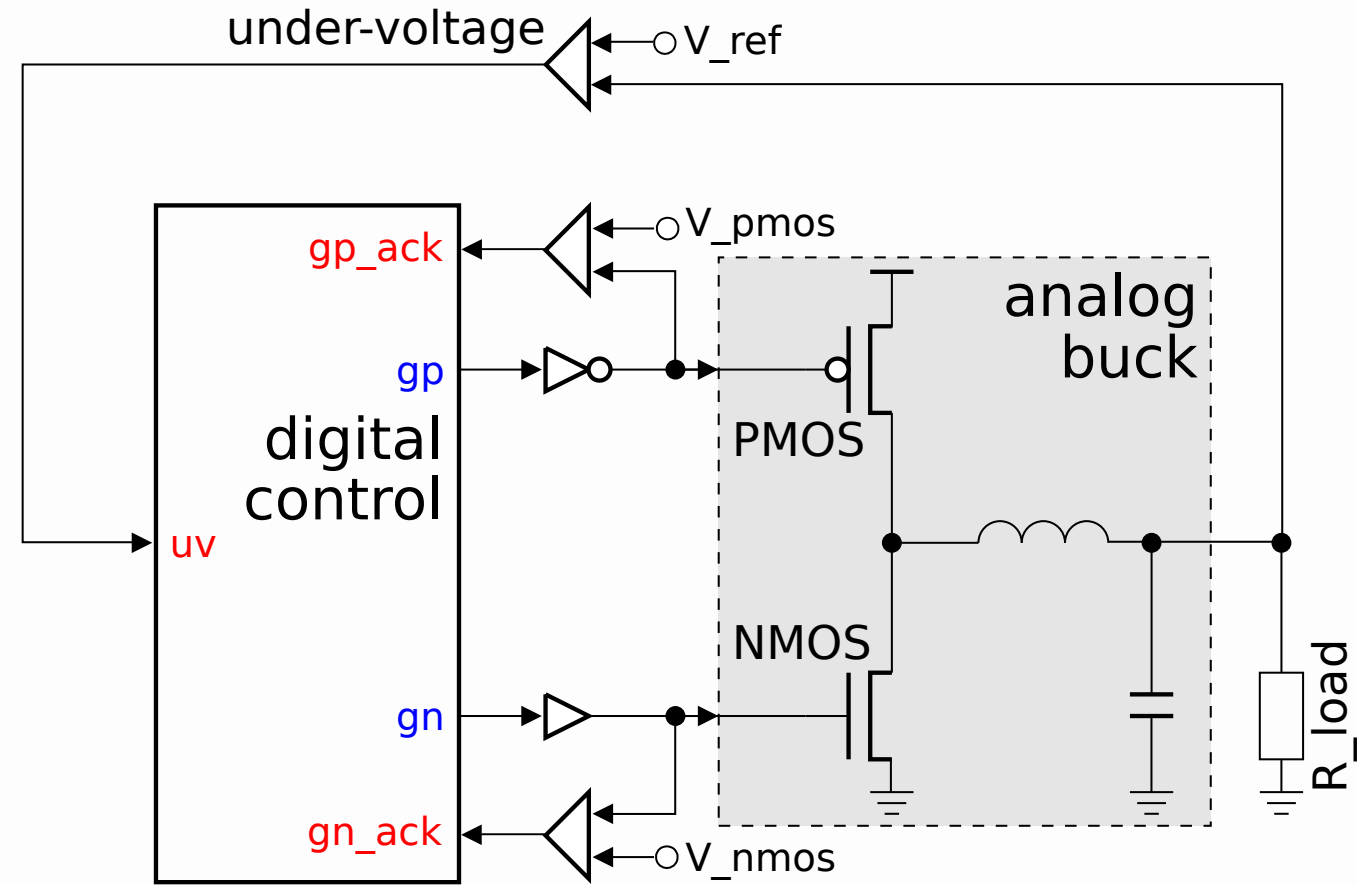


Analog-to-asynchronous (A2A) interfaces

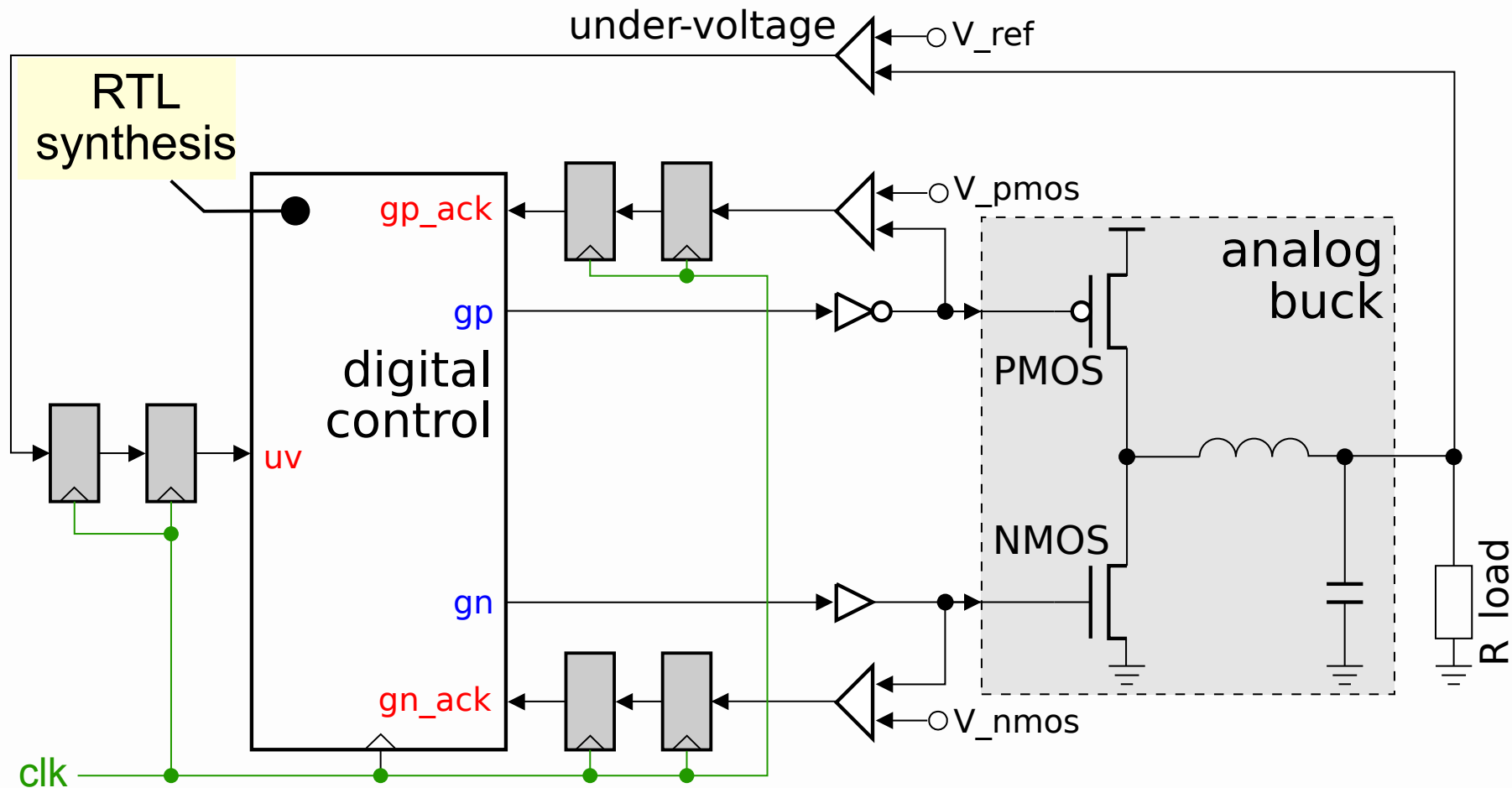
Danil Sokolov, Victor Khomenko, Alex Yakovlev

