

1 How we did it

1.1 Definitions

Let $f : \{0, 1\}^k \rightarrow \{0, 1\}$ be a k -input one-output Boolean function and \mathbb{B}_k be the family of such functions. A two-input **nor** gate is the specific function

$$\text{nor} = \{((0, 0), 1), ((0, 1), 0), ((1, 0), 0), ((1, 1), 0)\}.$$

For conciseness, we will write the application of $\text{nor}(\cdot, \cdot)$ as $\cdot \star \cdot$. By a **nor expression** we mean any string of symbols generated by the family of grammars

$$S_k \rightarrow i_1 | i_2 | \cdots | i_k | 0 | (S_k \star S_k), k \in \mathbb{N}.$$

We denote the set of strings generated by S_k as $\mathcal{L}(S_k)$. The Boolean function **implemented** by a nor expression e is the function described by the string e . Two nor expressions e, f are called **equivalent**, denoted $e \equiv f$, if and only if the functions they implement are equal to each other. For a nor expression e , let G_e be a graph with vertex and edge sets defined as below:

1. $e \in V(G_e)$, and
2. if $(x \star y) \in V(G_e)$, then $x \in V(G_e)$ and $y \in V(G_e)$, and $(x, (x \star y)) \in E(G_e)$ and $(y, (x \star y)) \in E(G_e)$.

For a nor expression e , we call G_e its **circuit**. We call a circuit G_e **optimal** if and only if for every other equivalent nor expression e' , $|V(G_e)| \leq |V(G_{e'})|$. The longest path in G_e is called the **depth** of e , denoted $\delta(e)$.

1.2 Algorithm

Let $X, Y \subseteq \mathcal{L}(S_k)$. We define $X \star Y = \{\{x, y\} : x \in X, y \in Y, x \neq y\}$. Let $f_0 = \{a, b, c, 0\}$ and define

$$f_n = f_{n-1} \star \bigcup_{i=0}^{n-1} f_i. \quad (1)$$

Let $\phi(f_n) = \{(x \star y) : \{x, y\} \in f_n\}$ —we will write $\phi(\{x, y\})$ to mean $(x \star y)$.

Here $\phi(f_n)$ is a set of nor expressions of depth n . One can show that it is sufficient to search $\bigcup_{i=0}^n \phi(f_i)$ to obtain optimal circuits of depths no greater than n .

2 Results

In the following pages, the top picture shows a circuit, and the bottom picture shows a schematic of the sequence of parts in each circuit, generated by a post-order traversal of the circuit. For each truth table, the inputs a, b , and c are labeled from left to right, with a being the most significant bit and c being the least significant bit.

Figure 1 shows the number of circuits of each size.

Table 2 shows the number of circuits in which each repressor is used.

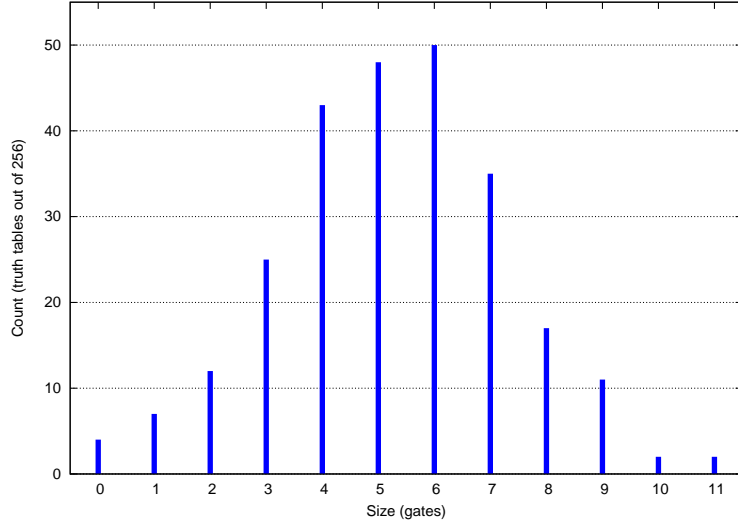


Figure 1: Distribution of circuit sizes

Repressor	Count	Position
1	229	3
2	215	7
3	189	9
4	189	2
5	174	6
6	165	8
7	90	1
8	62	5
9	18	0
10	6	4
11	2	-

Table 1: A count of circuits by repressor




Position	0	1	2	3	4	5	6	7	8	9	10	11
Rank	9	7	4	1	10	8	5	2	6	3	-	-
Color											GFP	Input

Table 2: Repressor usage count-based static ordering heuristic for transcriptional units

3 Modular Cloning Assembly

Let $\mathcal{P} = \{p_0, p_1, \dots, p_{n_p}\}$ be a set of parts and let $\mathcal{T} = \{t_0, t_1, \dots, t_{n_t}\}$ be a set of transcriptional units, where each t_i is a string over the alphabet \mathcal{P} . Let $\mathcal{F} = \{f_0, f_1, \dots, f_{n_f}\}$ be a set of fusion sites. A *vector* v is a pair of fusion sites $(v^{5'}, v^{3'})$, such that $v^{5'} \neq v^{3'}$. Let $\mathcal{V} = \{v : v \in \mathcal{F} \times \mathcal{F}, v^{5'} \neq v^{3'}\}$ denote the set of all vectors derived from \mathcal{F} . For $k > 0$, a sequence of vectors $V = (v_1, \dots, v_k)$ is called a *vector chain* of length k if and only if, for $i \in \{1, \dots, k-1\}$ $v_i^{3'} = v_{i+1}^{5'}$. Let $S = \{t_1, t_2, \dots, t_r\} \subseteq \mathcal{T}$. A *linearization* of S is a bijection $\lambda : \{1, \dots, r\} \rightarrow S$. A *vector assignment* of S is a one-to-one function $\phi : S \rightarrow \mathcal{V}$ such that $(\phi(\lambda(1)), \phi(\lambda(2)), \dots, \phi(\lambda(r)))$ is a vector chain.

The *Modular Cloning Assembly* problem: Given a family of sets $\mathcal{C} = \{S : S \subseteq \mathcal{T}\}$ compute a linearization and vector assignment for each S such that

$$|\{v : v \in \mathcal{V} \text{ and } v \text{ appears in the vector assignment of some } S\}|$$

is minimized.

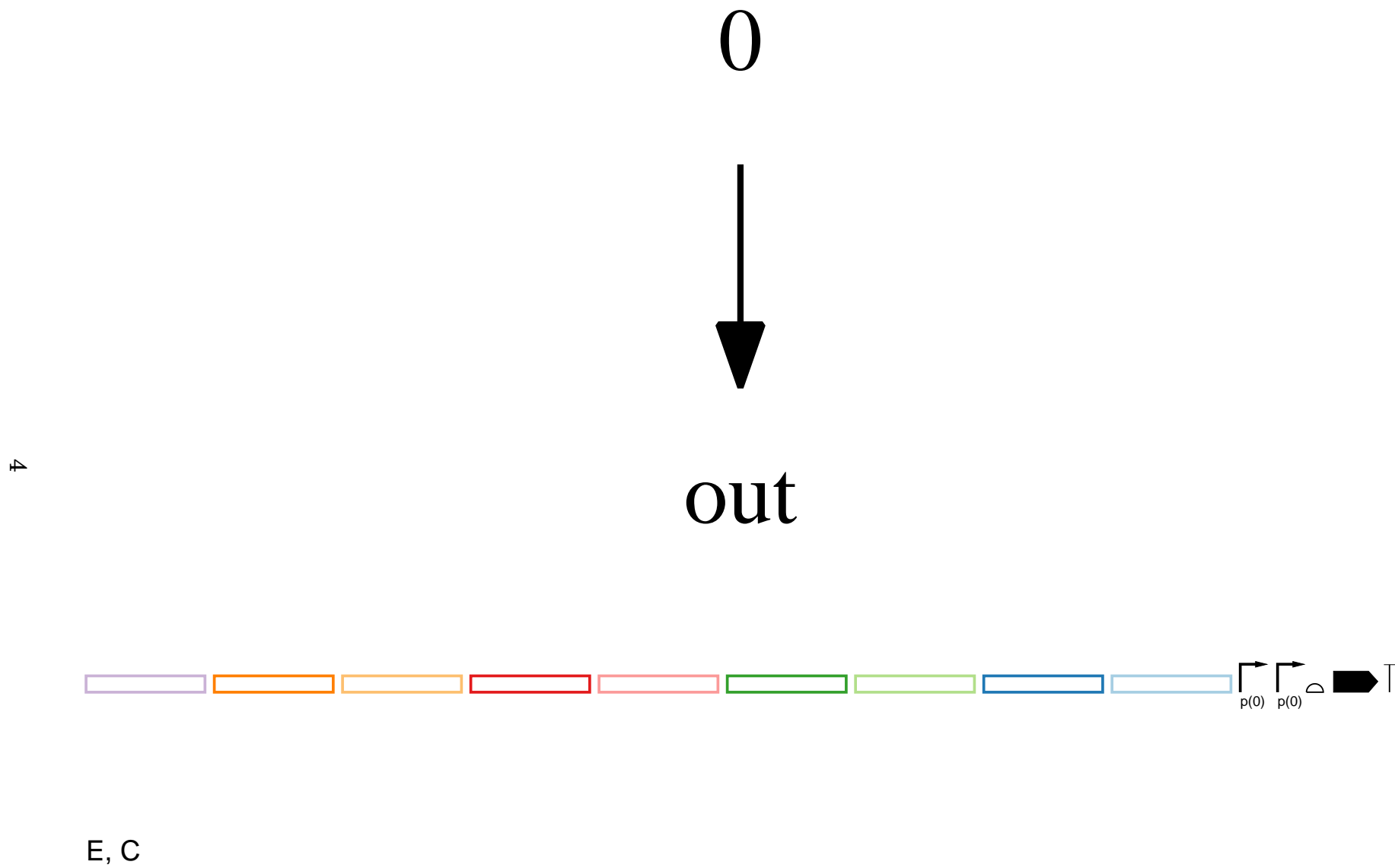
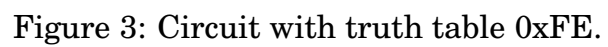


Figure 2: Circuit with truth table 0x0.



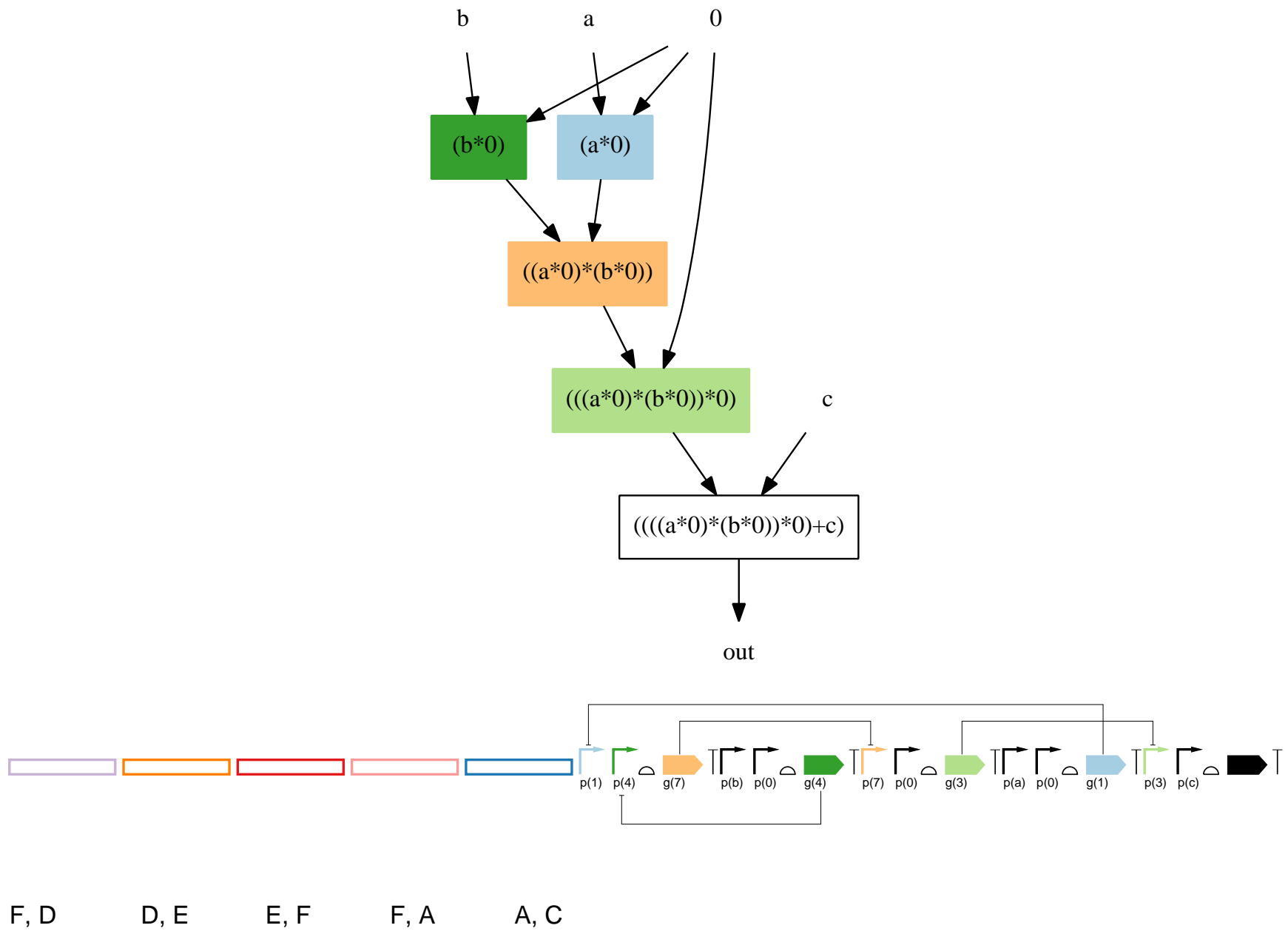


Figure 4: Circuit with truth table 0xFD.

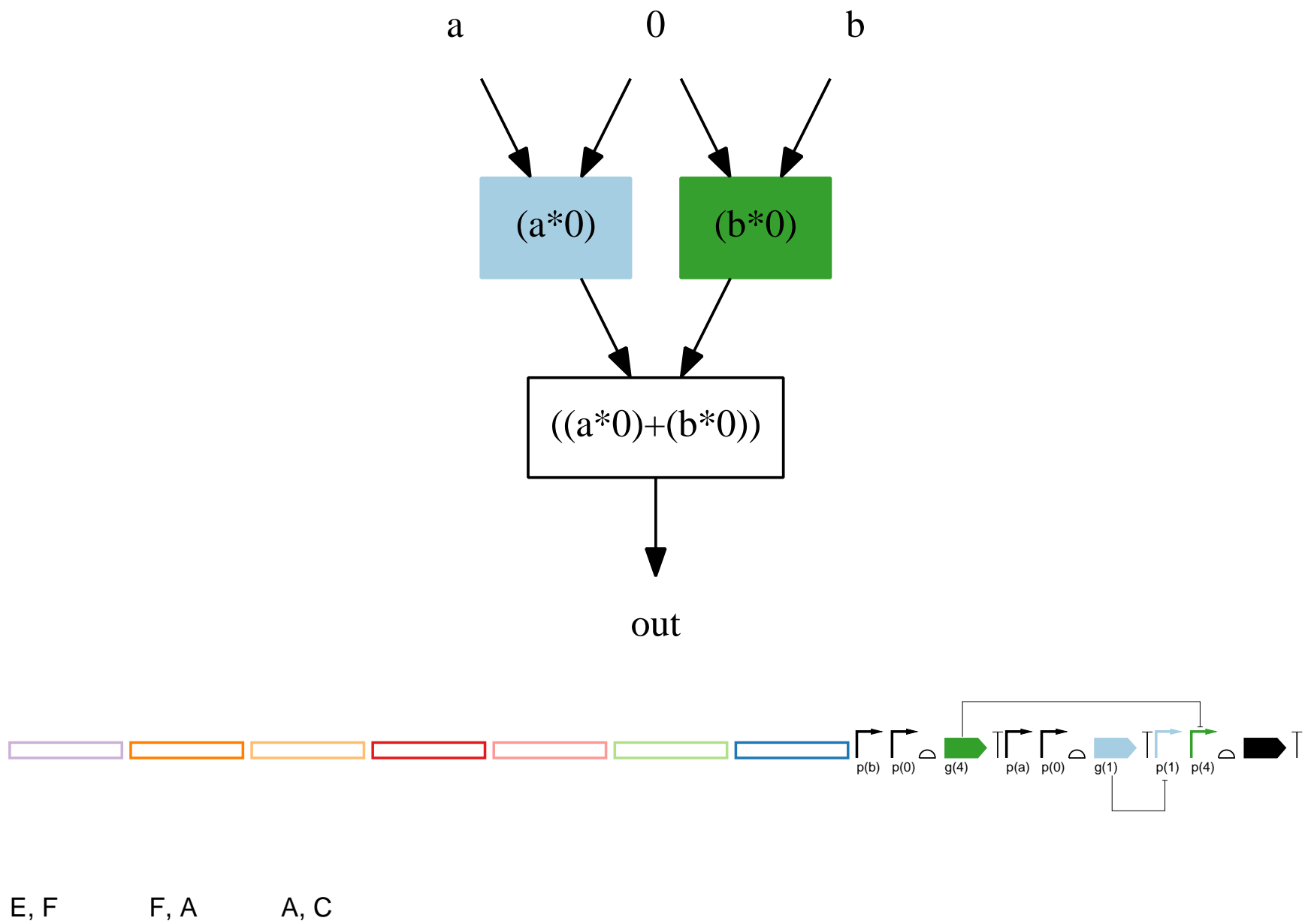


Figure 5: Circuit with truth table 0xFC.

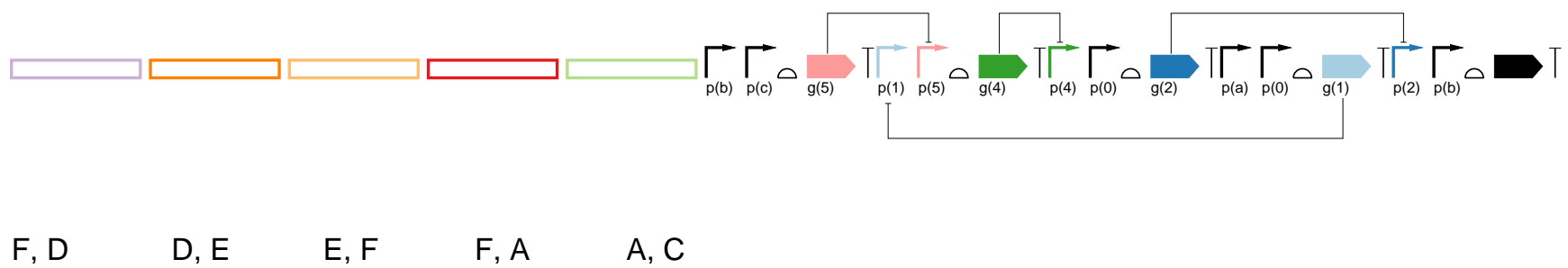
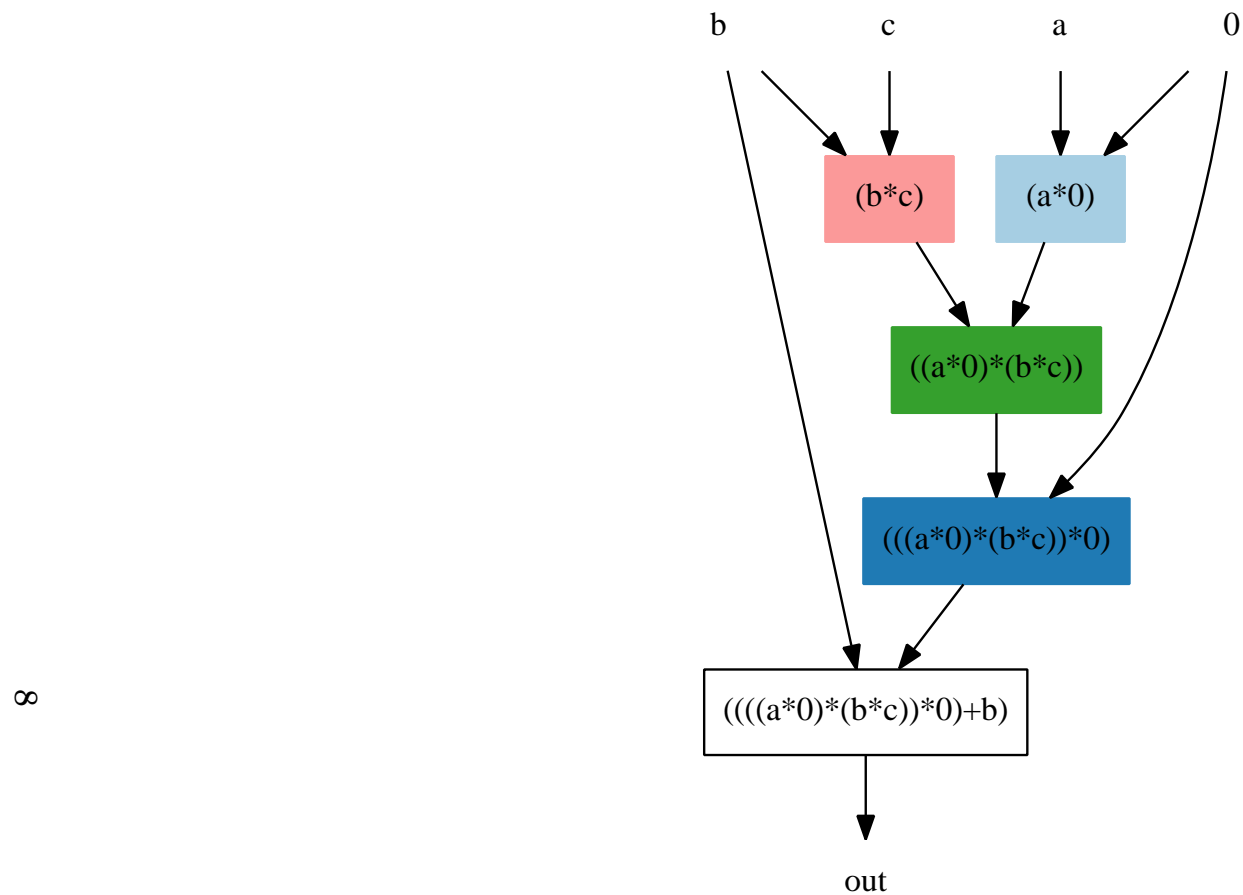


Figure 6: Circuit with truth table 0xFB.

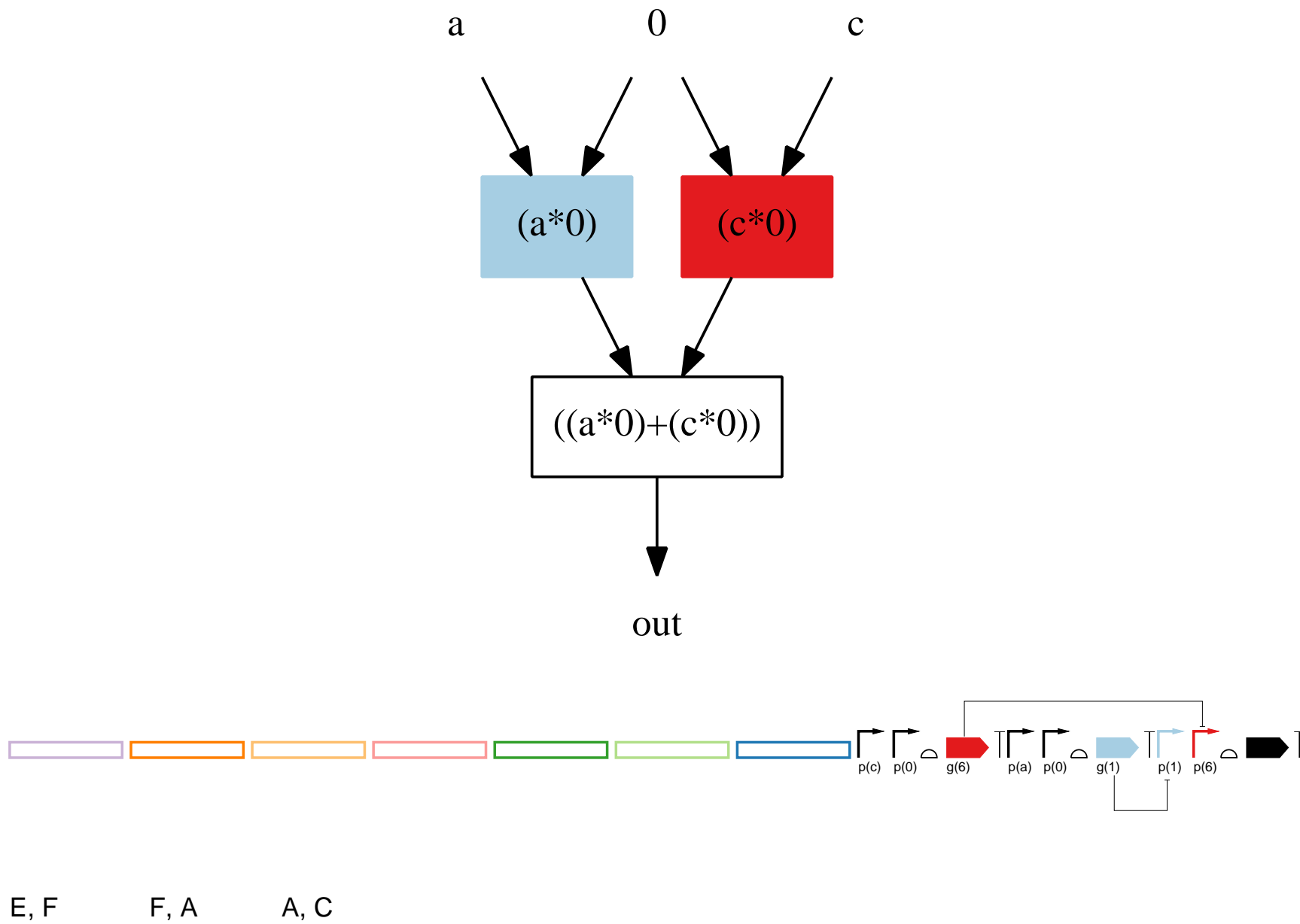


Figure 7: Circuit with truth table 0xFA.

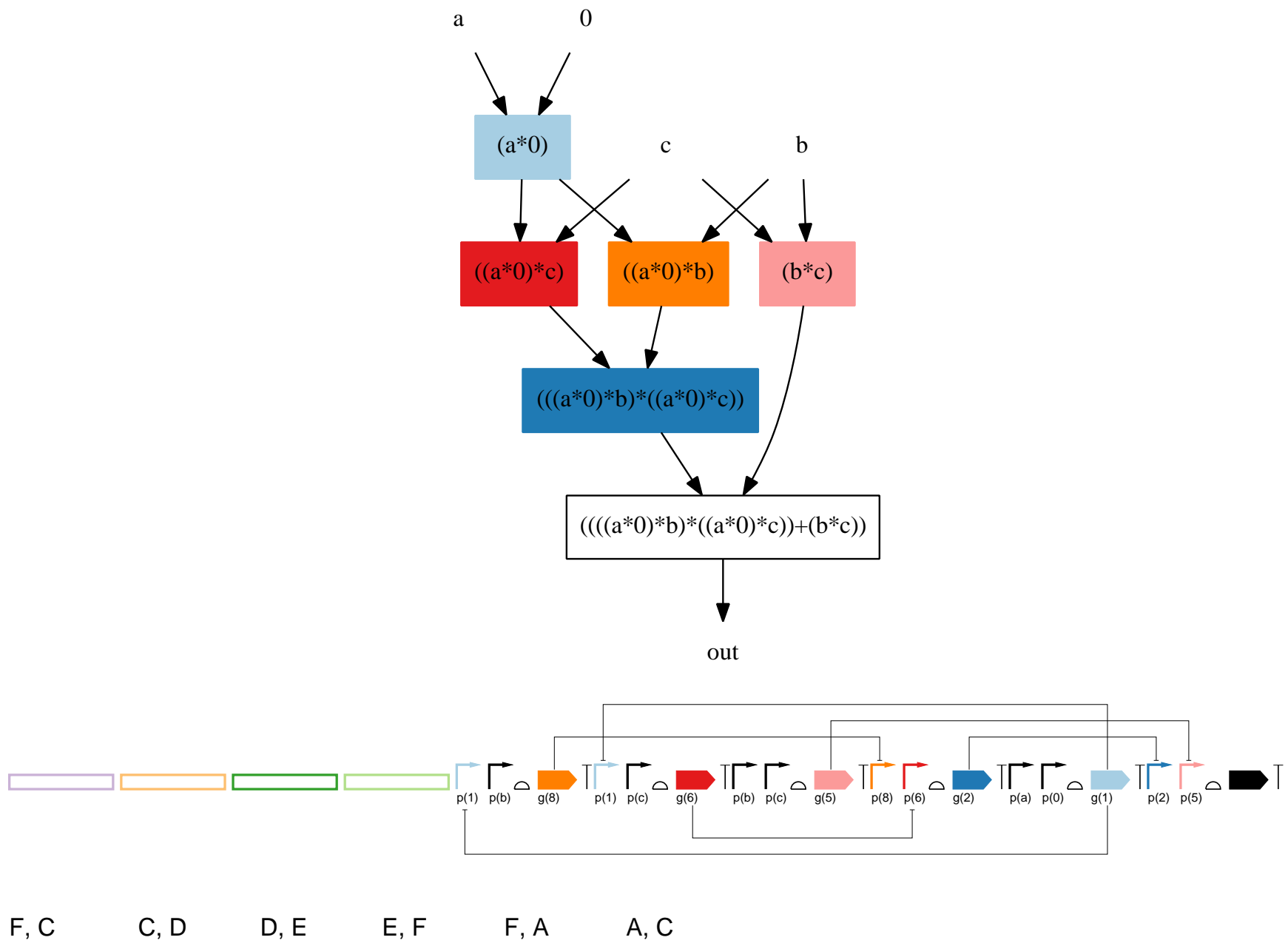


Figure 8: Circuit with truth table 0xF9.

