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Supplementary Materials for

Reset-free DNA logic circuits for real-time input processing and memory

Junho Sim *et al.*

Corresponding author: Yeongjae Choi, yeongjae@kaist.ac.kr

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The PDF file includes:

Figs. S1 to S12
Tables S1 to S9
Legend for data S1

Other Supplementary Material for this manuscript includes the following:

Data S1

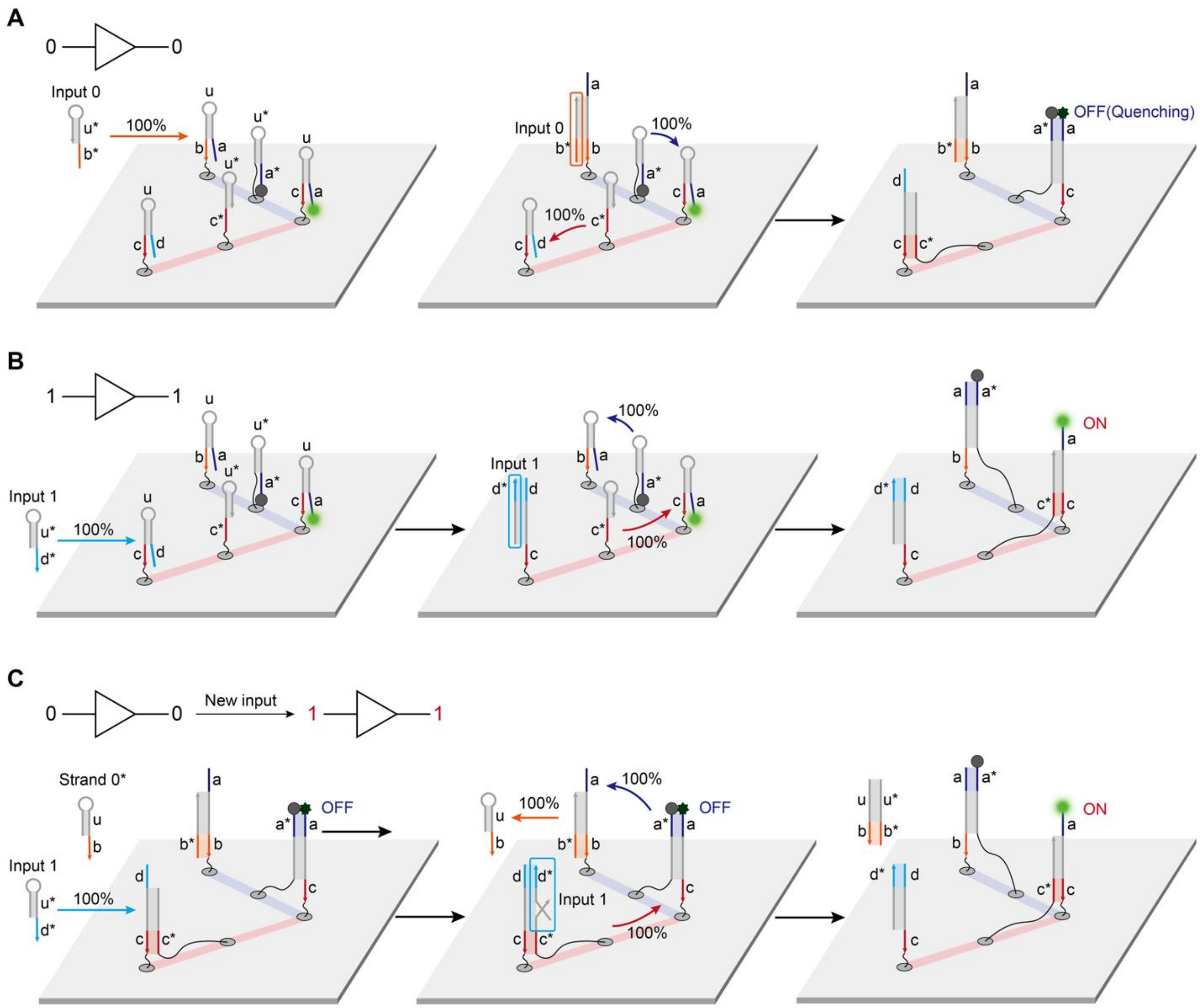


Fig. S1. Step-wise schematics of the TCR-based YES gate operation. (**A**) Operation for 'Input 0': the input binds to its gate, causing the signal strand to migrate and bind to the quencher-modified reporter, resulting in an OFF (Quenching) state. (**B**) Operation for ‘Input 1’: the input binds to its gate, displacing the signal strand from the gate, which results in an ON state. (**C**) State transition from OFF to ON: a new input set introduces 'Input 1' and a complementary strand to the past 'Input 0'. The new 'Input 1' drives the realignment of the signal strand away from the reporter, producing an ON state, followed by the complementary strand inactivates the past input. An asterisk (*) denotes the complementary strand.

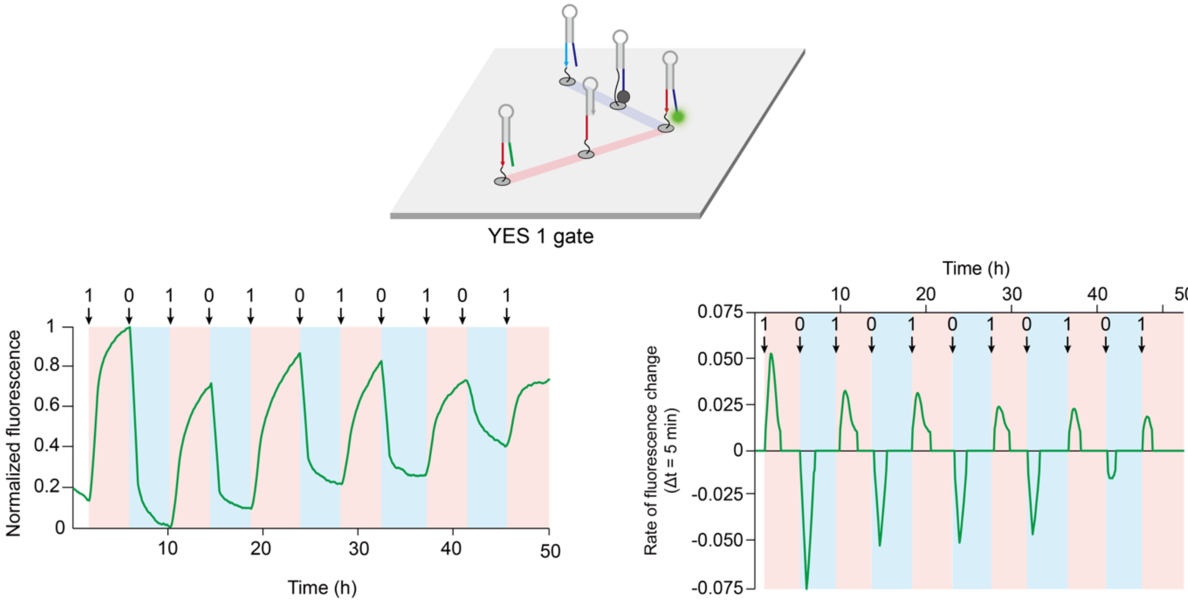
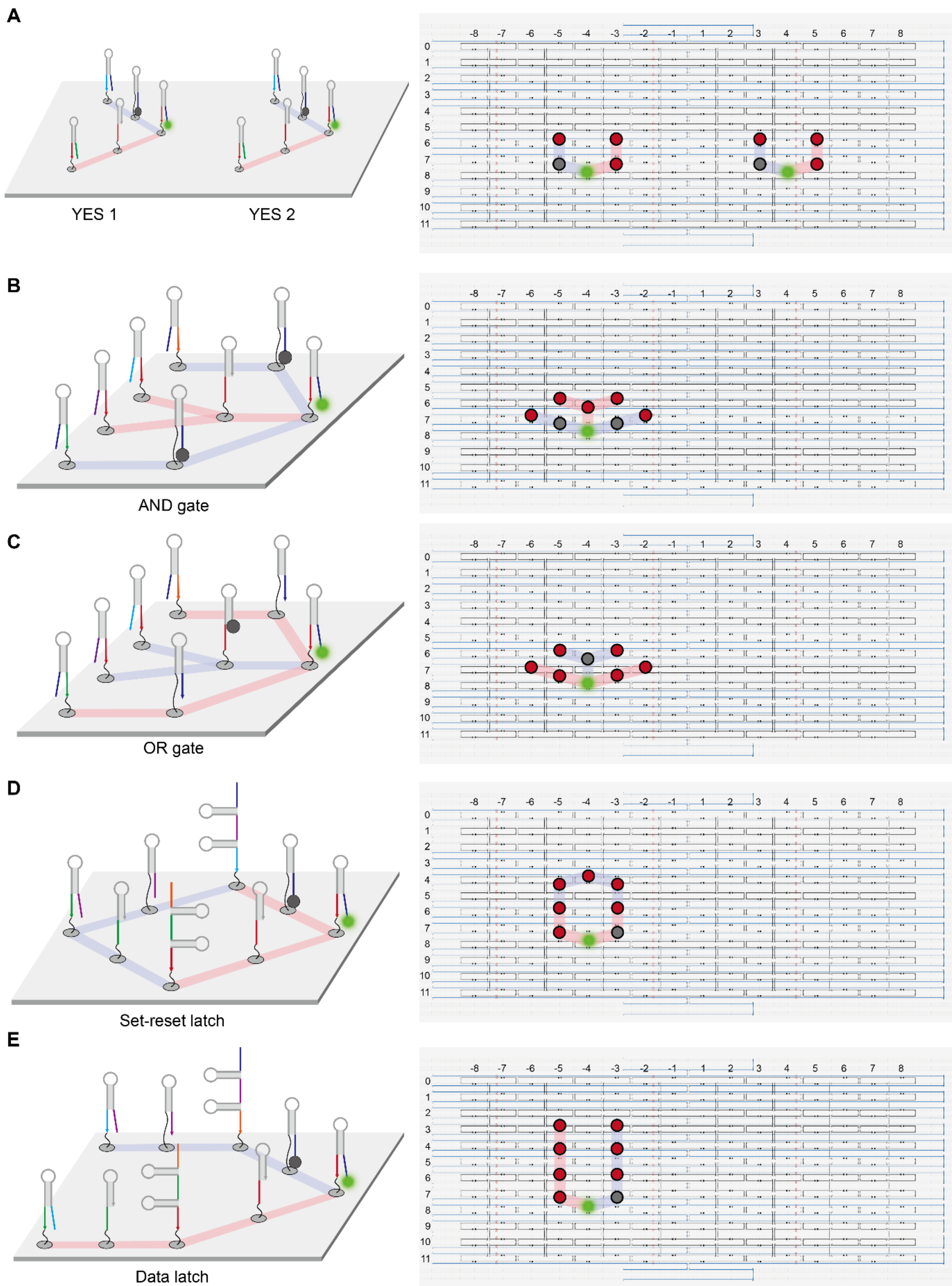


Fig. S2. Repeated real-time operation of the TCR-based YES gate under alternating inputs. The system was sequentially subjected to five Input 0 signals and six Input 1 signals. Despite 11 cycles, fluorescence quenching by Input 0 and recovery by Input 1 remained efficient, demonstrating capability of the system for repeated real-time input processing.


