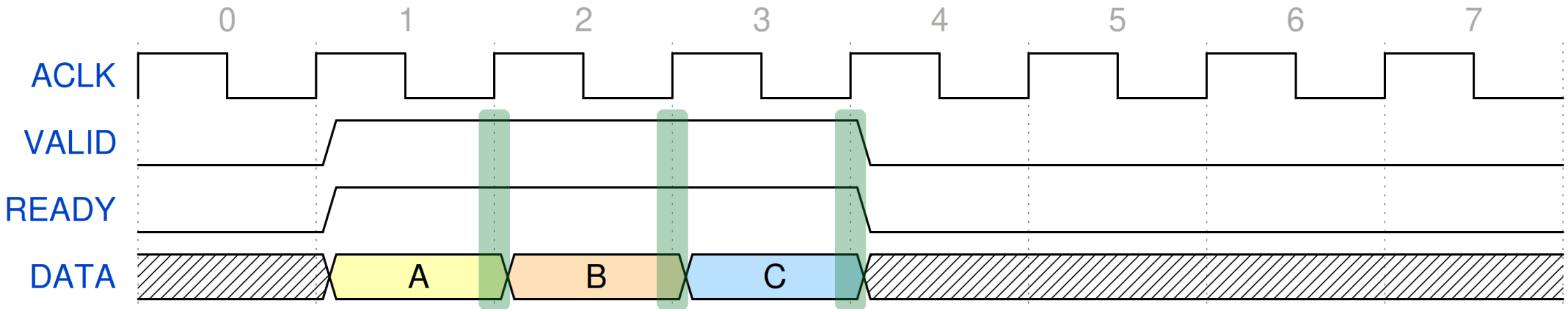
Legal or illegal? How many transfers happen?



6. Back-to-back transfers

LEGAL

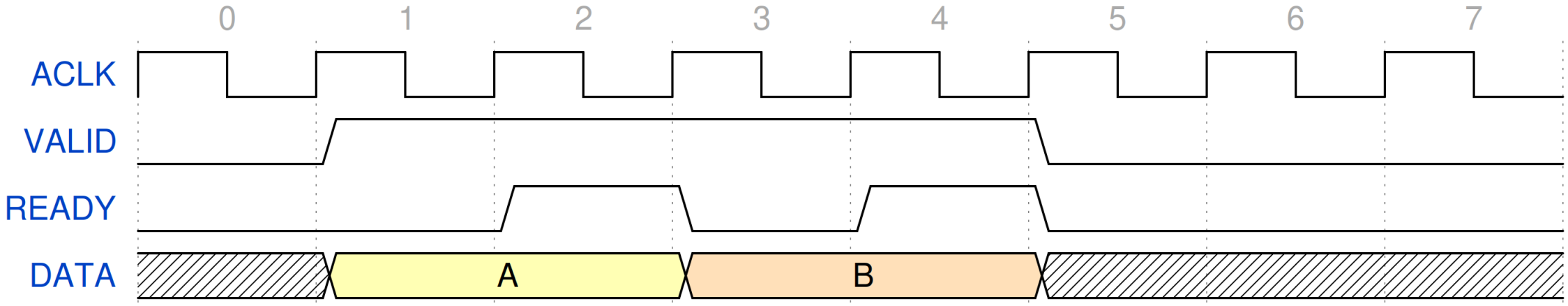
Three transfers (A, B, C), one on every rising edge where VALID and READY are both high.



Green: transfer (VALID and READY high at a rising edge). Red: rule violation.

7. Count the transfers

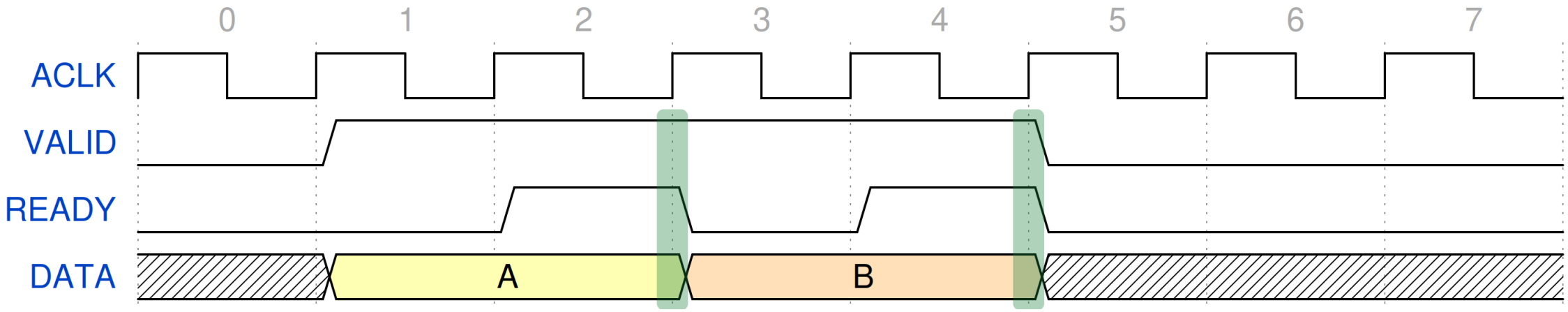
Legal or illegal? How many transfers happen?