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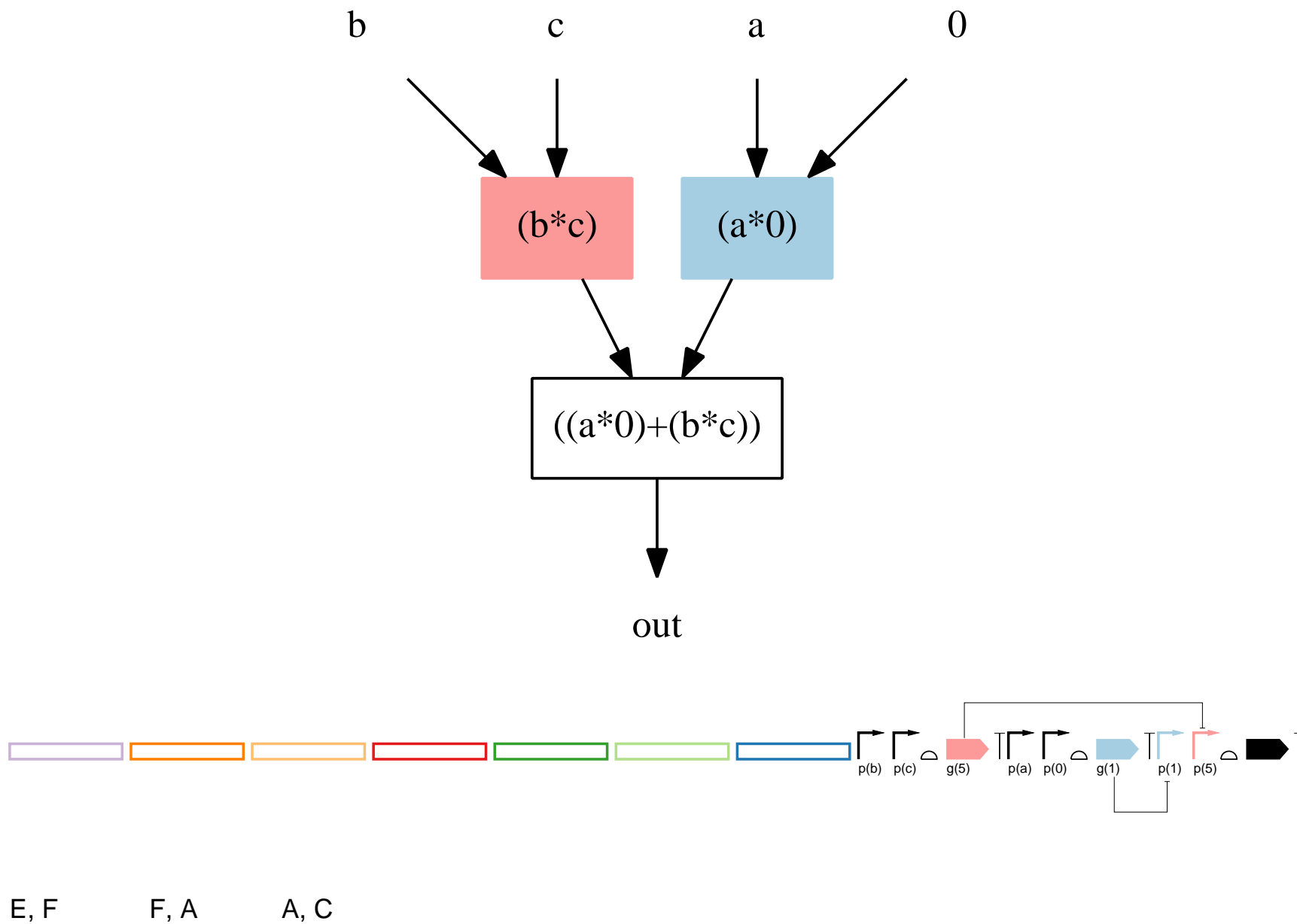


Figure 9: Circuit with truth table 0xF8.

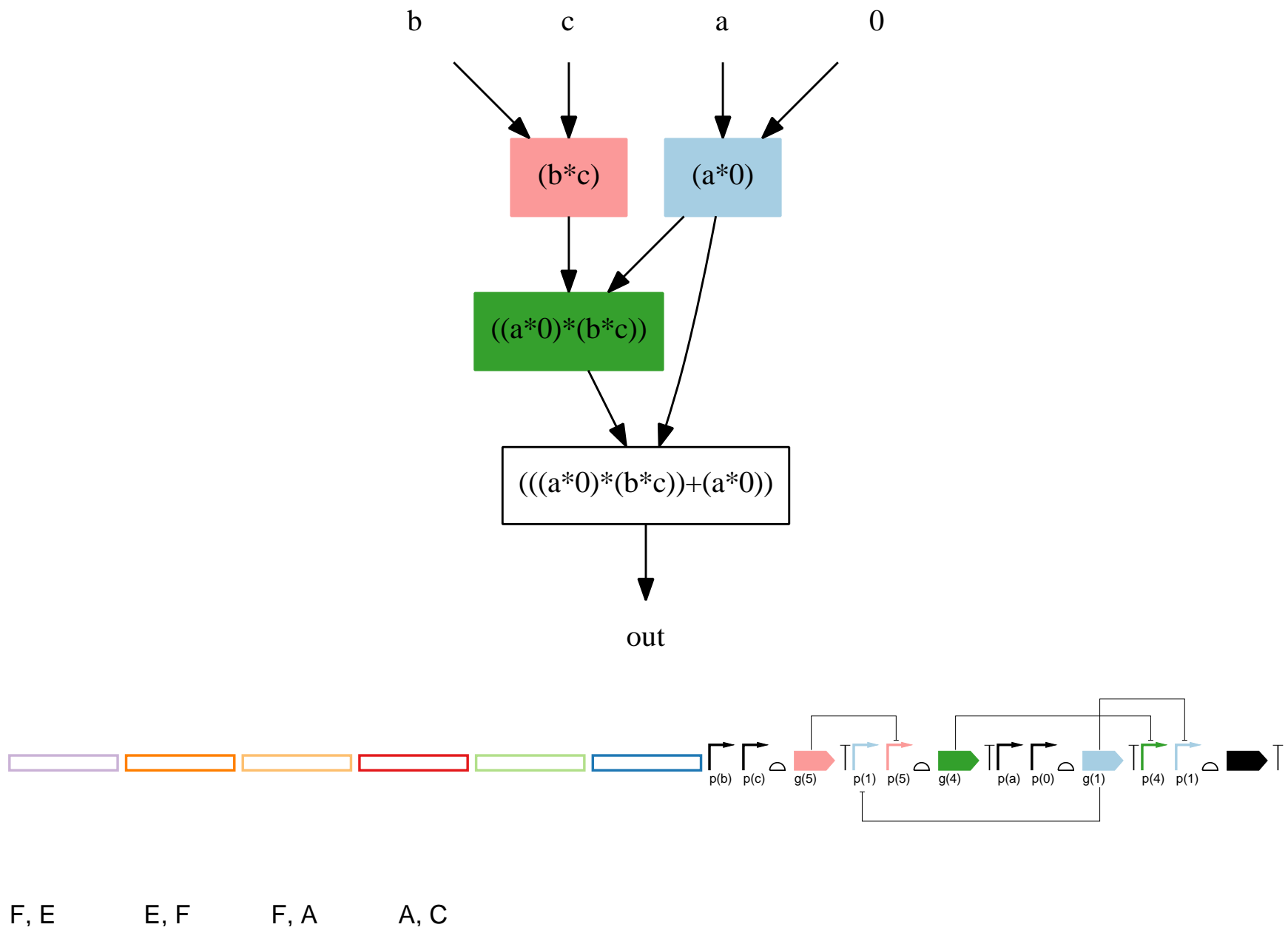


Figure 10: Circuit with truth table 0xF7.

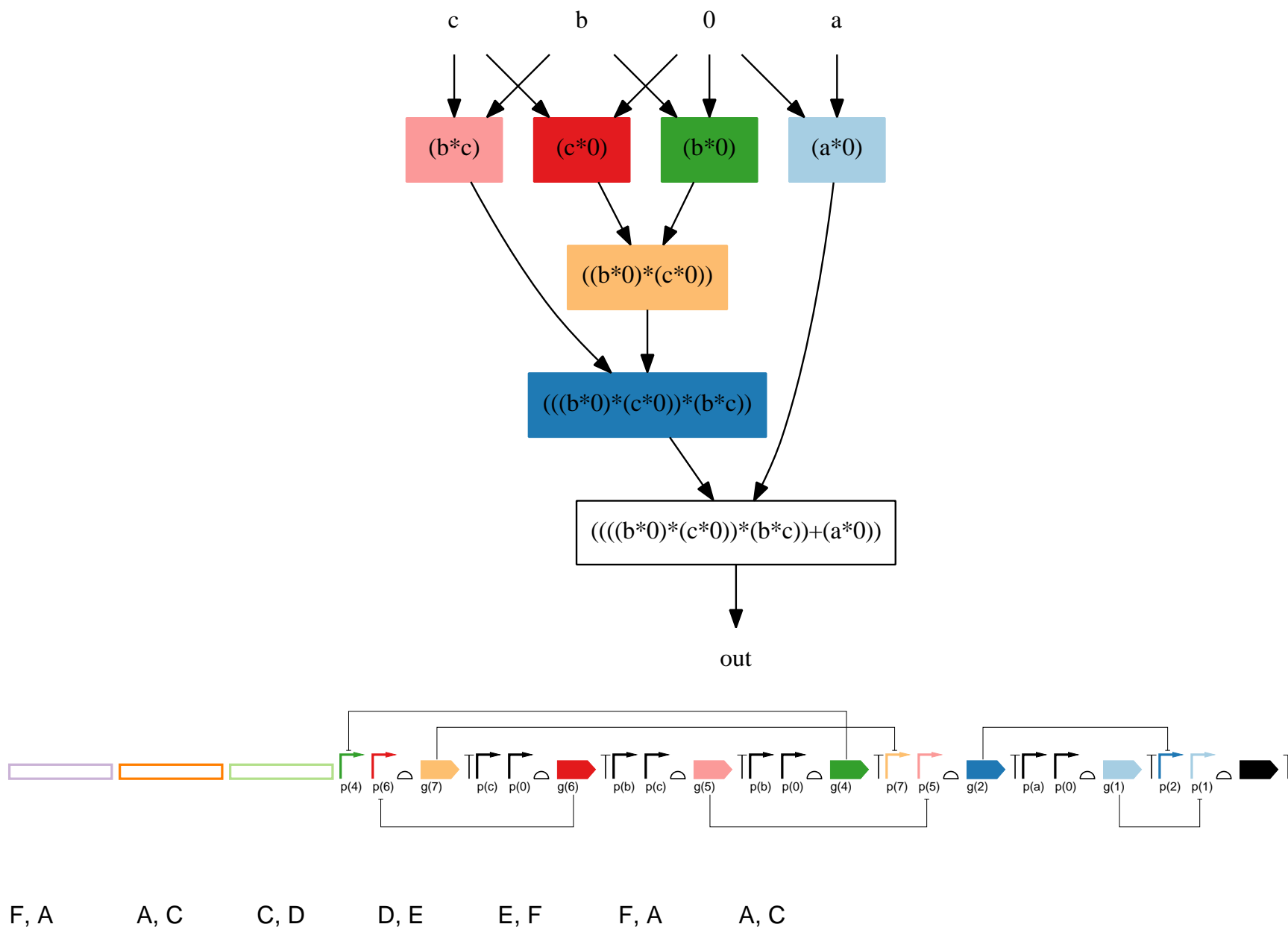
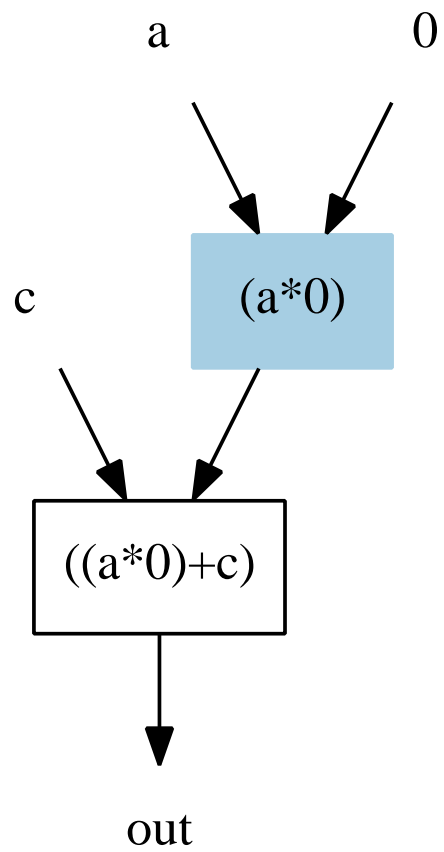


Figure 11: Circuit with truth table 0xF6.



E, A

A, C

Figure 12: Circuit with truth table 0xF5.

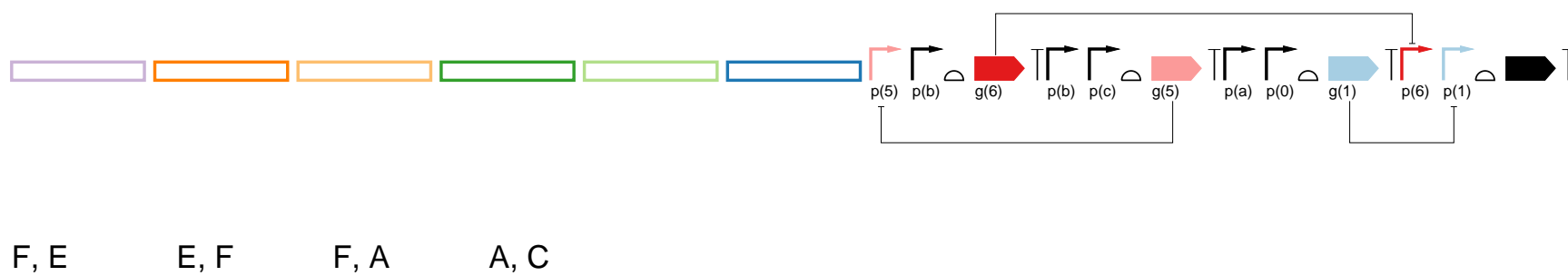
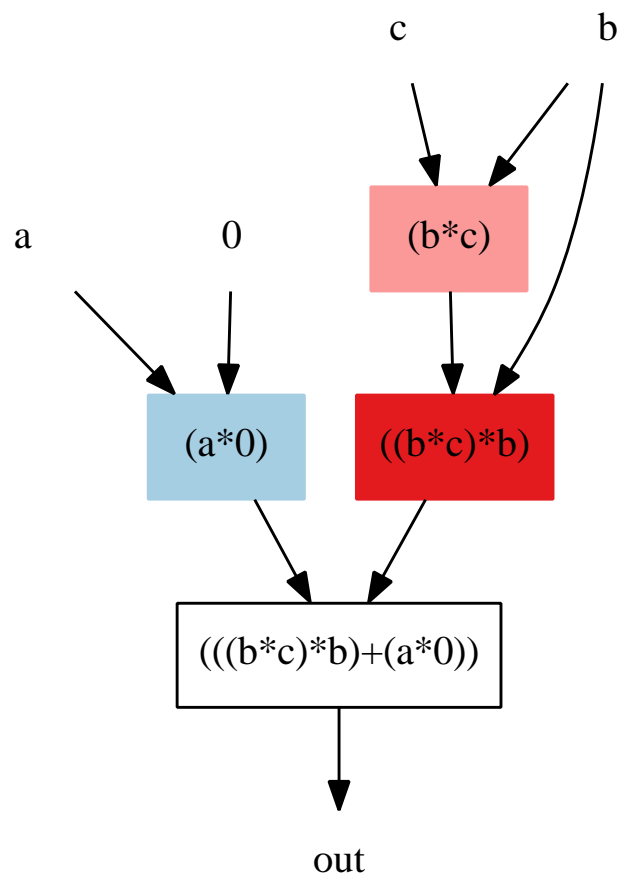
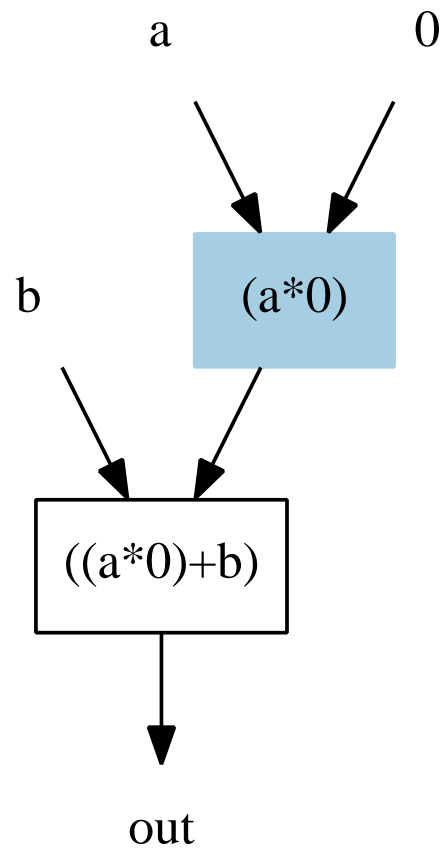


Figure 13: Circuit with truth table 0xF4.

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E, A

A, C

Figure 14: Circuit with truth table 0xF3.

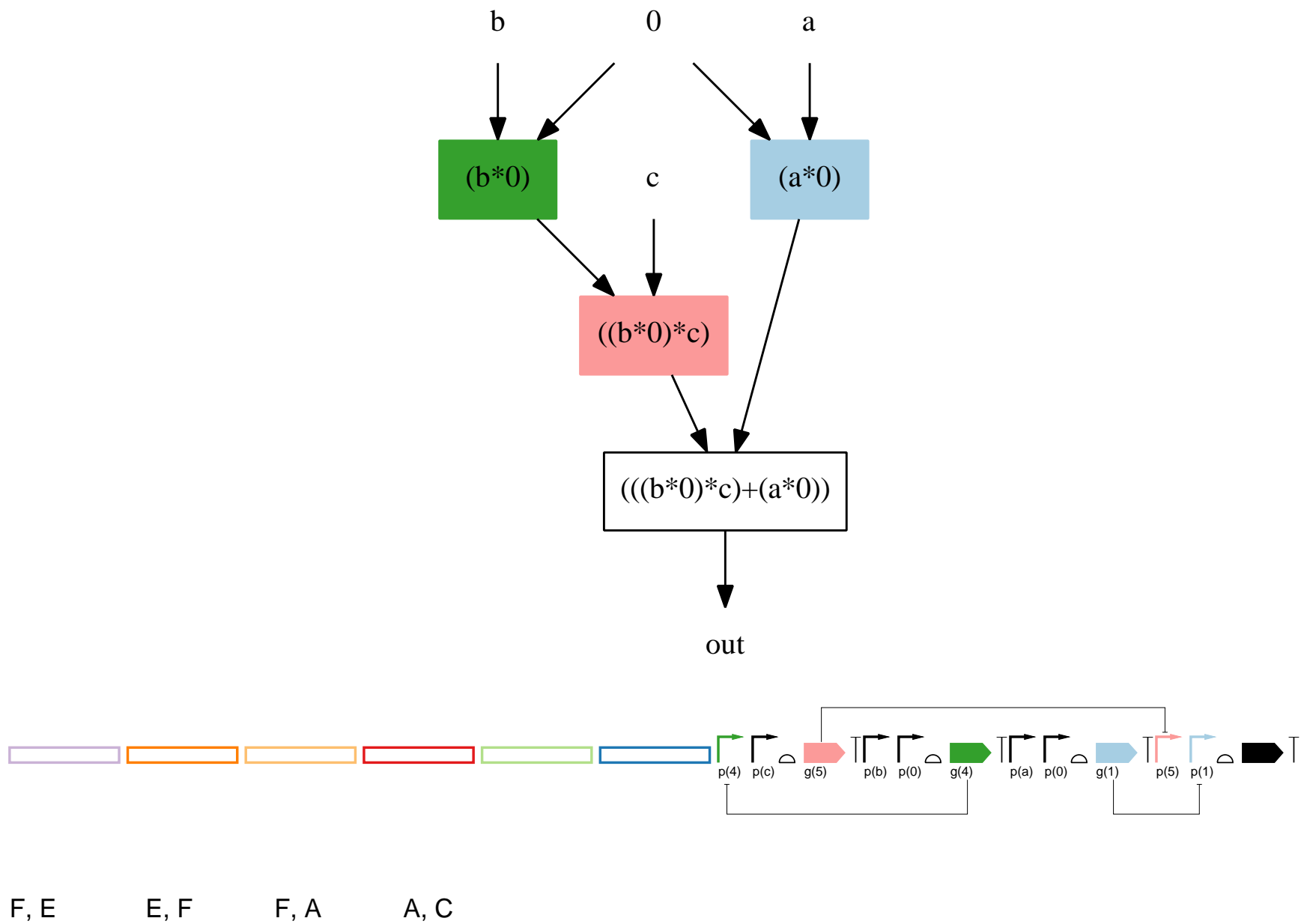


Figure 15: Circuit with truth table 0xF2.

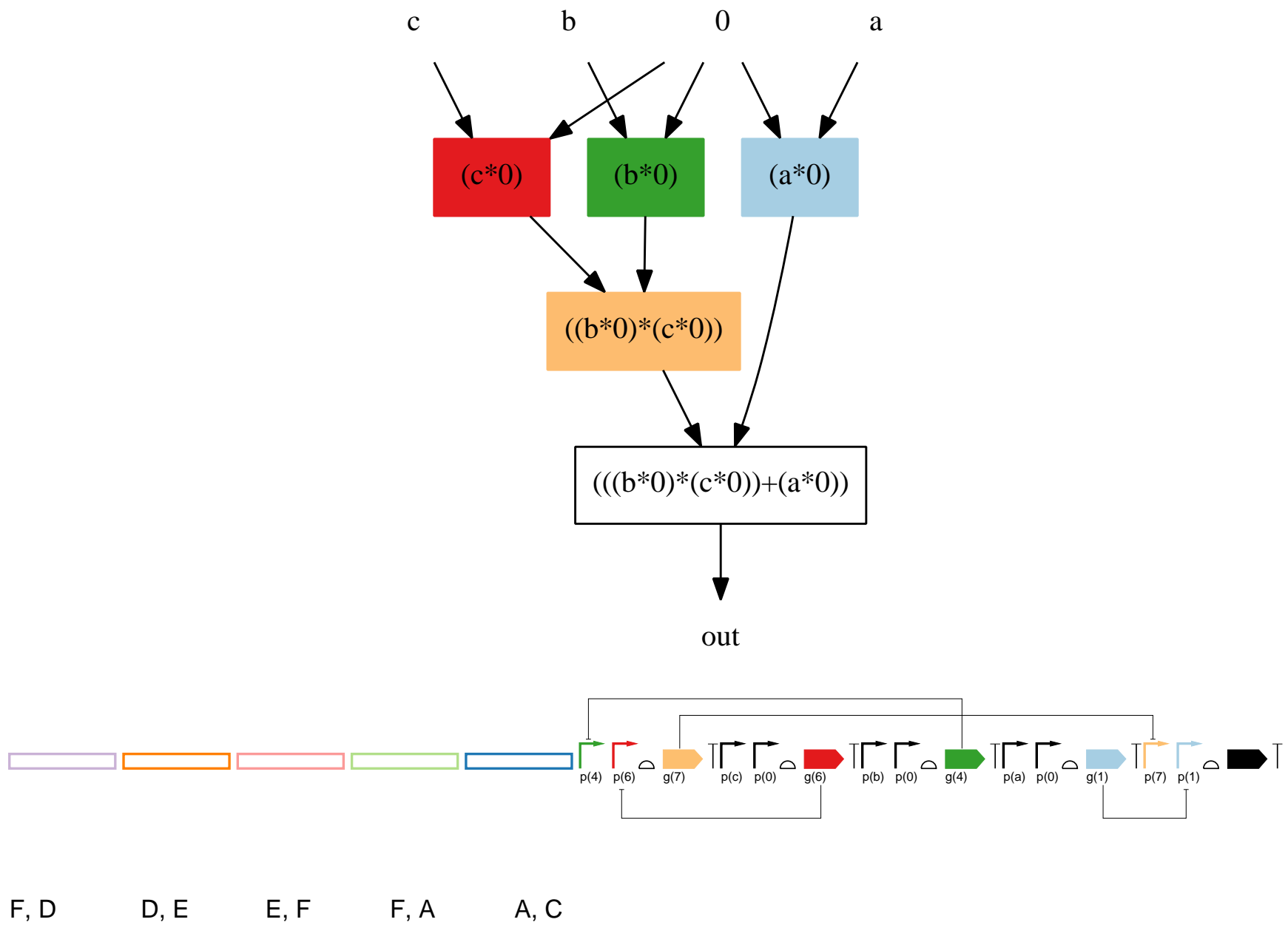


Figure 16: Circuit with truth table 0xF1.

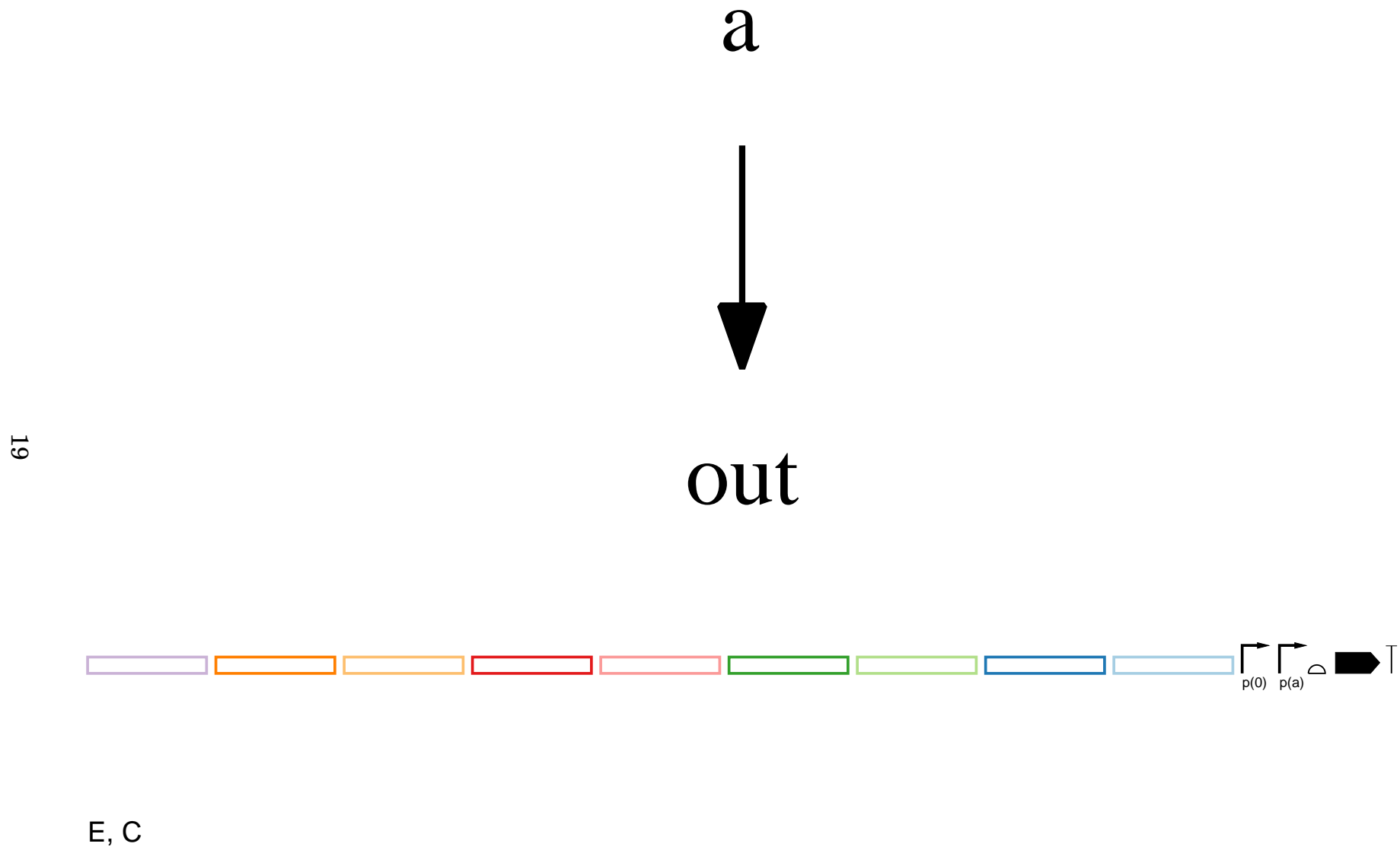


Figure 17: Circuit with truth table 0xF.