Newcastle University, UK

Motivating example: toy buck converter

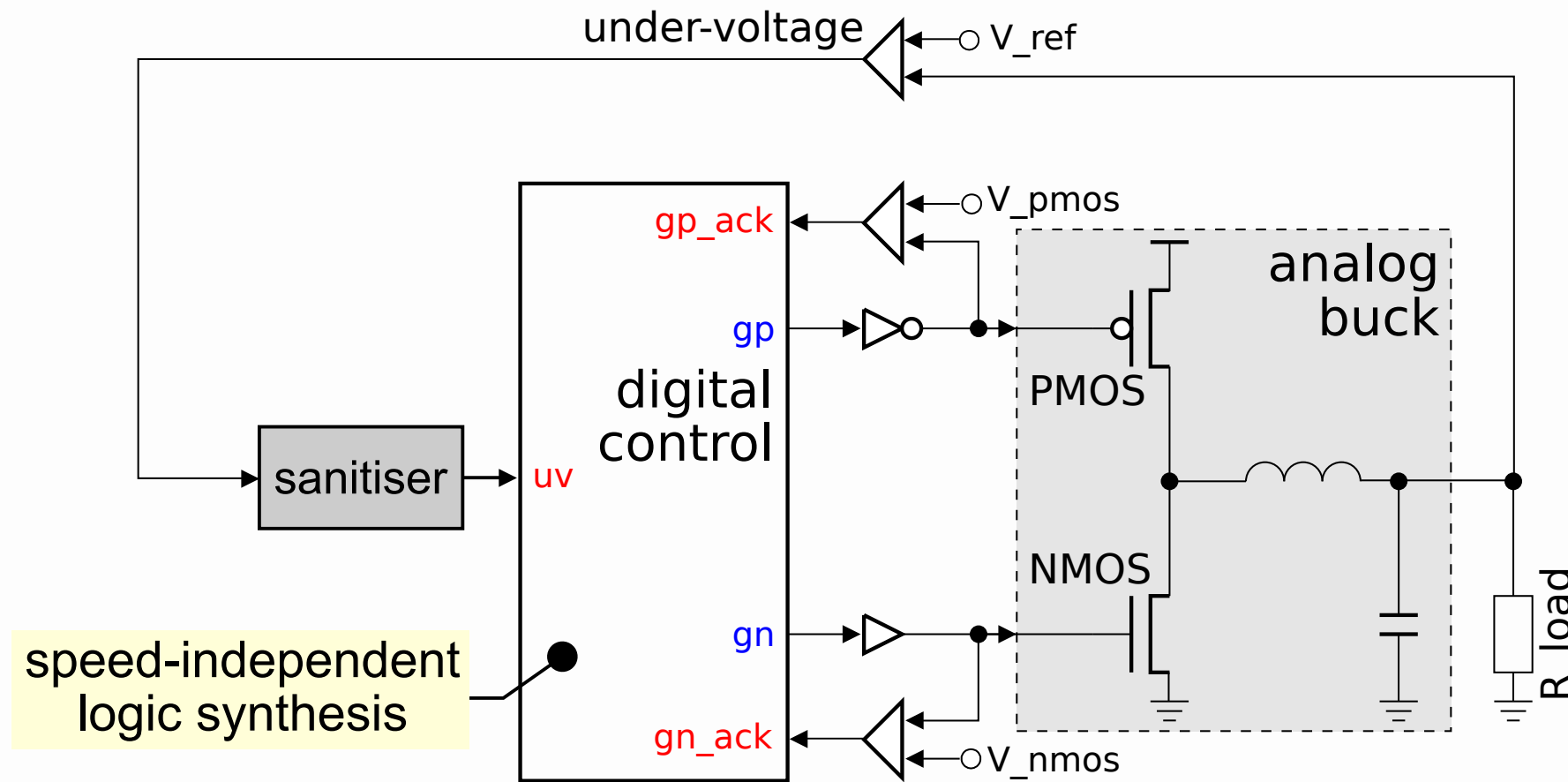


Motivating example: toy buck converter



- Synchronous implementation – requires synchronisers for asynchronous inputs
 - Synchronisers also sanitize hazardous / dirty inputs from analog environment
 - Reaction time – 3 clock cycles

Motivating example: toy buck converter

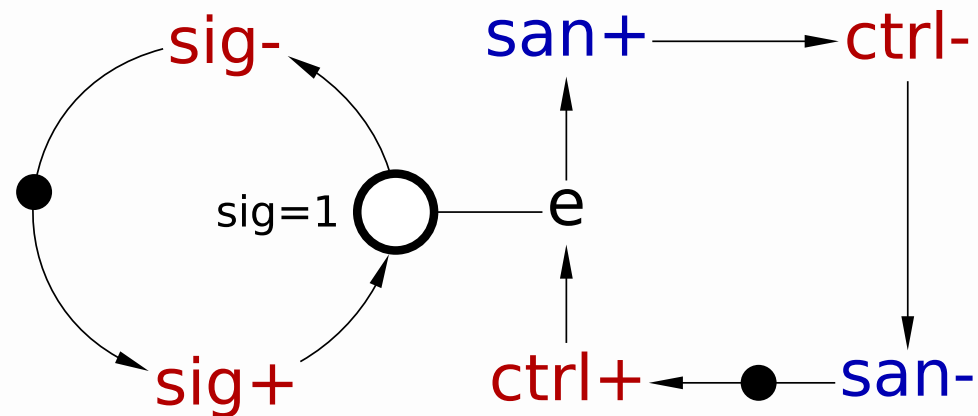
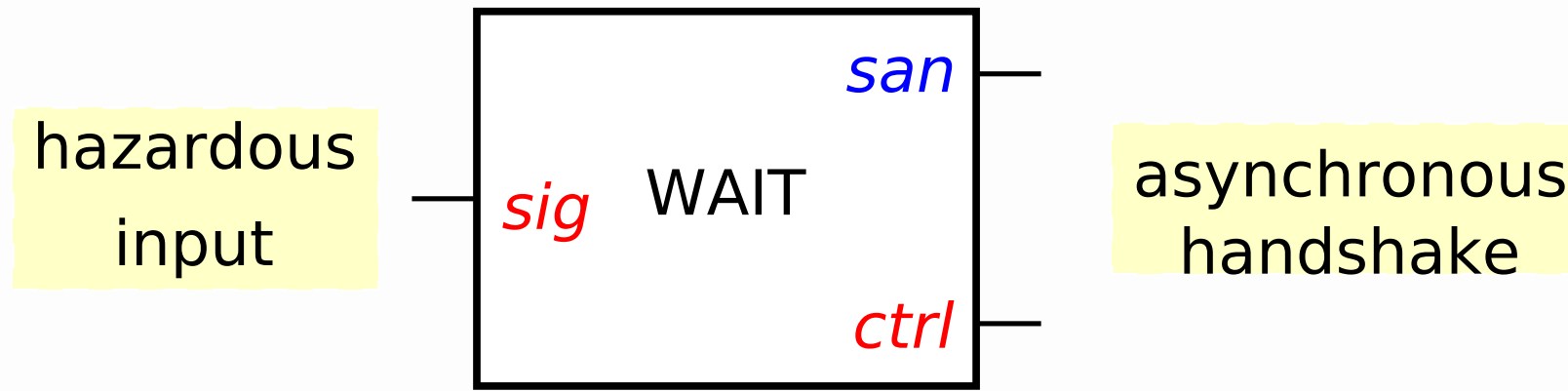


- Asynchronous implementation – natural for asynchronous inputs
 - Reaction time – several gate delays
 - Need to sanitise hazardous under-voltage input

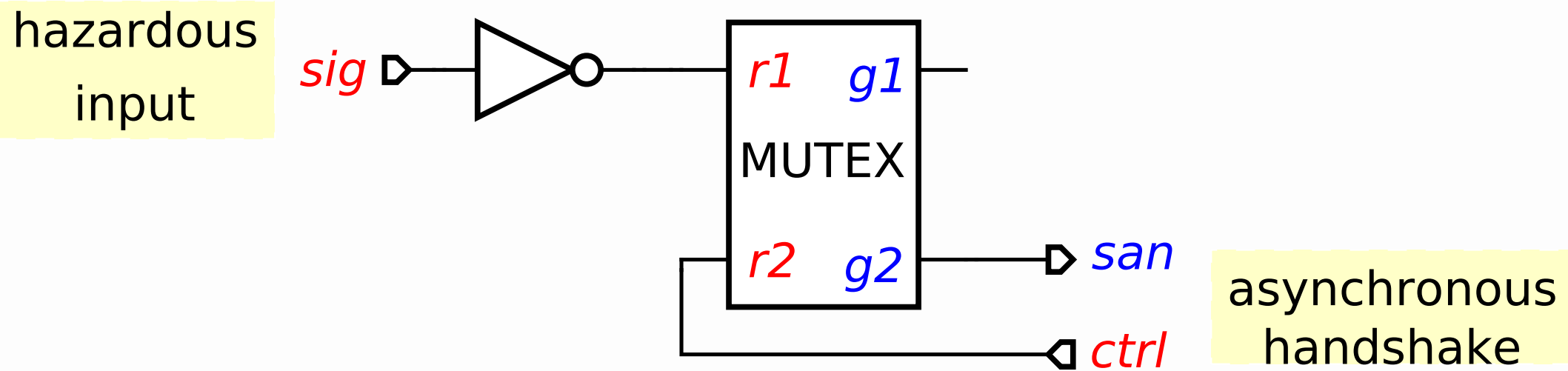
Asynchronous arbitration primitives

- Synchronisation
 - WAIT: synchronise with high level of hazardous input
 - RWAIT: WAIT that can be with released/cancellation
 - WAIT01: synchronise with hazardous rising edge
 - WAIT2: synchronise with both phases of a hazardous input
- Decision-making
 - WAITX: arbitrate between two hazardous inputs
 - SAMPLE: sample a hazardous input