7. Count the transfers

LEGAL

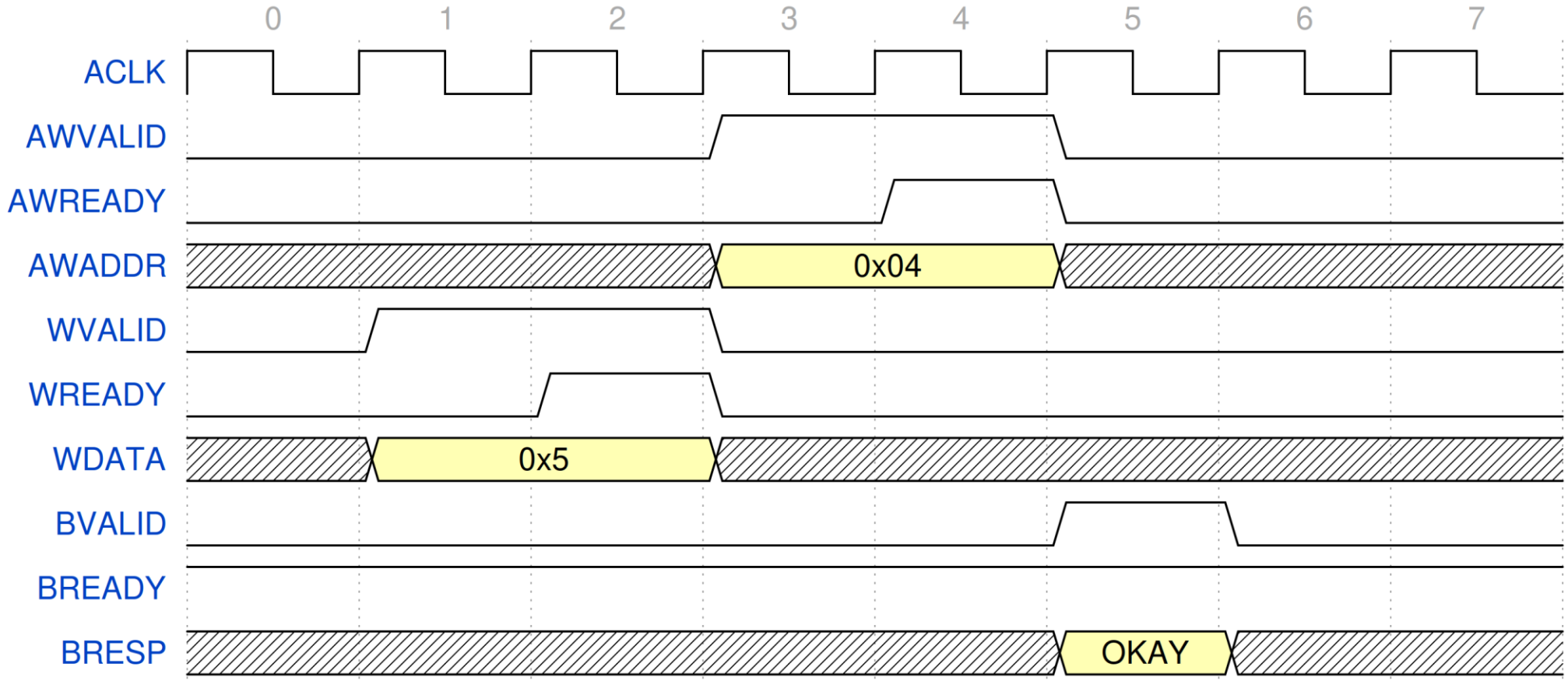
Two transfers: A at the start of cycle 3 and B at the start of cycle 5. DATA only changes right after a transfer.



Green: transfer (VALID and READY high at a rising edge). Red: rule violation.