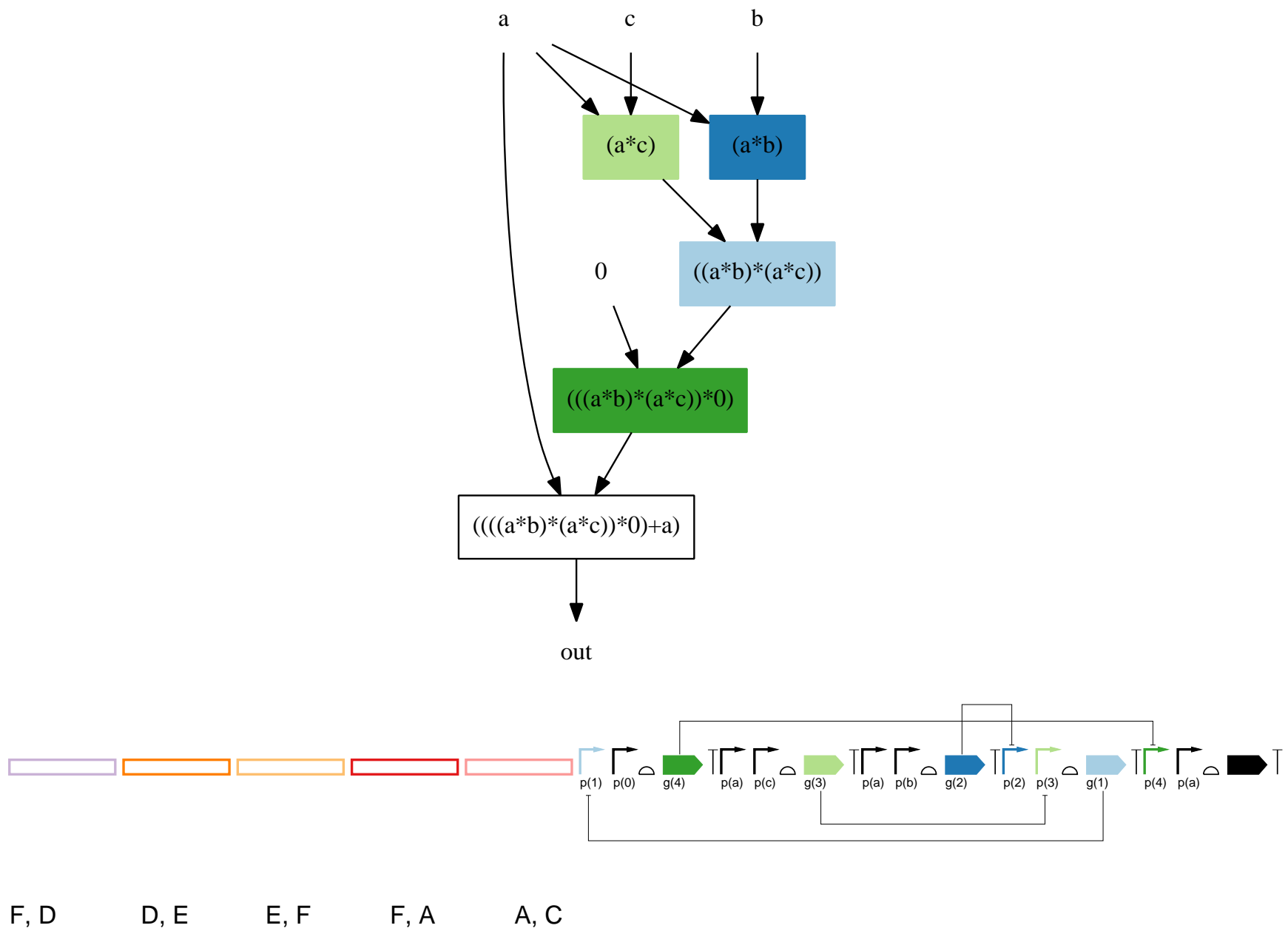


Figure 18: Circuit with truth table 0xEF.

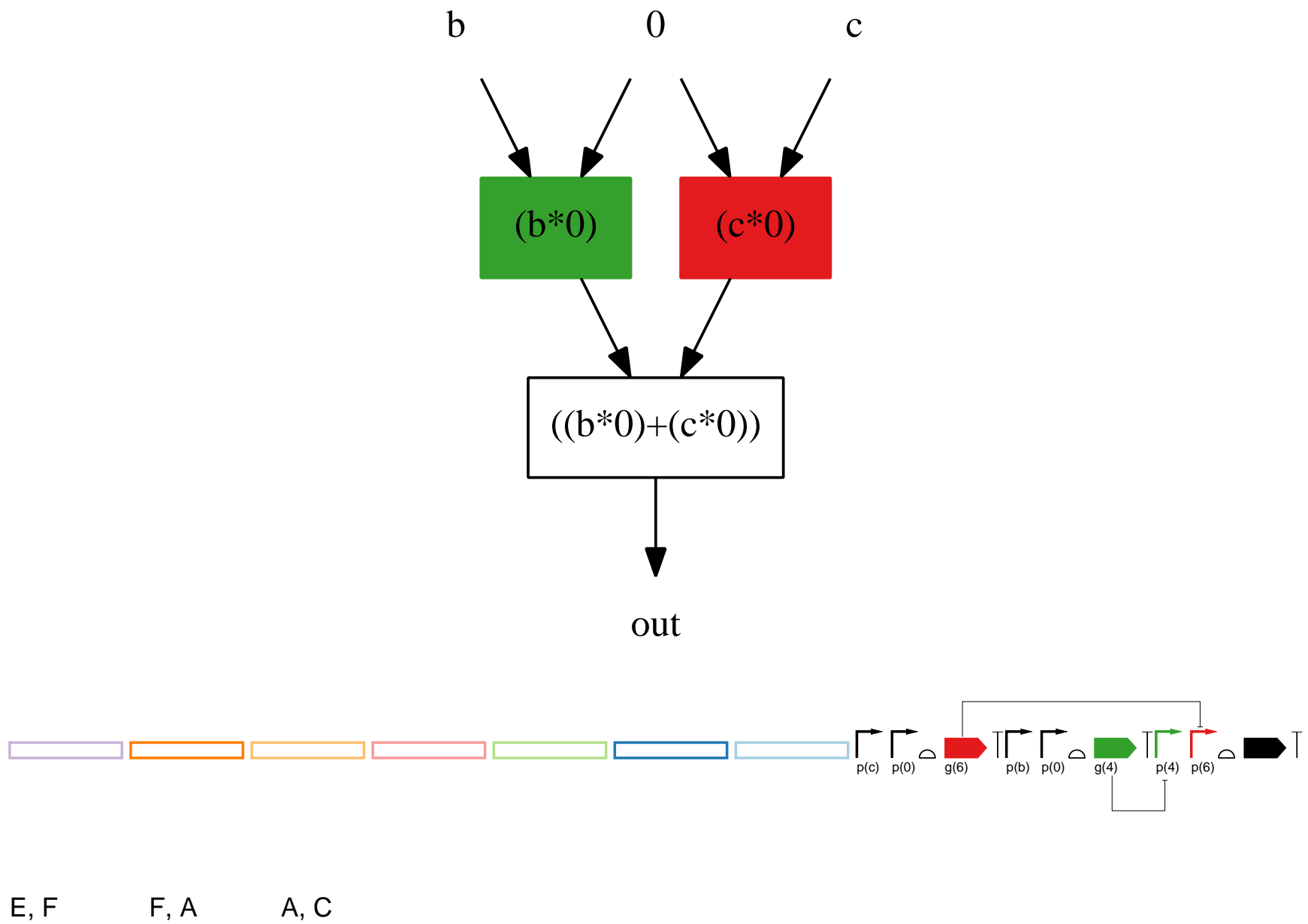


Figure 19: Circuit with truth table 0xEE.

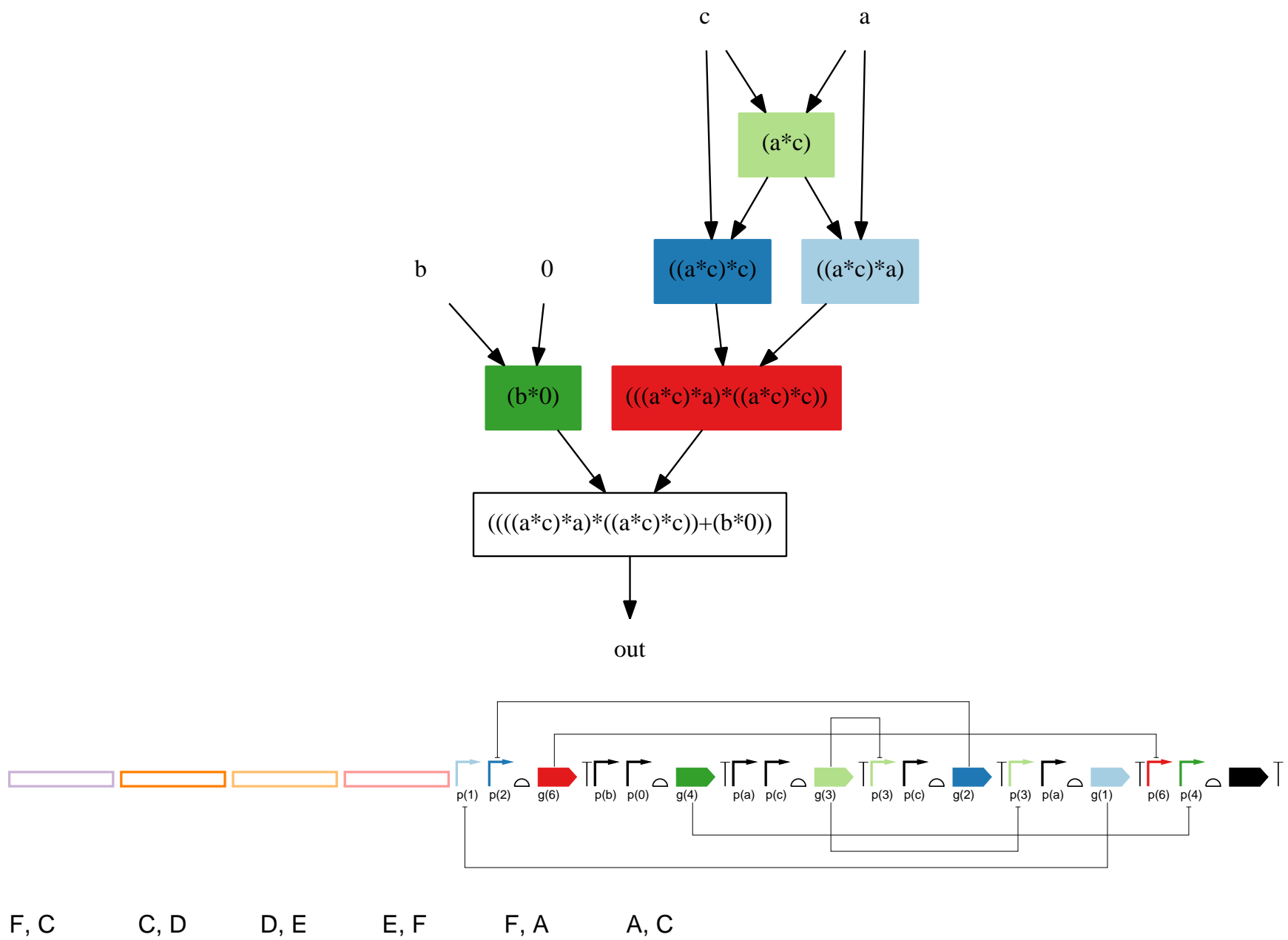


Figure 20: Circuit with truth table 0xED.

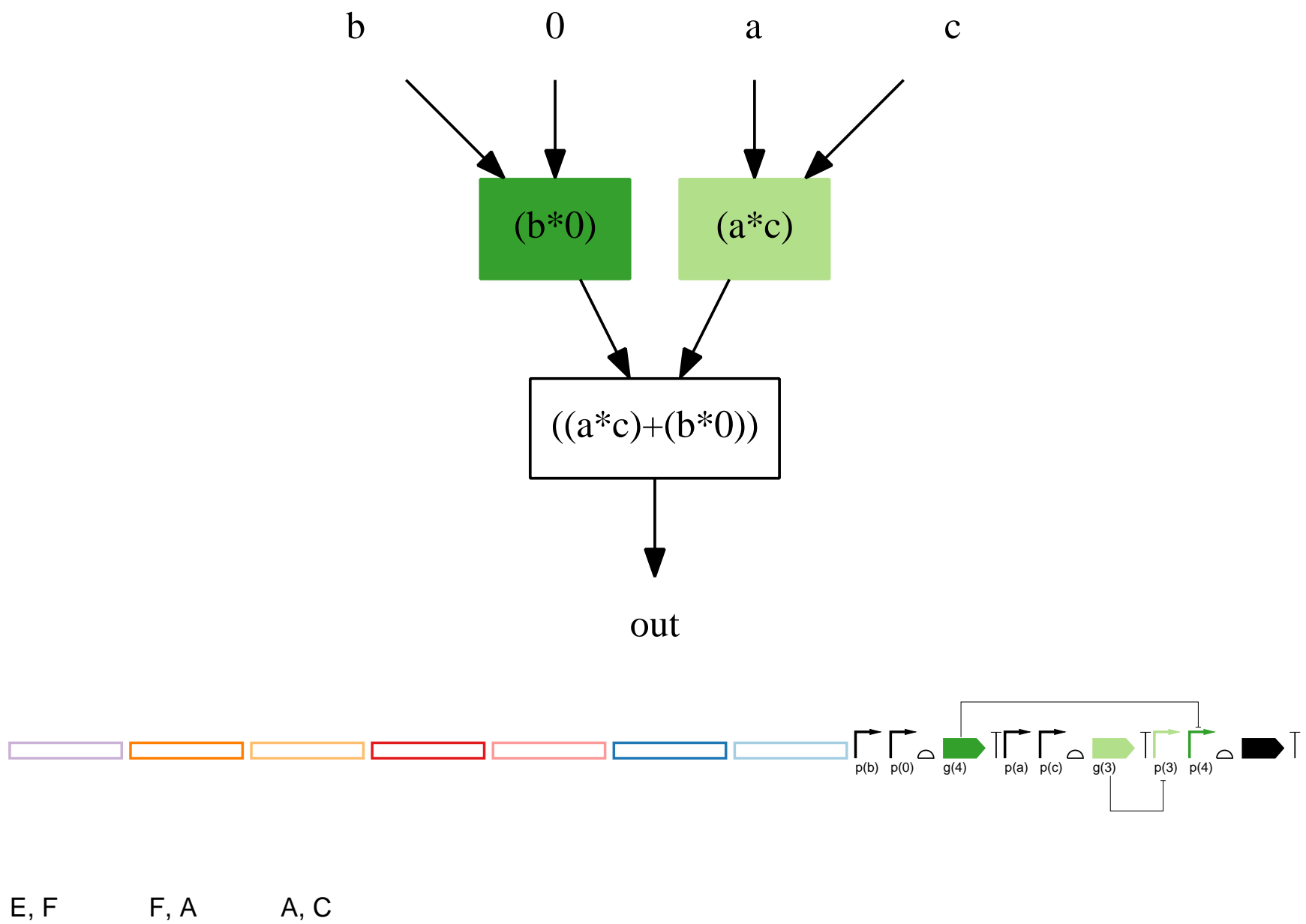


Figure 21: Circuit with truth table 0xEC.

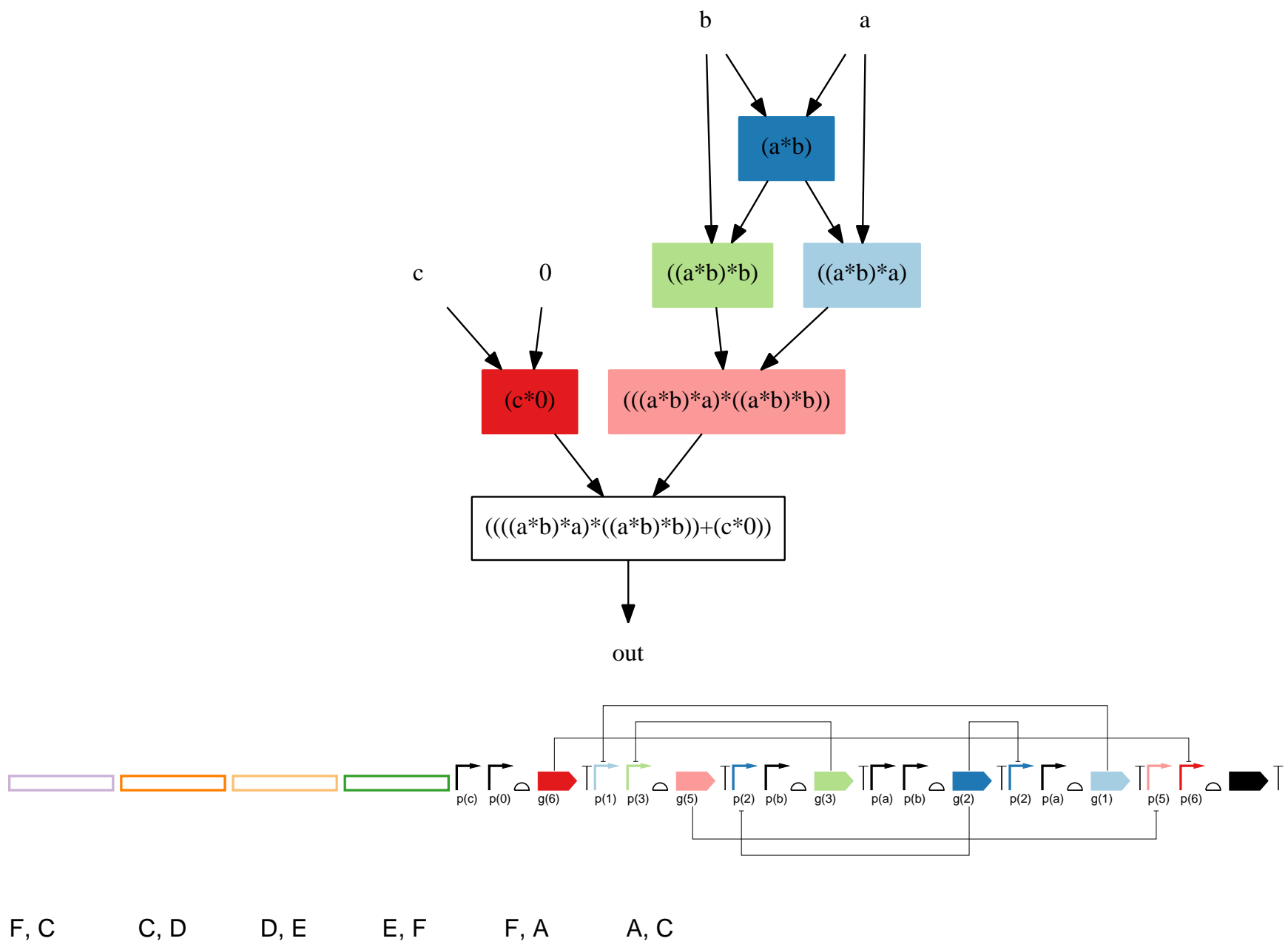
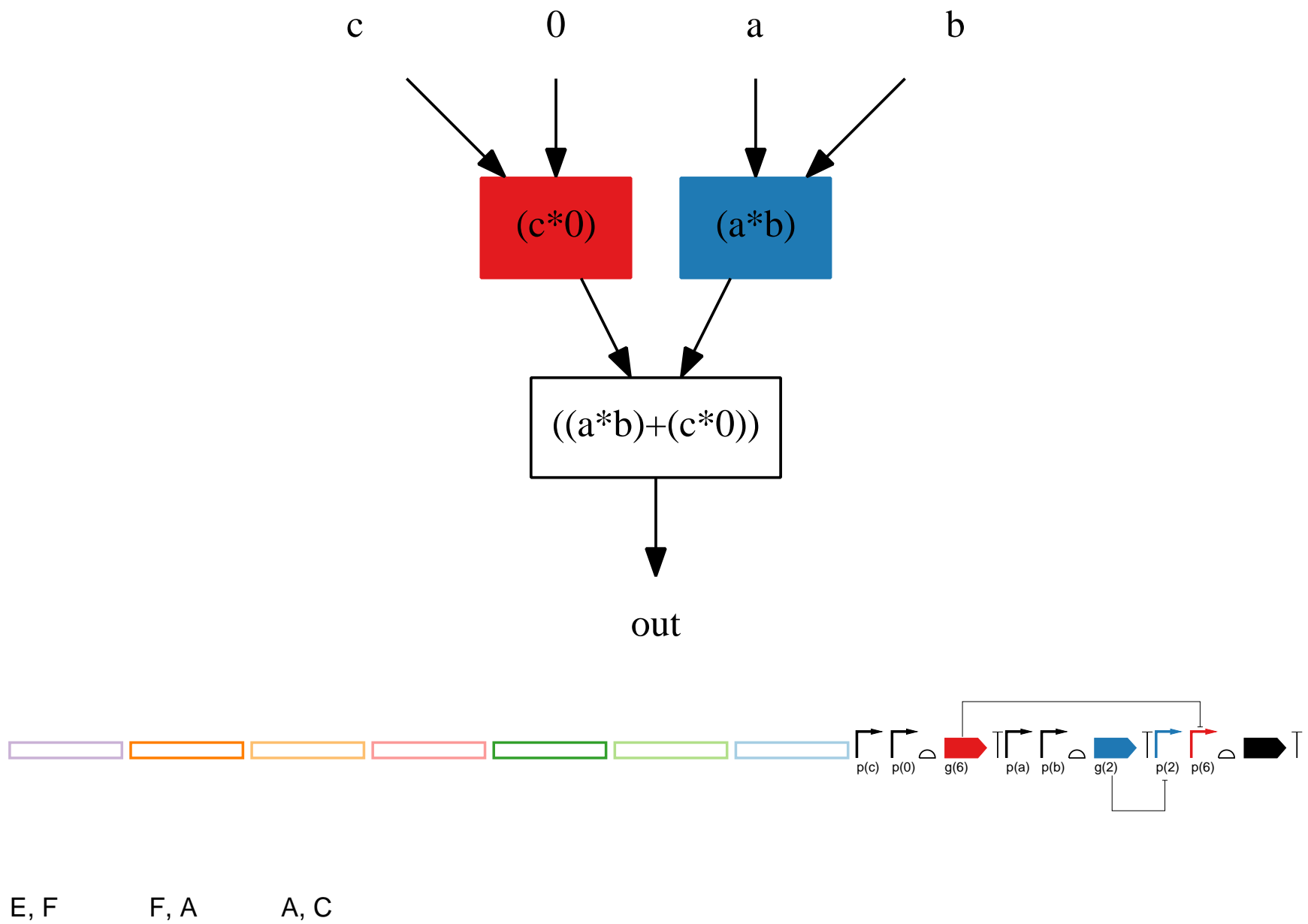


Figure 22: Circuit with truth table 0xEB.



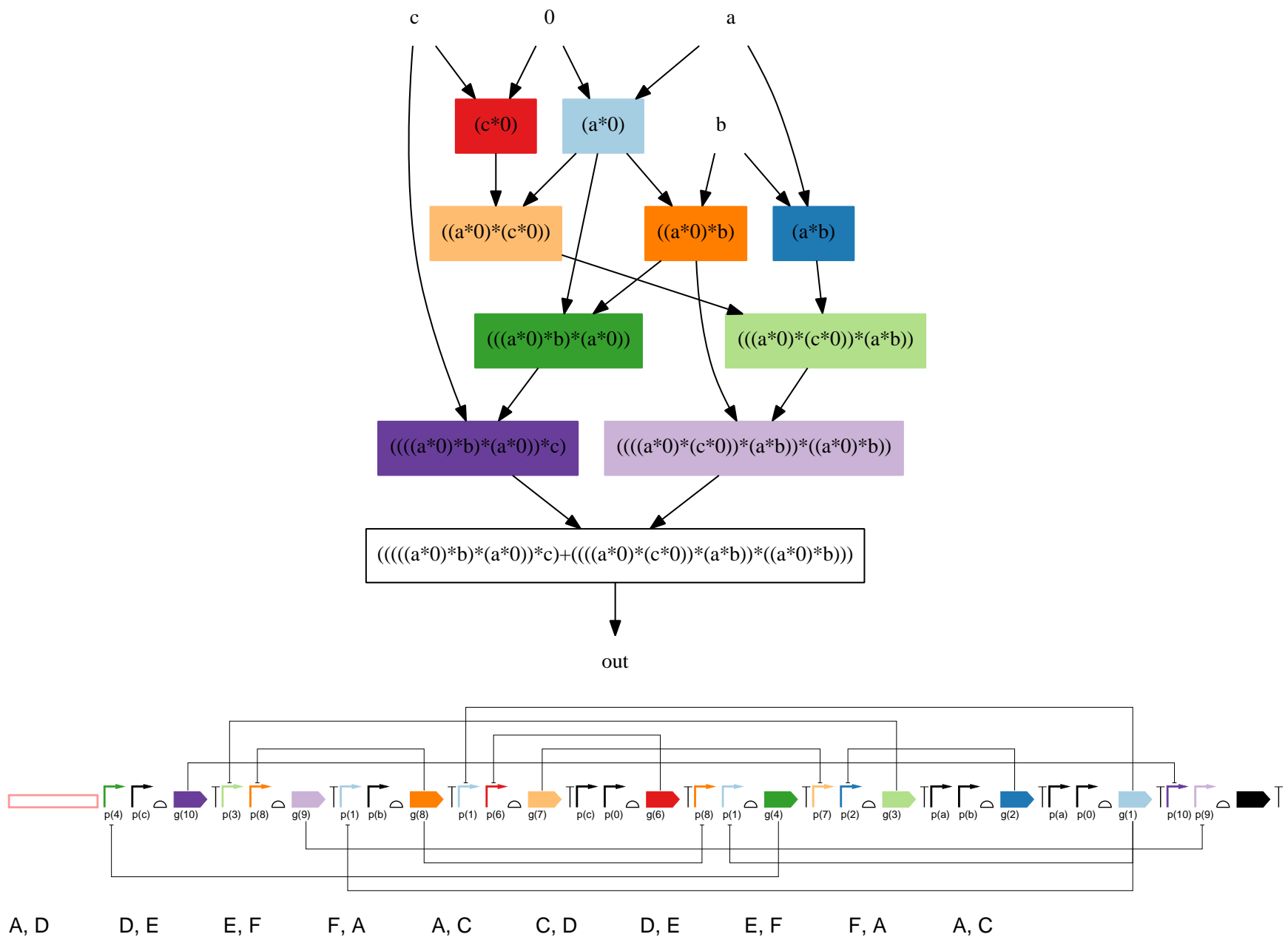


Figure 24: Circuit with truth table 0xE9.

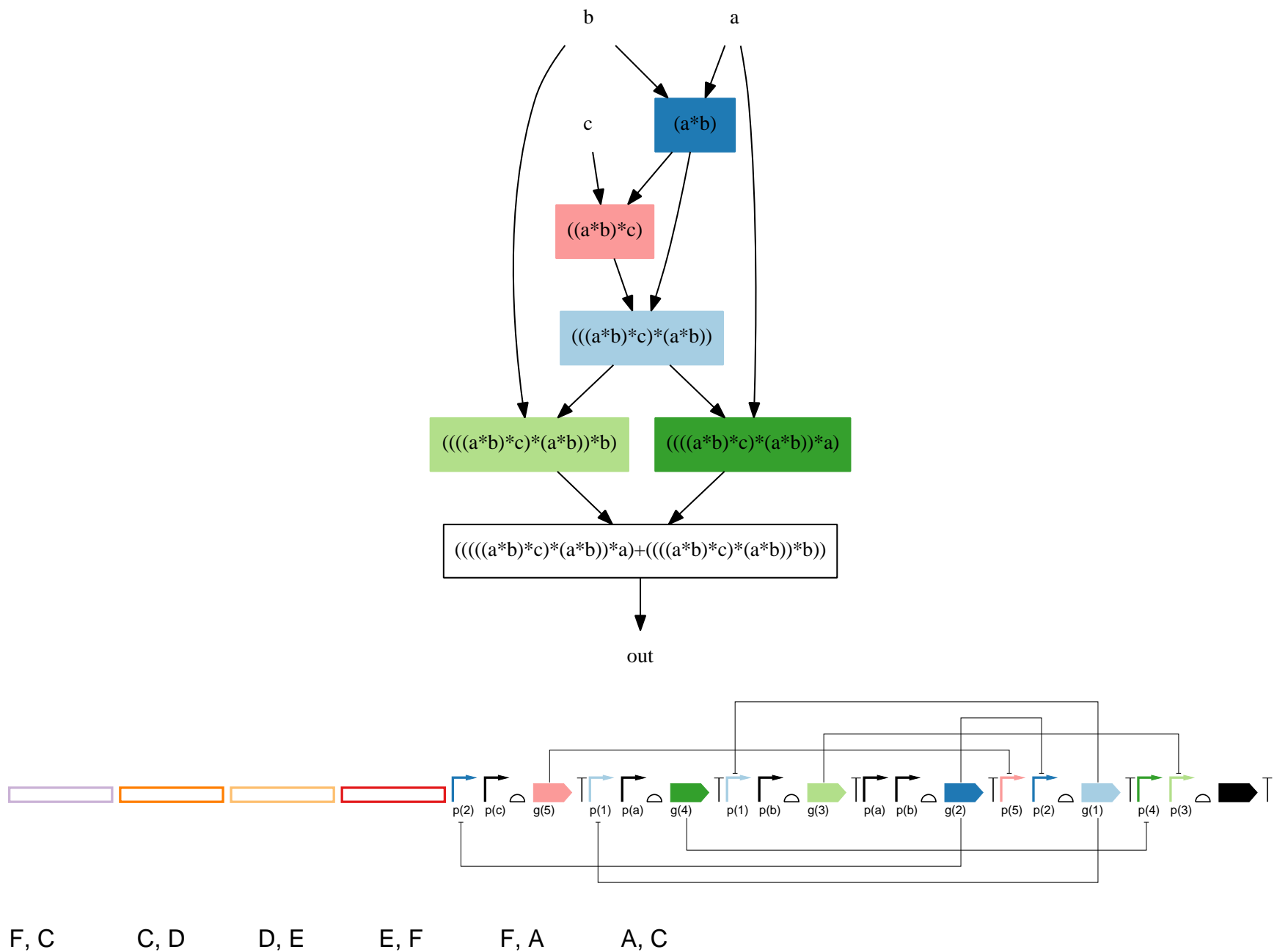


Figure 25: Circuit with truth table 0xE8.