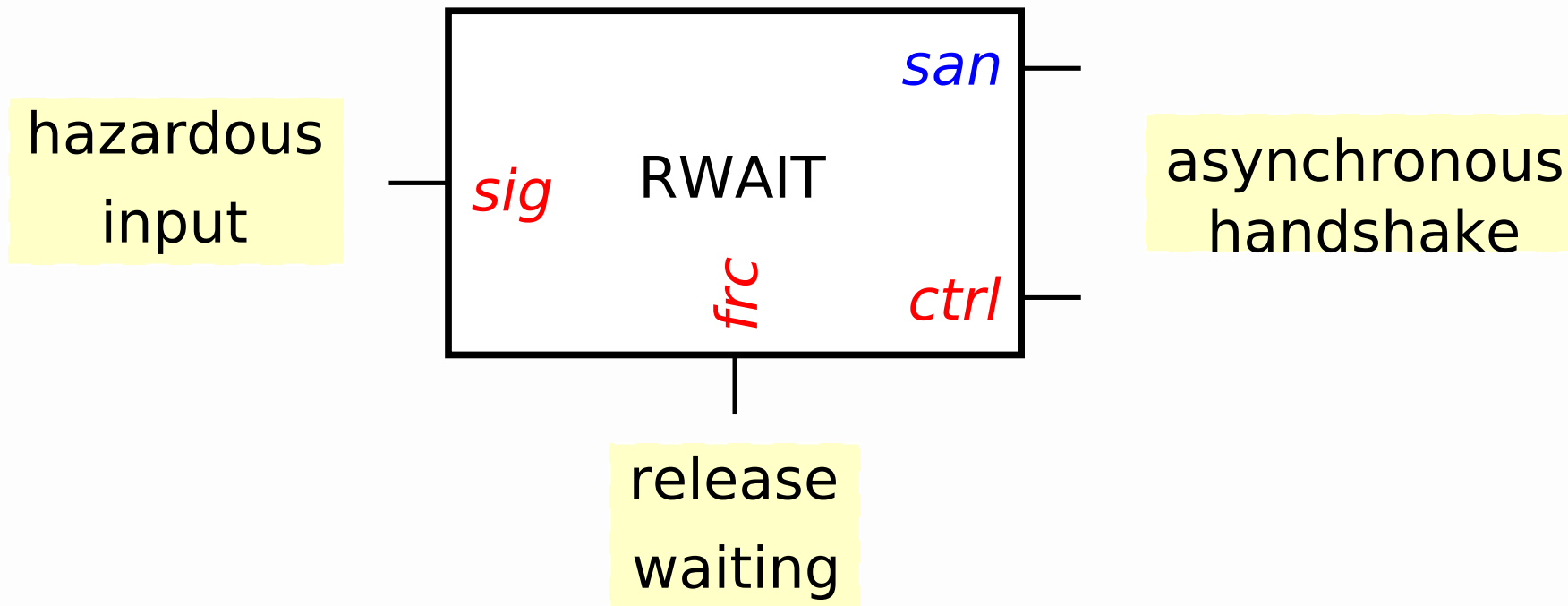
WAIT: synchronise handshake with high level of hazardous input



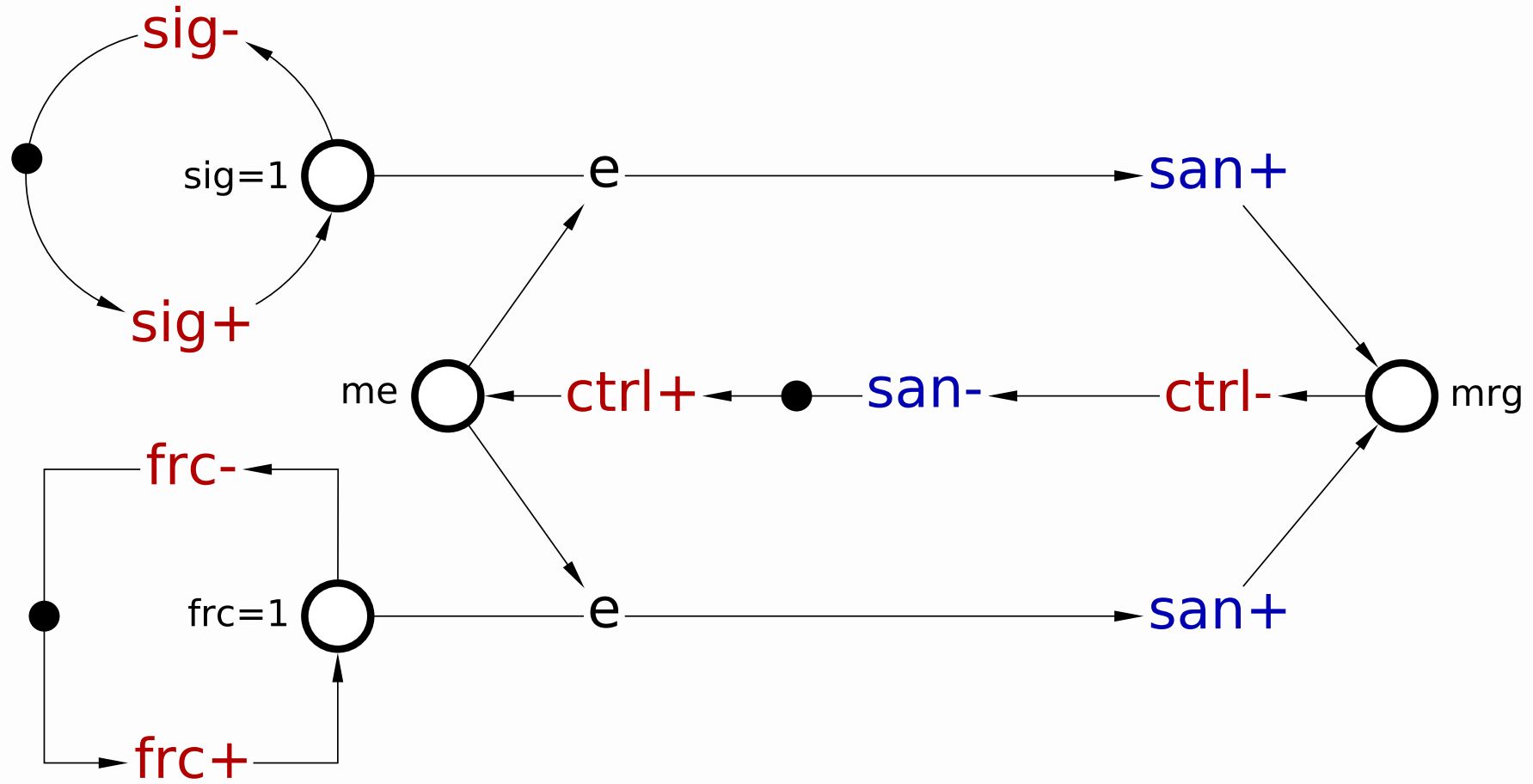
WAIT: synchronise handshake with high level of hazardous input