A
YES 1
YES 2
B
AND gate
C
OR gate
D
Set-reset latch
E
Data latch

F

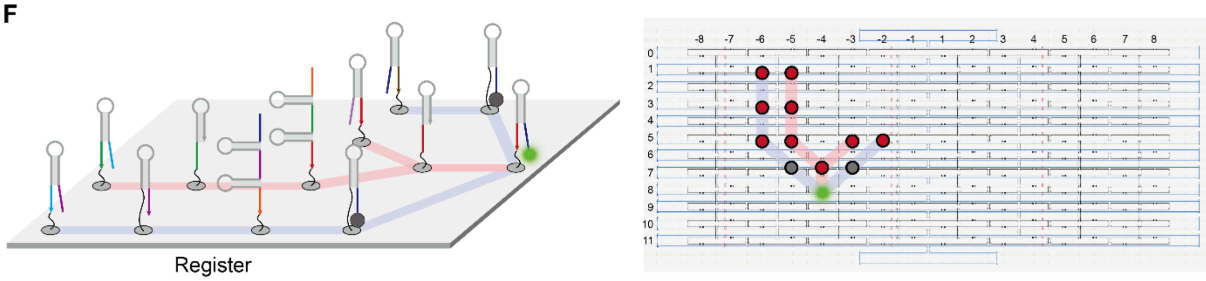


Fig. S3. Layouts of TCR-based circuits on origami. TCR-based gates and circuits were implemented on a rectangular DNA origami structure. The size of rectangular DNA origami is 100 nm x 60 nm. Staple modification sites are indicated on the DNA origami scaffold (gray: quencher modified staple, green: fluorophore, red: gate and signal components). There is a slight difference between the schematic illustration and the actual arrangement of gates on the DNA origami. (**A**) YES 1 and YES 2 gates. (**B**) AND gate. (**C**) OR gate. (**D**) Set-reset latch. (**E**) Data latch. (**F**) Register.

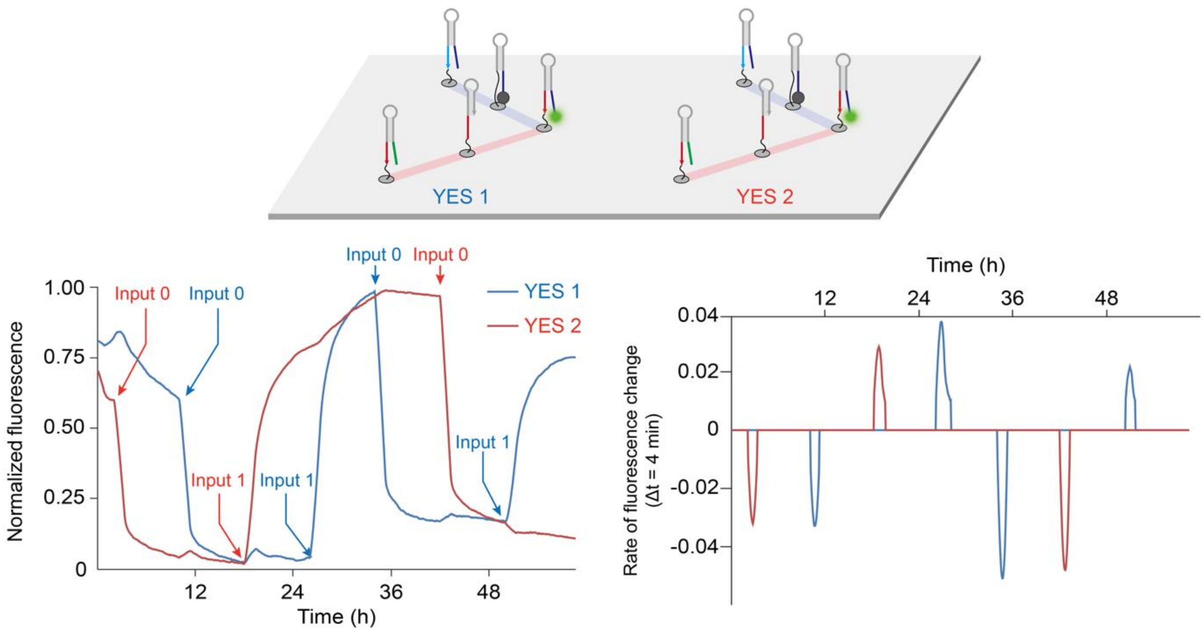


Fig. S4. Independent operation of multiple YES gates on a single DNA origami. Two YES gates were placed on the same DNA origami structure to evaluate potential interference between parallel localized circuits. Inputs were introduced at staggered time intervals to each gate (YES 1: 0–1–0–1, YES 2: 0–1–0). Both gates exhibited distinct fluorescence responses corresponding to their input sequences, with no significant crosstalk observed. These results demonstrate that multiple logic gates can be integrated on a single DNA origami and operate independently.

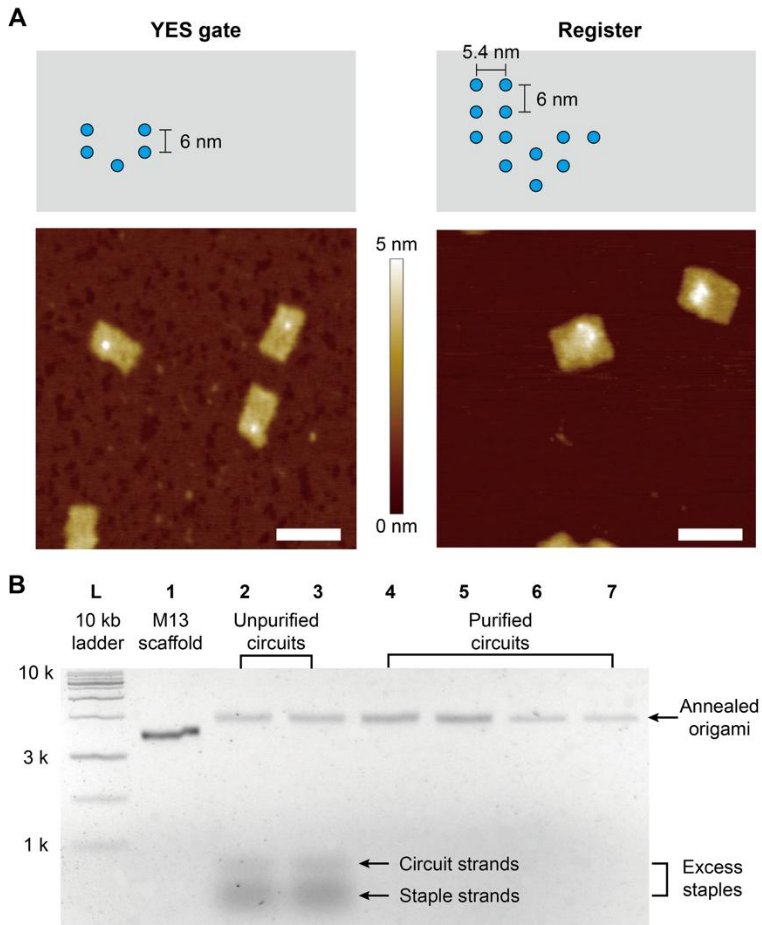


Fig. S5. Structural characterization of DNA origami-based circuits. (**A**) AFM images and schematics of YES gate and register circuits. The top schematics illustrate the expected arrangement of streptavidin-tagged probes on the origami surface for a YES gate and a register. The bottom AFM images show the assembled rectangular DNA origami. For the YES gate, streptavidin-tagged probes appear as distinct dots. For the register, a more complex, larger structure is observed, consistent with the higher density and linear arrangement of multiple streptavidin molecules. Scale bars represent 100 nm. (**B**) 1.5% Agarose gel characterization of DNA origami framework. Lane L: 10 kb ladder; Lane 1: M13mp18 single strand scaffold; Lane 2: Annealed unpurified origami(YES gate); Lane 3: Annealed unpurified origami(register); Lane 4: Origami after purification by Amicon spin filter(YES gate); Lane 5: Origami after purification by Amicon spin filter(register); Lane 6: Origami after purification by Freeze 'N Squeeze spin columns(YES gate); Lane 7: Origami after purification by Freeze 'N Squeeze spin columns(register).