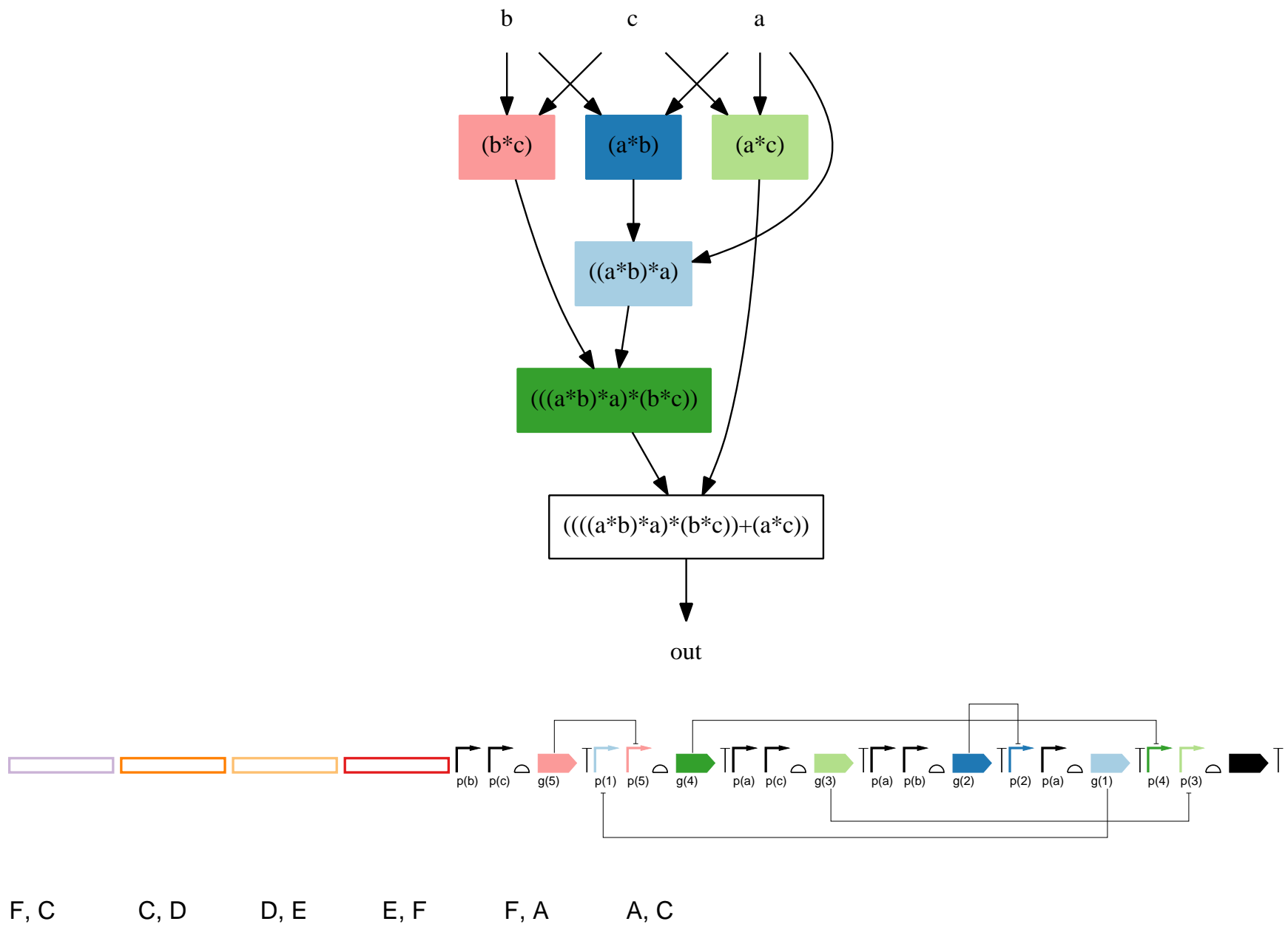
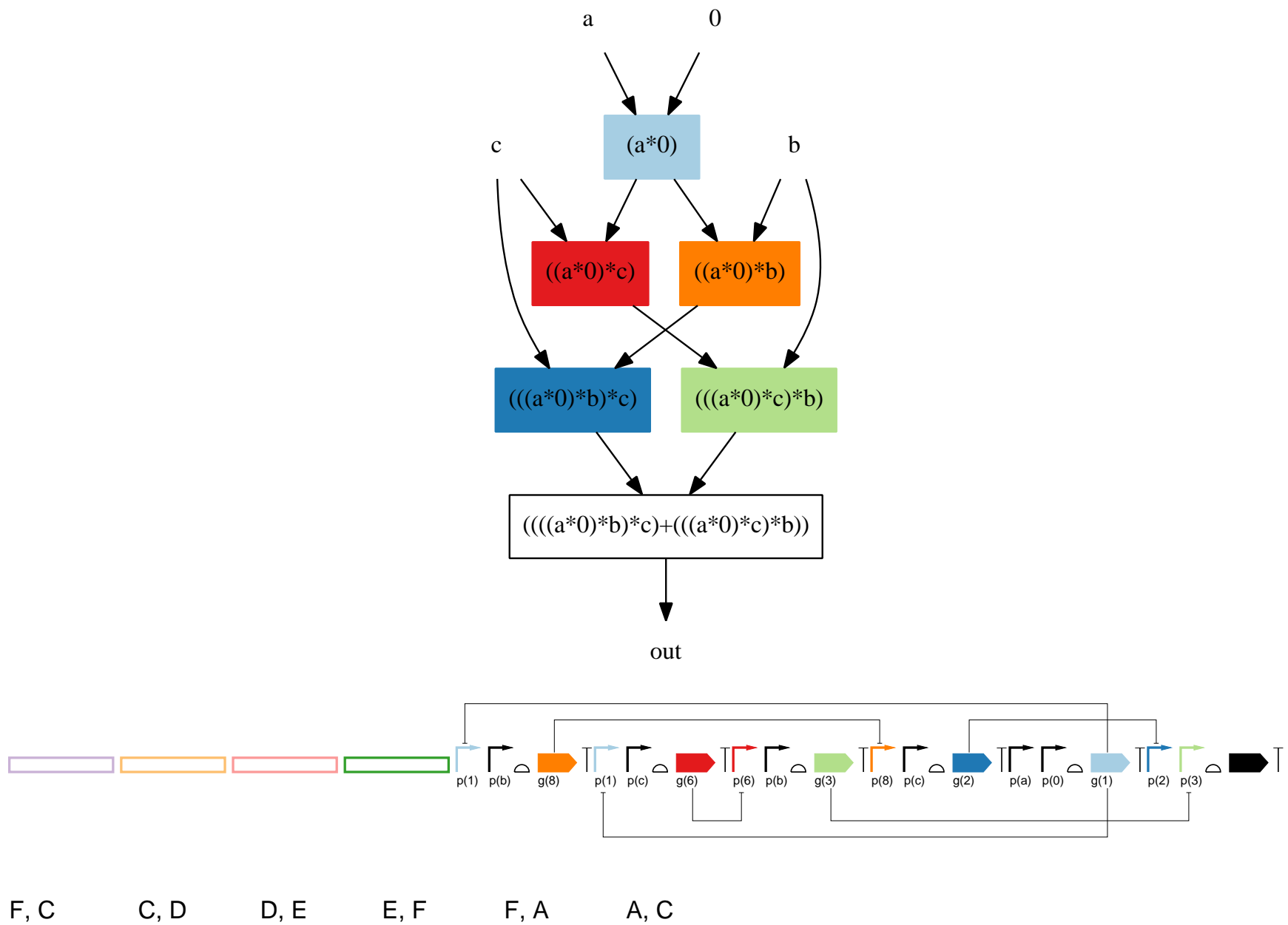


Figure 26: Circuit with truth table 0xE7.



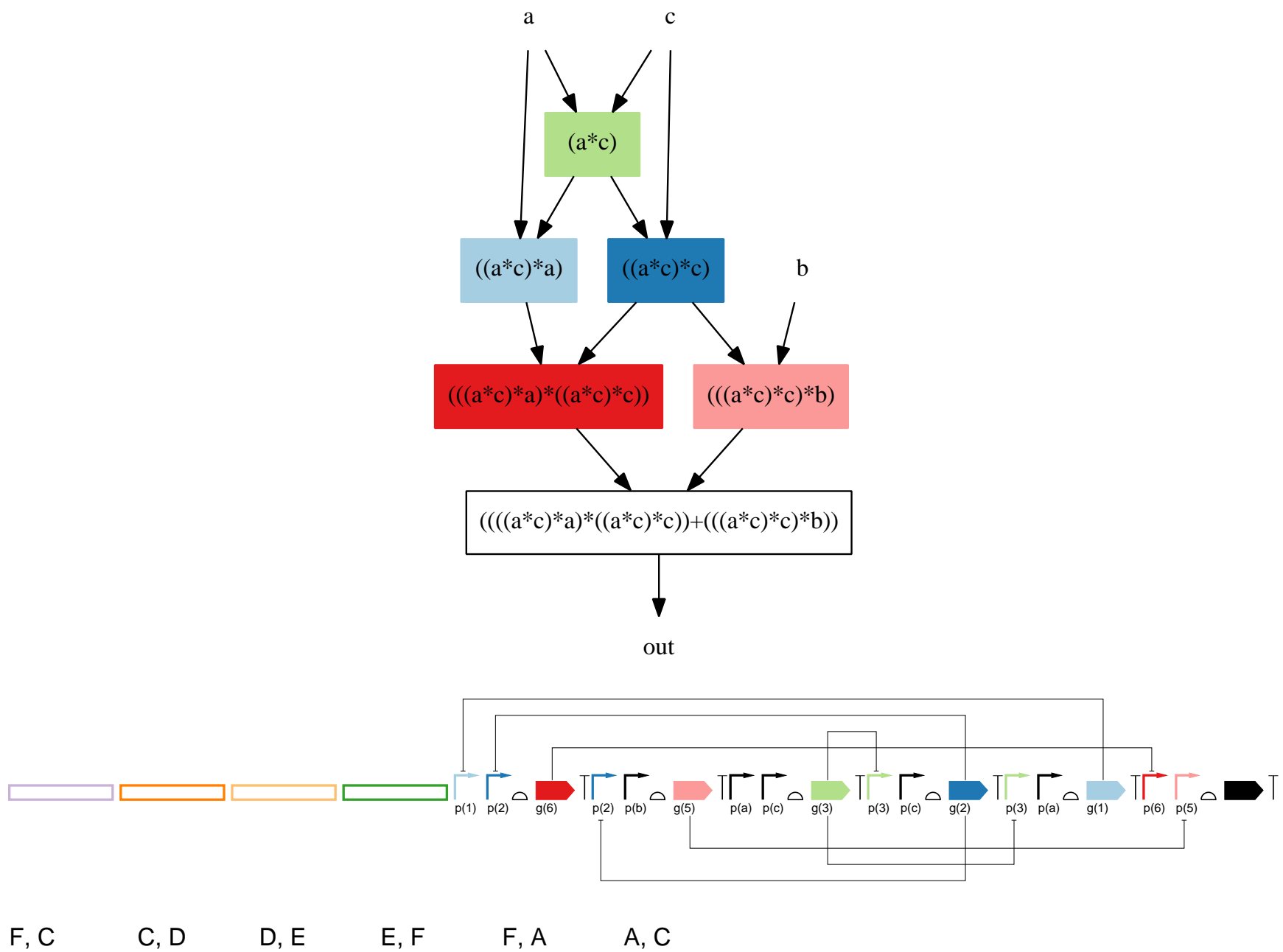


Figure 28: Circuit with truth table 0xE5.

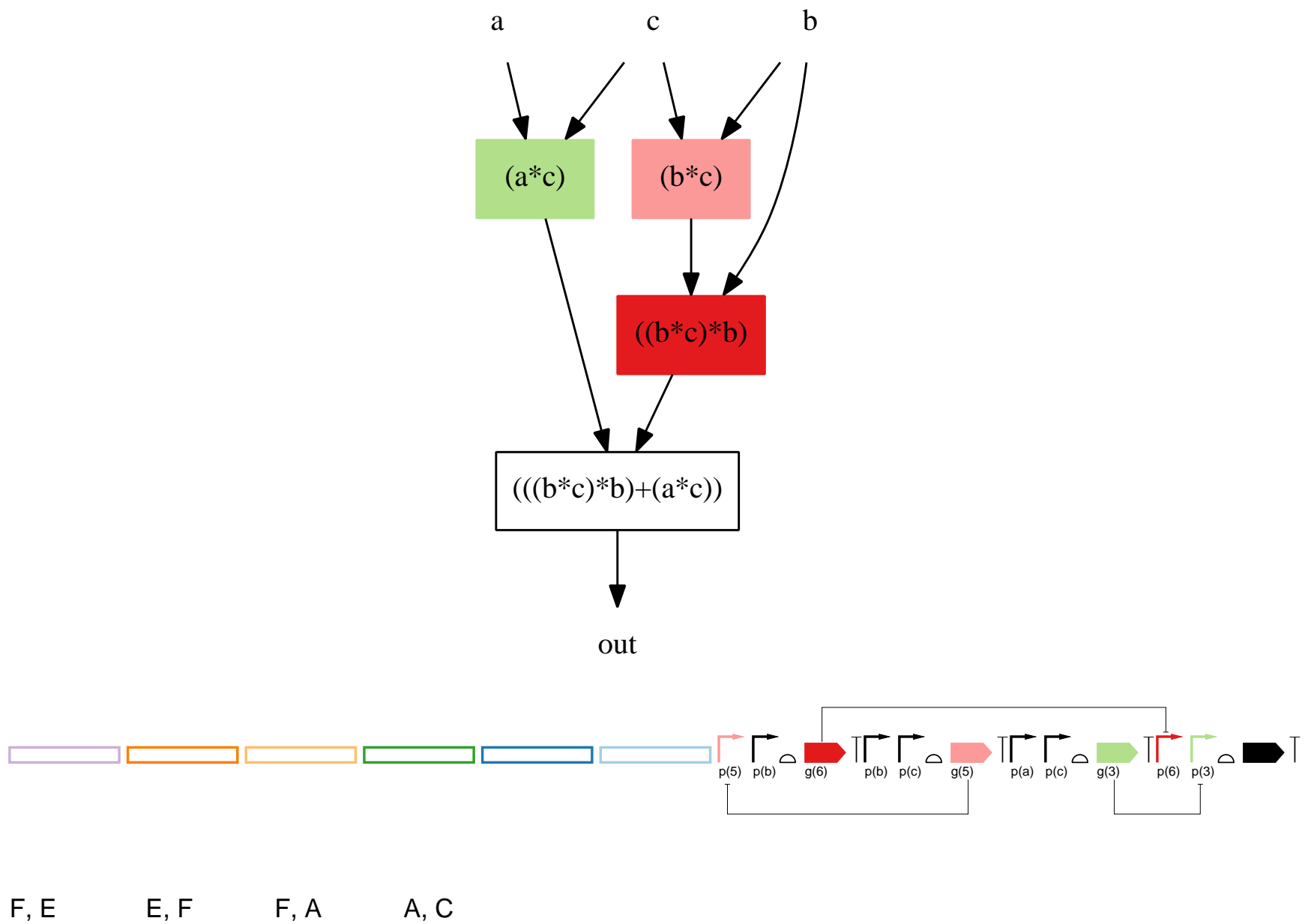


Figure 29: Circuit with truth table 0xE4.

Figure 30: Circuit with truth table 0xE3.

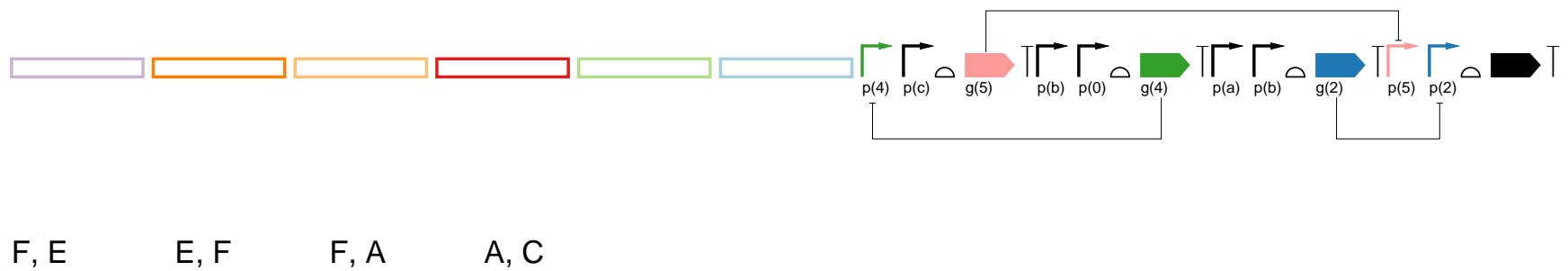
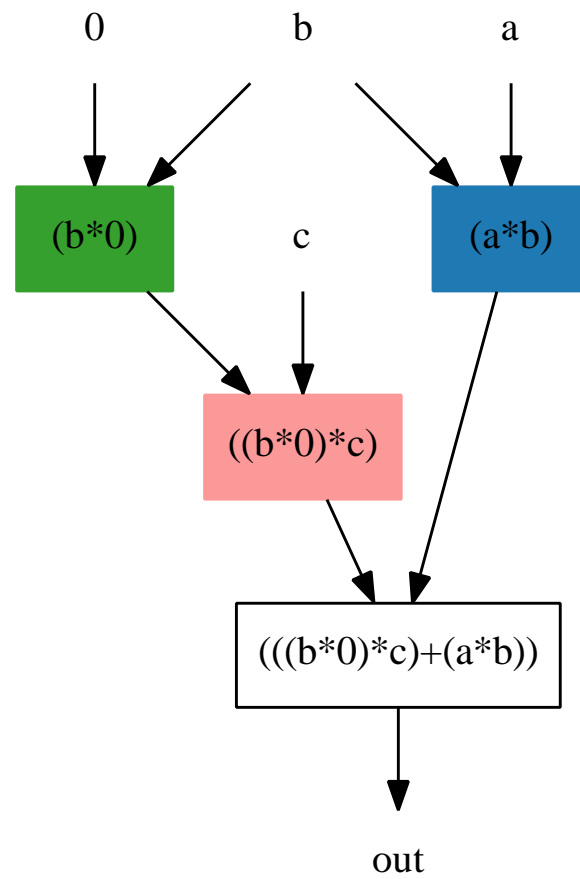


Figure 31: Circuit with truth table 0xE2.

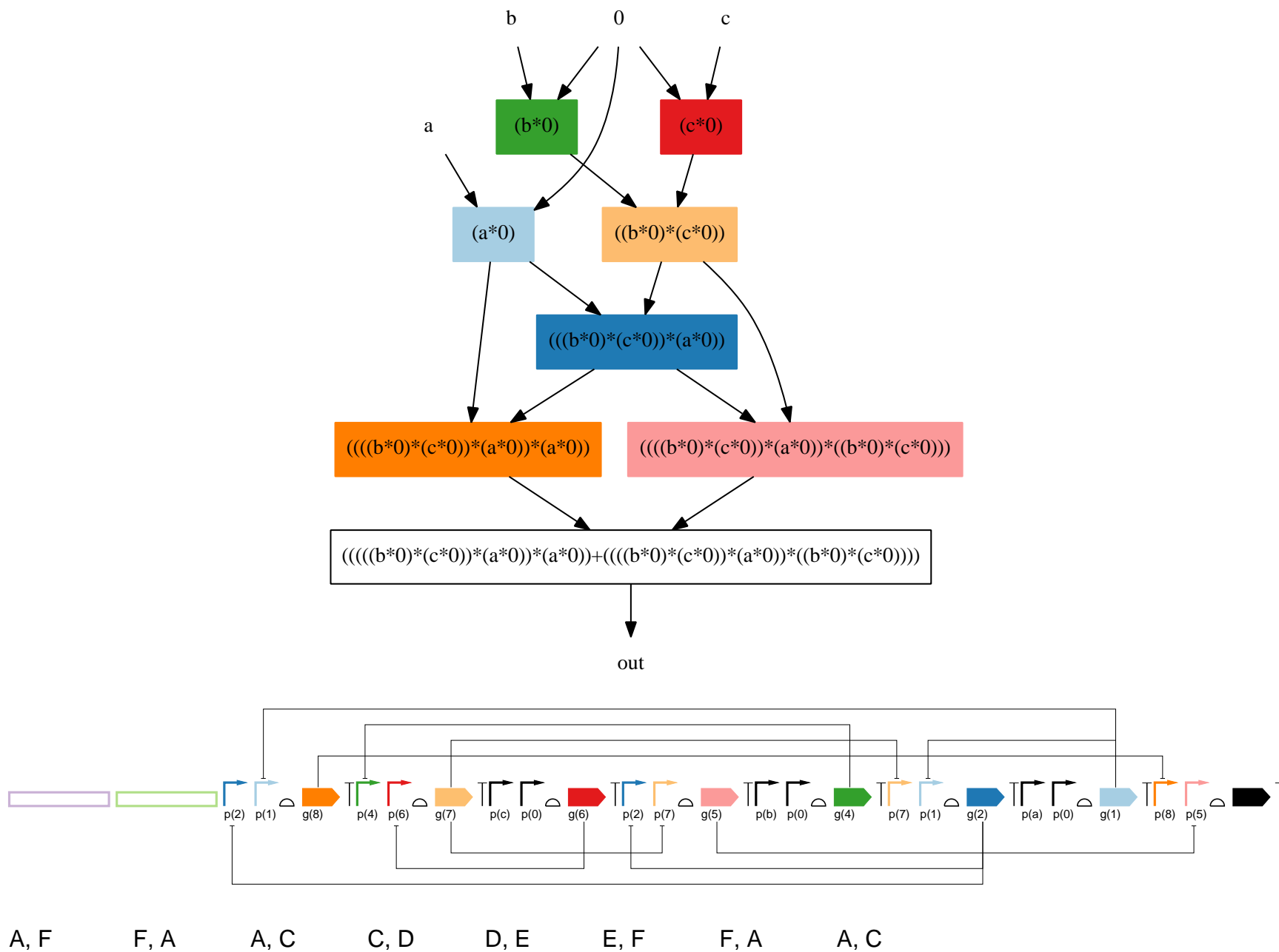


Figure 32: Circuit with truth table 0xE1.

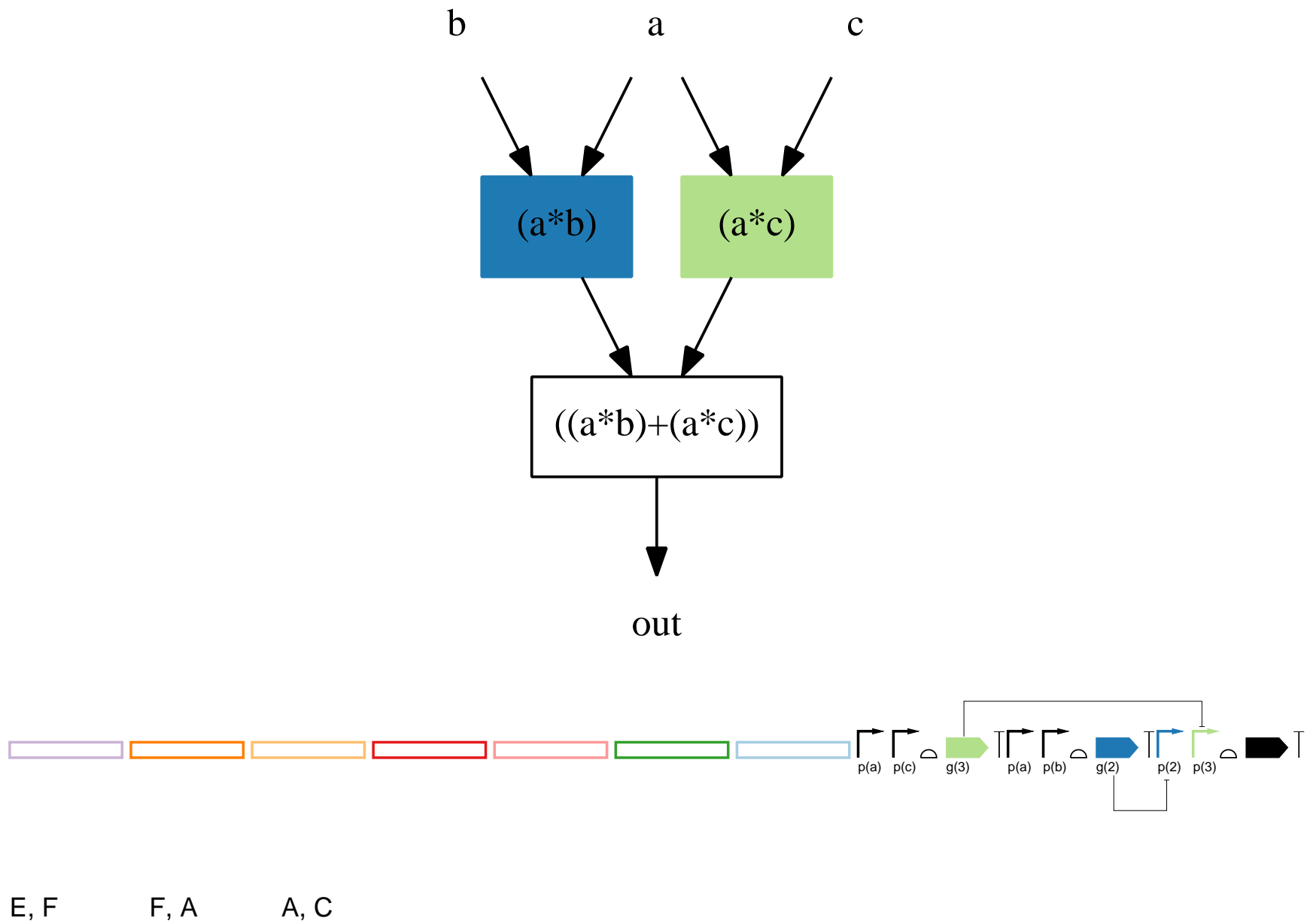


Figure 33: Circuit with truth table 0xE0.

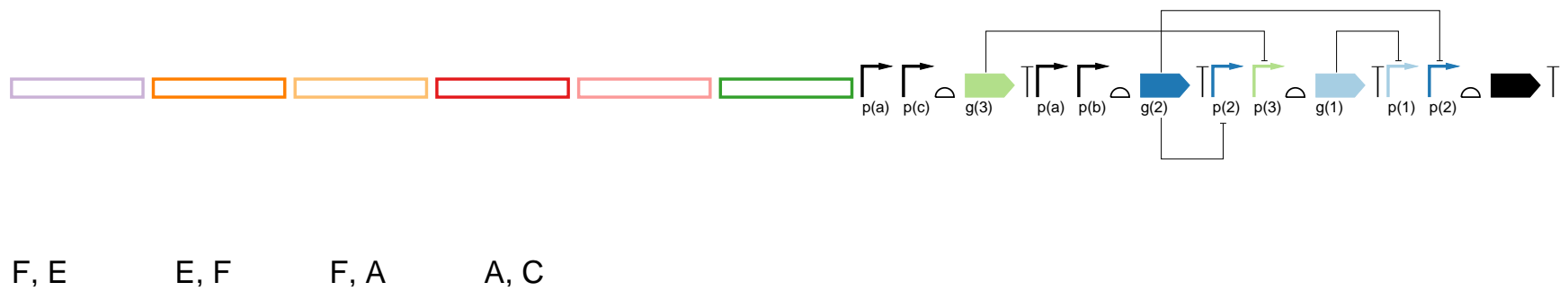
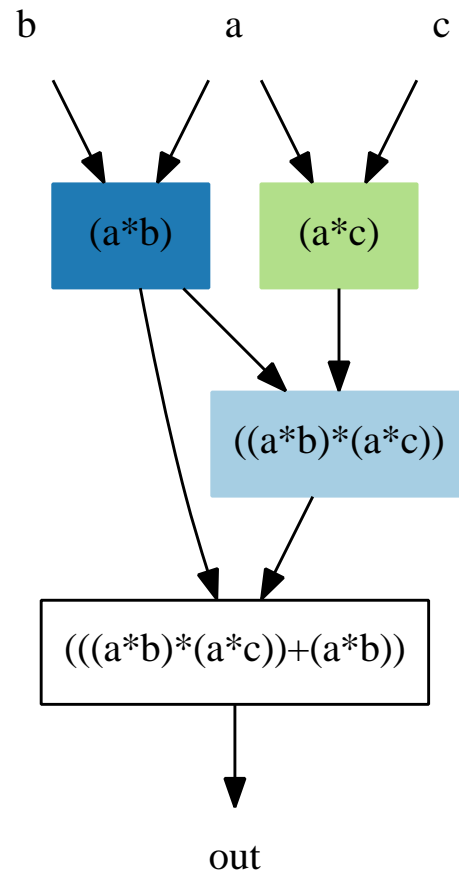


Figure 34: Circuit with truth table 0xDF.