RWAIT: WAIT that can be released/cancelled



RWAIT: WAIT that can be released/cancelled



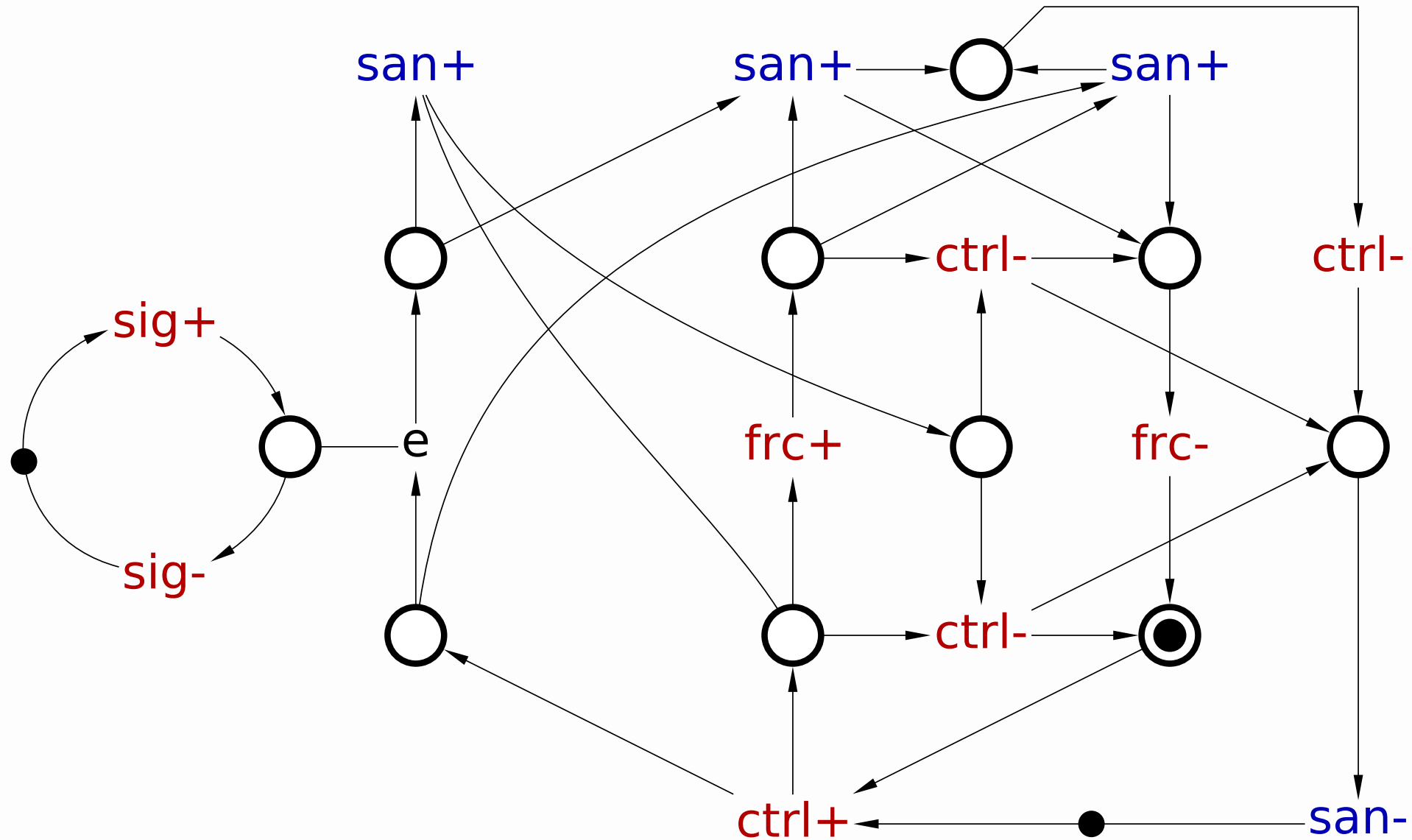
frc and san form a handshake

RWAIT: WAIT that can be released/cancelled

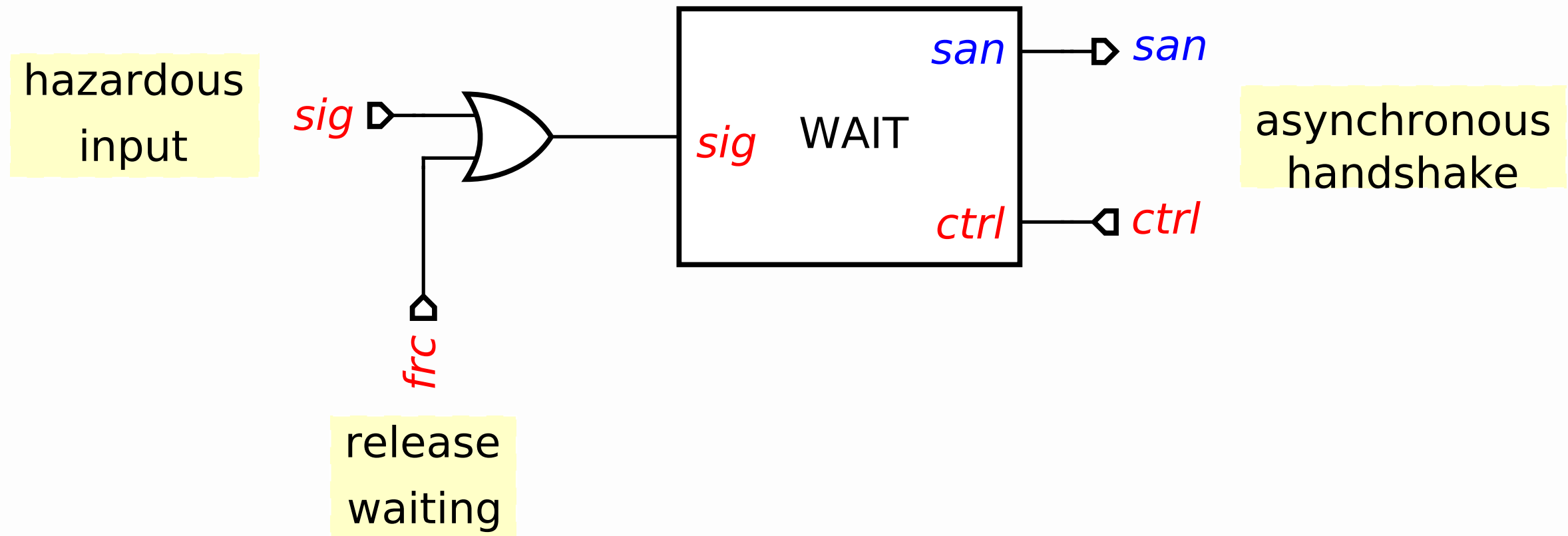
san caused by sig

san caused by sig or frc

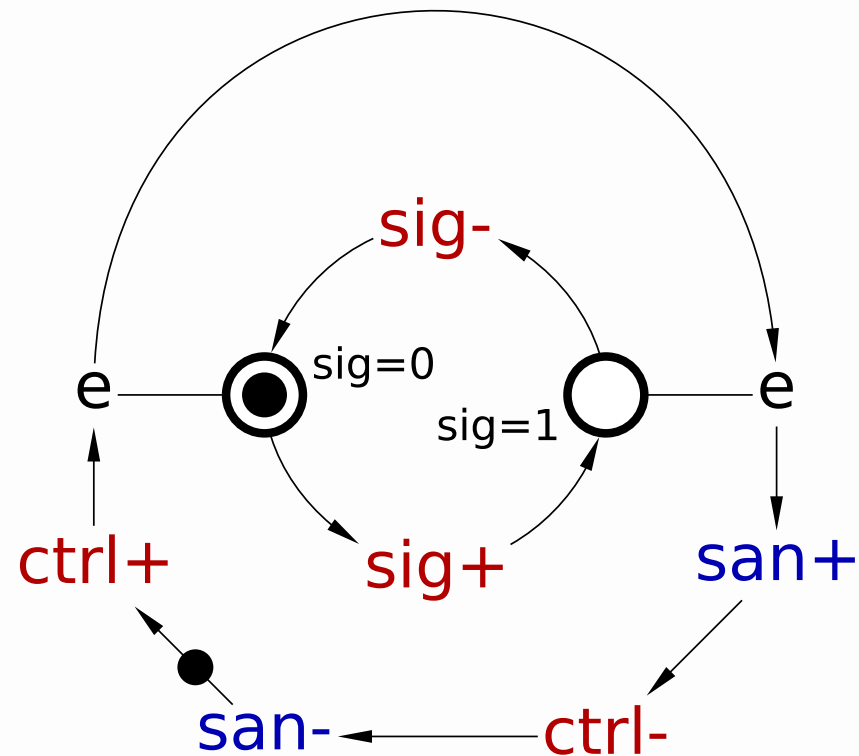
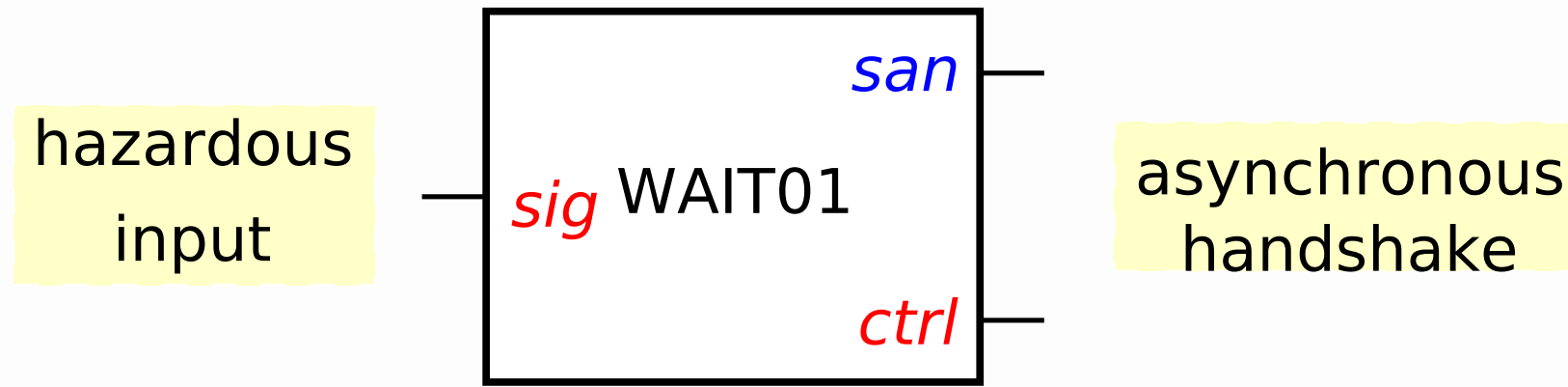
san caused by frc