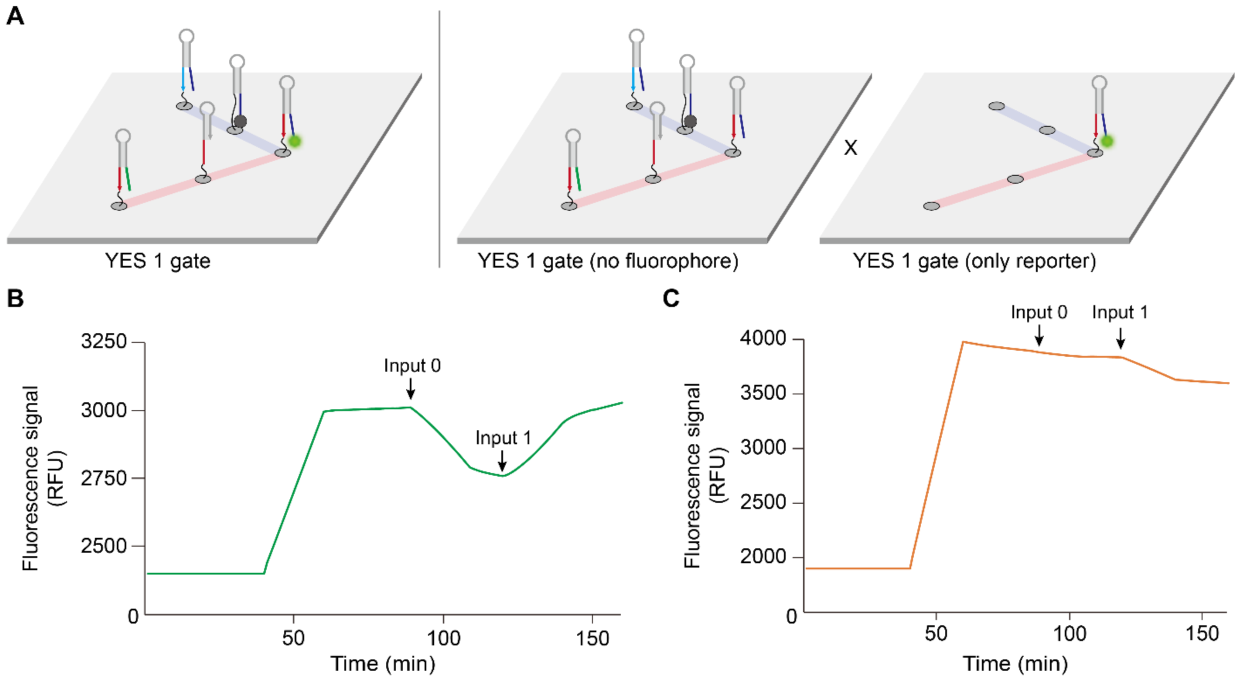


Fig. S6. Verification of crosstalk between DNA origami structures. (**A**) Potential crosstalk was tested by separating the YES gate into two distinct DNA origami structures, one containing only the reporter and the other containing the remaining components. Inputs were introduced to the mixture. (**B**) Output of the normal YES gate in response to inputs. (**C**) Output of mixture of two DNA origami structures in response to inputs. This result demonstrates the absence of interference between components across different DNA origami structures.

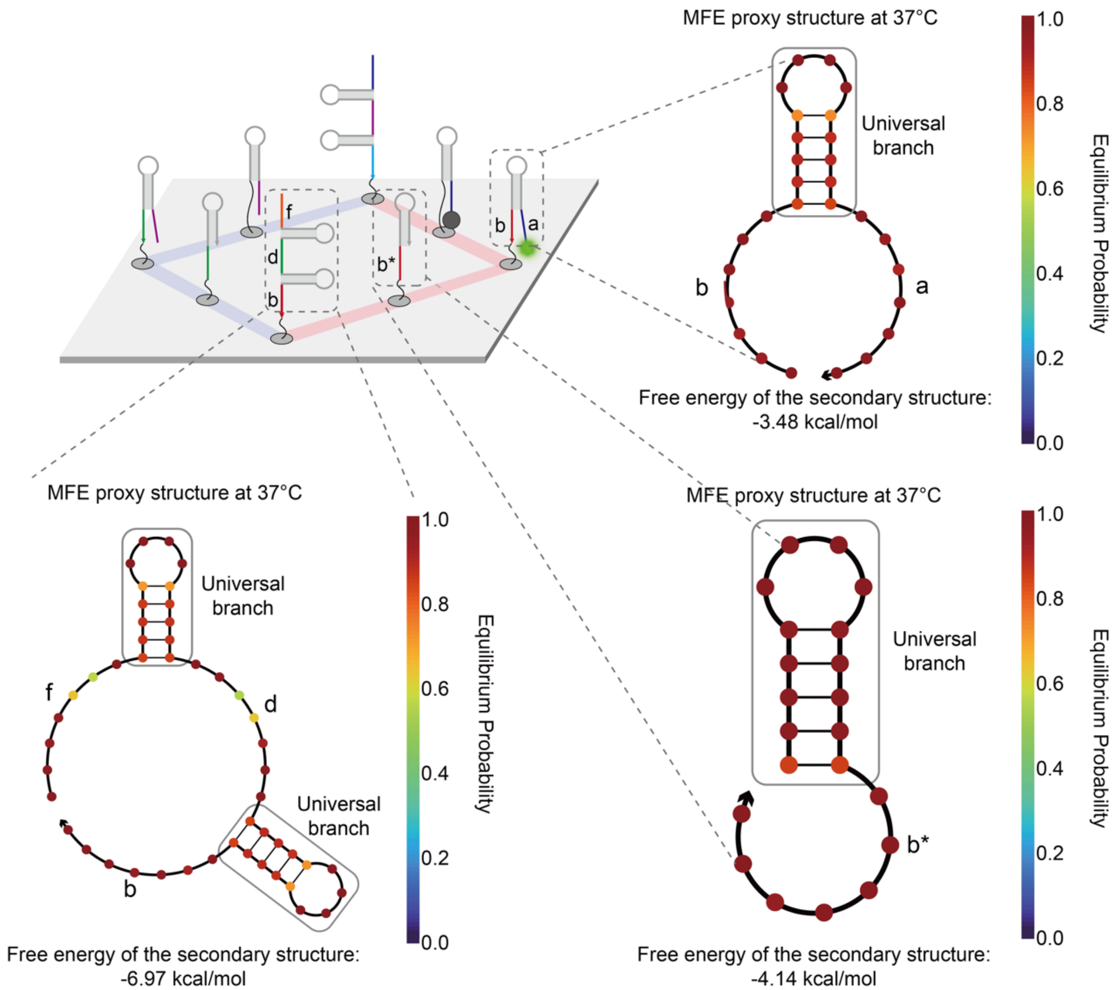


Fig. S7. Structural design of gate and signal components in the TCR-based circuit. The strands in TCR-based logic gates can be categorized into three types: gate strands composed of one universal branch domain and two toehold domains, gate strands in memory composed of two branch domains and three toehold domains, and signal strands composed of one universal branch domain and one toehold domain. To verify that none of these DNA strands form unintended secondary structures under circuit operating conditions, the T chain segments and logic gate regions of all DNA strands, excluding the regions that hybridize with the DNA origami, were validated using NUPACK at 37°C.

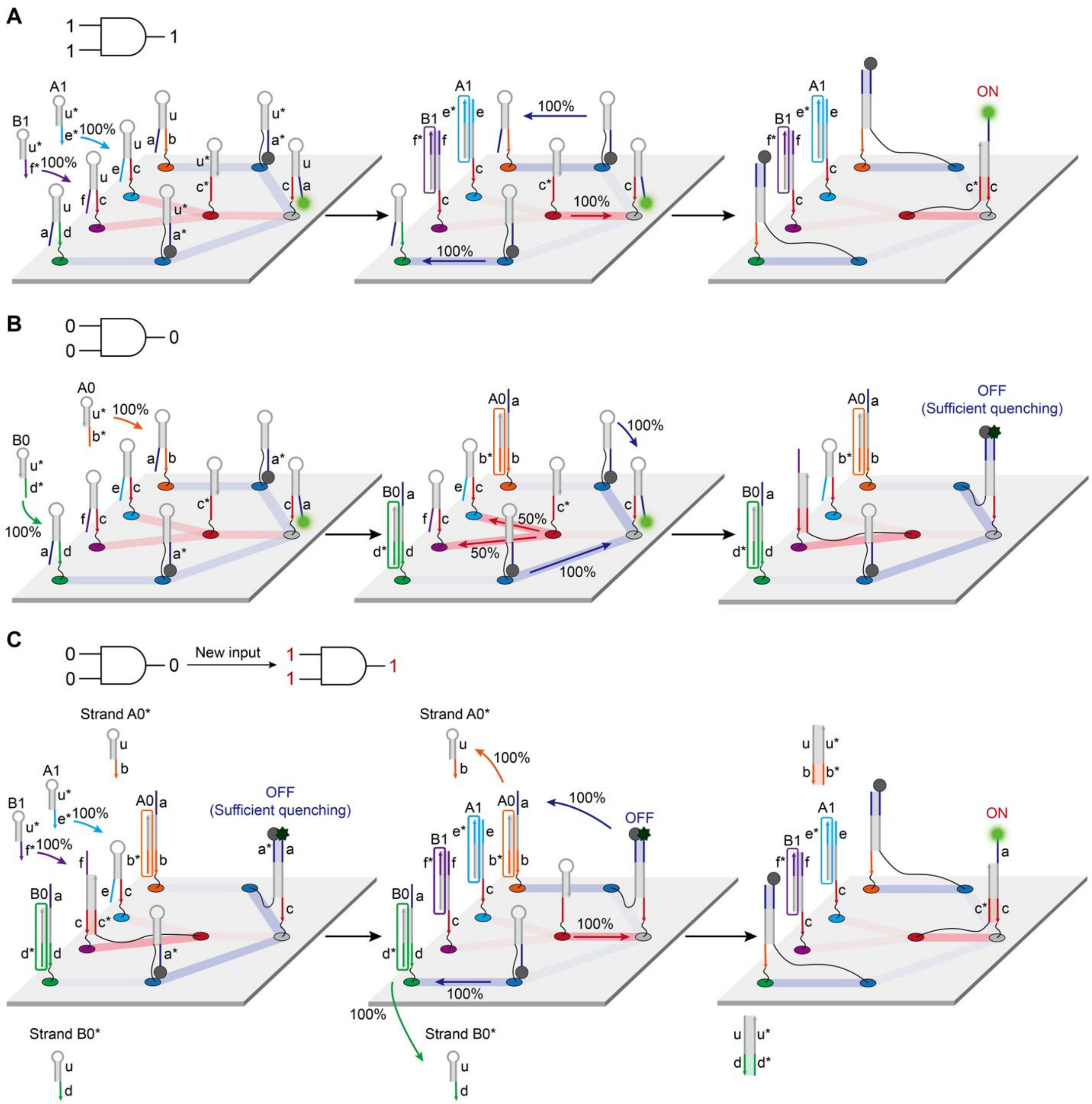


Fig. S8. Step-wise schematics of the TCR-based AND gate operation. (A) Operation for the {1, 1} input: binding of 'Input A1' and 'Input B1' causes the signal strands to align away from the quencher-modified reporters, resulting in an ON state. **(B)** Operation for the {0, 0} input: binding of 'Input A0' and 'Input B0' releases signal strands that migrate to the reporter, where the binding of one of these strands is sufficient to quench the fluorescence, resulting in an OFF state. **(C)** State transition from OFF to ON: a new input set, containing 'Input 1' (for both A and B) and complementary strands to the past 'Input 0's, is introduced. The new inputs drive the realignment of the signal strands away from the reporters to produce an ON state, followed by the complementary strands inactivate the past inputs. An asterisk (*) denotes the complementary strand.