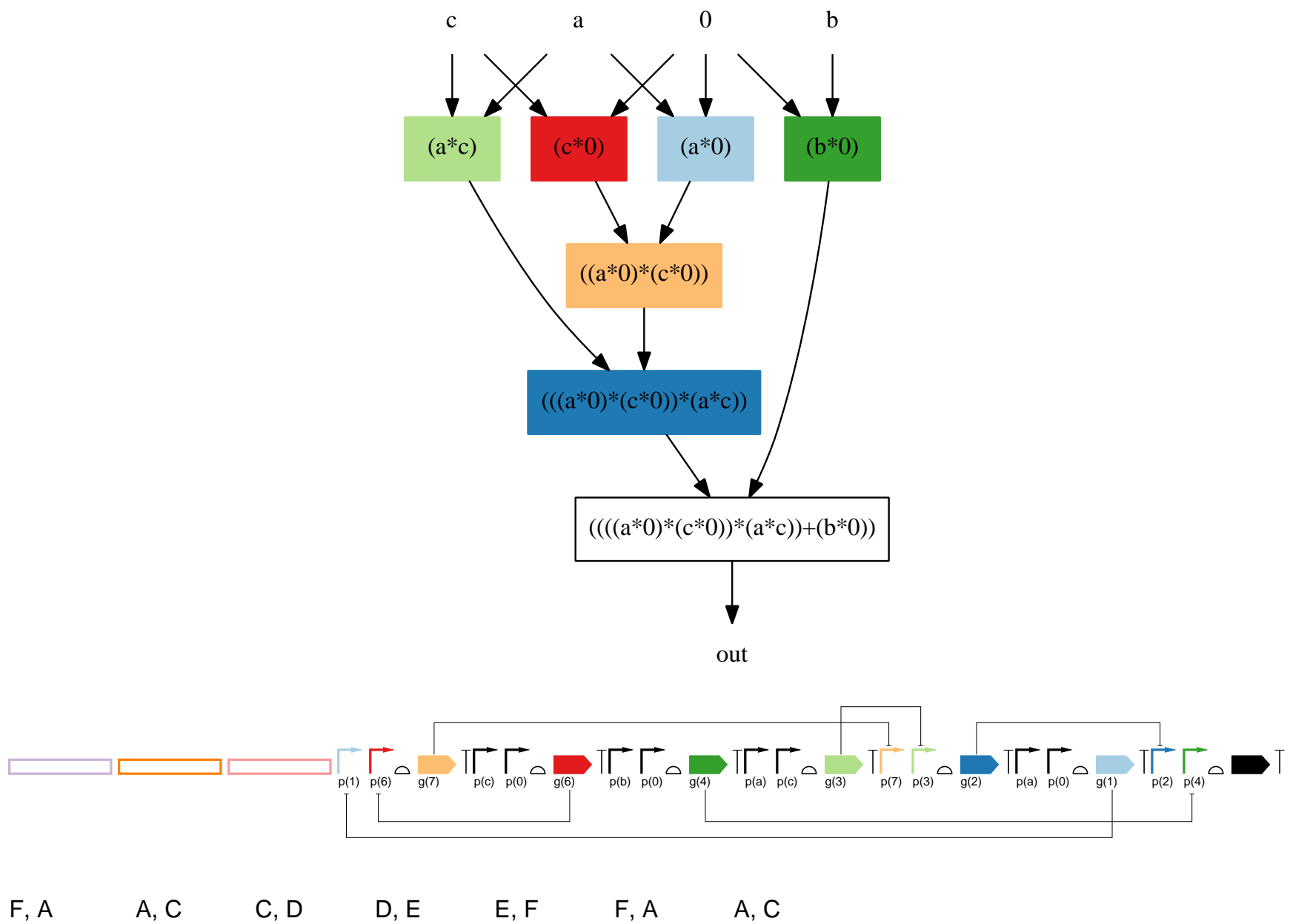
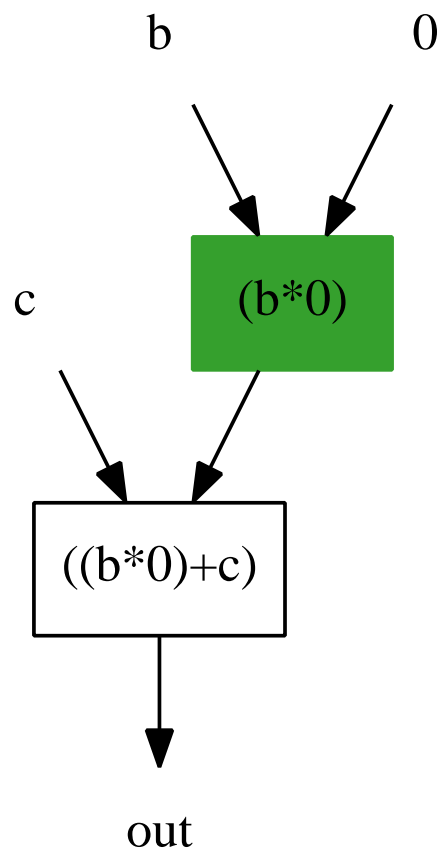


Figure 35: Circuit with truth table 0xDE.



E, A

A, C

Figure 36: Circuit with truth table 0xDD.

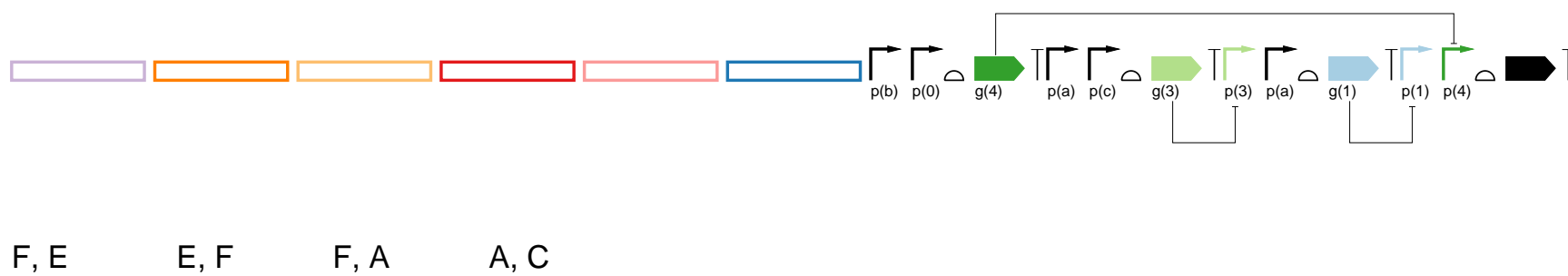
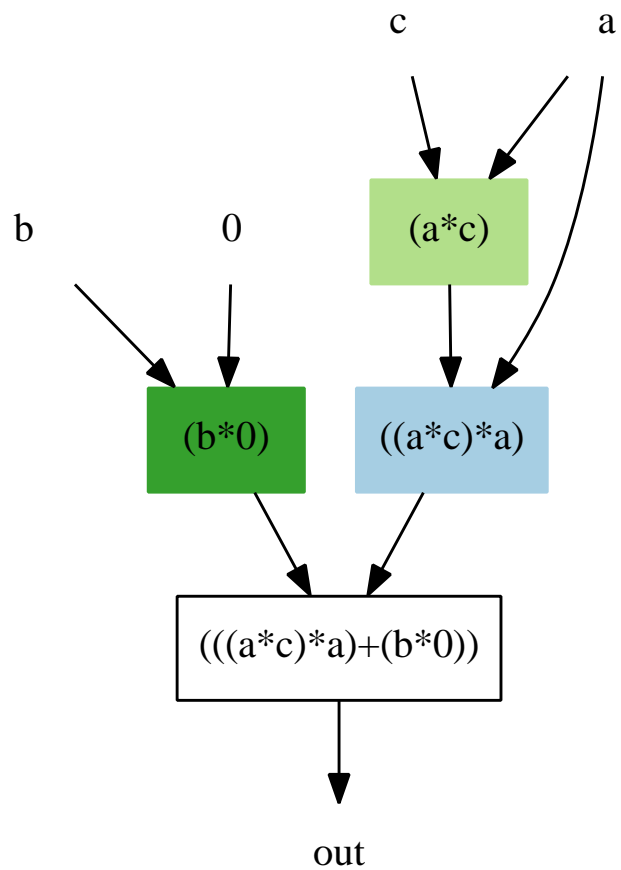


Figure 37: Circuit with truth table 0xDC.

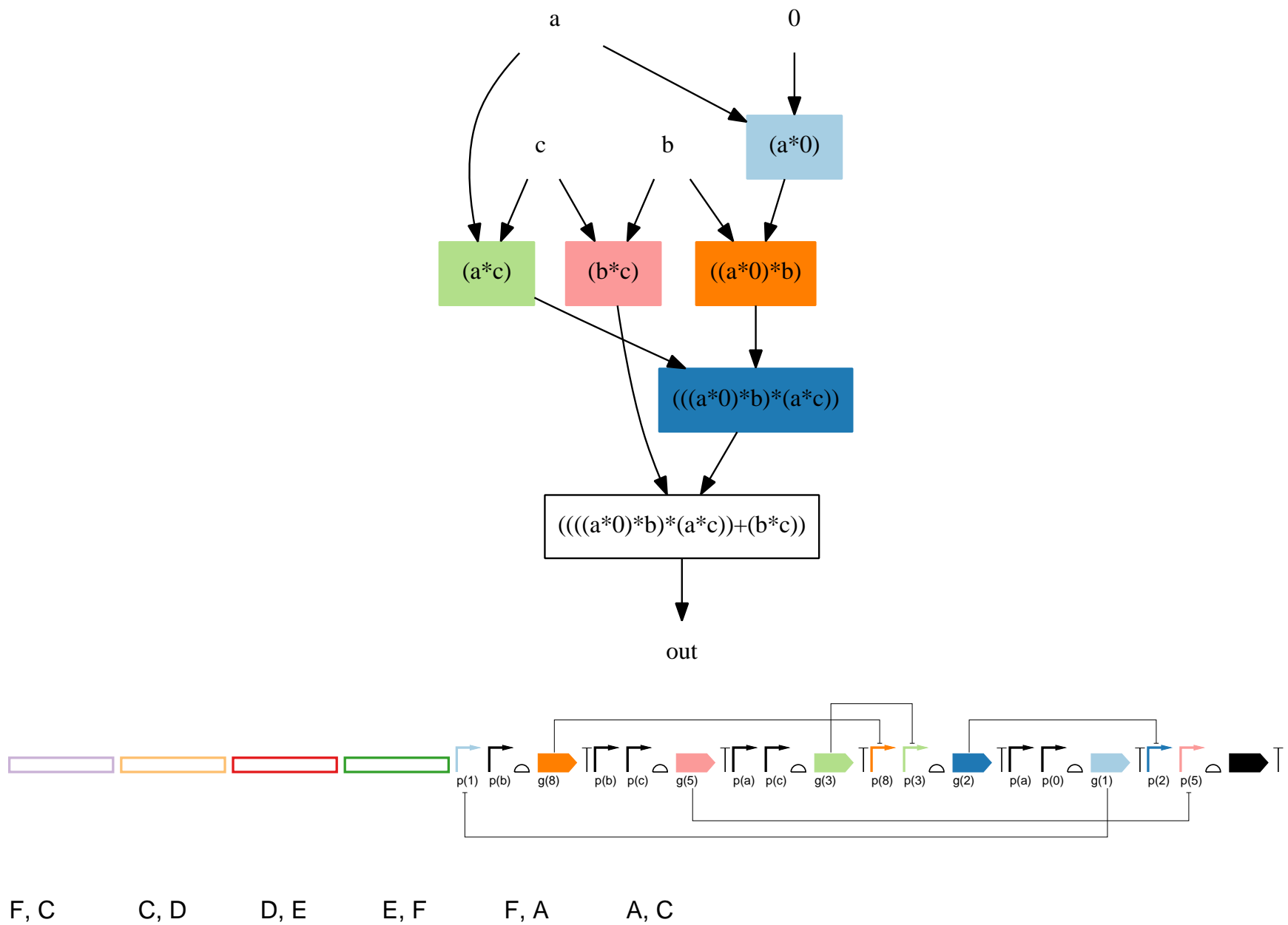


Figure 38: Circuit with truth table 0xDB.

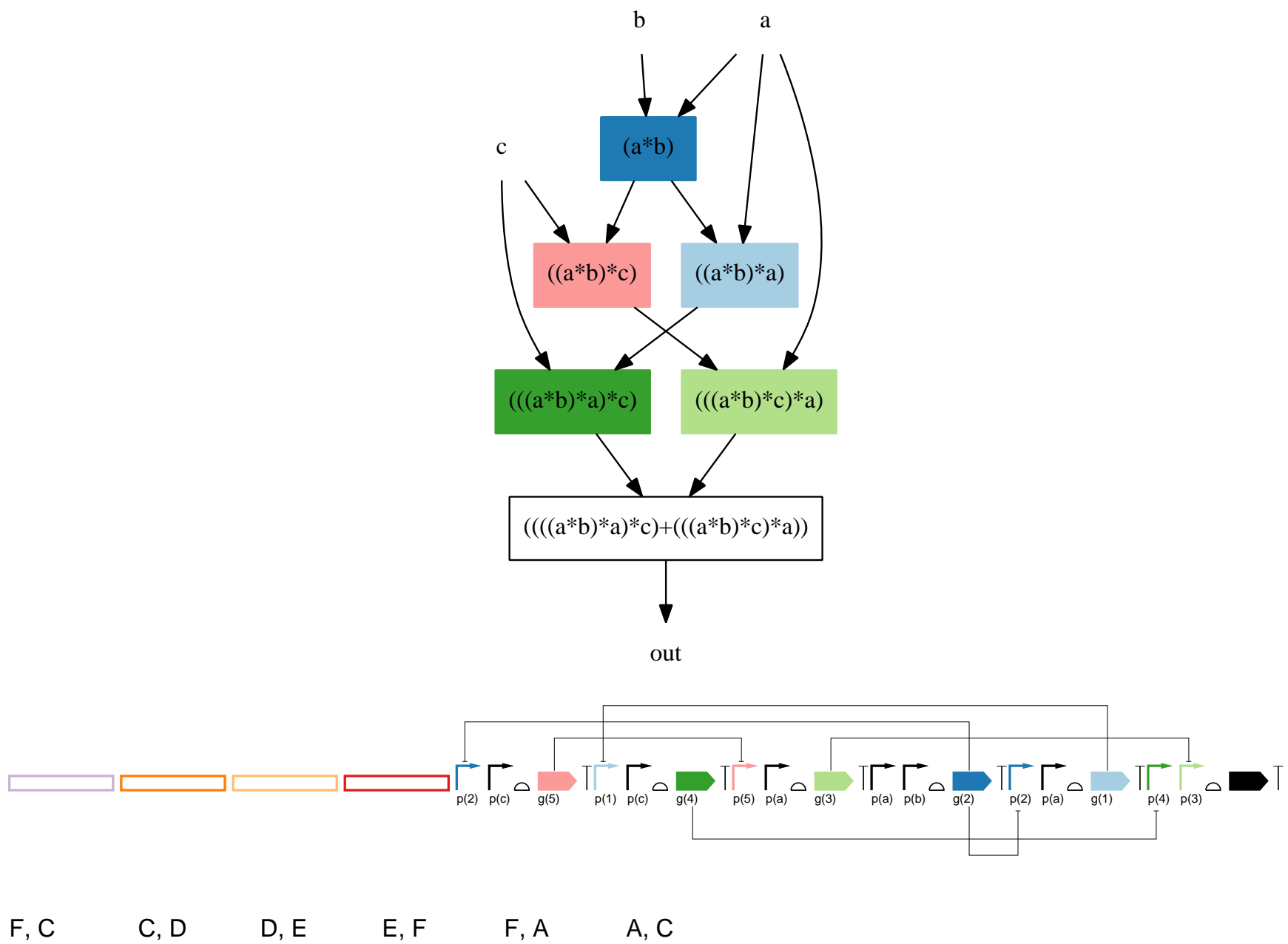


Figure 39: Circuit with truth table 0xDA.

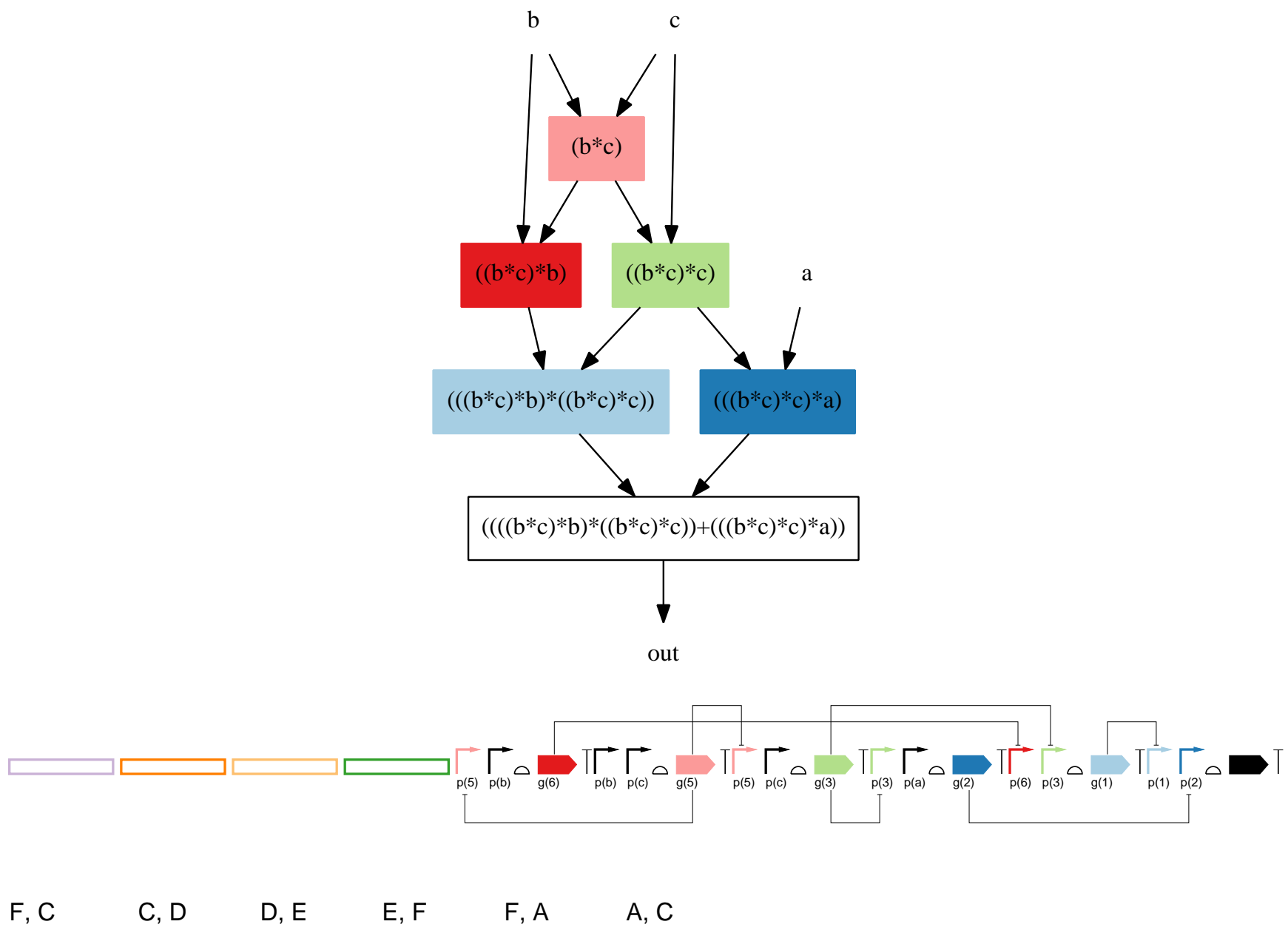


Figure 40: Circuit with truth table 0xD9.

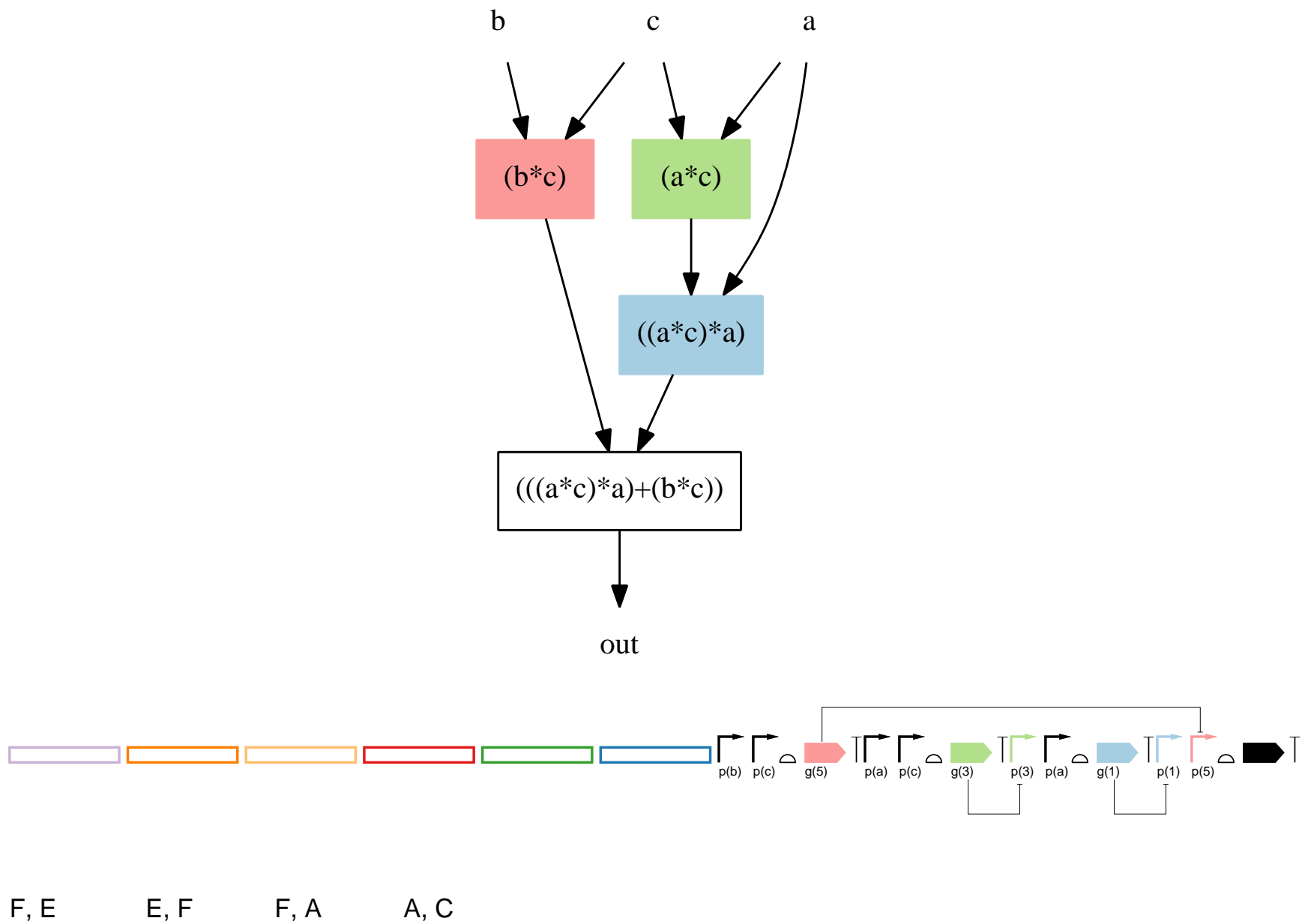


Figure 41: Circuit with truth table 0xD8.

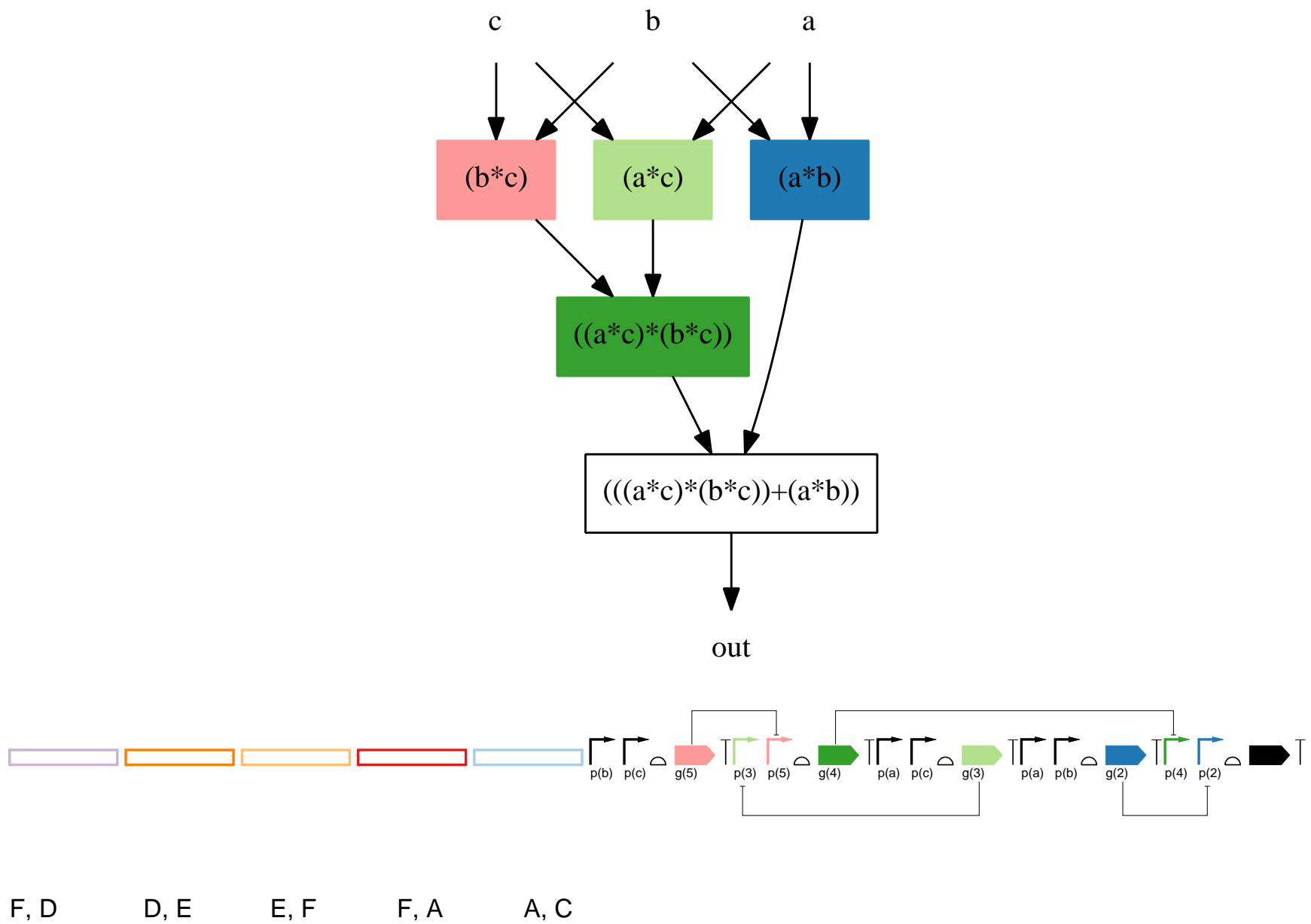


Figure 42: Circuit with truth table 0xD7.