8. Write data before the address

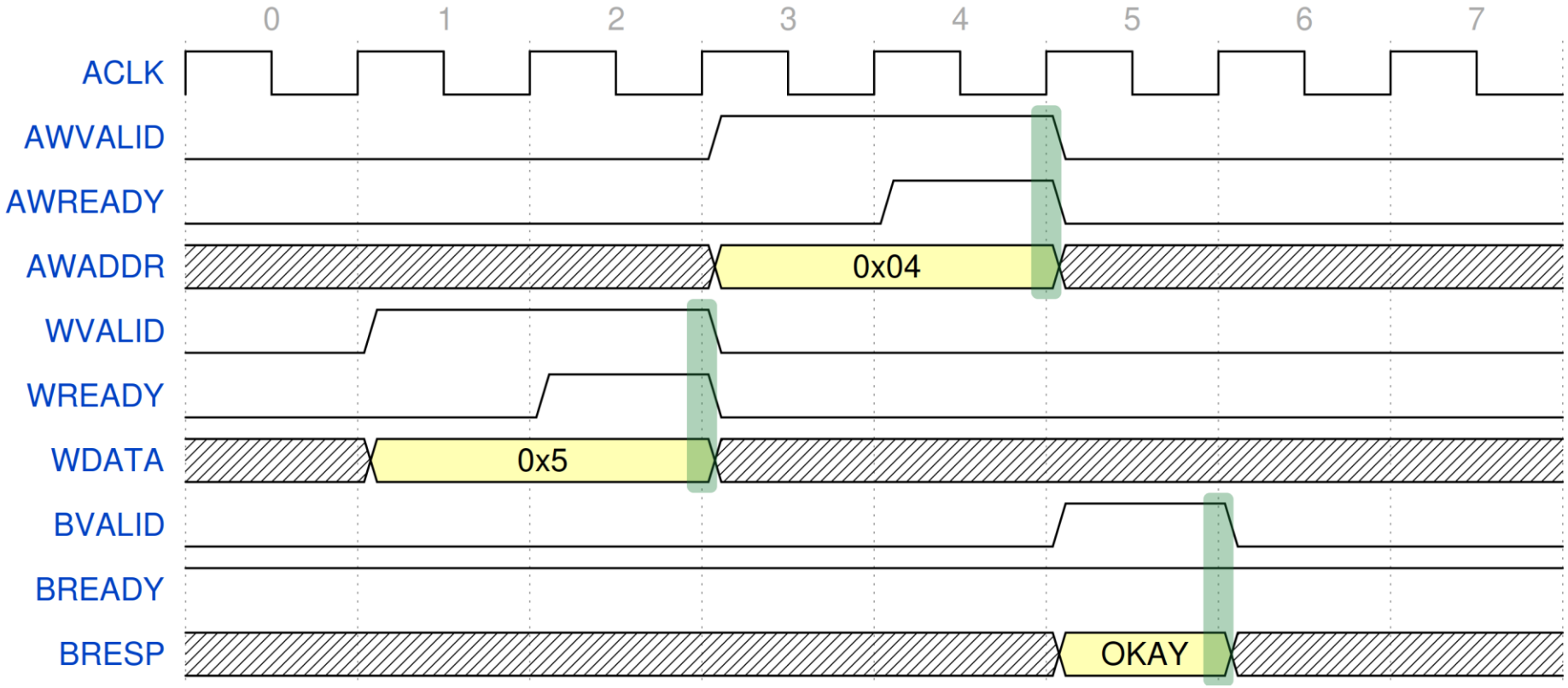
AXI4-Lite write. Legal or illegal?



8. Write data before the address

LEGAL

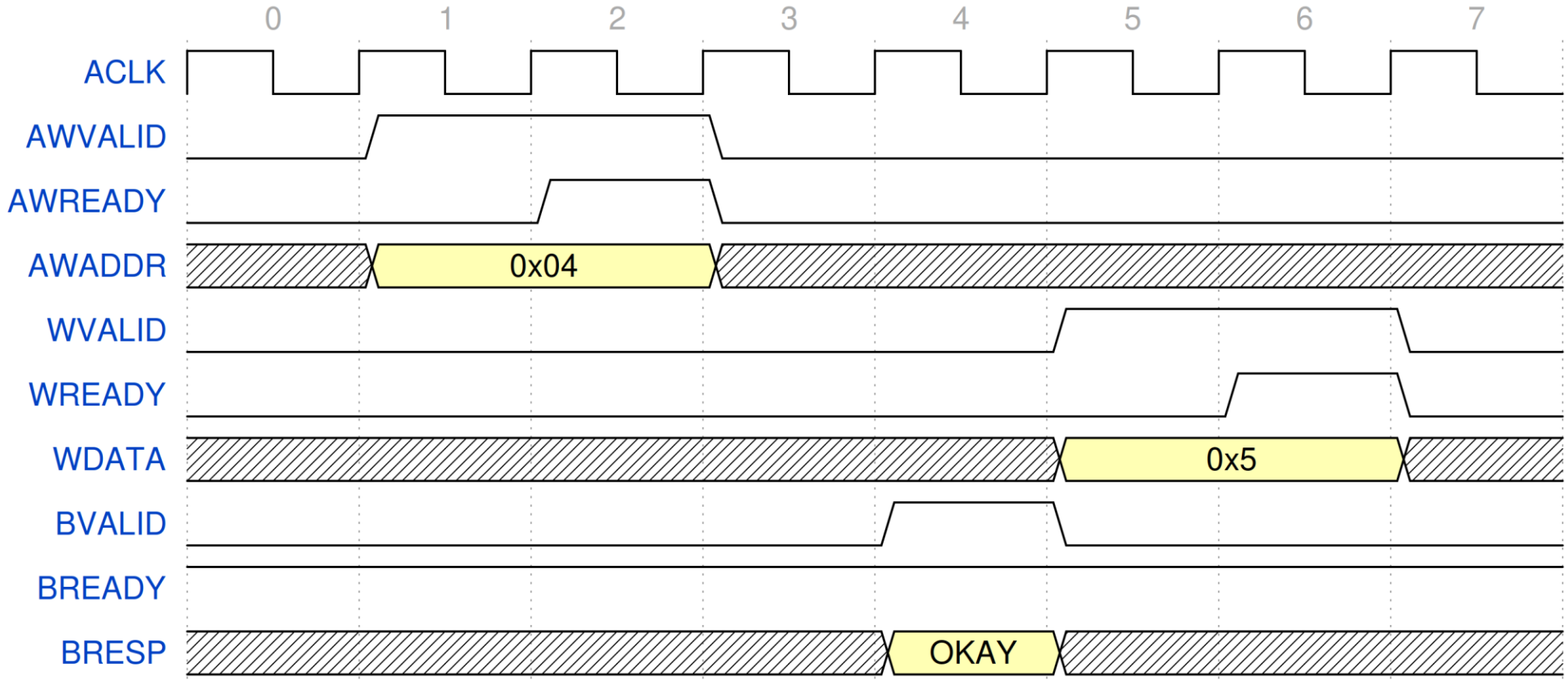
AW and W are independent channels and may arrive in either order. BVALID waits until both have transferred.