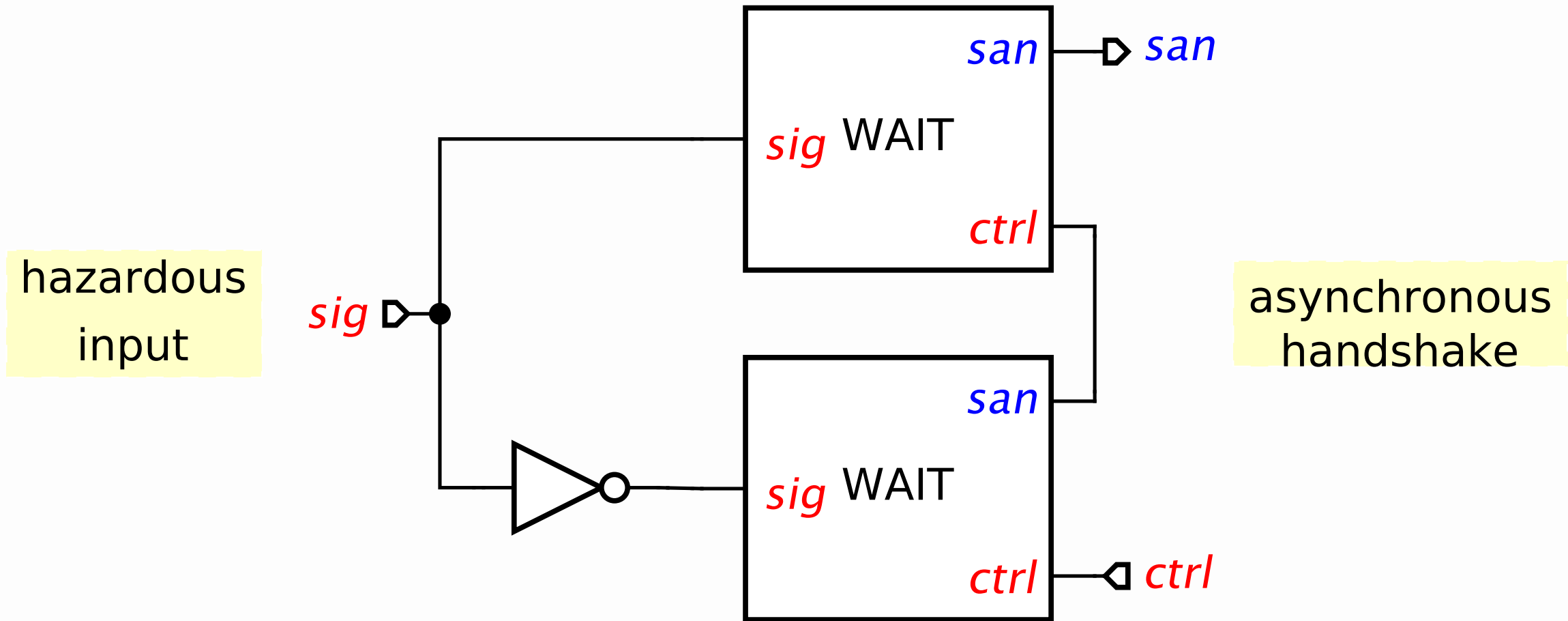
RWAIT: WAIT that can be released/cancelled



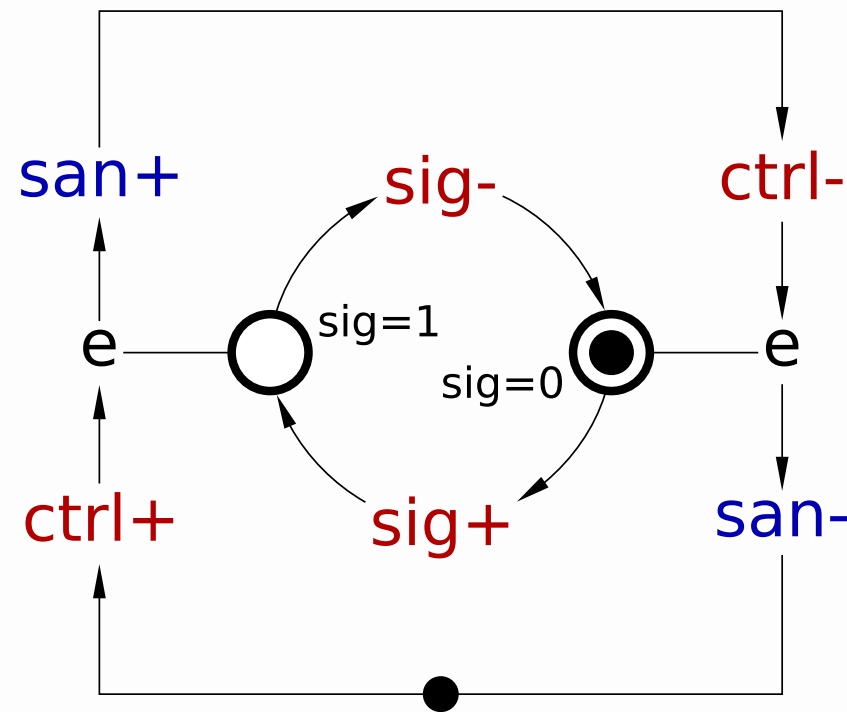
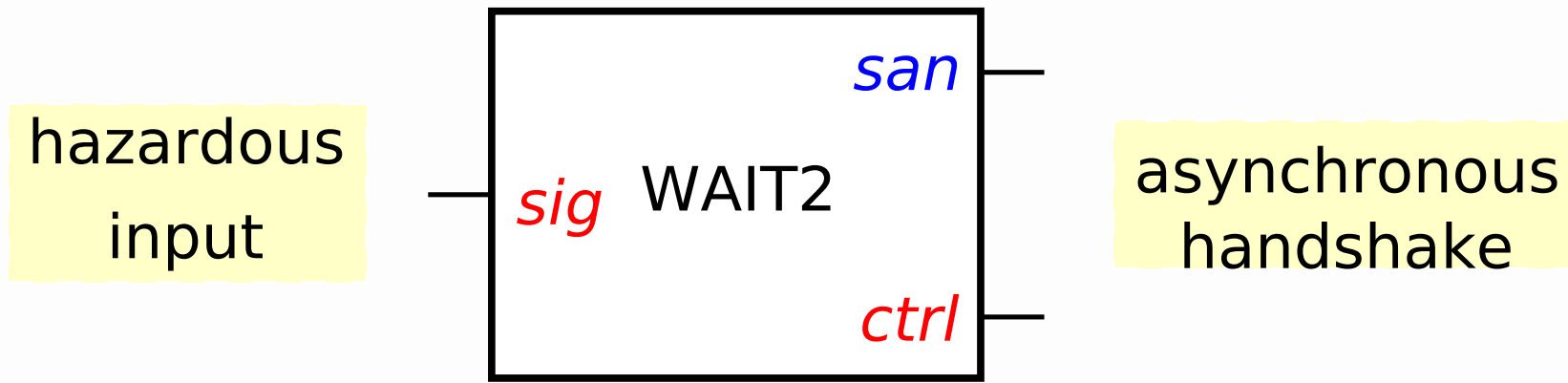
WAIT01: synchronise handshake with rising edge of hazardous input



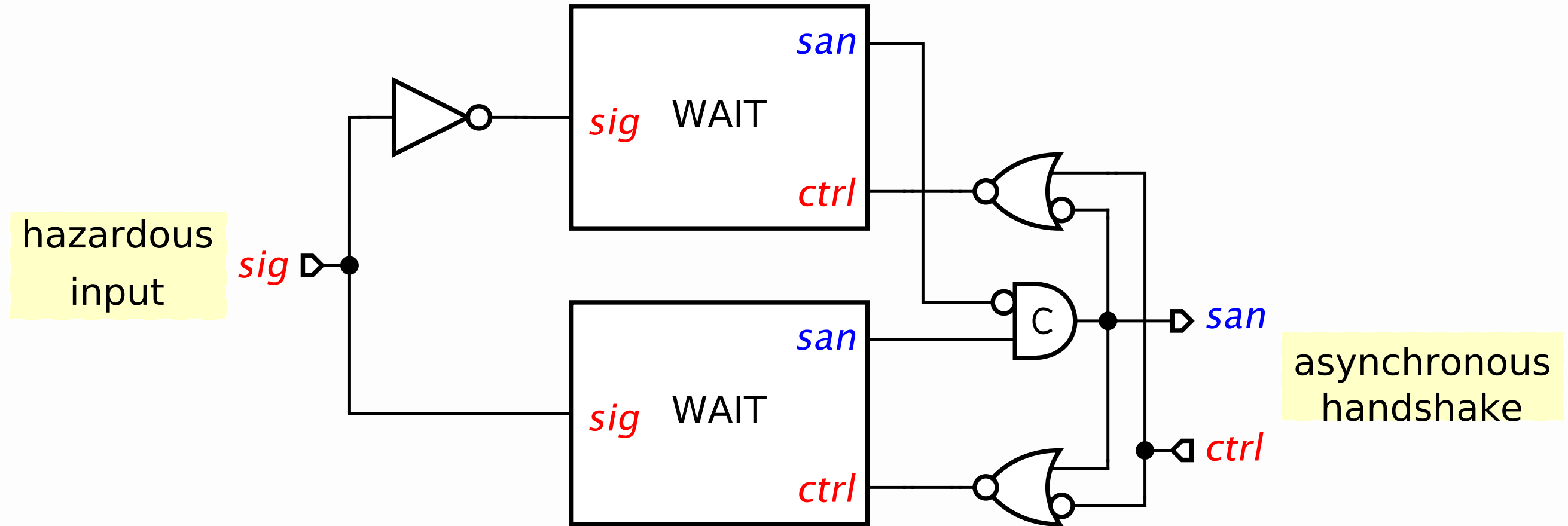
WAIT01: synchronise handshake with rising edge of hazardous input