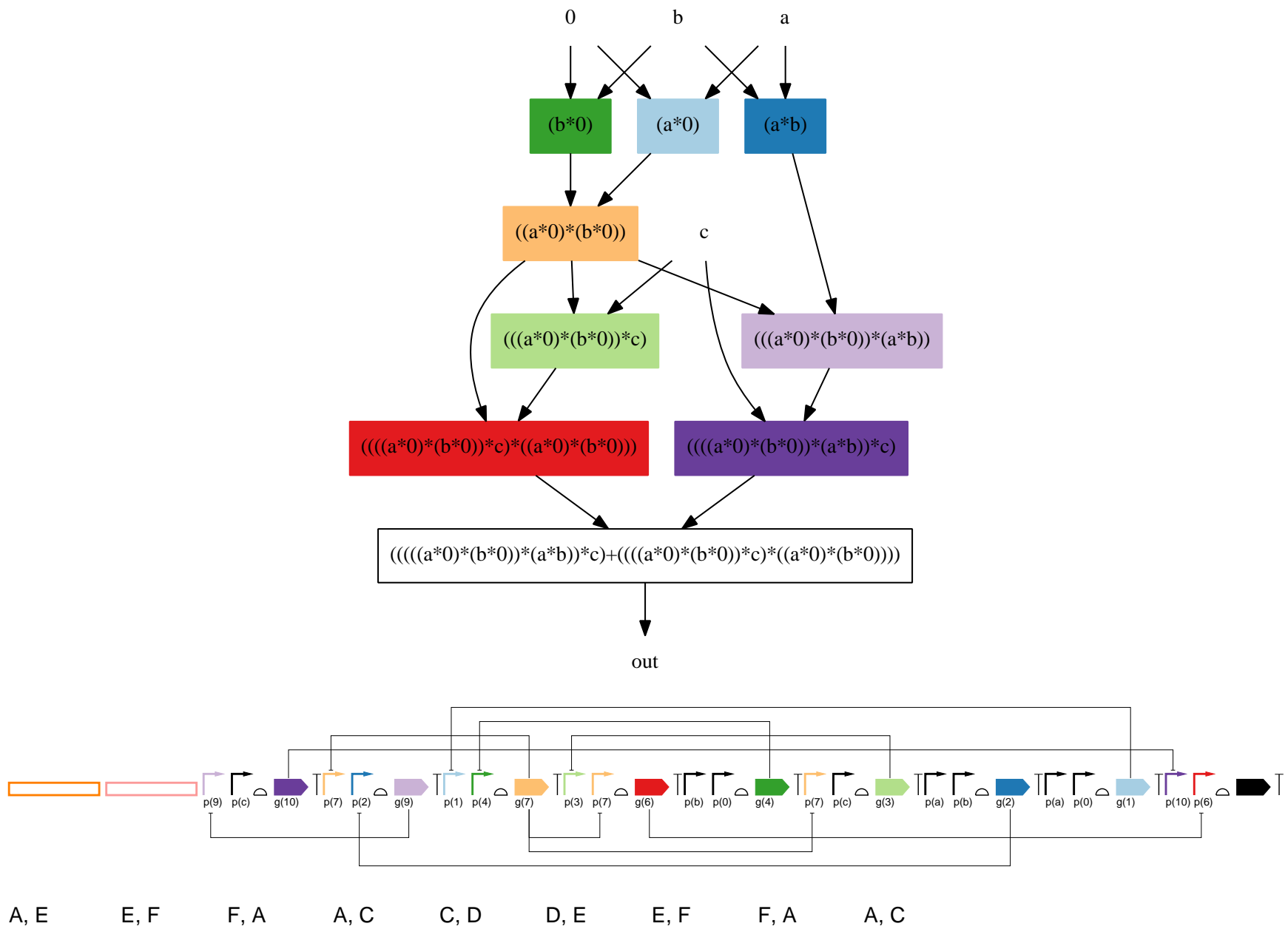
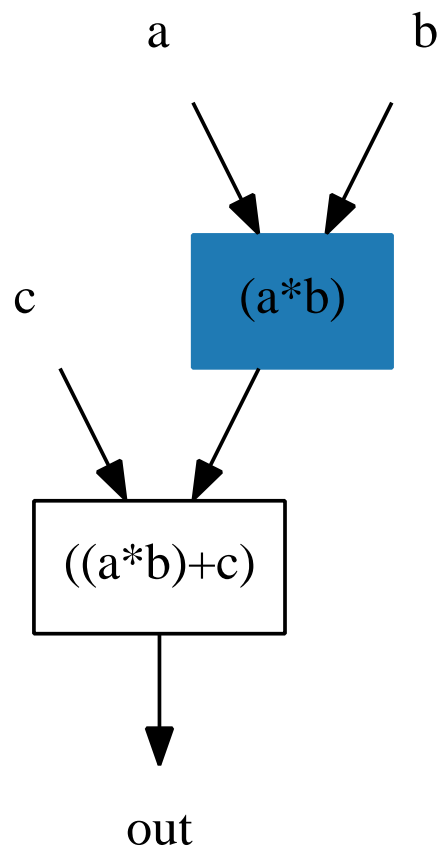


Figure 43: Circuit with truth table 0xD6.



E, A

A, C

Figure 44: Circuit with truth table 0xD5.

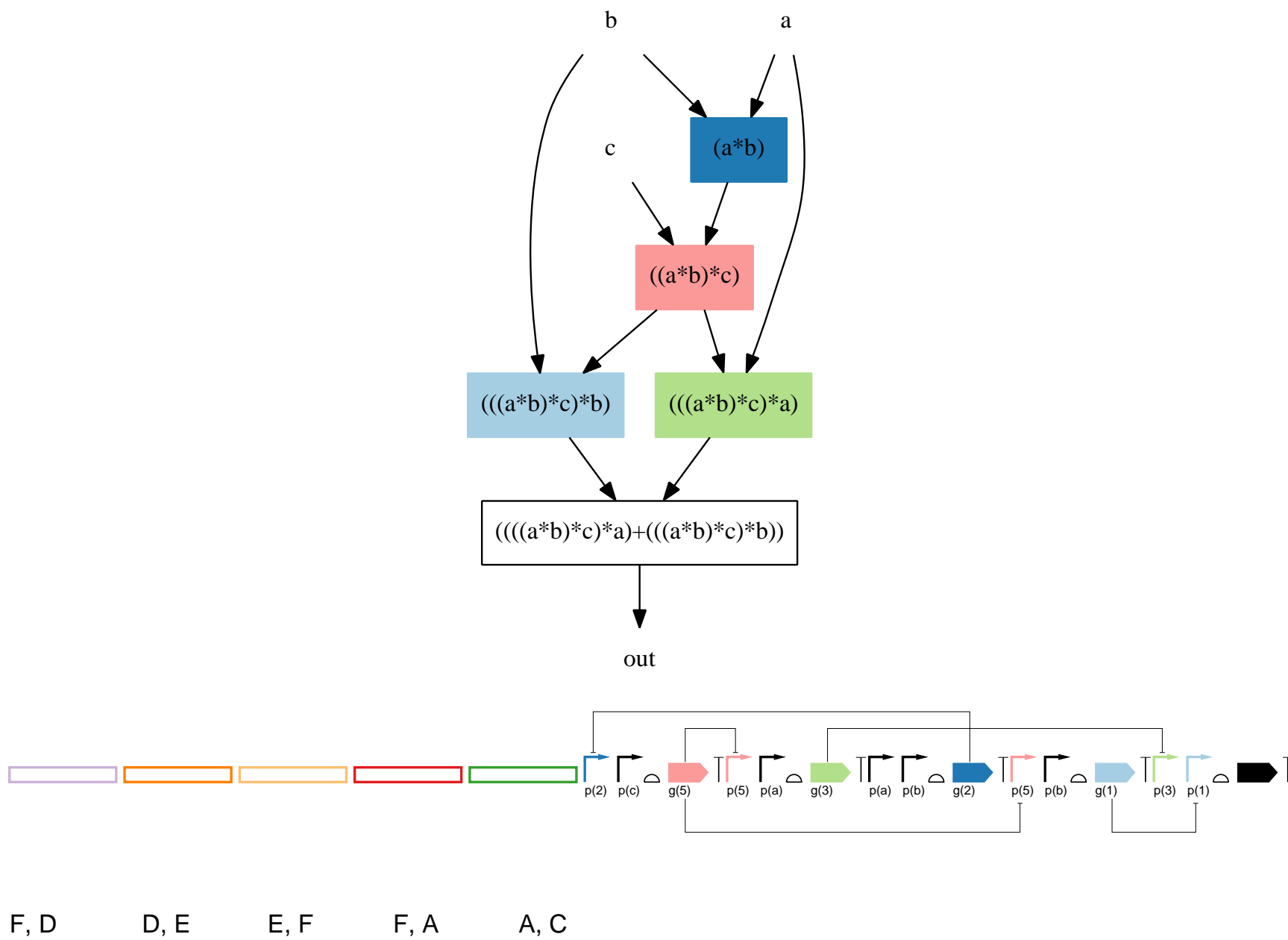


Figure 45: Circuit with truth table 0xD4.

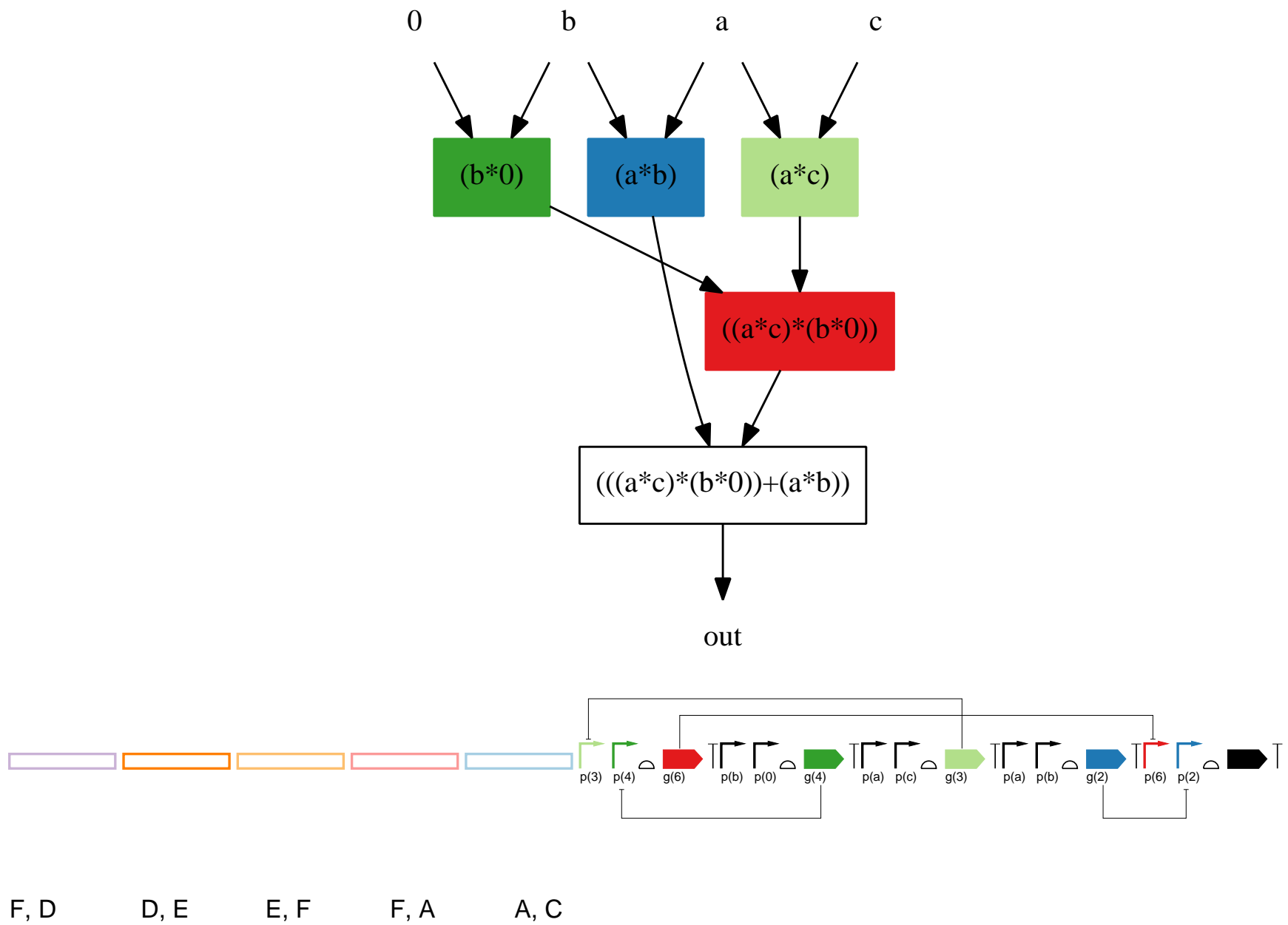


Figure 46: Circuit with truth table 0xD3.

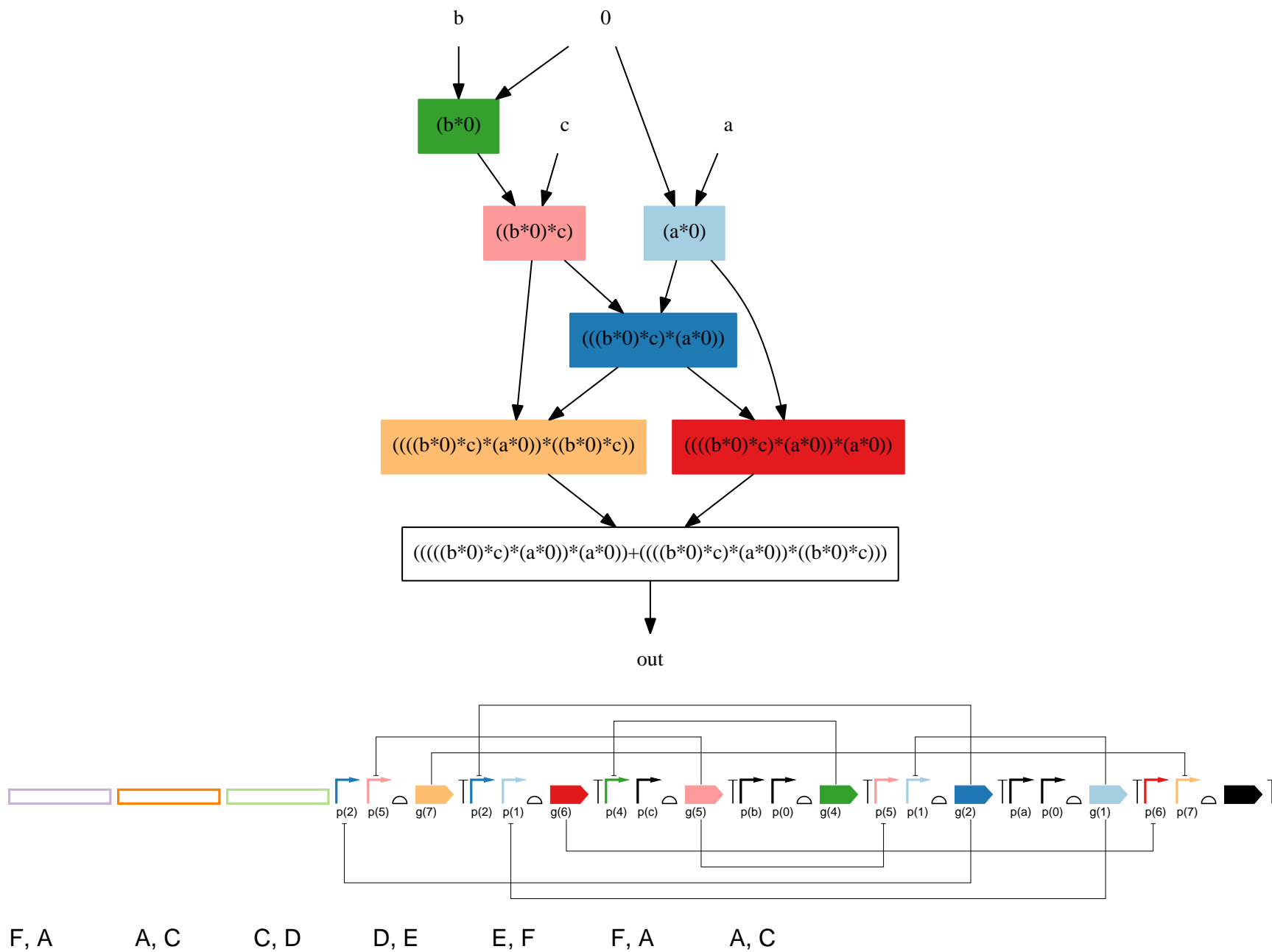


Figure 47: Circuit with truth table 0xD2.

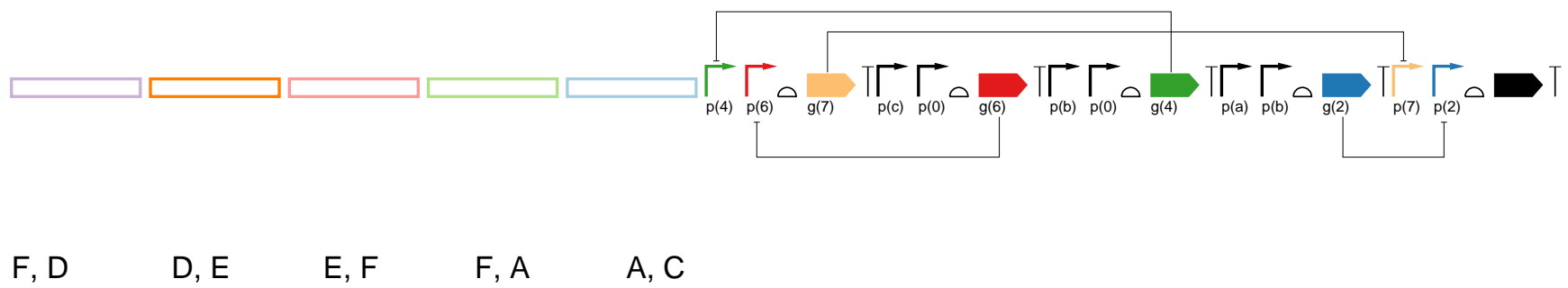
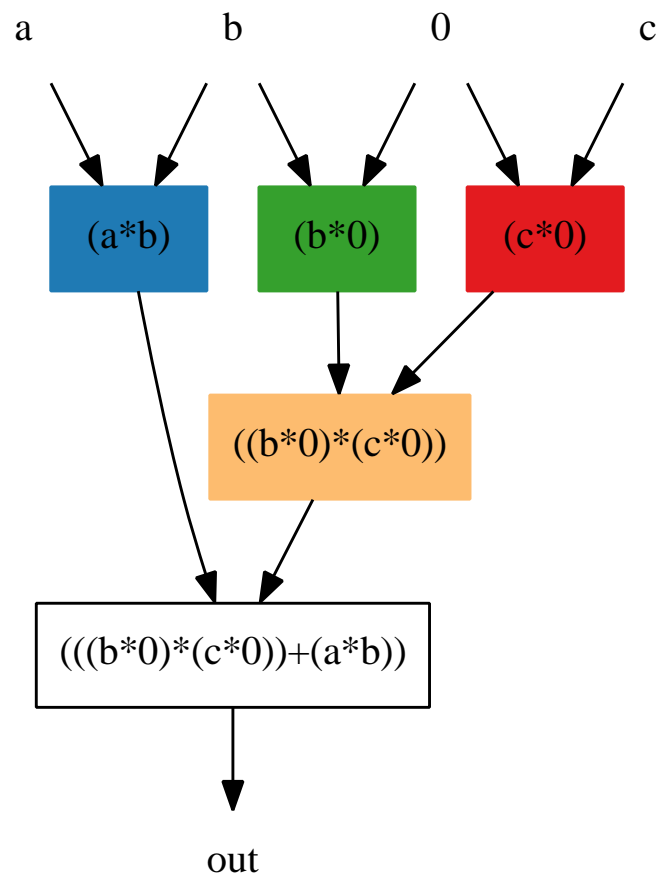


Figure 48: Circuit with truth table 0xD1.

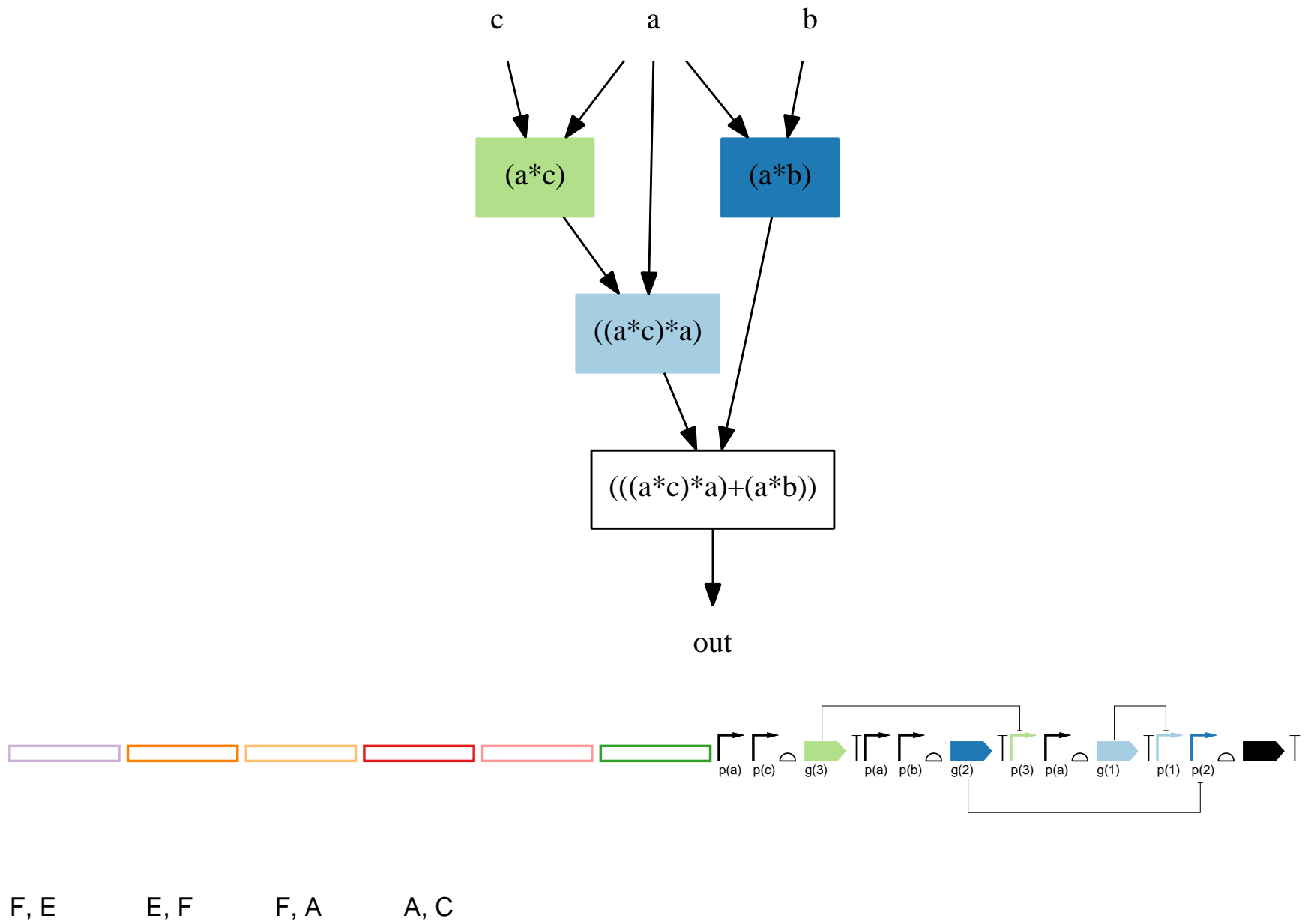


Figure 49: Circuit with truth table 0xD0.

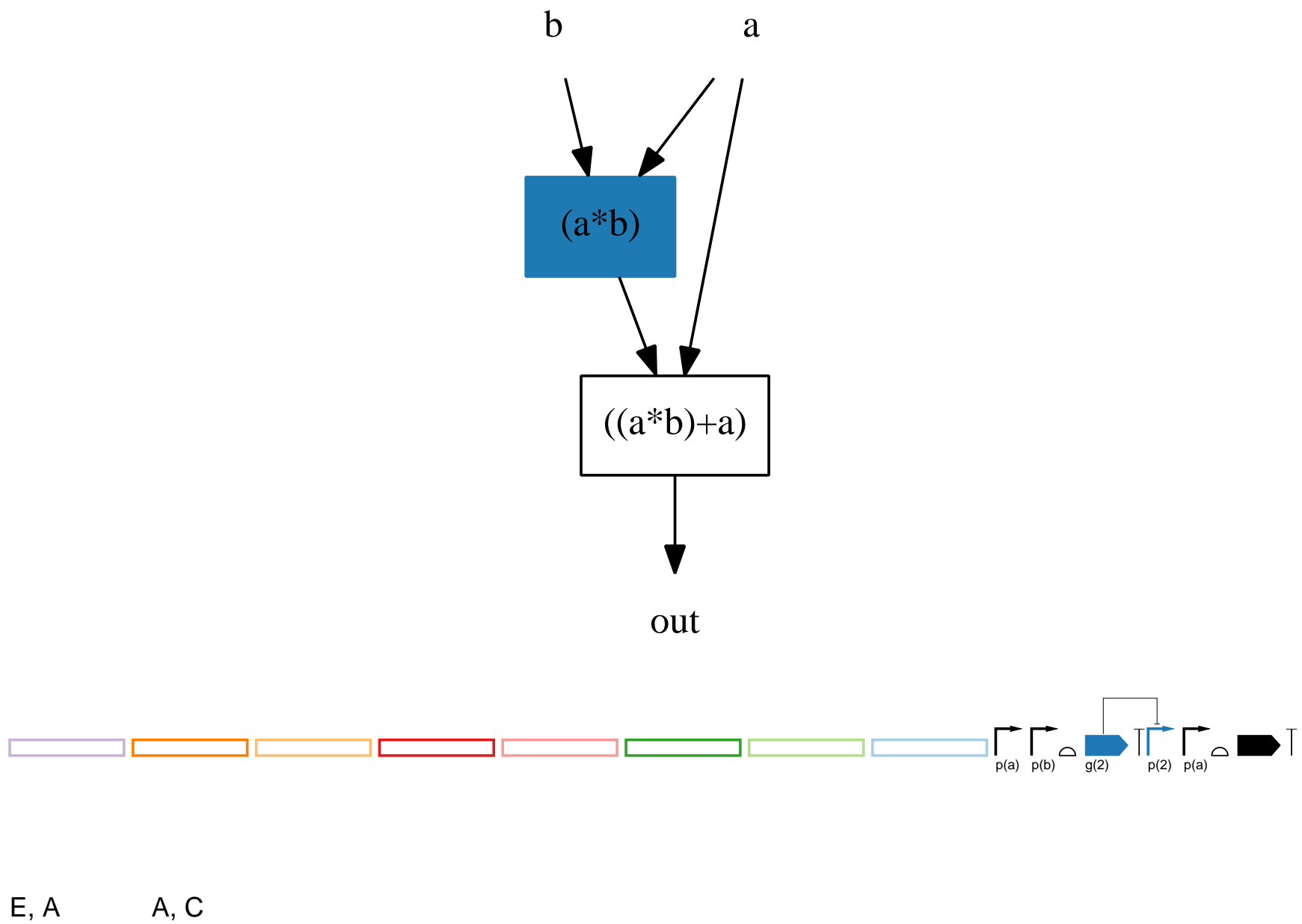


Figure 50: Circuit with truth table 0xCF.

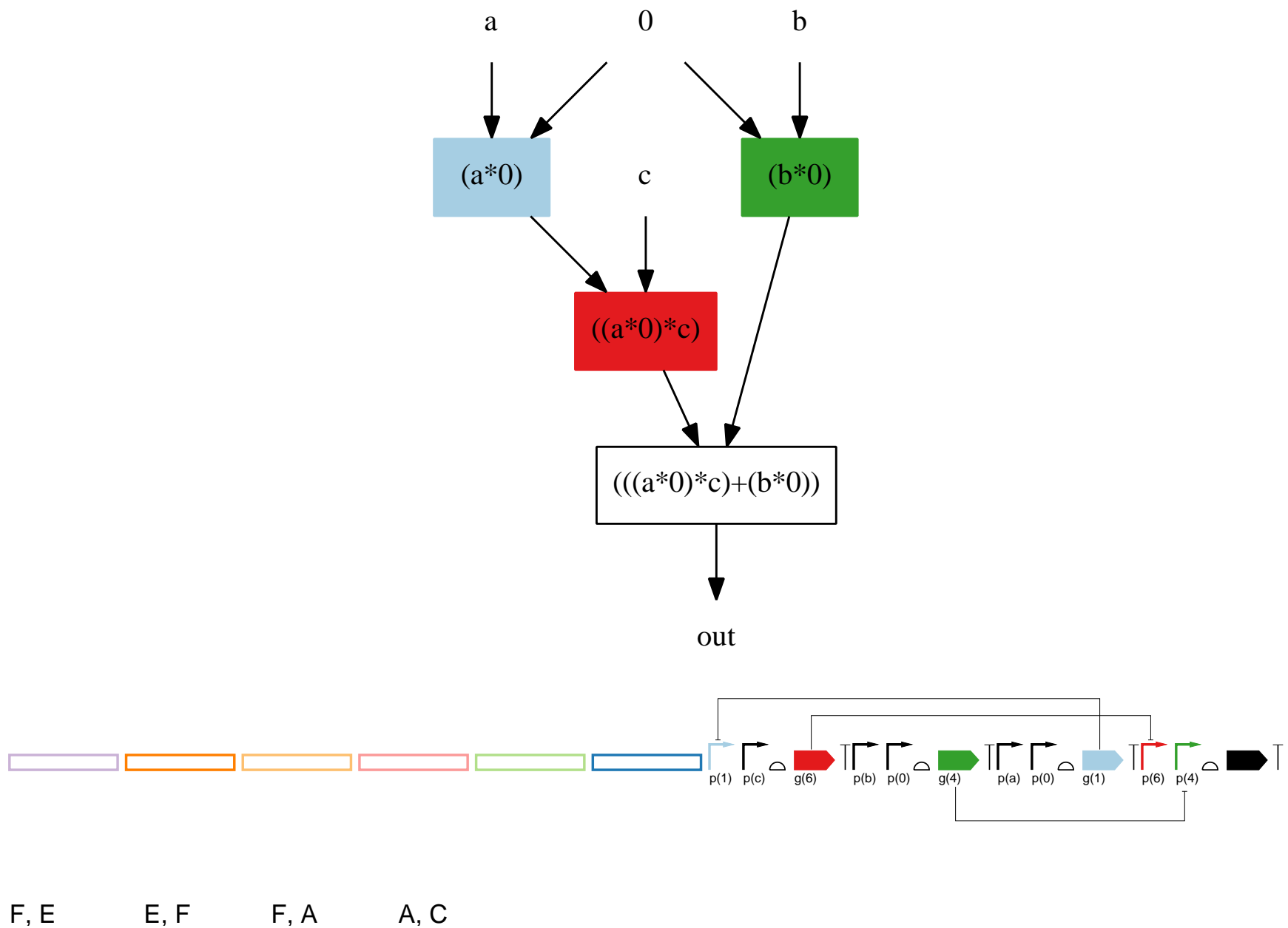


Figure 51: Circuit with truth table 0xCE.