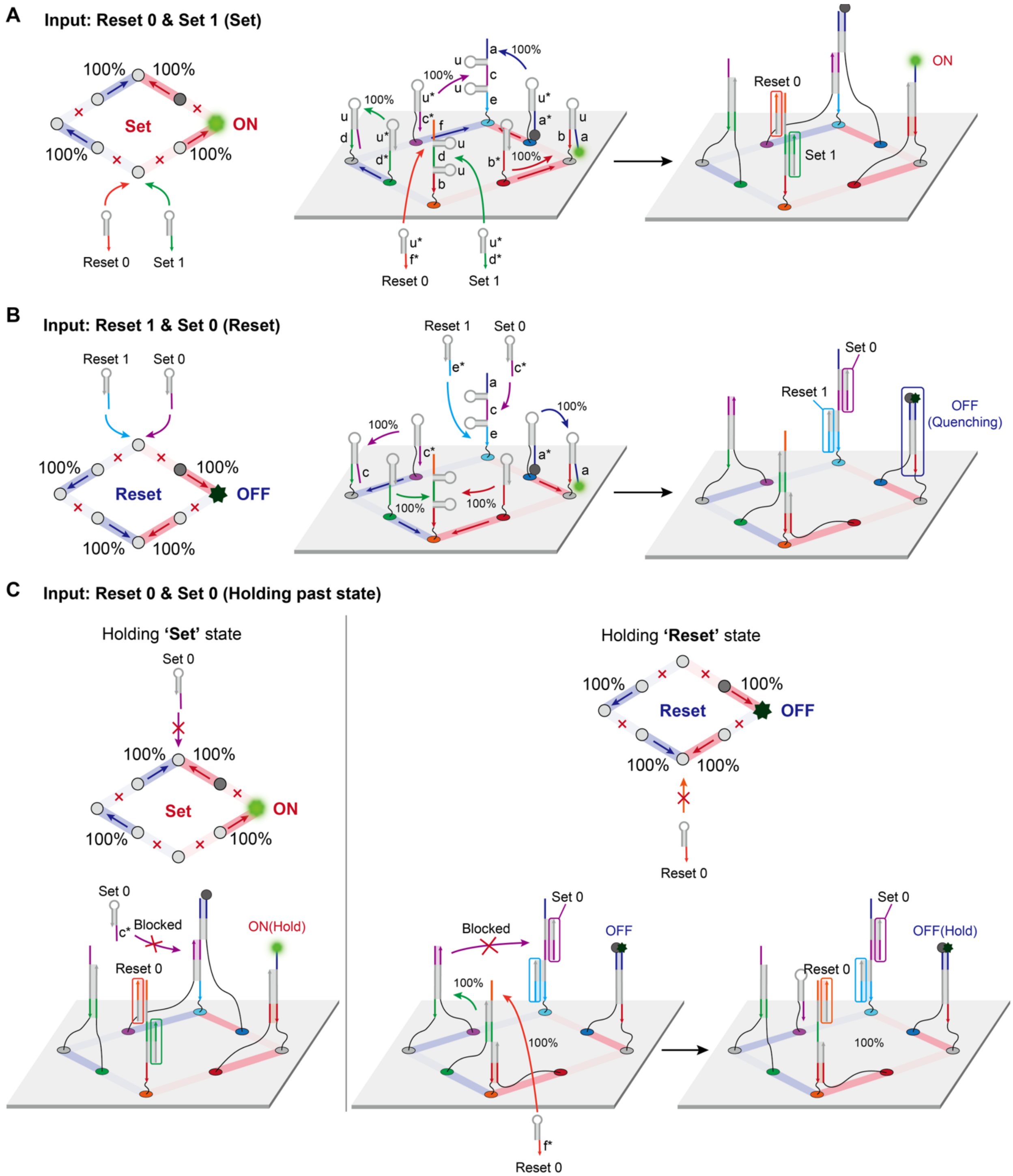


Fig. S9. Step-wise schematics of the TCR-based SR-latch operation for each combinatorial state. (**A**) Operation for the 'Set' input {Reset 0, Set 1}: 'Reset 0' makes the gate for 'Set 1' accessible, leading to a signal strand alignment that produces an ON output. (**B**) Operation for the 'Reset' input {Reset 1, Set 0}: 'Reset 1' makes the gate for 'Set 0' accessible, causing the signal strand to align in the opposite direction for an OFF output. (**C**) Operation for the 'Hold' input {Reset 0, Set 0}: if past state was 'Set’, the 'Set 0' input cannot bind due to its unavailable toehold, thus preserving the ON state, and similarly, if past state was 'Reset', the 'Reset 0' input does not trigger a new alignment, maintaining the OFF state.

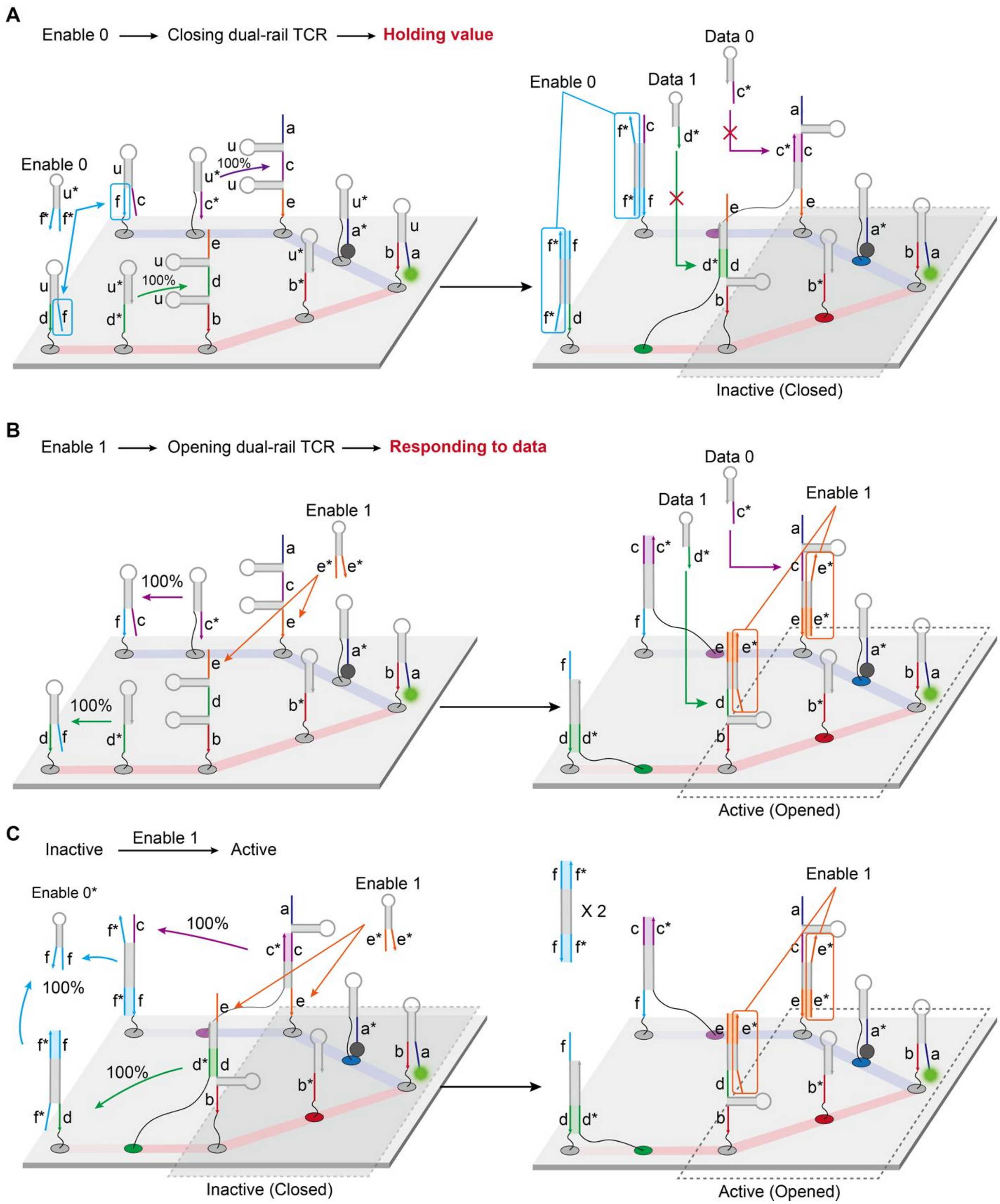


Fig. S10. Step-wise schematics of the TCR-based D-latch operation for each combinatorial state. (**A**) Operation for the 'Enable 0' input: input triggers the alignment of the closing dual-rail TCR, which blocks the toeholds required for Data inputs, rendering the main data latch 'Inactive' and holding its current state. (**B**) Operation for the 'Enable 1' input: 'Enable 1' input binds to its gate, triggering the alignment of the opening dual-rail TCR, which releases the blocking signal strand and makes the toeholds for the Data inputs accessible, rendering the data latch 'Active'. (**C**) State transition from Inactive to Active: a new input set containing 'Enable 1' and a complementary strand to the past 'Enable 0' ('c-Enable 0') is introduced. The complementary strand inactivates the past input, while the new 'Enable 1' drives the alignment of the opening dual-rail TCR, switching the latch to the 'Active' state. An asterisk (*) denotes the complementary strand.