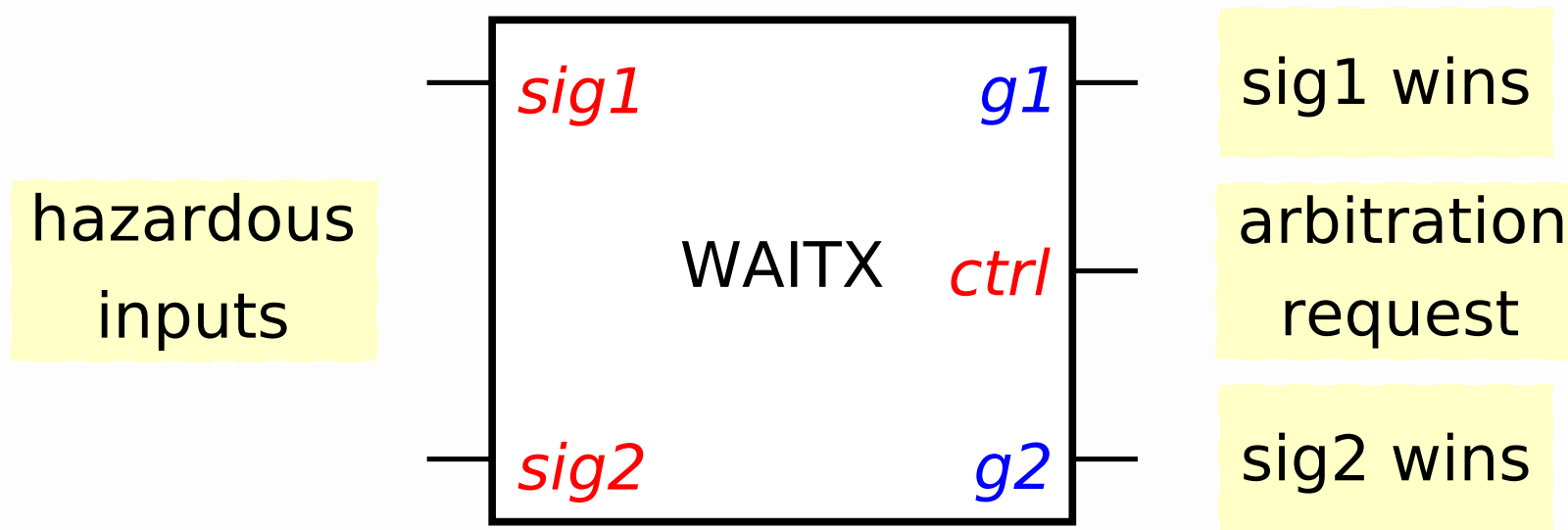
WAIT2: synchronise handshake with both phases of hazardous input



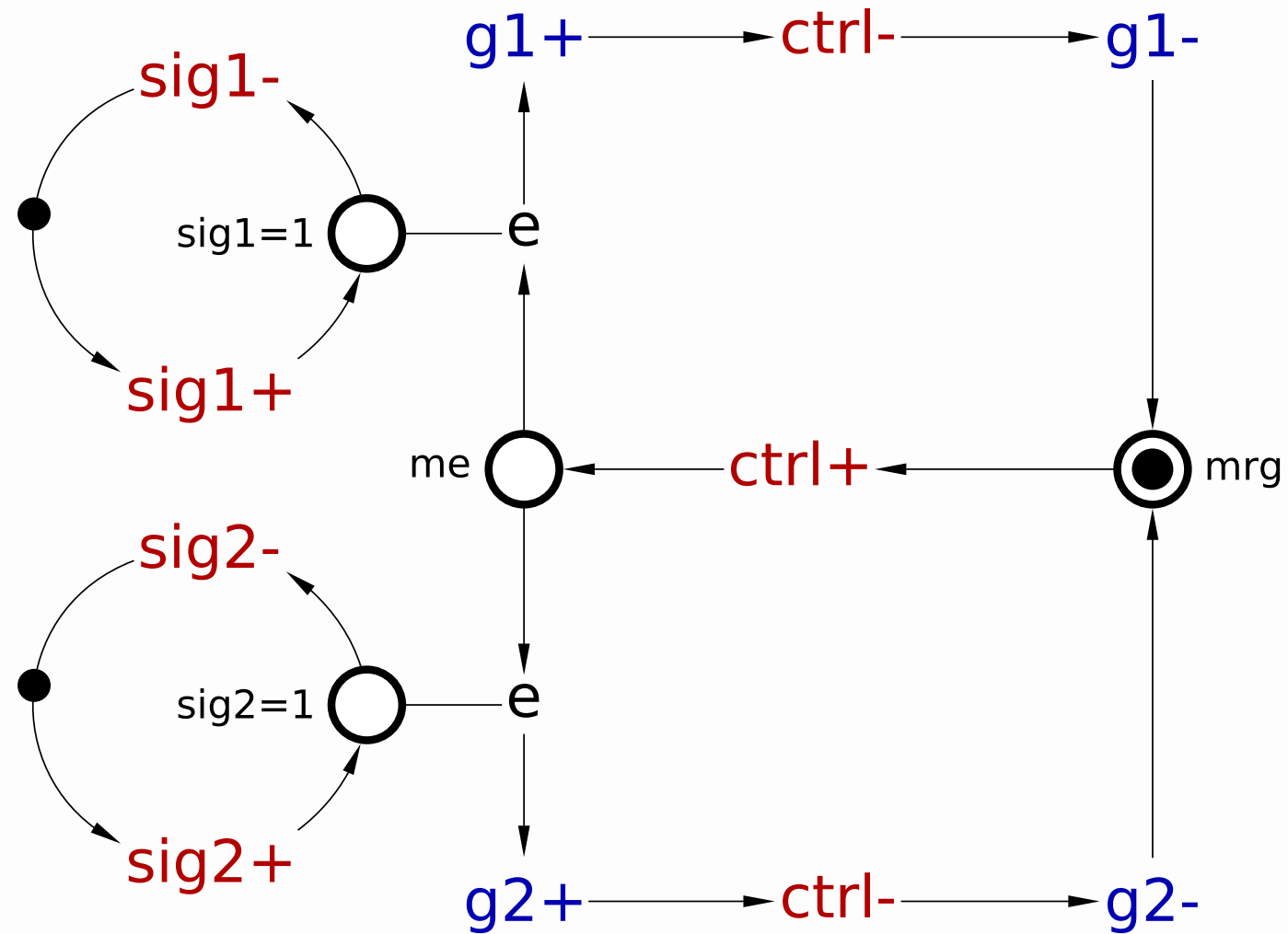
WAIT2: synchronise handshake with both phases of hazardous input



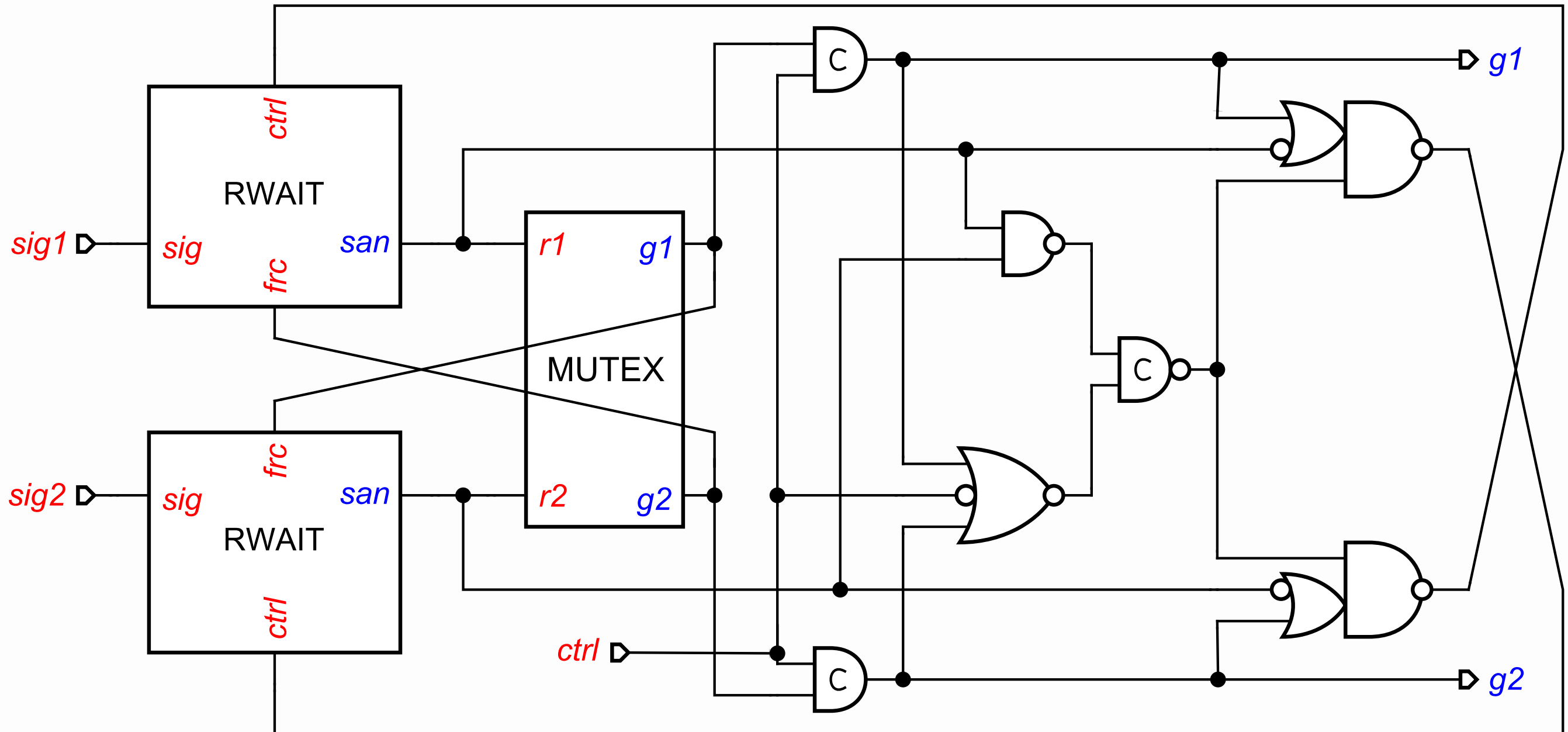
WAITX: arbitrate between two hazardous inputs