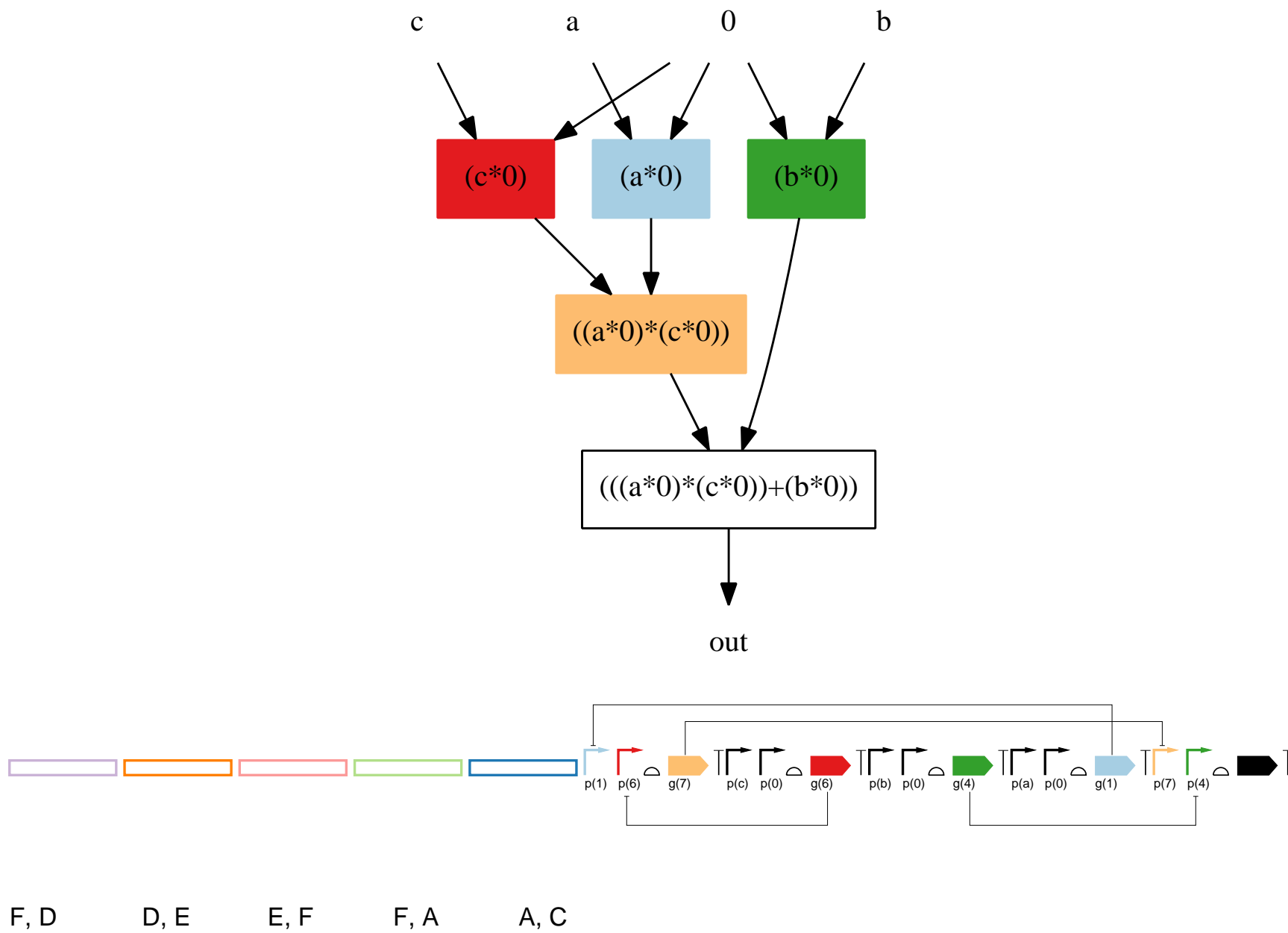


Figure 52: Circuit with truth table 0xCD.

55

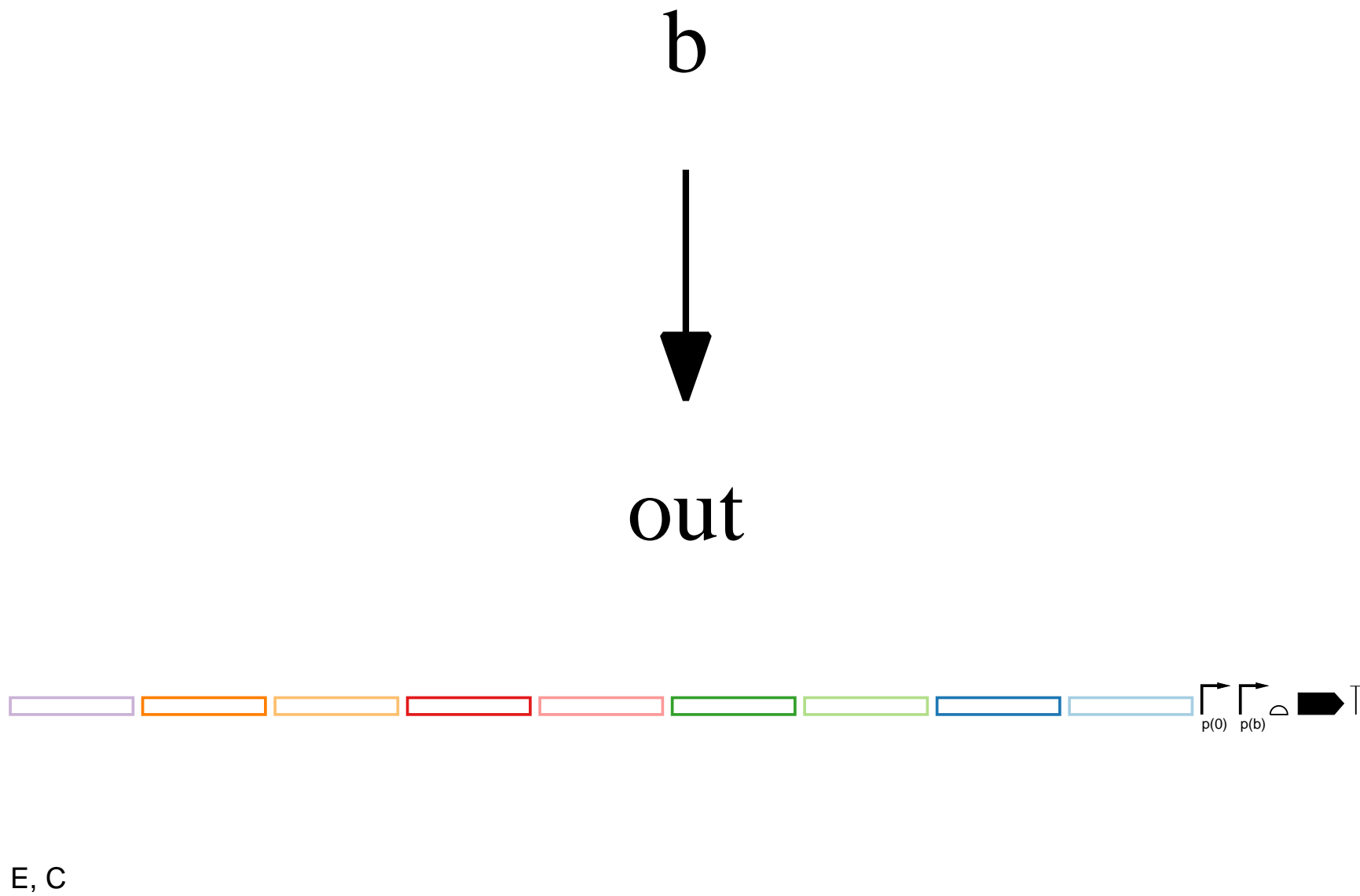


Figure 53: Circuit with truth table 0x33.

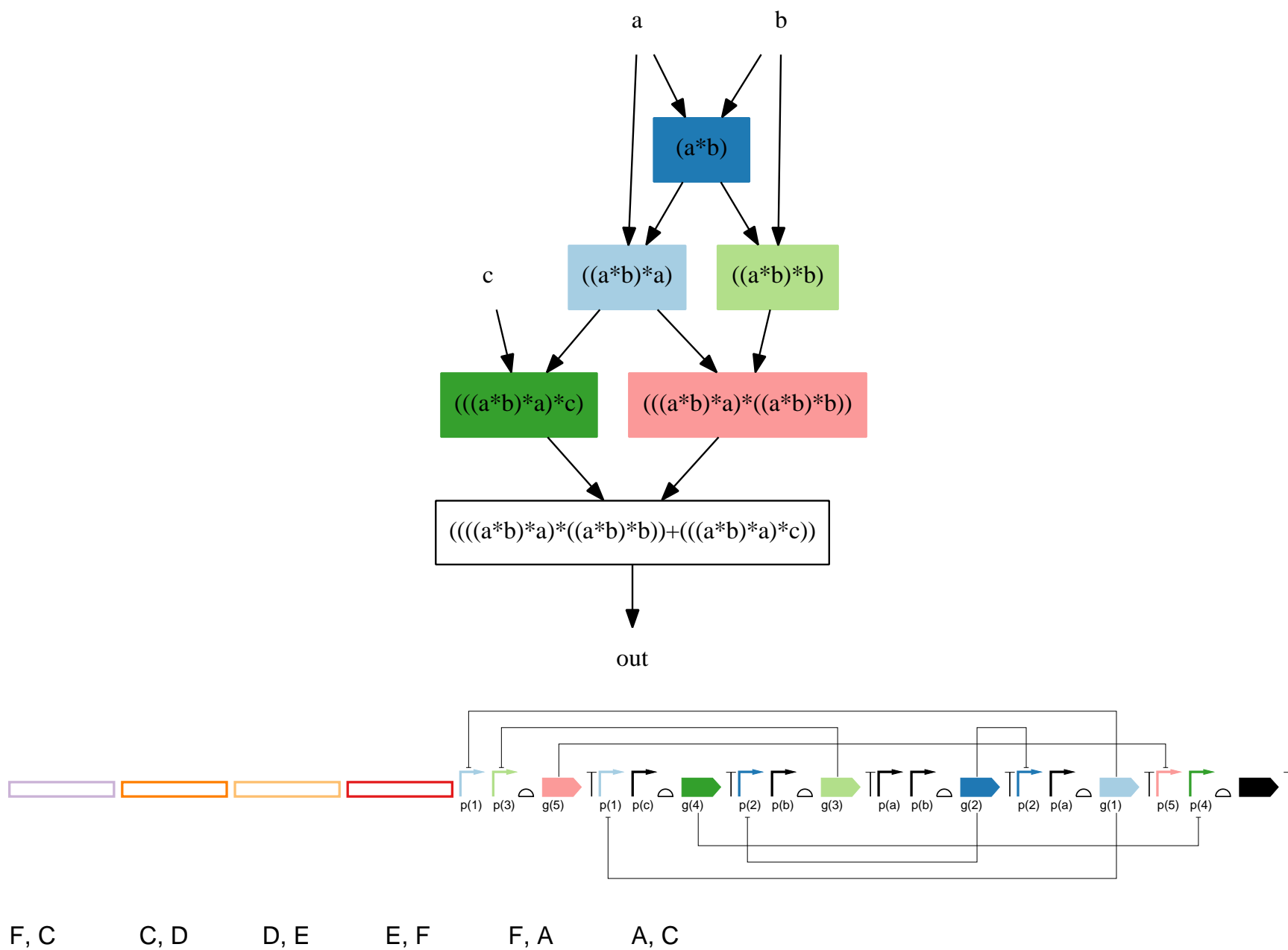


Figure 54: Circuit with truth table 0xCB.

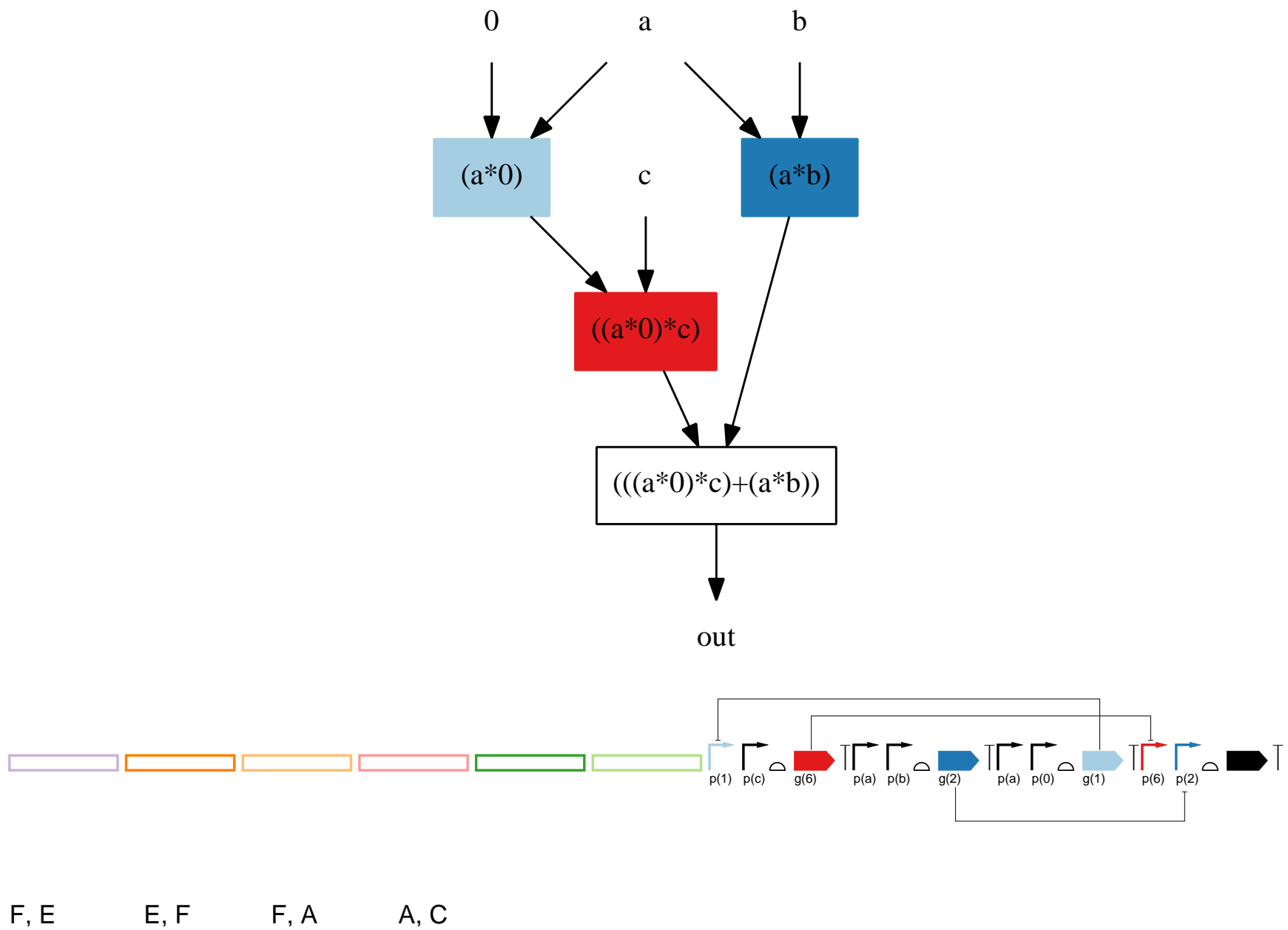


Figure 55: Circuit with truth table 0xCA.

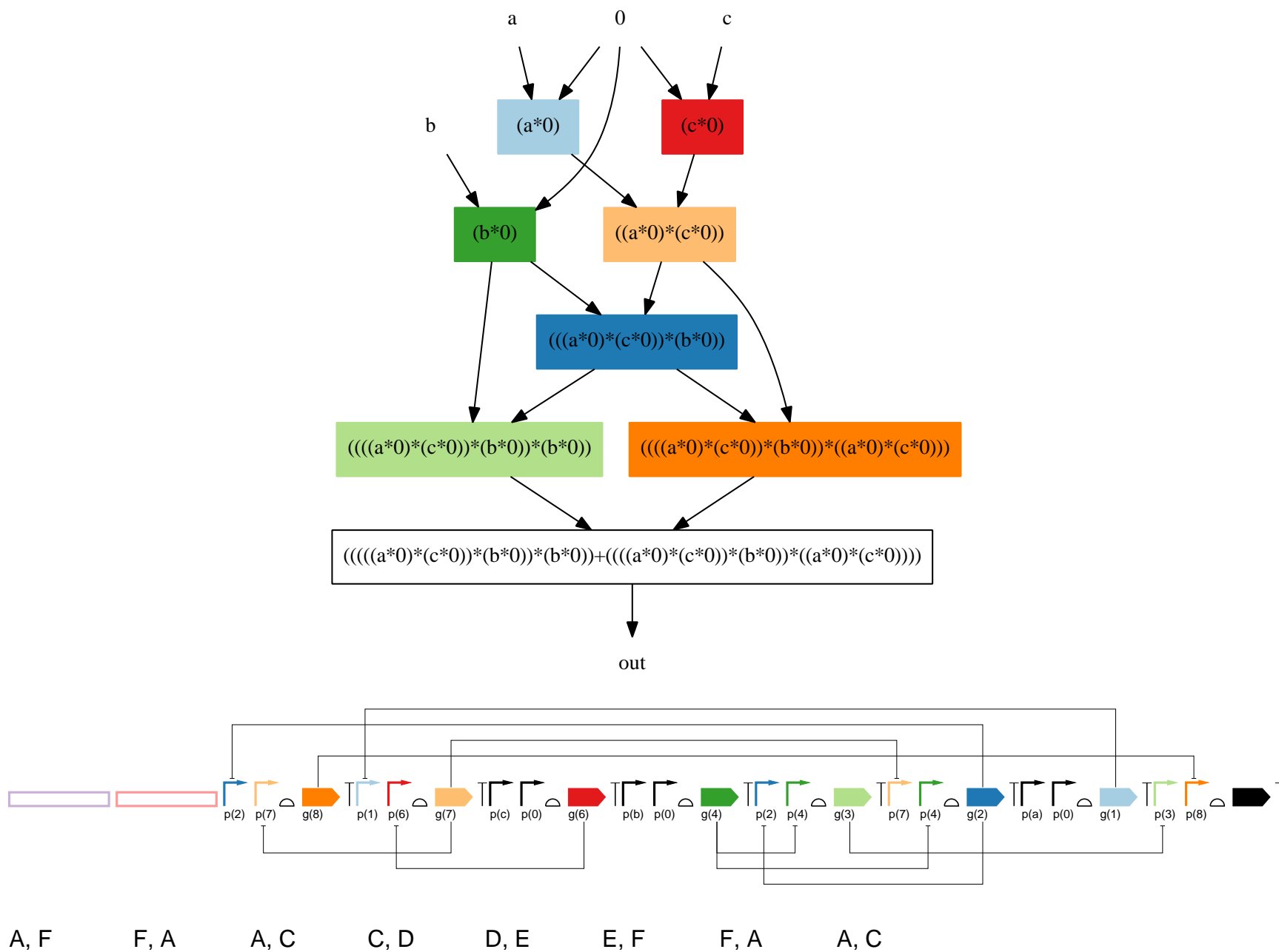


Figure 56: Circuit with truth table 0xC9.

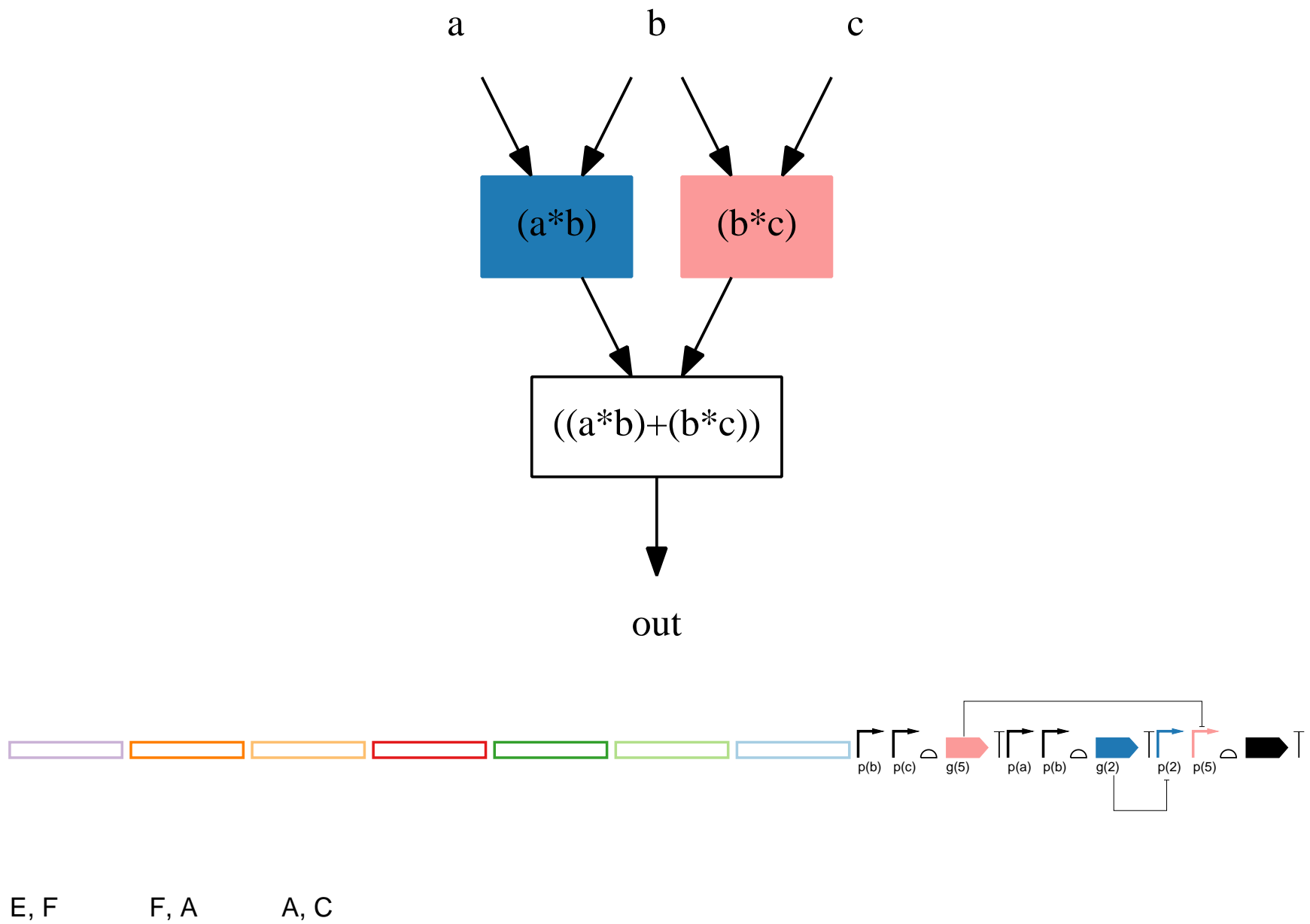


Figure 57: Circuit with truth table 0xC8.

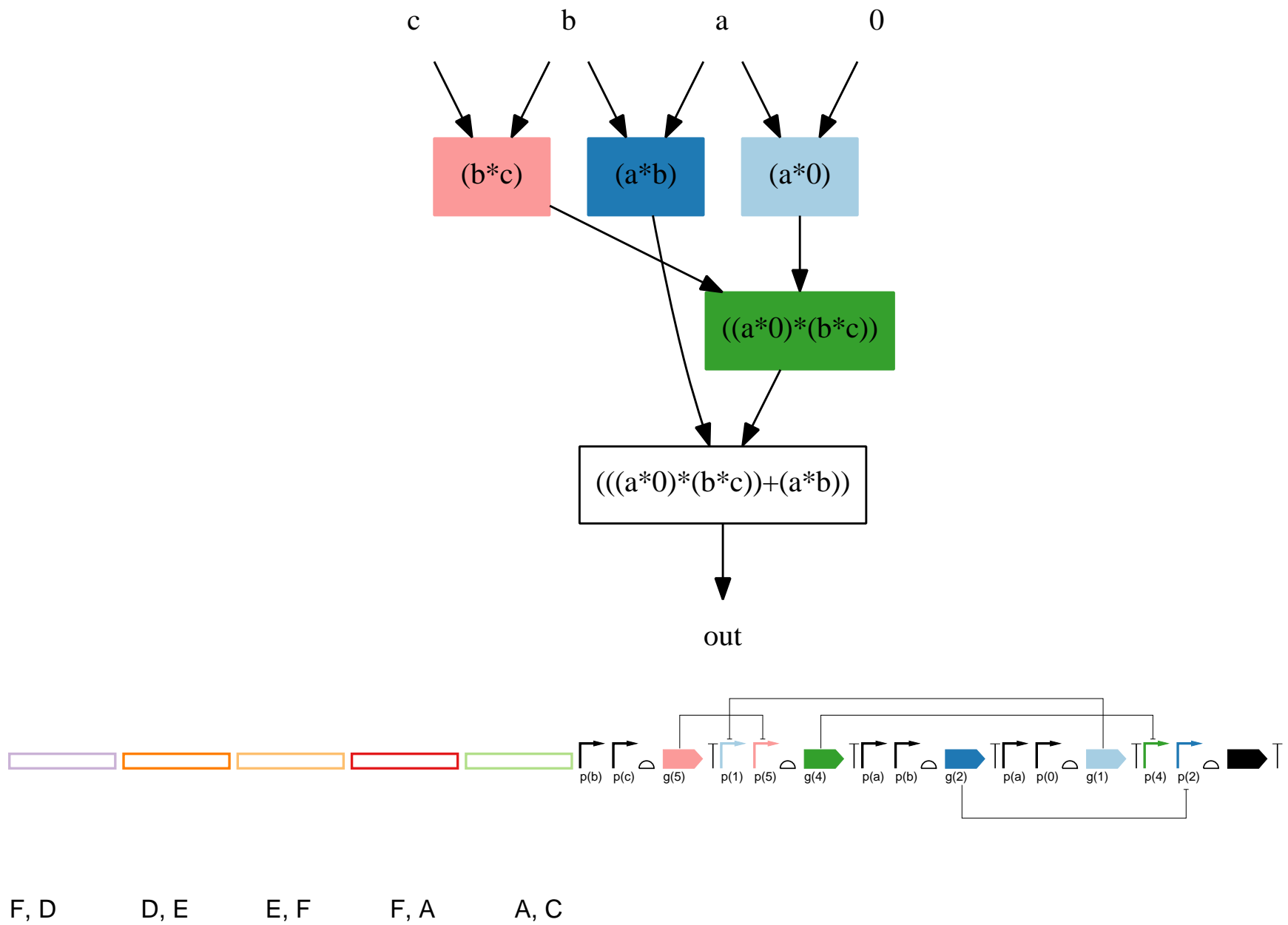


Figure 58: Circuit with truth table 0xC7.