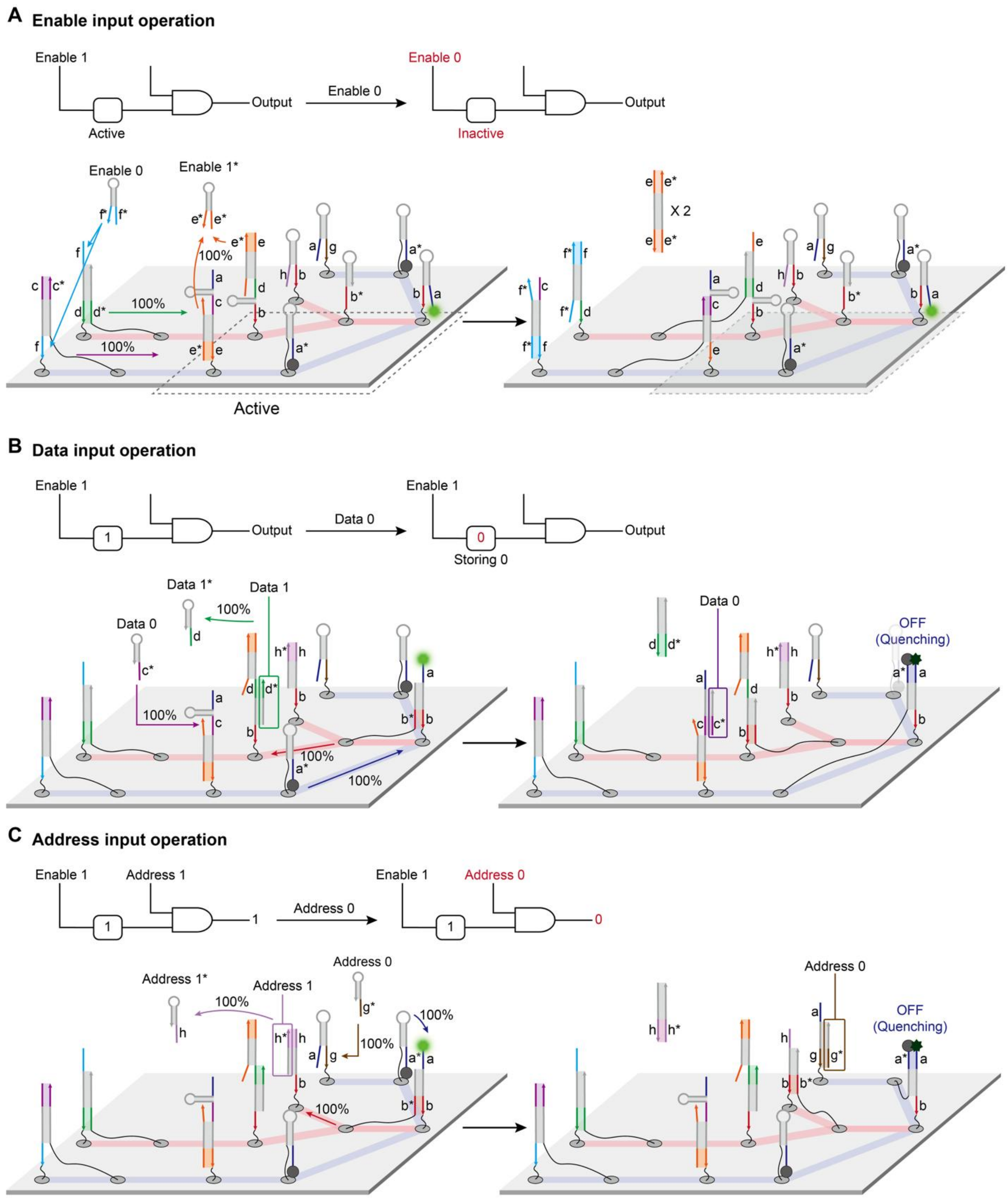


Fig. S11. Step-wise schematics of the TCR-based register operation. (**A**) Enable input operation: 'Enable 1' input switches the register from 'Inactive' to 'Active' state, opening the toeholds for the data latch and rendering the circuit ready to store information. (**B**) Data input operation: While the register is in the 'Active' state, a 'Data' input (e.g., 'Data 0') sets the state of the integrated D-latch and stores the data value. (**C**) Address input operation. The Address input determines the stored data output. Initially, 'Data 1' is stored in the D-latch, and the 'Address 1' input is active. The AND gate processes both inputs ('Data 1' and 'Address 1'), resulting in an ON output. Subsequently, the address is switched by introducing a new input set containing 'Address 0' and a complementary strand to the past 'Address 1'. This changes the address input for the AND gate to '0', causing the final output to switch to OFF. This process demonstrates that the Address input can selectively enable or disable the output of the stored data. An asterisk (*) denotes the complementary strand.

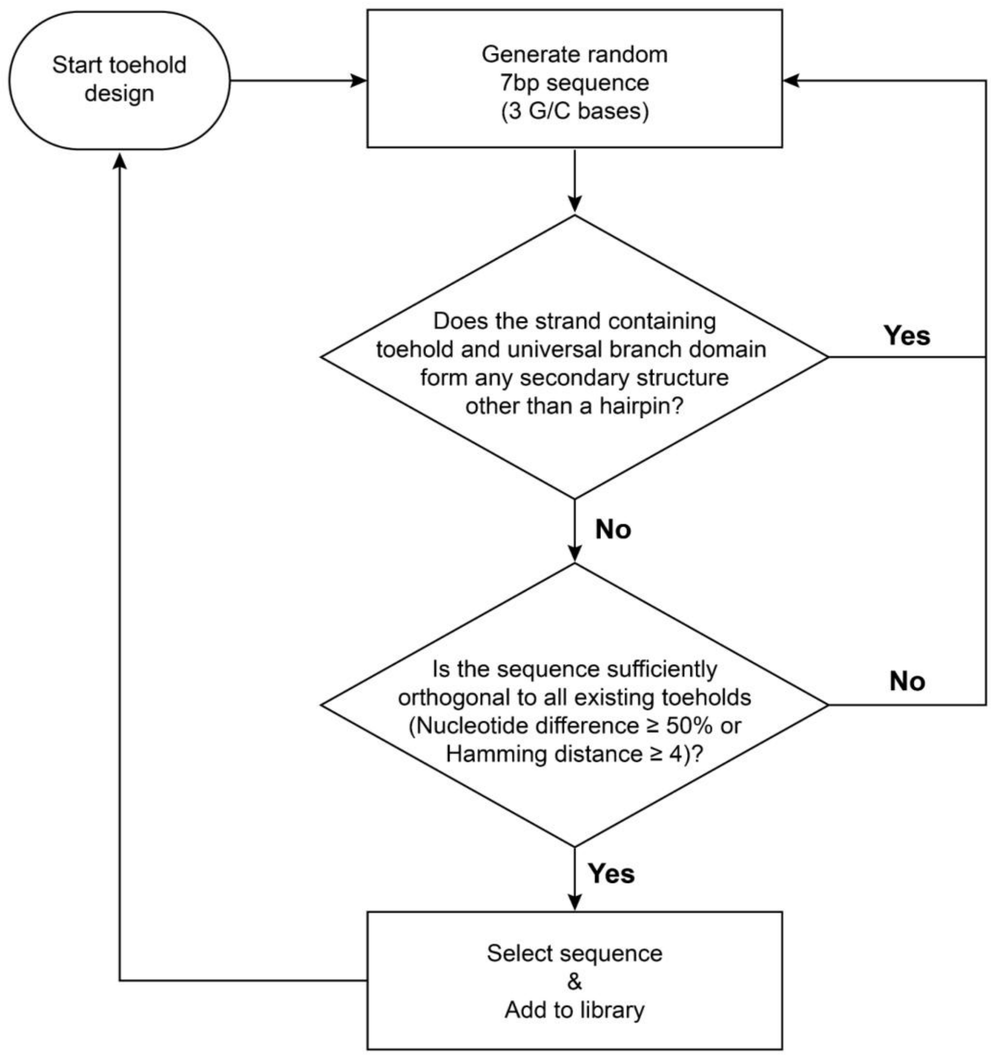


Fig. S12. Flowchart for the toehold sequence design. The algorithm is designed to generate a library of orthogonal toehold sequences with uniform binding affinities to ensure the reversibility and specificity of the TCR system. A random 7-nucleotide sequence with a fixed GC content (3 G/C bases) is generated and subjected to two validation checks: first, for undesired secondary structures using NUPACK (44, 45), and second, for sufficient difference from all existing toeholds to ensure orthogonality. If a sequence fails either check, it is discarded, and the process repeats until a valid candidate is generated and added to the library.

Table S1. Sequences of YES 1 gate components.

Strand name	Sequence (5'-3')
YES1_G0	CATCACAGGATCAAAAGATCCACTCGATTTTTTTTATCATATGAAGAACGC
YES1_G1	GACATCAGGATCAAAAGATCCCCTATTCTTTTTTTGAATCATATAGTTAAT
YES1_O0	AGCGTCTTTCAGATATTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTGGATCTTTTGATCCTGTGATG/BHQ1/
YES1_O1	GCGTTTTAAGAAAAATTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTGAATAGGGGATCTTTTGATCC
YES1_Rep	/FAM/CATCACAGGATCAAAAGATCCCCTATTCTTTTTTTCTTACCAAAGACGGGA
YES1_G0_add	GAGAAAACGATAGCTT
YES1_G1_add	TTCATCTTTAATTTTC
YES1_O0_add	AGAAGGCTATGTAGAA
YES1_O1_add	CAATTTTAAACGCGAG
YES1_Rep_add	ATTCTAAGTCCTGAAT
YES1_Input_0	ATCGAGTGGATCTTTTGATCC
YES1_Input_1	GGATCTTTTGATCCTGATGTC
YES1_Catcher_0	GGATCAAAAGATCCACTCGAT
YES1_Catcher_1	GACATCAGGATCAAAAGATCC

Table S2. Sequences of YES 2 gate components.