Green: transfer (VALID and READY high at a rising edge). Red: rule violation.

9. An early write response

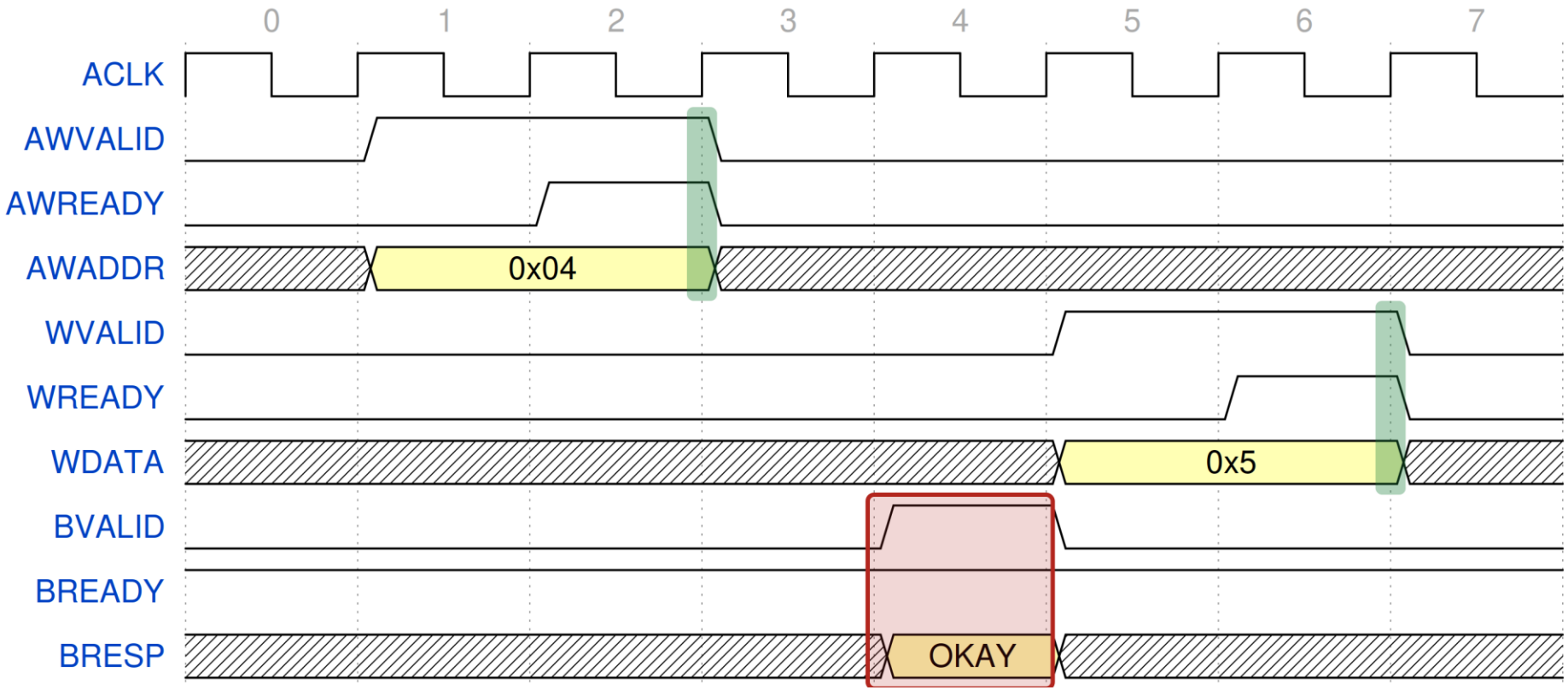
AXI4-Lite write. Legal or illegal?