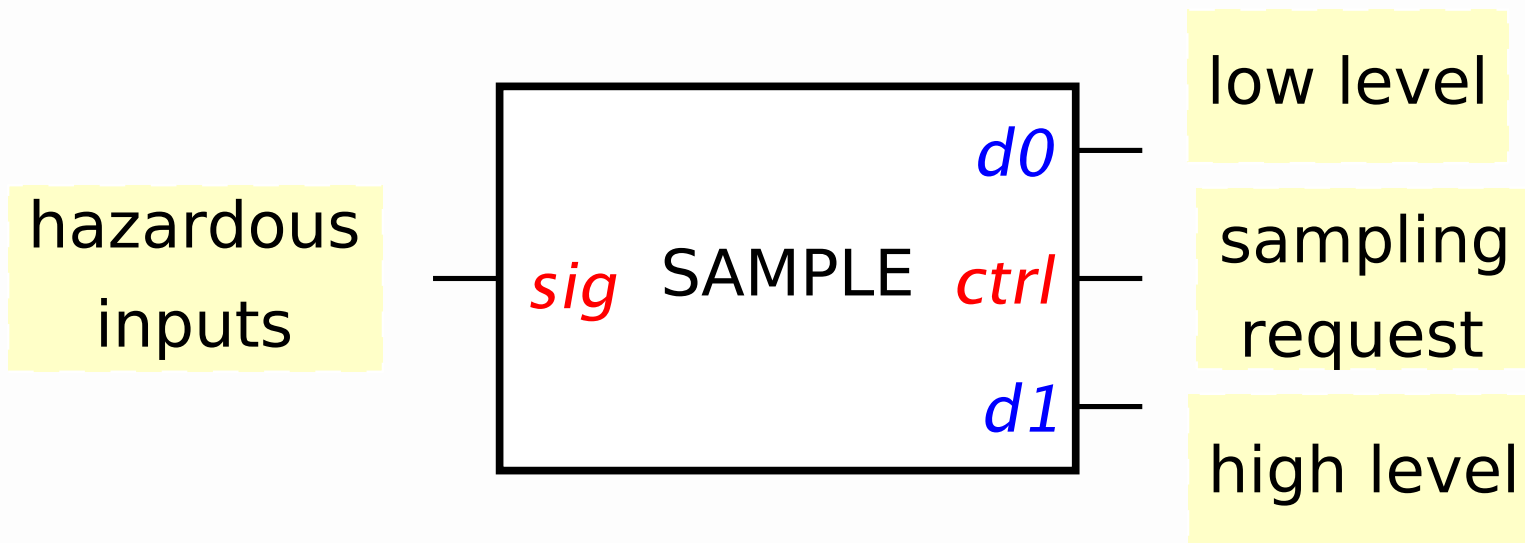
WAITX: arbitrate between two hazardous inputs



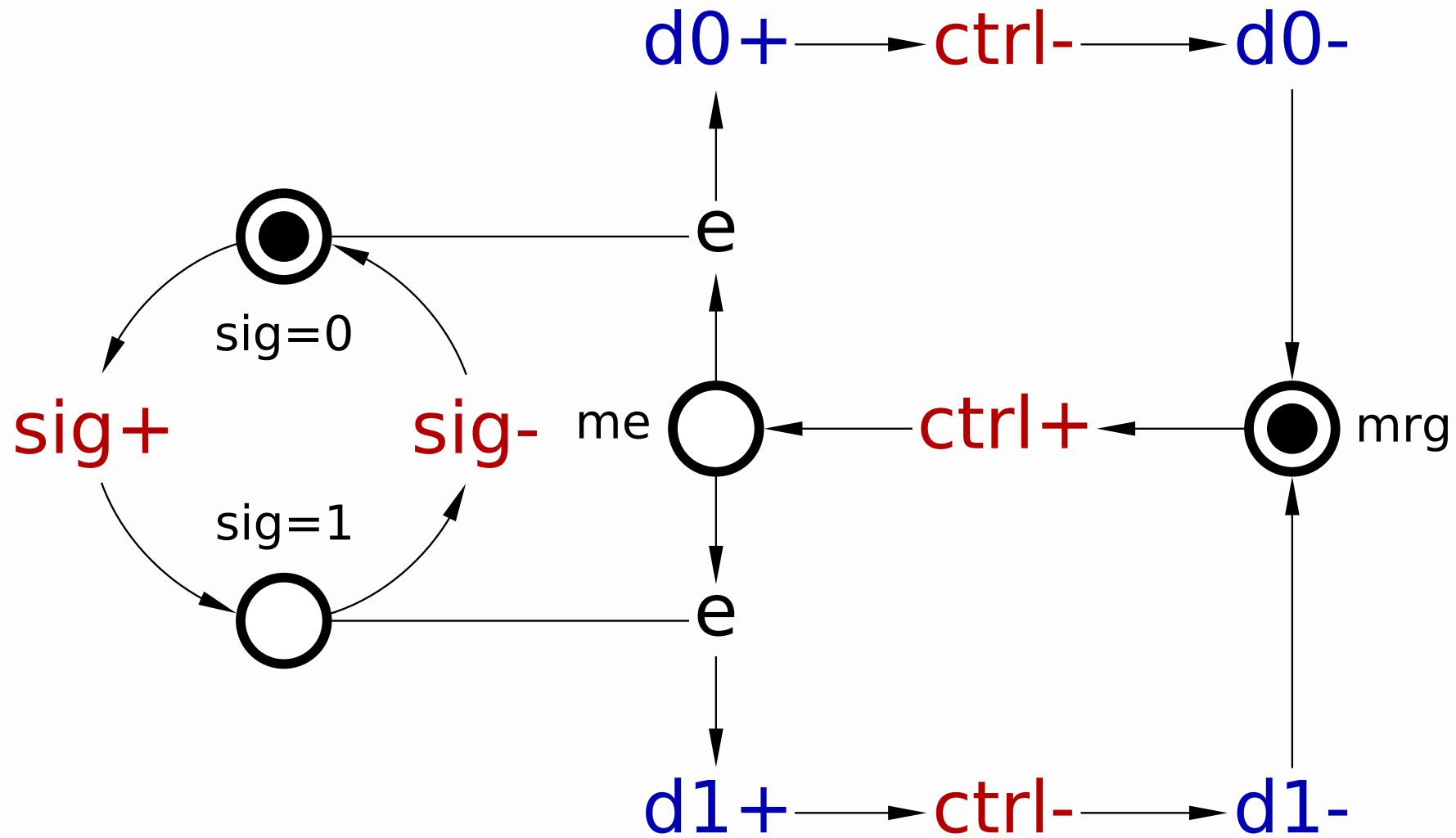
WAITX: arbitrate between two hazardous inputs