Strand name	Sequence (5'-3')
YES2_G0	CTATGTCGGATCAAAAGATCCACGTCTATTTTTTTATCGCGTTCCAGAGGG
YES2_G1	CTTGTACGGATCAAAAGATCCTCAACCATTTTTTTAGATTAAGGGATAGCG
YES2_O0	CTATCATACTTTAATCTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTGGATCTTTTGATCCGACATAG/BHQ1/
YES2_O1	AAAGGAATTTAAGAACTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTGGTTGAGGATCTTTTGATCC
YES2_Rep	/FAM/CTATGTCGGATCAAAAGATCCTCAACCATTTTTTTCAAAGCTGTTACCTTA
YES2_G0_add	TGCTCCTTCTTCAAAT
YES2_G1_add	ATGGCTTACATCAAAA
YES2_O0_add	GGTAATAGGAGCAACA
YES2_O1_add	TCCAATACTAACGCCA
YES2_Rep_add	TGCGATTTACGAGG
YES2_Input_0	TAGACGTGGATCTTTTGATCC
YES2_Input_1	GGATCTTTTGATCCGTACAAG
YES2_Catcher_0	GGATCAAAAGATCCACGTCTA
YES2_Catcher_1	CTTGTACGGATCAAAAGATCC

Table S3. Sequences of AND gate components.

Strand name	Sequence (5'-3')
AND_AG0	CATCACAGGATCAAAAGATCCCAGTCAATTTTTTGCAAGACACGTTATAC
AND_AG1	TAGACCTGGATCAAAAGATCCCCTATTCTTTTTTAGATTAAGAATTAATT
AND_BG0	CATCACAGGATCAAAAGATCCACTCGTTTTTTTAATTTAAGCGTTAAA
AND_BG1	CTCAATCGGATCAAAAGATCCCCTATTCTTTTTTCCTTAGAAACCTTTTT
AND_O0(1)	AGAAGGCTATGTAGAATTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTGGATCTTTTGATCCTGTGATG/BHQ1/
AND_O0(2)	CGTTTTAAGAAAAATTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTGGATCTTTTGATCCTGTGATG/BHQ1/
AND_O1	AAAAAGCCAGGTAAAGTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTGAATAGGGGATCTTTTGATCC
AND_Rep	/FAM/CATCACAGGATCAAAAGATCCCCTATTCTTTTTTTTGAATTAACACAATGAA
AND_AG0_add	AAATTCTTCCAGTAAT
AND_AG1_add	ACATTTAAACAGTACC
AND_BG0_add	TAAGAATAAACAACA
AND_BG1_add	TAATGGAATTTCAGGT
AND_O0(1)_add	AGCGTCTTTCAGATAT
AND_O0(2)_add	CAATTTTAAACGCGAG
AND_O1_add	ATATATTTATTACTAG
AND_Rep_add	ATAGCAATATACATAA
AND_Input_A0	TTGACTGGGATCTTTTGATCC
AND_Input_A1	GGATCTTTTGATCCAGGTCTA
AND_Input_B0	AACGAGTGGATCTTTTGATCC
AND_Input_B1	GGATCTTTTGATCCGATTGAG
AND_Catcher_A0	GGATCAAAAGATCCCAGTCAA
AND_Catcher_A1	TAGACCTGGATCAAAAGATCC
AND_Catcher_B0	GGATCAAAAGATCCACTCGTT

AND_Catcher_B1	CTCAATCGGATCAAAAGATCC

Table S4. Sequences of OR gate components.

Strand name	Sequence (5'-3')
OR_AG0	CATCACAGGATCAAAAGATCCCTTCTACTTTTTTATCATATGAAGAACGC
OR_AG1	TGCACTTGGATCAAAAGATCCGCTTTACTTTTTTCTGTCTTTCCCAATAG
OR_BG0	CATCACAGGATCAAAAGATCCCAGTCTATTTTTTGAATCATATAGTTAAT
OR_BG1	TAGACCTGGATCAAAAGATCCGCTTTACTTTTTTCTGAACAGCGAACCT
OR_O0	AAAAAGCCAGGTAAAGTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTGGATCTTTTGATCCTGTGATG/BHQ1/
OR_O1(1)	AGCGTCTTTCAGATATTTTTTTTTTTTTTTTTTTGTAAAGCGGATCTTTTGATCC
OR_O1(2)	CAATTTTAAACGCGAGTTTTTTTTTTTTTTTTTTTGTAAAGCGGATCTTTTGATCC
OR_Rep	/FAM/CATCACAGGATCAAAAGATCCGCTTTACTTTTTTTTCTTACCAAAGACGGGA
OR_AG0_add	GAGAAAACGATAGCTT
OR_AG1_add	AAGAGAATATAATCGG
OR_BG0_add	TTCATCTTTAATTTTC
OR_BG1_add	TGTTCAGGATAAGTC
OR_O0_add	ATATATTTATTACTAG
OR_O1(1)_add	TAGAAGGCTATGTAGAA
OR_O1(2)_add	GCGTTTTAAGAAAAAT
OR_Rep_add	ATTCTAAGTCCTGAAT
OR_Input_A0	GTAGAAGGGATCTTTTGATCC
OR_Input_A1	GGATCTTTTGATCCAAGTGCA
OR_Input_B0	TAGACTGGGATCTTTTGATCC
OR_Input_B1	GGATCTTTTGATCCAGGTCTA
OR_Catcher_A0	GGATCAAAAGATCCCTTCTAC
OR_Catcher_A1	TGCACTTGGATCAAAAGATCC
OR_Catcher_B0	GGATCAAAAGATCCCAGTCTA
OR_Catcher_B1	TAGACCTGGATCAAAAGATCC

Table S5. Sequences of Set-reset latch circuit components.

Strand name	Sequence (5'-3')
SR_G0	CTATGTCGGATCAAAAGATCCCATTCACGGATCAAAAGATCCCACGTTA TTTTTTATCGCGTTCCAGAGGG
SR_G1	CAAGCATGGATCAAAAGATCCCCTCTATGGATCAAAAGATCCTCAACC ATTTTTTAGATTAAGGGATAGCG
SR_T0	GAAAGGCCCAATAAATTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTGGA TCTTTTGATCCGTGAATG
SR_T1	GTAATGTGGCAAAATTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTATA GAGGGGATCTTTTGATCC
SR_T	CATTCACGGATCAAAAGATCCCCTCTATTTTTTTTTTTTTTTTAGATTCA AAGAGATC
SR_O0	CTATCATACTTTAATCTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTGGAT CTTTTGATCCGACATAG/BHQ1/
SR_O1	AAAGGAATTTAAGAACTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTGG TTGAGGATCTTTTGATCC
SR_Rep	/FAM/CTATGTCGGATCAAAAGATCCTCAACCATTTTTTTCAAAGCTGTT ACCTTA
SR_G0_add	TGCTCCTTCTTCAAAT
SR_G1_add	ATGGCTTACATCAAAA
SR_T0_add	TATTTTTGAAGGGTGA
SR_T1_add	TCATTGCCATGCCTGA
SR_T_add	CTACAAAGGTTTGTTA
SR_O0_add	GGTAATAGGAGCAACA
SR_O1_add	TCCAATACTAACGCCA
SR_Rep_add	ATGCGATTTACGAGG
SR_S0	GTGAATGGGATCTTTTGATCC
SR_S1	GGATCTTTTGATCCATAGAGG
SR_R0	GGATCTTTTGATCCATGCTTG
SR_R1	TAACGTGGGATCTTTTGATCC
SR_Catcher_S0	GGATCAAAAGATCCCATTCAC
SR_Catcher_S1	CCTCTATGGATCAAAAGATCC
SR_Catcher_R0	CAAGCATGGATCAAAAGATCC

SR_Catcher_R1	GGATCAAAAGATCCCACGTTA

Table S6. Sequences of data latch circuit components.

Strand name	Sequence (5'-3')
D_G0	CTATGTCGGATCAAAAGATCCCAAGTACGGATCAAAAGATCCCGCTAAT TTTTTTATCGCGTTCCAGAGGG
D_G1	CGCTAATGGATCAAAAGATCCTACATCGGGATCAAAAGATCCTCAACCA TTTTTTAGATTAAGGGATAGCG
D_T0	GAGTGAATTCAATTCTTTTTTTTTTTTTTTGGATCTTTTGATCCGTACTTG
D_T1	TAATGGAATTTCAGGTTTTTTTTTTTTTTTTTTTTTTTTTTTTTCGATGTAGG ATCTTTTGATCC
D_RW0	CAAGTACGGATCAAAAGATCCCGGAATTTTTTTTTTTTTTTTTGAGCCGT CGGAGCACT
D_RW1	CGGAATTGGATCAAAAGATCCTACATCGTTTTTTTTTTTTTTTTAGAAGT AGAATTGAG
D_O0	CTATCATACTTTAATCTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTGGAT CTTTTGATCCGACATAG/BHQ1/
D_O1	AAAGGAATTTAAGAACTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTGG TTGAGGATCTTTTGATCC
D_Rep	/FAM/CTATGTCGGATCAAAAGATCCTCAACCATTTTTTTCAAAGCTGTTA CCTTA
D_G0_add	TGCTCCTTCTTCAAAT
D_G1_add	ATGGCTTACATCAAAA
D_T0_add	TATTTTTGAAGGGTGA
D_T1_add	TCATTGCCATGCCTGA
D_RW0_add	CATCAACAATTAAATT
D_RW1_add	CGTCGGATTTGTAAAC
D_O0_add	GGTAATAGGAGCAACA
D_O1_add	TCCAATACTAACGCCA
D_Rep_add	ATGCGATTTACGAGG
D_E0	AATTCCGGGATCTTTTGATCCAATTCCG
D_E1	ATTAGCGGGATCTTTTGATCCATTAGCG
D_D0	GTACTTGGGATCTTTTGATCC
D_D1	GGATCTTTTGATCCCGATGTA
D_Catcher_E0	CGGAATTGGATCAAAAGATCCCGGAATT

D_Catcher_E1	CGCTAATGGATCAAAAGATCCCGCTAAT
D_Catcher_D0	GGATCAAAAGATCCCAAGTAC
D_Catcher_D1	TACATCGGGATCAAAAGATCC

Table S7. Sequences of register 1 circuit components.