9. An early write response

ILLEGAL

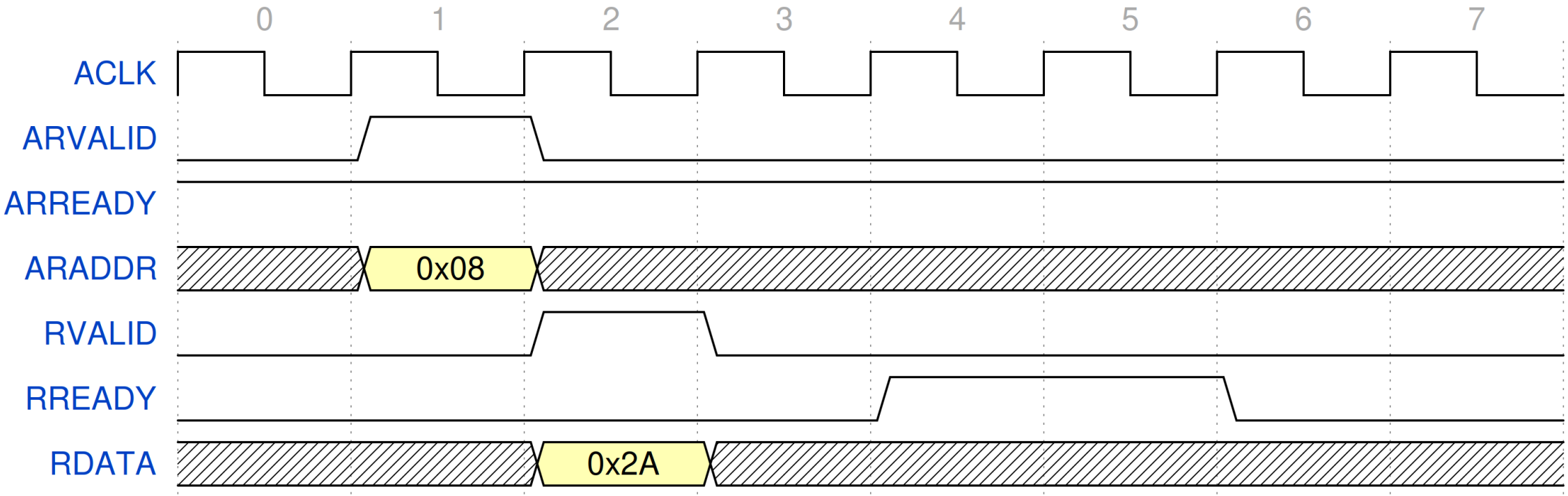
The slave answered "write done" before the write data arrived. BVALID must wait for both the AW and the W transfer.



Green: transfer (VALID and READY high at a rising edge). Red: rule violation.

10. The one-cycle RVALID

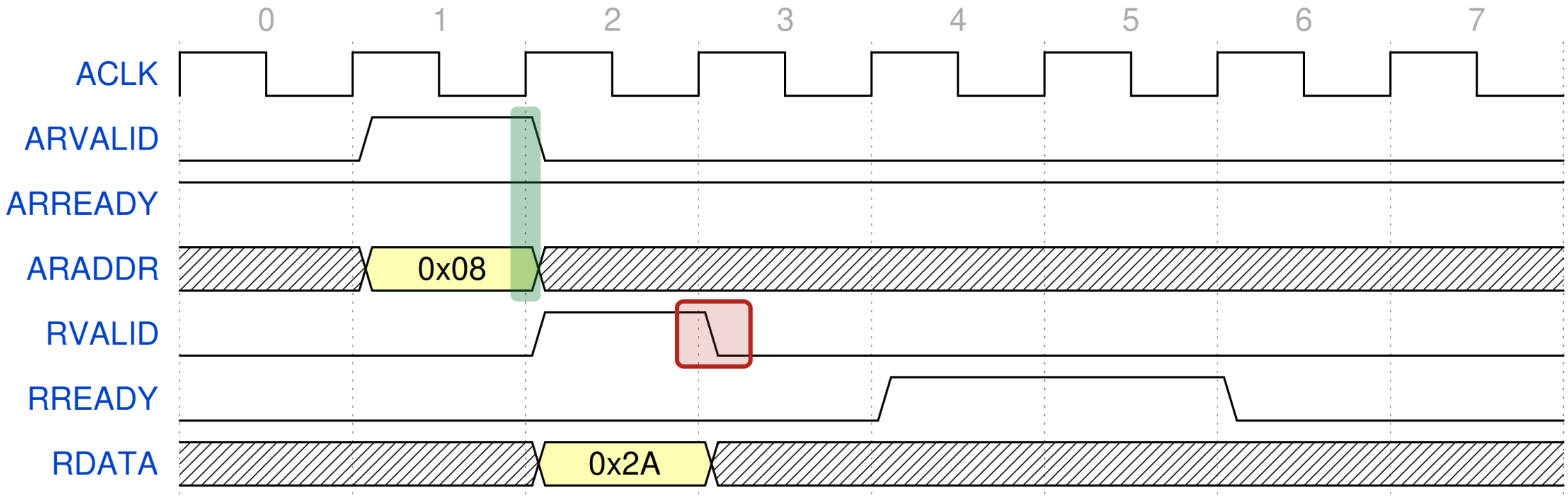
AXI4-Lite read. Legal or illegal?