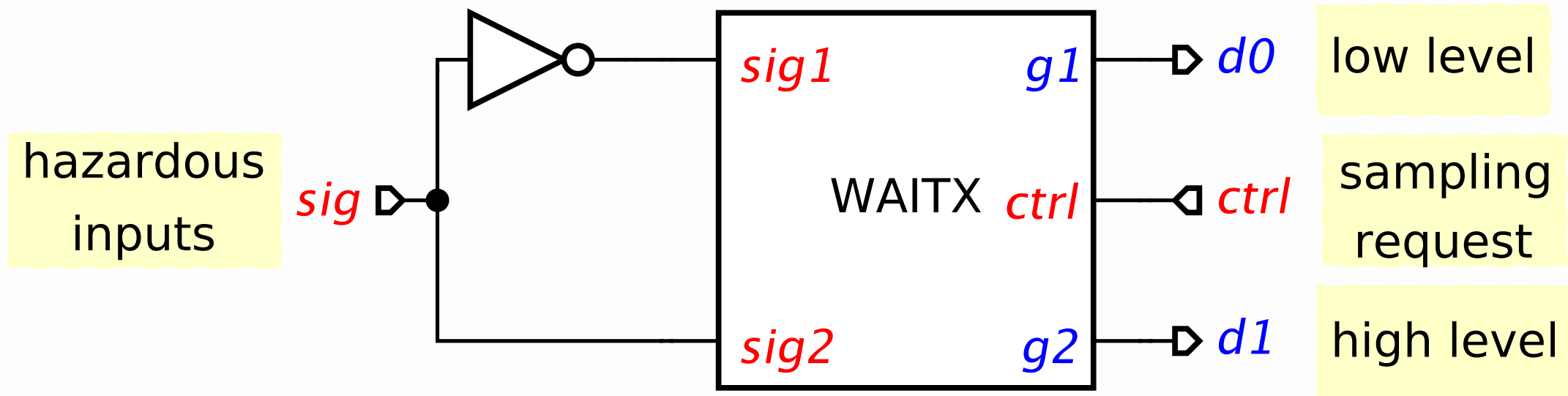
SAMPLE: sample a hazardous input



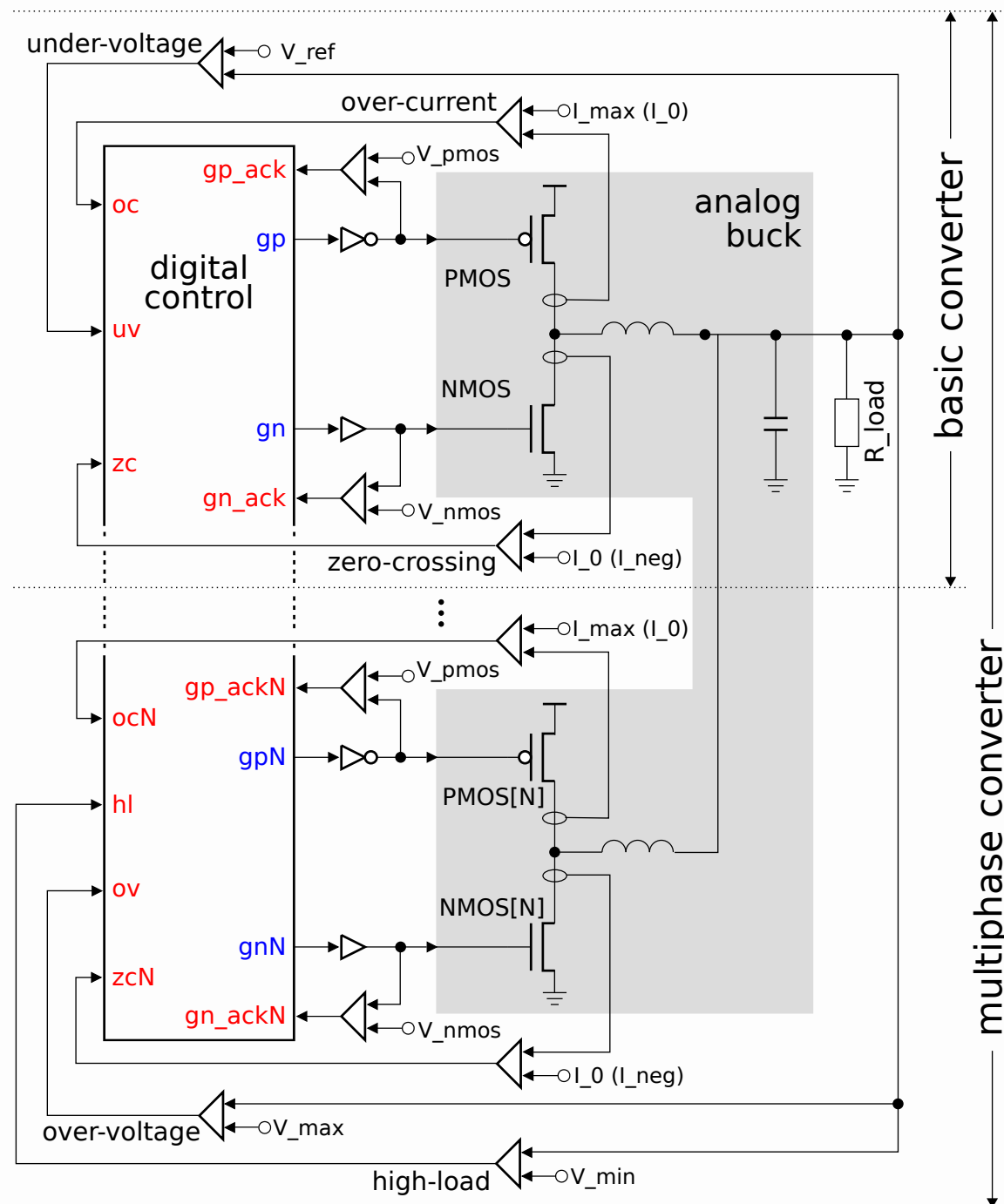
SAMPLE: sample a hazardous input



SAMPLE: sample a hazardous input



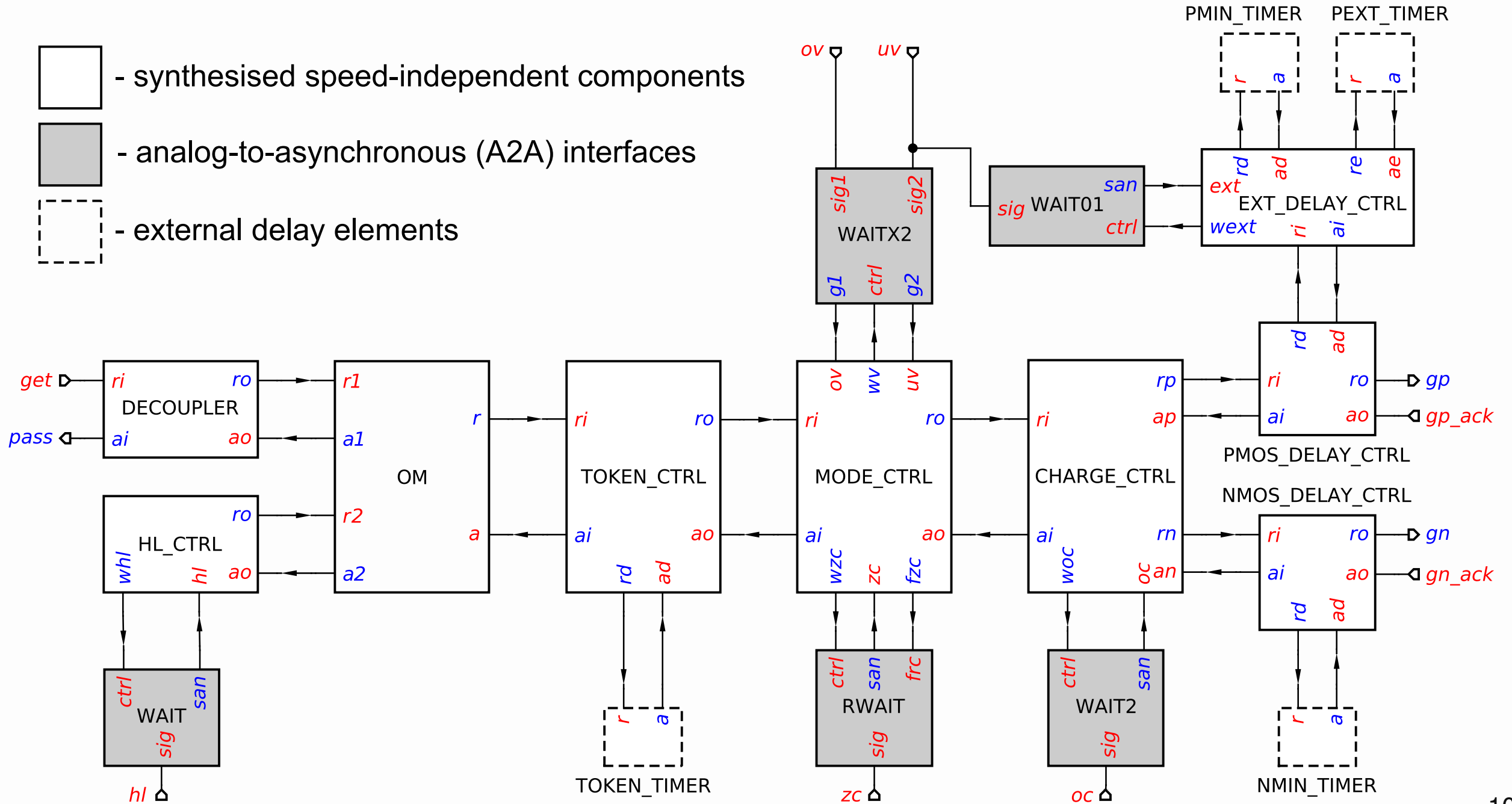
Application example: multiphase buck converter



- Phases – pairs of power regulating transistors
 - Each phase operates as a basic buck
 - Phases are activated sequentially
 - Active phases may overlap
- Many operating modes
 - under-voltage (UV)
 - over-current (OC)
 - zero-crossing (ZC)
 - over-voltage (OV)
 - high-load (HL)

Application example: multiphase buck converter

- synthesised speed-independent components
- analog-to-asynchronous (A2A) interfaces
- external delay elements



Application example: multiphase buck converter

- Benefits over conventional synchronous design with synchronisers
 - No synchronisation failures
 - Quick response time (few gate delays)
 - Reaction time can be traded off for smaller coils
 - Lower voltage ripple and peak current

Conclusions

- Library of asynchronous arbitration primitives (workcraft.org/a2a)
 - Low-latency synchronisation and decision-making
 - Developed and formally verified in WORKCRAFT
- Building blocks for applications that require:
 - Efficient synchronisation between clock and voltage domains
 - Sanitising 'dirty' signals from analog environment
- Demonstrated benefits in the domain of power converters