Strand name	Sequence (5'-3')
R1_RW0	CAGTCAAGGATCAAAAGATCCCTTATGCTTTTTTTTTTTTTTTAGTAATAAGATAAAAC
R1_RW1	CTTATGCGGATCAAAAGATCCTAGACCTTTTTTTTTTTTTTTTAATATCCAAGAATCCT
R1_T0	TTGCCCGACAGATGATTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTGGATCTTTTGATCCTTGACTG
R1_T1	AATCCTGAATTCGACATTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTAGGTCTAGGATCTTTTGATCC
R1_G0	CATCACAGGATCAAAAGATCCCAGTCAAGGATCAAAAGATCCCGCTAATTTTTTGCAAGACACGTTATAC
R1_G1	CGCTAATGGATCAAAAGATCCTAGACCTGGATCAAAAGATCCCCTATTCTTTTTTAGATTAAGAATTAATT
R1_O0(1)	AGAAGGCTATGTAGAATTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTGGATCTTTTGATCCTGTGATG/BHQ1/
R1_O0(2)	CGTTTTAAGAAAAATTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTGGATCTTTTGATCCTGTGATG/BHQ1/
R1_O1	AAAAAGCCAGGTAAAGTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTGAATAGGGGATCTTTTGATCC
R1_AND_G0	CATCACAGGATCAAAAGATCCACTCGTTTTTTTAATTTAAGCGTTAAA
R1_AND_G1	CTCTAACGGATCAAAAGATCCCCTATTCTTTTTTCCTTAGAAACCTTTTT
R1_Rep	/FAM/CATCACAGGATCAAAAGATCCCCTATTCTTTTTTTTGAATTAACACAATGAA
R1_RW0_add	AGAGGTGACAAACCCT
R1_RW1_add	GAGAAGTGACCCGCCG
R1_T0_add	CAATCAATTAAATCCT
R1_T1_add	TTTTACATATCAATAT
R1_G0_add	AAATTCTTCCAGTAAT
R1_G1_add	ACATTTAAACAGTACC
R1_O0(1)_add	AGCGTCTTTCAGATAT

R1_O0(2)_add	AGCGTCTTTCAGATAT
R1_O1_add	GCGTTTTAAGAAAAAT
R1_AND_G0_add	TAAGAATAAACAACA
R1_AND_G1_add	TAATGGAATTTCAGGT
R1_Rep_add	ATAGCAATATACATAA

Table S8. Sequences of register 2 circuit components.

Strand name	Sequence (5’-3’)
R2_RW0	CAGTCAAGGATCAAAAGATCCCATTAGCTTTTTTTTTTTTTTTAGTAATAAGATAAAAC
R2_RW1	CATTAGCGGATCAAAAGATCCTAGACCTTTTTTTTTTTTTTTTAATATCCAAGAATCCT
R2_T0	TTGCCCGACAGATGATTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTGGATCTTTTGATCCTTGACTG
R2_T1	AATCCTGAATTCGACATTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTAGGTCTAGGATCTTTTGATCC
R2_G0	CATCACAGGATCAAAAGATCCCAGTCAAGGATCAAAAGATCCCGAGAATTTTTTTGCAAGACACGTTATAC
R2_G1	CGAGAATGGATCAAAAGATCCTAGACCTGGATCAAAAGATCCCCTATTCTTTTTTAGATTAAGAATTAATT
R2_O0(1)	AGAAGGCTATGTAGAATTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTGGATCTTTTGATCCTGTGATG/BHQ1/
R2_O0(2)	CGTTTTAAGAAAAATTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTGGATCTTTTGATCCTGTGATG/BHQ1/
R2_O1	AAAAAGCCAGGTAAAGTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTGAATAGGGGATCTTTTGATCC
R2_AND_G0	CATCACAGGATCAAAAGATCCCTTCTACTTTTTTTAATTTAAGCGTTAAA
R2_AND_G1	TCTCCATGGATCAAAAGATCCCCTATTCTTTTTTCCTTAGAAACCTTTTT
R2_Rep	/HEX/CATCACAGGATCAAAAGATCCCCTATTCTTTTTTTTGAATTAACACAATGAA
R_D0	TTGACTGGGATCTTTTGATCC
R_D1	GGATCTTTTGATCCAGGTCTA
R1_E0	GCATAAGGGATCTTTTGATCCGCATAAG
R1_E1	ATTAGCGGGATCTTTTGATCCATTAGCG
R2_E0	GCTAATGGGATCTTTTGATCCGCTAATG
R2_E1	ATTCTCGGGATCTTTTGATCCATTCTCG
R1_A0	AACGAGTGGATCTTTTGATCC

R1_A1	GGATCTTTTGATCCGTTAGAG
R2_A0	GTAGAAGGGATCTTTTGATCC
R2_A1	GGATCTTTTGATCCATGGAGA
R_Catcher_D0	GGATCAAAAGATCCCAGTCAA
R_Catcher_D1	TAGACCTGGATCAAAAGATCC
R1_Catcher_E0	CTTATGCGGATCAAAAGATCCCTTATGC
R1_Catcher_E1	CGCTAATGGATCAAAAGATCCCGCTAAT
R2_Catcher_E0	CATTAGCGGATCAAAAGATCCCATTAGC
R2_Catcher_E1	CGAGAATGGATCAAAAGATCCCGAGAAT
R1_Catcher_A0	GGATCAAAAGATCCACTCGTT
R1_Catcher_A1	CTCTAACGGATCAAAAGATCC
R2_Catcher_A0	GGATCAAAAGATCCCTTCTAC
R2_Catcher_A1	TCTCCATGGATCAAAAGATCC

Table S9. Sequences of staples.

Strand name	Sequence (5'-3')
1	GGTTGCTTTGACGAGCACGTATACTAAACAG
2	CGCTTAATGCGCCGCTACAGGGCGACAGGAAC
3	GGTCACGCTGCGCGTAACCACCACTTTTTATA
4	GAGCGGGCGCTAGGGCGCTGGCAAGTCTGTC
5	TTCCGAAATCGGCAAAATCCCTTAAGCGAAAG
6	CCCCAGCAGGCGAAAATCCTGTTTTTGCGCTC
7	AGAGTTGCAGCAAGCGGTCCACGCACCTGTCG
8	CAGCTGATTGCCCTTCACCGCCTGCAACGCGC
9	GAGGCCGAAAAAACGCTCATGGAATGGATTAT
10	GGTACGCCGAACAATATTACCGCCACACGACC
11	ATCAGTGAACTCAAACTATCGGCCAACAGAGA
12	CATCACGTAGTAATAACATCACTAAGAATA
13	GTGAGCTATGTAAAGCCTGGGGTGGCAATACT
14	ACTGCCCGTTCCACACAACATACGTTACGCCA
15	TGCCAGCTTTTCCTGTGTGAAATTCAAGGCGA
16	GGGGAGAGCGAGCTCGAATTCGTATCCCAGTC
17	CAACAGGTTAAAGGGATTTTAGCGTACTAT
18	AATATCCAAGAATCCTGAGAAGTGACCCGCCG
19	GTAGAAGAGGCCACCGAGTAAAAGAGTGTAGC
20	TCTTTGATCAAATTAACCGTTGTACCTAATGA
21	GCATAAAGACTCACATTAATTGCGGATGGTGG
22	GCTCACAACTTTCCAGTCGGGAATGGTTTG
23	CATAGCTGGCATTAATGAATCGGCGCCCTGAG
24	CCGGGTACGCGGTTTGCGTATTGGACGGGCAA
25	TTACATTGCACCGCCTGCAACAGTCTAAAGCA
26	AGTAATAAGATAAAACAGAGGTGACAAACCCT
27	TAGAACCCCATTAAAAATACCGAAAATCAACA
28	CGTGGCAAATGCGCGAACTGATTCTAAAAT
29	CGATCGGTAGGCTGCGCAACTGTTATGGCTAT
30	GCTGGCGACCGGAAACCAGGCAAACCAGCTTT
31	TTAAGTTGTCCAGCCAGCTTTCCGTAACAACC

32	ACGACGTTCGACGACAGTATCGGCCGGCGGAT
33	GTATTAAGCAGATTCACCAGTCAGCCATTG
34	CAGCAGAAAAGGGACATTCTGGCCTTGCTGGT
35	AACATCGCTTCTGACCTGAAAGCGTTGCCTGA
36	TAGTCTTTCAGACAATATTTTTGAGGGAAGGG
37	CGCCATTCGCGGGCCTCTTCGCTAAGCCGGAA
38	TTCTGGTGAAGGGGGATGTGCTGGTTATCC
39	GATCGCACGGTAACGCCAGGGTTTATCATGGT
40	TGAGGGGAGTAAAACGACGGCCAGGAGGATCC
41	TCACCTTGAAAGTTTGAGTAACATGGAGCGGA
42	CAATCAATTAAATCCTTTGCCCGACAGATGAT
43	GTTGAAAGTTAGACTTTACAAACATTGTTTGG
44	ATCTTTAAATAGATAATACATTGTTAGAAC
45	AATTCGCGACCAATAGGAACGCCAATAGATTA
46	CATCAACAATTAAATTTTTGTTAAAGGGTAGC
47	CGTCGGATTTGTAAACGTTAATATCTATCAGG
48	TGACCGTAAAACAGGAAGATTGTAACAAGAGA
49	AATTTTACTGAACCTCAAATATGGCGGTCA
50	ACTCGTATATCTGGTCAGTTGGCACGAACCAC
51	TAGAAGTAGAATTGAGGAAGGTTAAGCCCTAA
52	GAGCCGTCGGAGCACTAACAACTATCAAAAAT
53	ATTTTTTATCTGGCCTTCCTGTAGGCGCCATT
54	AAATTCGCTTAAATGTGAGCGAGGCACCGC
55	TATTTAAATCTCCGTGGGAACAAACTCAGGAA
56	AGCCCCAAATGGGATAGGTCACGTTGCCAGTT
57	ATTATCATCTTTGAATACCAAGTTAATTACCT
58	GGCAATTCCGGGAGAAACAATAACAACATCAA
59	ATTATACTAGATGAATATACAGTACAATTTCA
60	CTACCATAGAAATTGCGTAGATACAGTACA
61	CTAGCTGACCATCAATATGATATTCGTAAAAC
62	TATTTTTGAAGGGTGAGAAAGGCCCAATAAAT
63	TCATTGCCATGCCTGAGTAATGTGGCAAAATT
64	ATCGATGAAATTTTTAGAACCCTCAGCTAAAT