10. The one-cycle RVALID

ILLEGAL

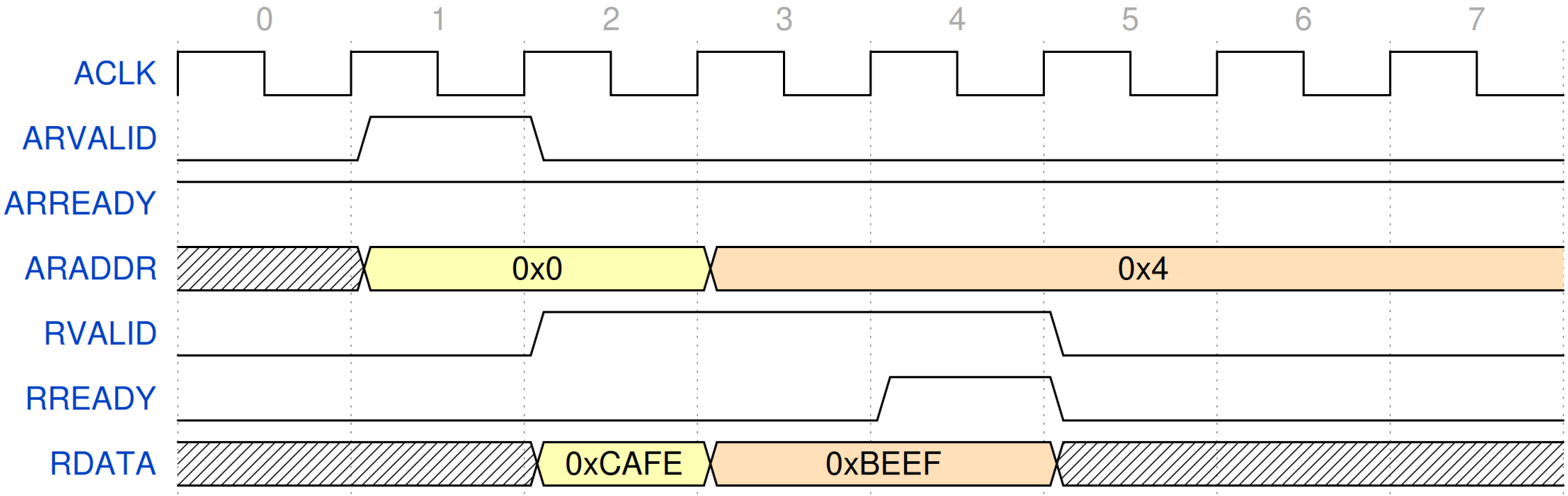
RVALID is a one-cycle pulse, but the master wasn't ready. RVALID must stay high until RREADY.



Green: transfer (VALID and READY high at a rising edge). Red: rule violation.

11. Read data that moves

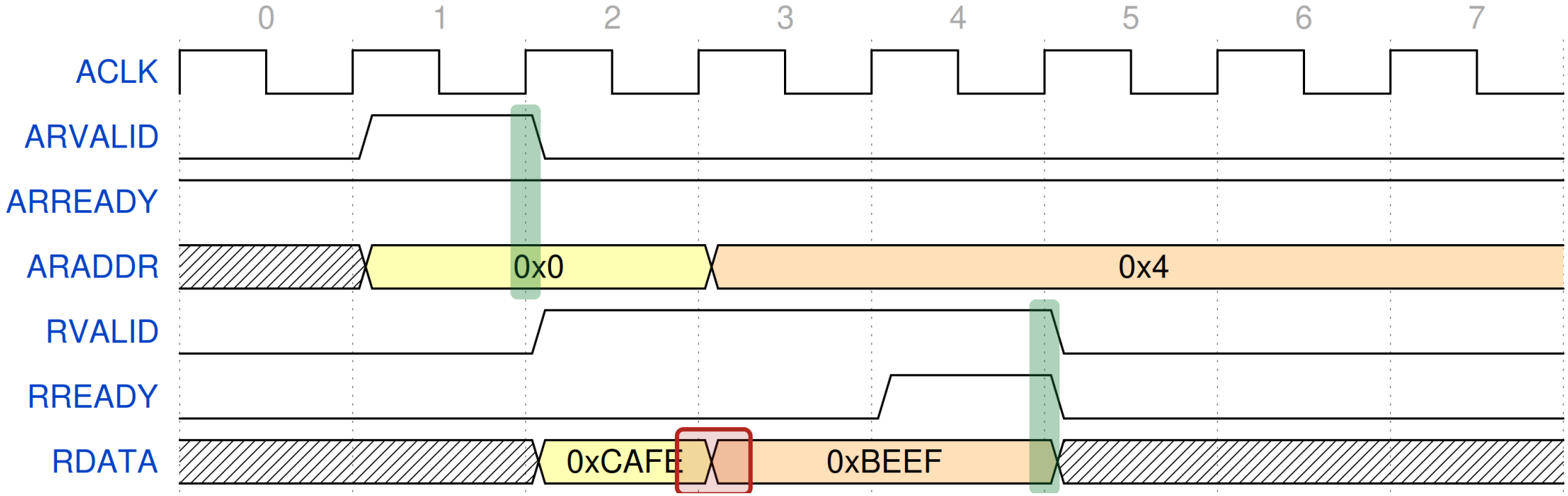
AXI4-Lite read. Legal or illegal?



11. Read data that moves

ILLEGAL

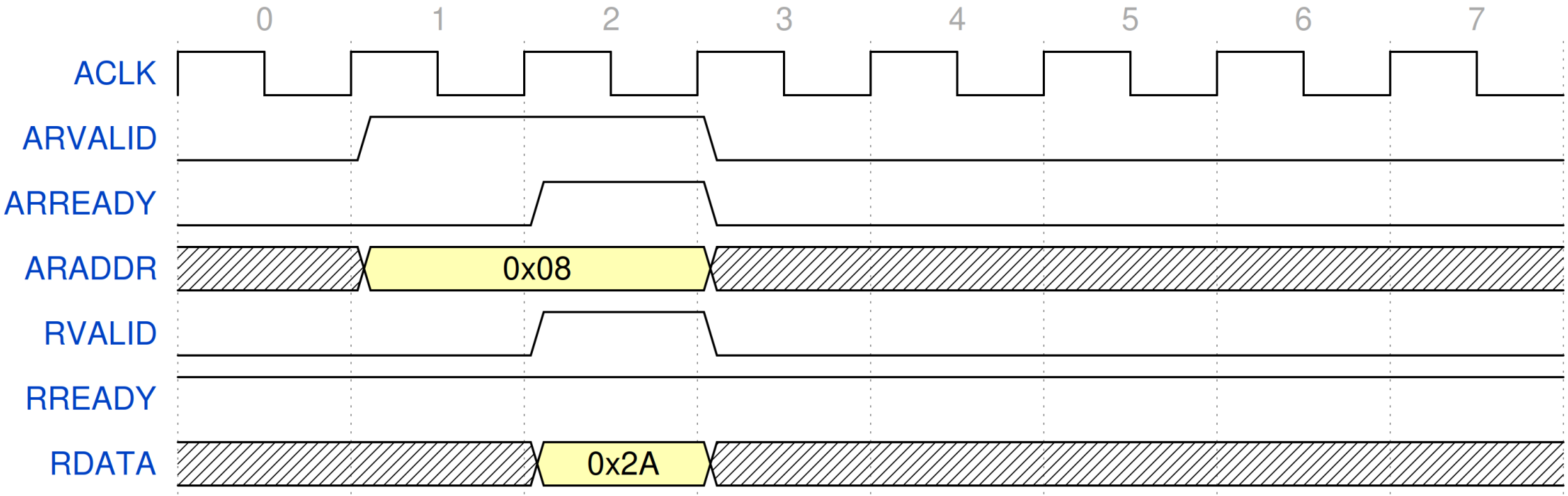
RDATA changed while RVALID was waiting for RREADY. The master asked for 0x0 but received the value at 0x4.



Green: transfer (VALID and READY high at a rising edge). Red: rule violation.

12. Answering before the question

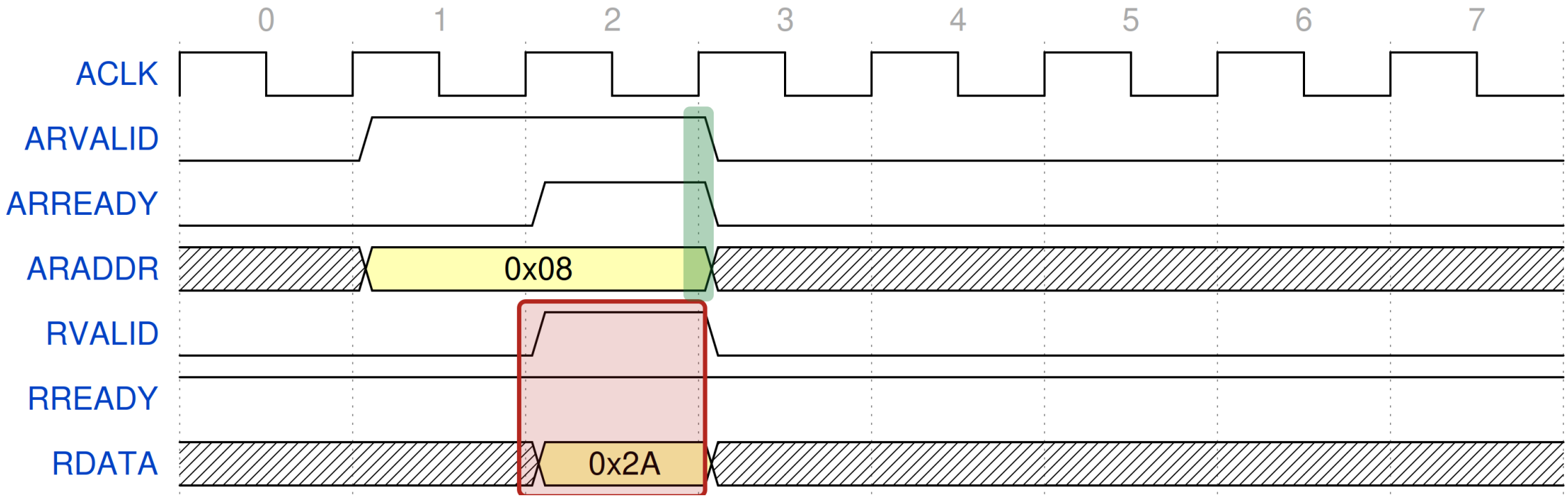
AXI4-Lite read. Legal or illegal?