65	CTGATTGCATATTCCTGATTATACGTTATT
66	TTTTACATATCAATATAATCCTGAATTCGACA
67	TTAACGTCTCTGAATAATGGAAGGTGAGGATT
68	AGAAATAAATCAAAATTATTTGCACAACCGTT
69	TCAAATCATAAATTAATGCCGGAGATCAGCTC
70	AGATTCAAAGAGATCTACAAAGGTTTGTTA
71	TAAATGCATGAGAGTCTGGAGCAATAAGCAAA
72	AGGATAAAACGGTAATCGTAAAACATCAGAAA
73	GAGCAAAAAAATCATAGGTCTGAGGTTATATA
74	GAAAACAAACGCTGAGAAGAGTCAATCCAATC
75	TTTGAATTTCCTTGAAAACATAGCTTTTTCAA
76	TAAATCAATCGTCGCTATTAATCTGACCTA
77	ACTAATAGAGCTGAAAAGGTGGCAAACCTTGC
78	CATACAGGACCTGTTTAGCTATATCCTTTAAT
79	AAGCAATAACCATTAGATACATTTTTTTGCGG
80	CGGTTGTATCCCAATTCTGCGAACTATAATGC
81	TTTATCAGAAGATGATGAAACAGGATTCGC
82	AGATTAAGAATTAATTACATTTAAACAGTACC
83	CCTTAGAAACCTTTTTTAATGGAATTTCAGGT
84	TTCTGTAAATATATGTGAGTGAATTCAATTCT
85	GGGGCGCGTAGTAGCATTAACATCGGAGACAG
86	GGTCAATACAAGGCAAAGAATTATAGGTAA
87	TTAGTTTGAAGCCTCAGAGCATAAATATATTT
88	CAGTTGATCCAAAAACATTATGACTCAACGCA
89	ACTATATGACGCTCAACAGTAGGGAACATGTA
90	GCAAGACACGTTATACAAATTCTTCCAGTAAT
91	ATATATTTATTACTAGAAAAAGCCAGGTAAAG
92	AATTTAAGCGTTAAATAAGAATAAACAACA
93	CCAACAGGAGCGAACCAGACCGGACCGTGTGA
94	TGCTCCTTCTTCAAATATCGCGTTCCAGAGGG
95	ATGGCTTACATCAAAAAGATTAAGGGATAGCG
96	TGTAGCTCCTGACTATTATAGTCAATATTCAT
97	AAAGCCATAAATGCTGATGCAAATAGTGAA

98	ATCATATGAAGAACGCGAGAAAACGATAGCTT
99	GAATCATATAGTTAATTTCATCTTTAATTTTC
100	TAAATAAGTGGTTTGAAATACCGAAGCAAACT
101	AGCTTCAATCAGGATTAGAGAGTATTTCATTT
102	CCGAAAGATTGATAAGAGGTCATCGCAAAT
103	GCGGATTGGAGCTTAATTGCTGAAGAGTAGAT
104	TCTTTACCAACATGTTTTAAATATCCATATAA
105	ATTTAGGCAACGGGTATTAAACCATTTTATTT
106	AAGAGAATATAATCGGCTGTCTTTCCCAATAG
107	TAATTCTGATCCTAATTTACGAGCTATCCGGT
108	TGTTCAGGATAAGTCCTGAACAGCGAACCT
109	GAGGCTTTCGACGATAAAAACCAACTGTTTAT
110	GGTAATAGGAGCAACACTATCATACTTTAATC
111	TCCAATACTAACGCCAAAAGGAATTTAAGAAC
112	TGAATCCCTAGGAATACCACATTCTTGGGAAG
113	TTCCAAGAGAGGCATTTTCGAGACCAGTAT
114	ACCAATCAATAAAGTACCGACAAATGTTTAGT
115	AATATCCCTCCAGACGACGACAATAAACACCG
116	CAACAATACTAATGCAGAACGCGCAATAGCGA
117	TTACCAGATGCAAAAGAAGTTTTGTTAATTCG
118	CATAGTAATAAAATGTTTAGACTAGGAAGC
119	CAGATACATGCGGAATCGTCATAAGAAGCAAA
120	TTGAGATTCCTCAAATGCTTTAAAAAATCAGG
121	TCATCGTAACAGCCATATTATTTAAACGTCAA
122	CAAGCAAATCCAGAGCCTAATTTGGAGAGAAT
123	ATTCTAAGTCCTGAATCTTACCAAAGACGGGA
124	CCCGACTAGTTGCTATTTTGCAAGTCAGAG
125	GGGCTTGAAAACACCAGAACGAGTGCCTTAAA
126	ATTGTGAACTCATTCAGTGAATAAAAATTGTG
127	TGGCTCATATTCATTACCCAAATCGTTACTTA
128	AAAAATCTTTCATCAAGAGTAATCATCATAAG
129	AAAATAAGGAATCATTACCGCGCCTTATCA
130	AGCGTCTTTCAGATATAGAAGGCTATGTAGAA

131	CAATTTTAAACGCGAGGCGTTTTAAGAAAAAT
132	TCAAGATTTGCGGGAGGTTTTGAAAGTAAATT
133	CTGACGAGGATGGTTTAATTTCAAACCCTCGT
134	CAAAGCTGTTACCTTATGCGATTTACGAGG
135	AACCGGATTATACCAGTCAGGACGAACTAATG
136	GGCTGACCACGTTAATAAAACGAATTCATCAG
137	AAATGAAAACAAAGTTACCAGAAGCCAAAAGA
138	AACATAAACCCTTTTTAAGAAAAGTTACGCAG
139	GAATTAACACAATGAAATAGCAATATACATAA
140	GGTAATTATTGAGTTAAGCCCACAAAGACA
141	CGGAGATTTACCAAGCGCGAAACAGAGATAAC
142	TCGAAATCCTAAAACACTCATCTTTCGCTGAG
143	GCCGGAACCAACCTAAAACGAAAGTTTTGCGG
144	GGAACCGAGGGTAAAATACGTAATACAGCATC
145	TAGCCGAATAGCAGCCTTTACACCAGTTAC
146	TACCGAAGAACAGGGAAGCGCATTCGCTAACG
147	AGCAAGAATGAACACCCTGAACAACCCAGCTA
148	CCACAAGAGAGCGCTAATATCAGAAAGTACAA
149	AGCGATTATGTATCATCGCCTGATGGCTTGCC
150	AGAATACACGCGACCTGCTCCATAACGTAA
151	GAAGGCACGAGGCGCAGACGGTCATTGACAAG
152	CATTAAACACTGACCAACTTTGAACATAGGCT
153	ACTGGCATAATTATCACCGTCACCAATCACCA
154	TATGTTAGAAATATTGACGGAAATGCCGGAAA
155	AGGTGGCAGGCGACATTCAACCGACAGCACCG
156	CCACGGATCATATGGTTTACCATTGCCTTT
157	CCCACGCACGCCGACAATGACAACACAATCAA
158	GCTTGCAGGAATTTCTTAAACAGCAAGTTTTG
159	GATCGTCATTGTATCGGTTTATCATGAATTTT
160	GGAACGAGTCCAAAAAAAAGGCTCTTTCAACA
161	AAAGGTGGATTAAGACTCCTTATAAGCAGA
162	GGGAAGGTCAAACGTAGAAAATACAGCTATCT
163	GACAAAAGACATATAAAAGAAACGATAATAAG

164	TAGAAAATATAAGTTTATTTTGTCAACCATCG
165	GATAGTTGTAACCGATATATTCGGTGACCCCC
166	TTCGAGGTGGAGTTAAAGGCCGCAGGCAAA
167	GCCTTTAACCCTCAGCAGCGAAAGGCCACTAC
168	TGAAAATCGGTAGCAACGGCTACAGAAGTTTC
169	GTAGCACCTCAGAACCGCCACCCTCCACCACC
170	CGTCACCAACCGGAACCGCCTCCCGAGGTTGA
171	TAATCAGTTCATAATCAAAATCACTATTCACA
172	AGCGTCACATAGCCCCCTTATTAGAATGGA
173	CCTCATAGCGCCTGTAGCATTCCACATCGGCA
174	TCGTCTTTACACTGAGTTTCGTCATTAGGATT
175	CTGTATGGTAGCAAGCCCAATAGGGCGGATAA
176	GTTTCAGCACCCTCAGAGCCACCAGTATAGCC
177	GCCACCCATTACCATTAGCAAGTATTCATT
178	GAGCCACCATGAAACCATCGATAGTTGAGGGA
179	CCATCTTTAGCGACAGAATCAAGTGCGCCAAA
180	TTTTCGGTGACTGTAGCGCGTTTTCAGACAGC
181	AACTACAATTAGCGTAACGATCTATTGATACC
182	GTACCGTACCAGACGTTAGTAAAGCTTGCT
183	TTCAGGGAGATTTTGCTAAACAACCAAAAGGA
184	GAACCGCCGGAGTGAGAATAGAAATTTCACGT
185	AGAGCCGCCGCCAGCATTGACAGTCAGAGCC
186	GGCAGGTCAGACGATTGGCCTTGACGGAACCA
187	AACAAATAAATCCTCATTAAAGCCAGCGTTTG
188	AAGCGCAGTCTCTGAATTTACCGTATTAAGA
189	GGCTGAGACTCCTCAAGAGAAGGACCAGTACA
190	AGCGGGGTTTTGCTCAGTACCAGAACCCAT
191	GTGCCGTCGAGAGGGTTGATATAACCCTCATT
192	CGGAATAGGTGTATCACCGTACTCCACCCTCA

Data S1.

Raw fluorescence measurement data