12. Answering before the question

ILLEGAL

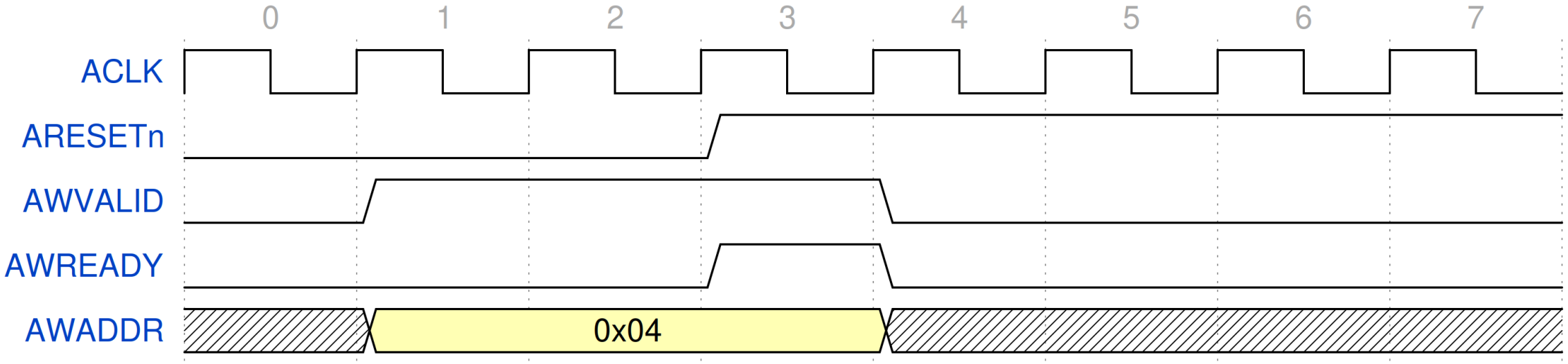
RVALID went high before the AR handshake finished. The slave must wait for ARVALID and ARREADY first.



Green: transfer (VALID and READY high at a rising edge). Red: rule violation.

13. VALID during reset

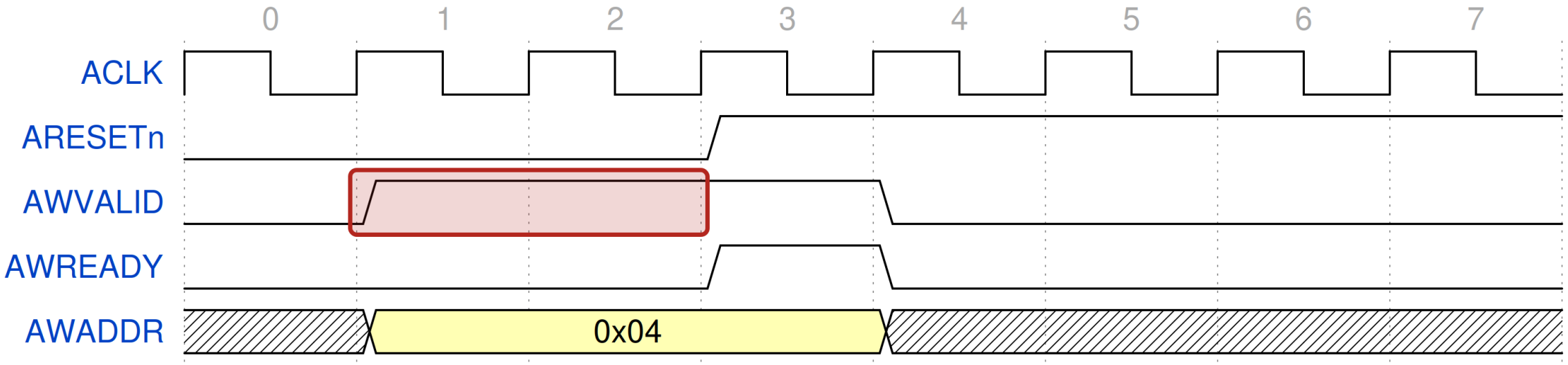
Legal or illegal?



13. VALID during reset

ILLEGAL

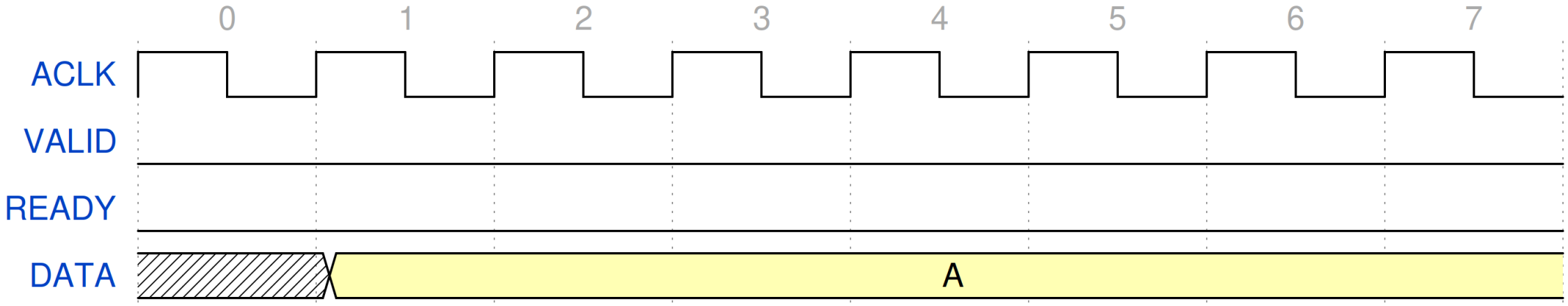
During reset, masters must drive VALID low. The earliest VALID may rise is a rising edge after ARESETn is high.



Green: transfer (VALID and READY high at a rising edge). Red: rule violation.

14. Nothing happens

The master has data to send. Nothing ever happens. Whose fault is it?



14. Nothing happens

The master's The source must not wait for READY before asserting VALID. The destination is allowed to wait for VALID, so the master caused this deadlock.