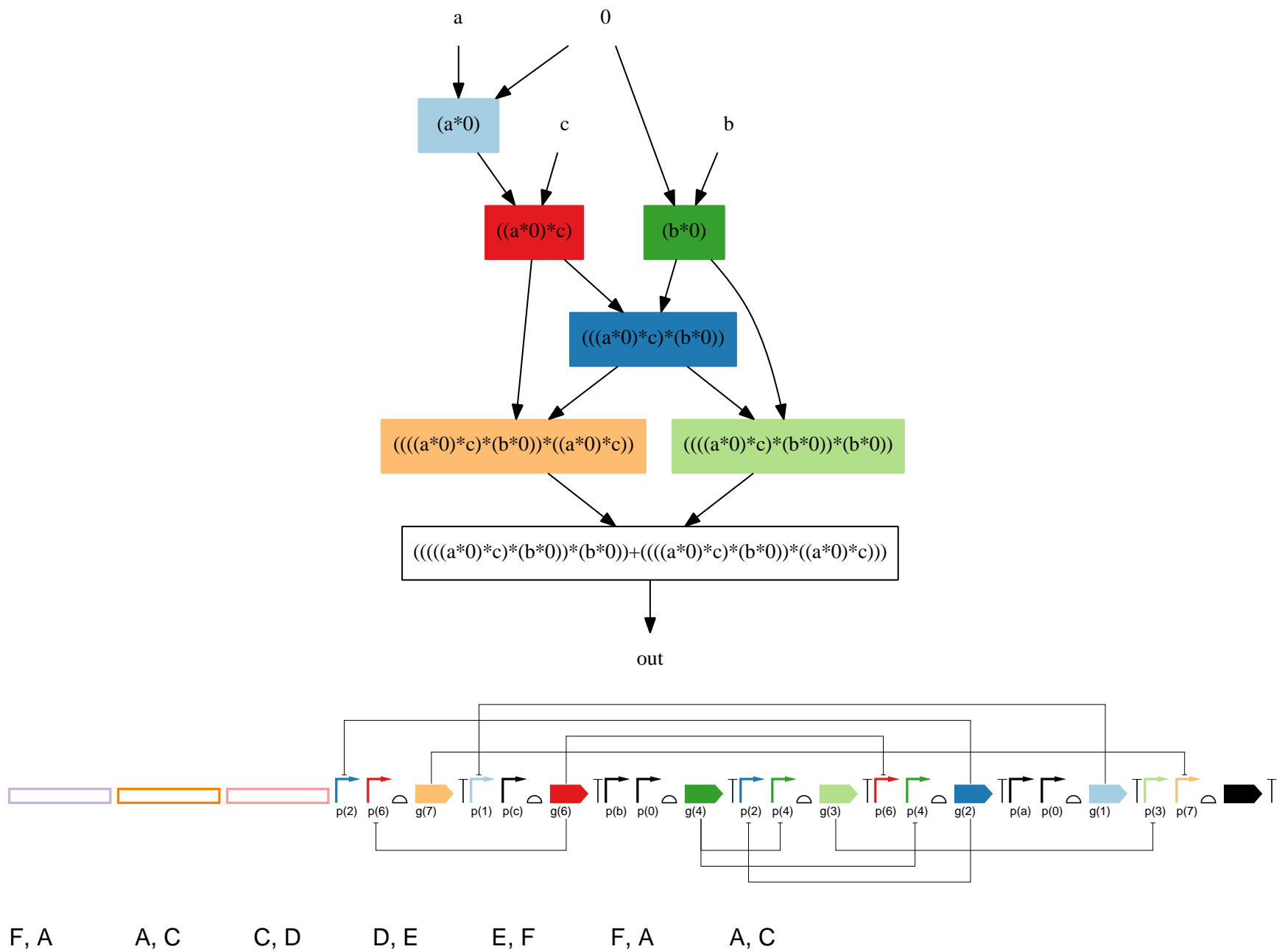


Figure 59: Circuit with truth table 0xC6.

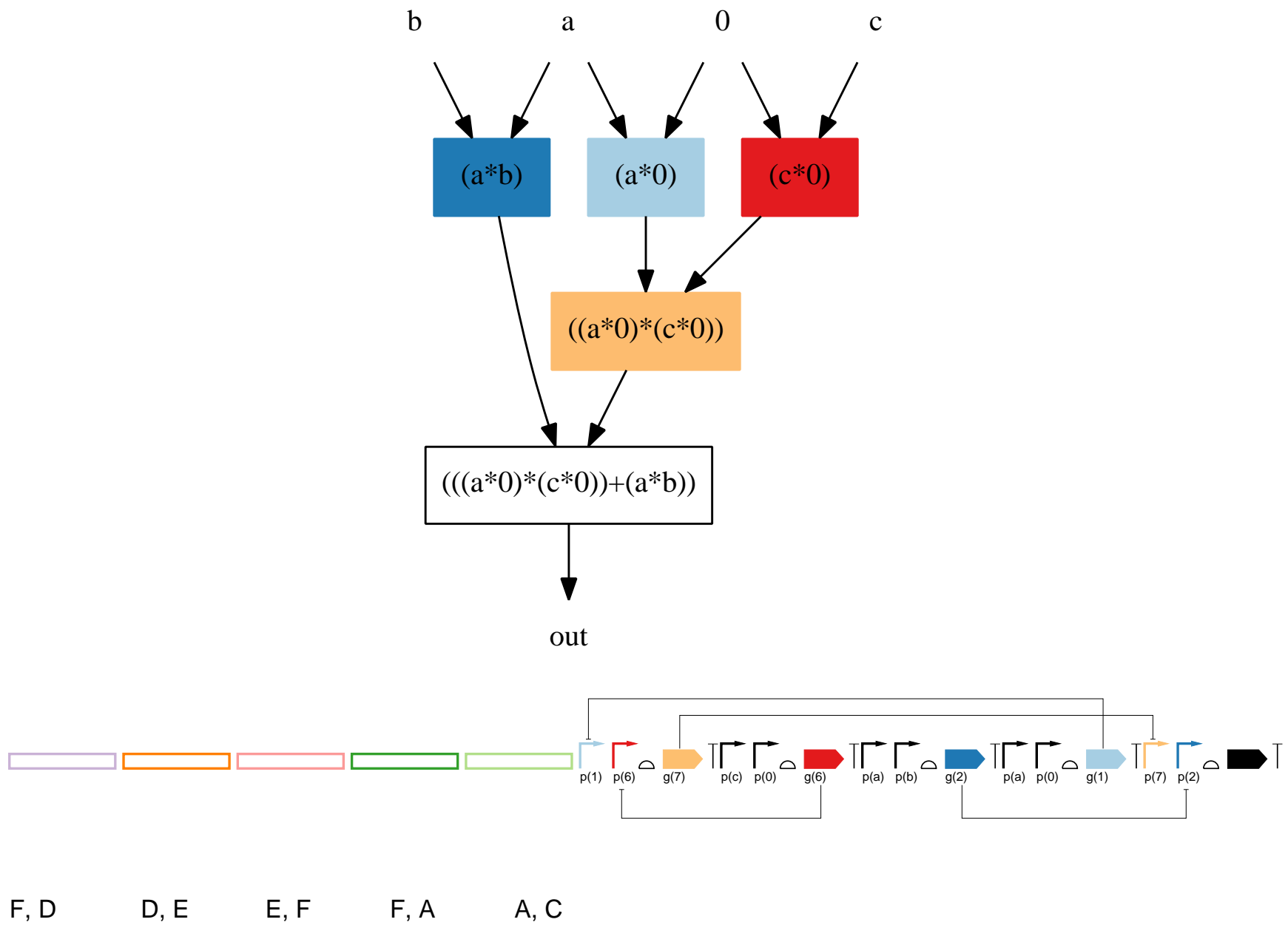


Figure 60: Circuit with truth table 0xC5.

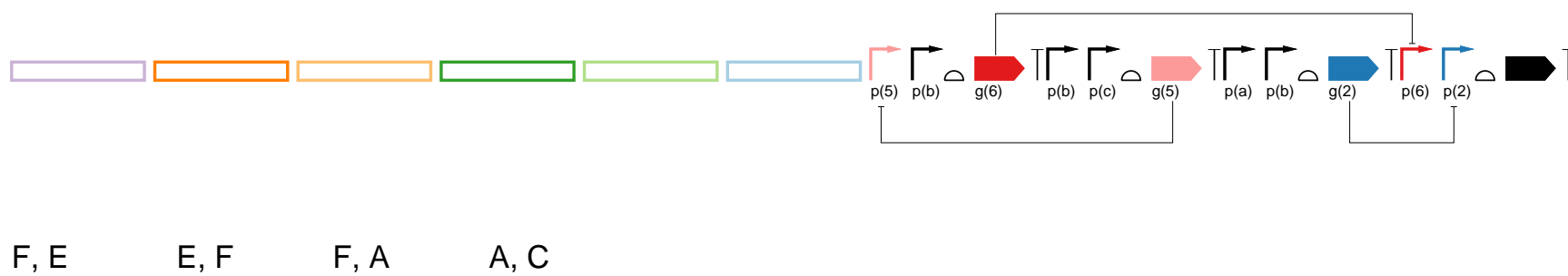
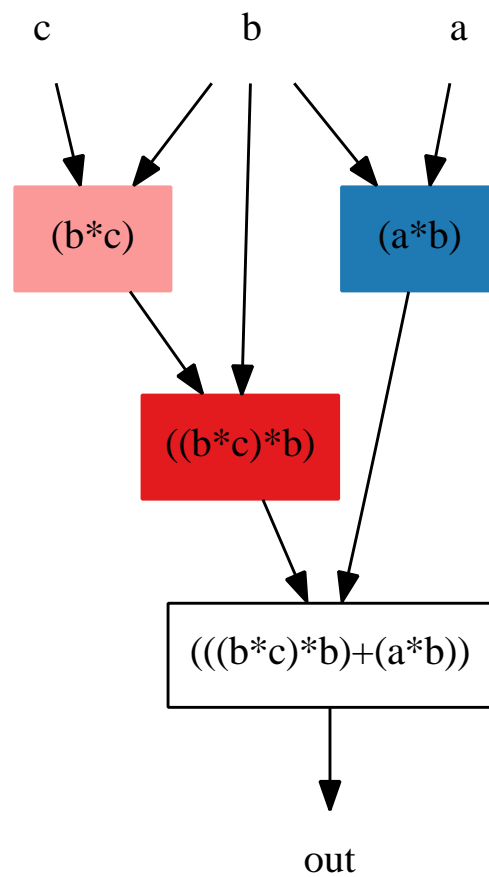


Figure 61: Circuit with truth table 0xC4.

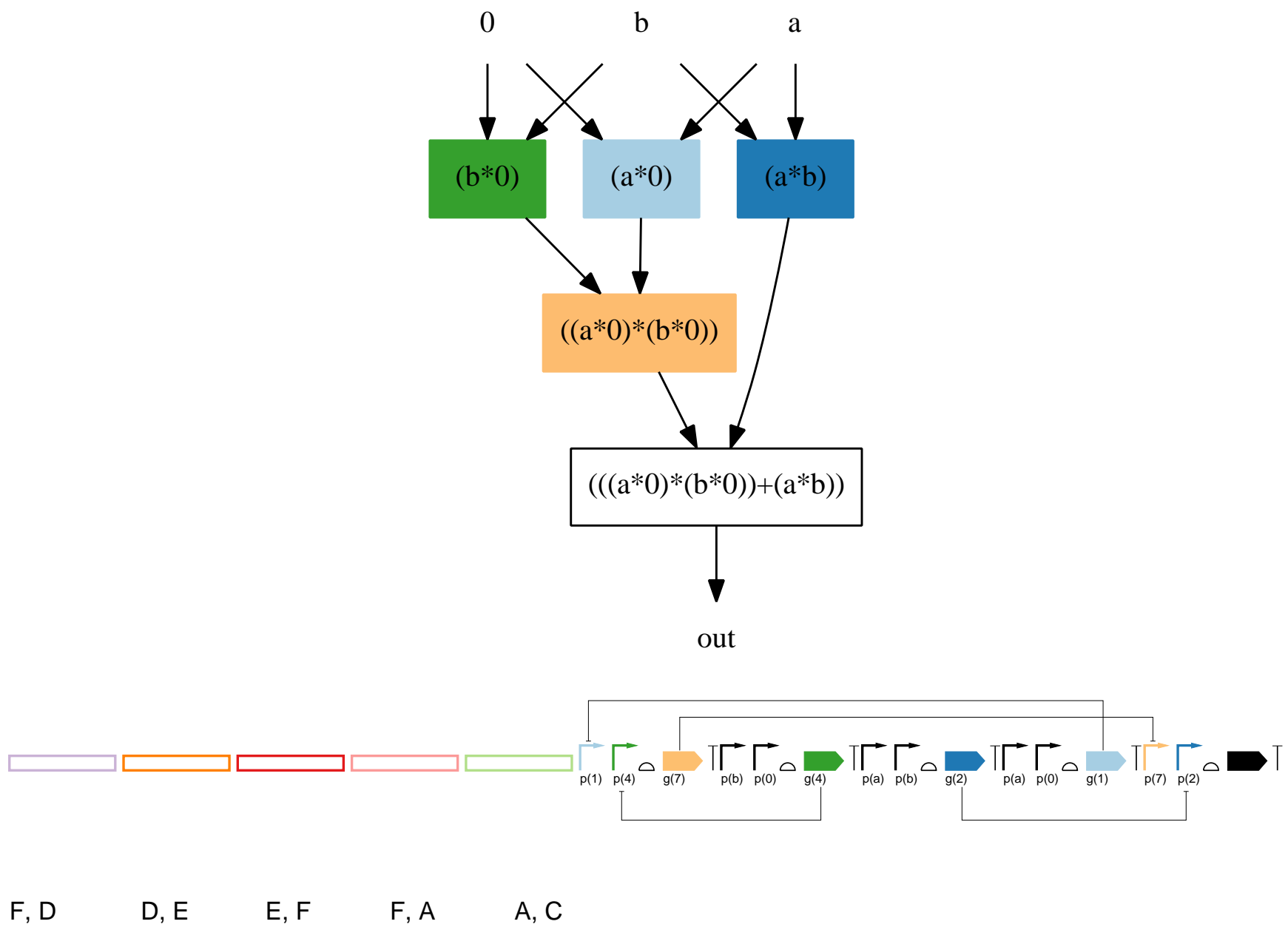
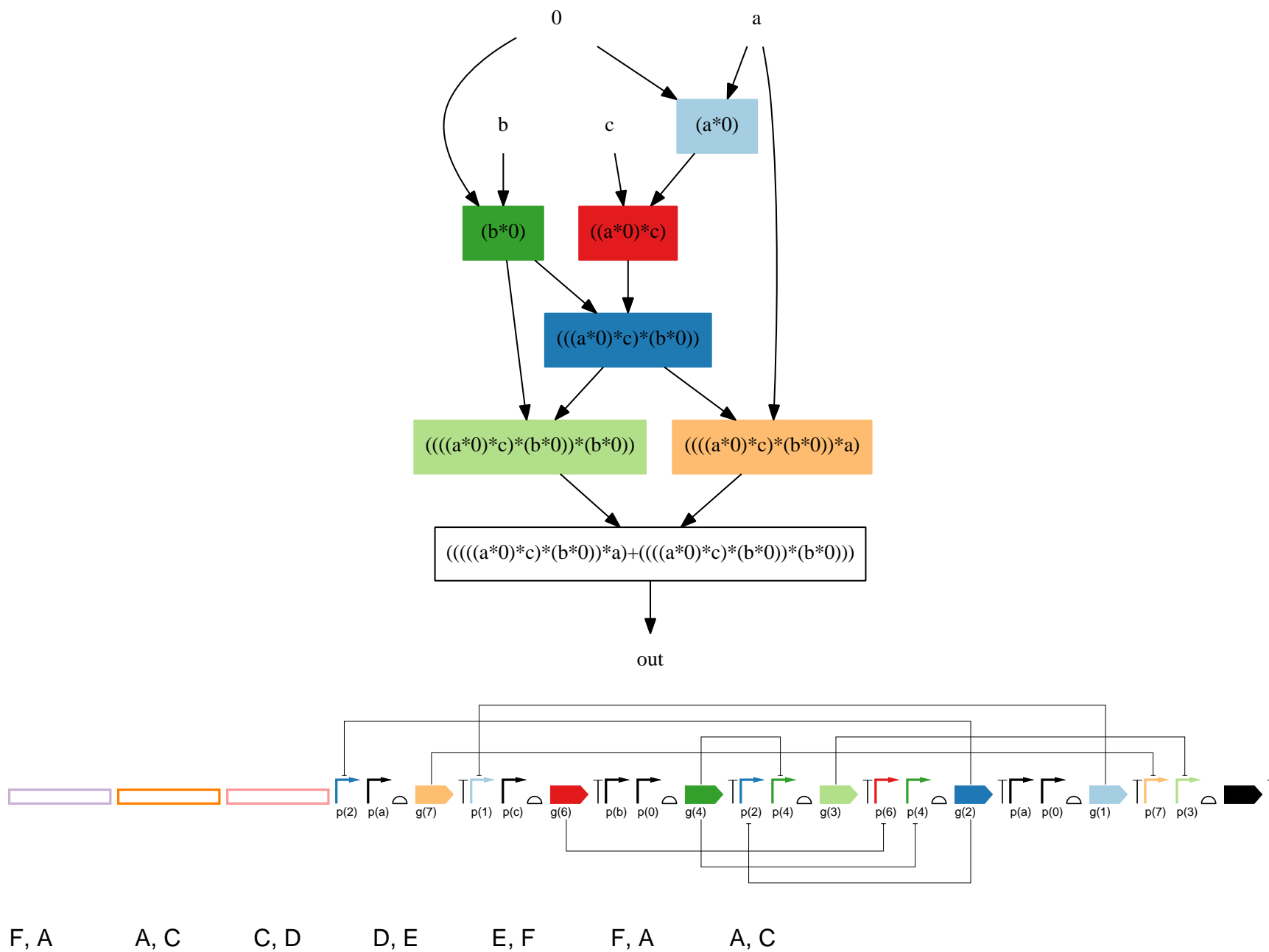


Figure 62: Circuit with truth table 0xC3.



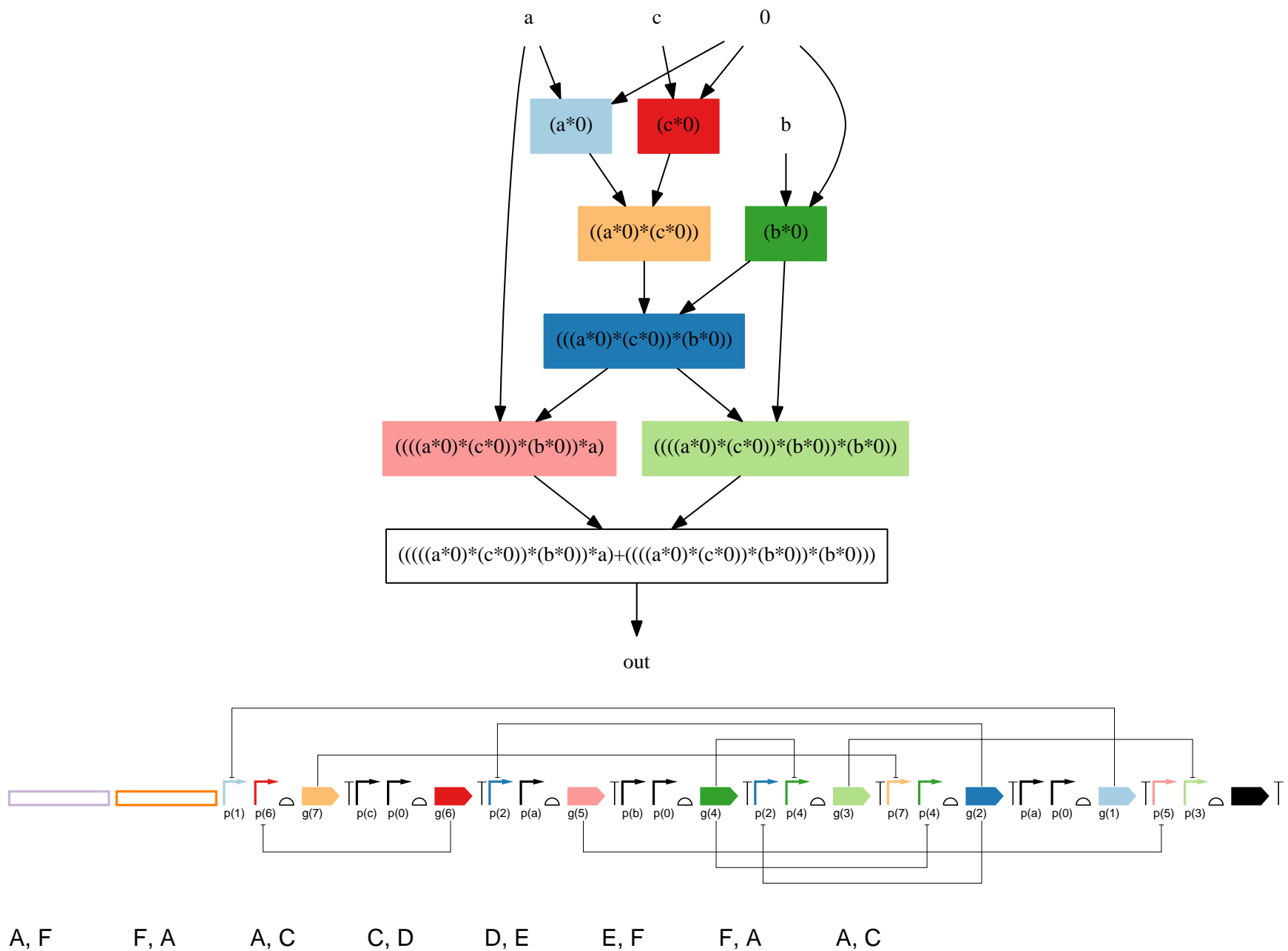
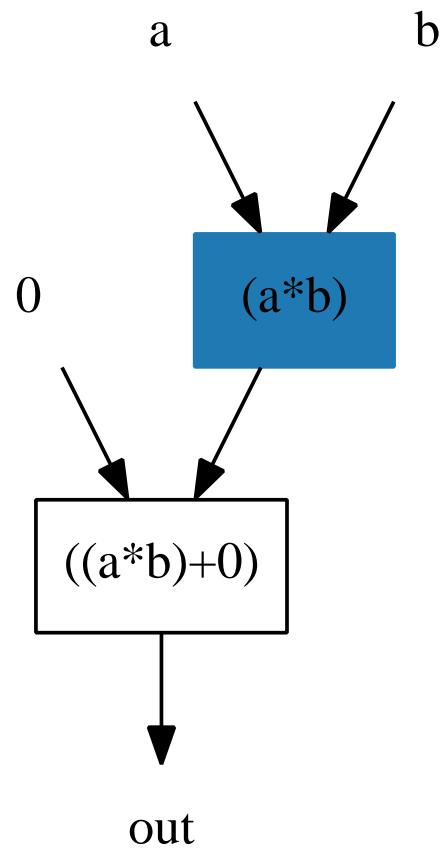


Figure 64: Circuit with truth table 0xC1.



E, A

A, C

Figure 65: Circuit with truth table 0xC0.

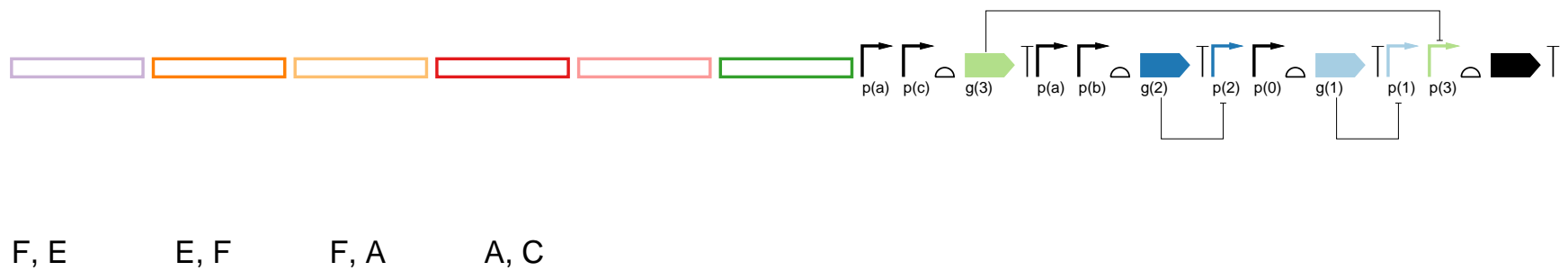
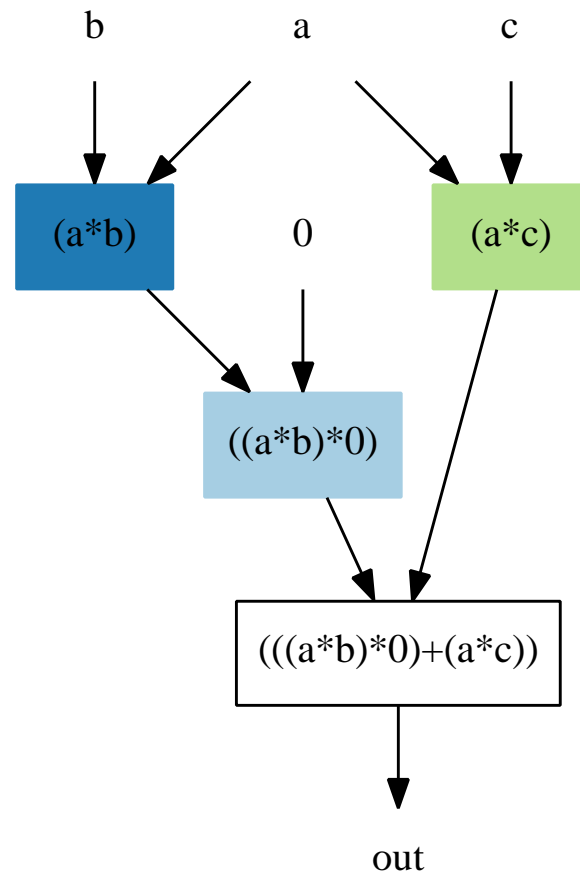


Figure 66: Circuit with truth table 0xBF.

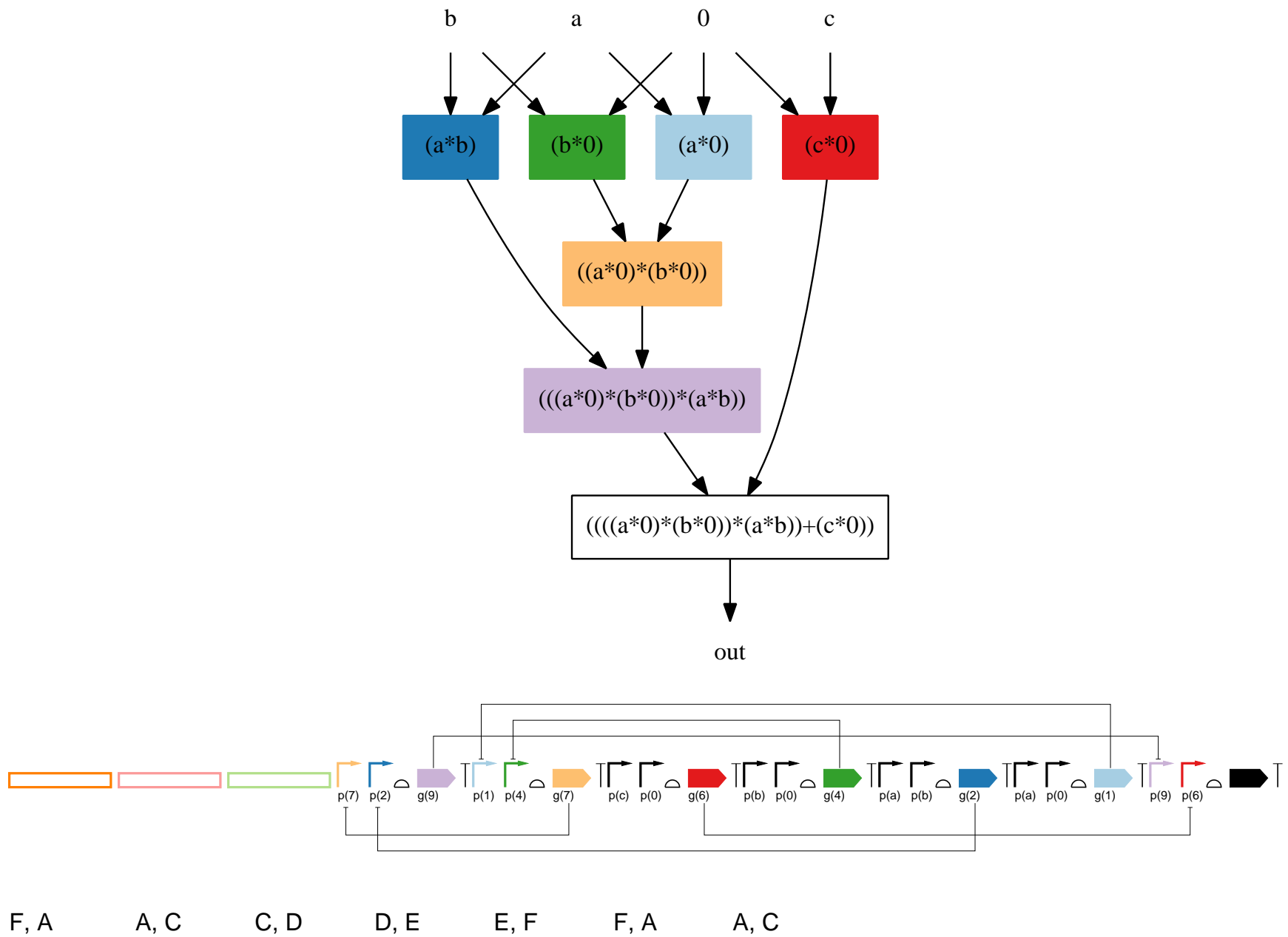


Figure 67: Circuit with truth table 0xBE.

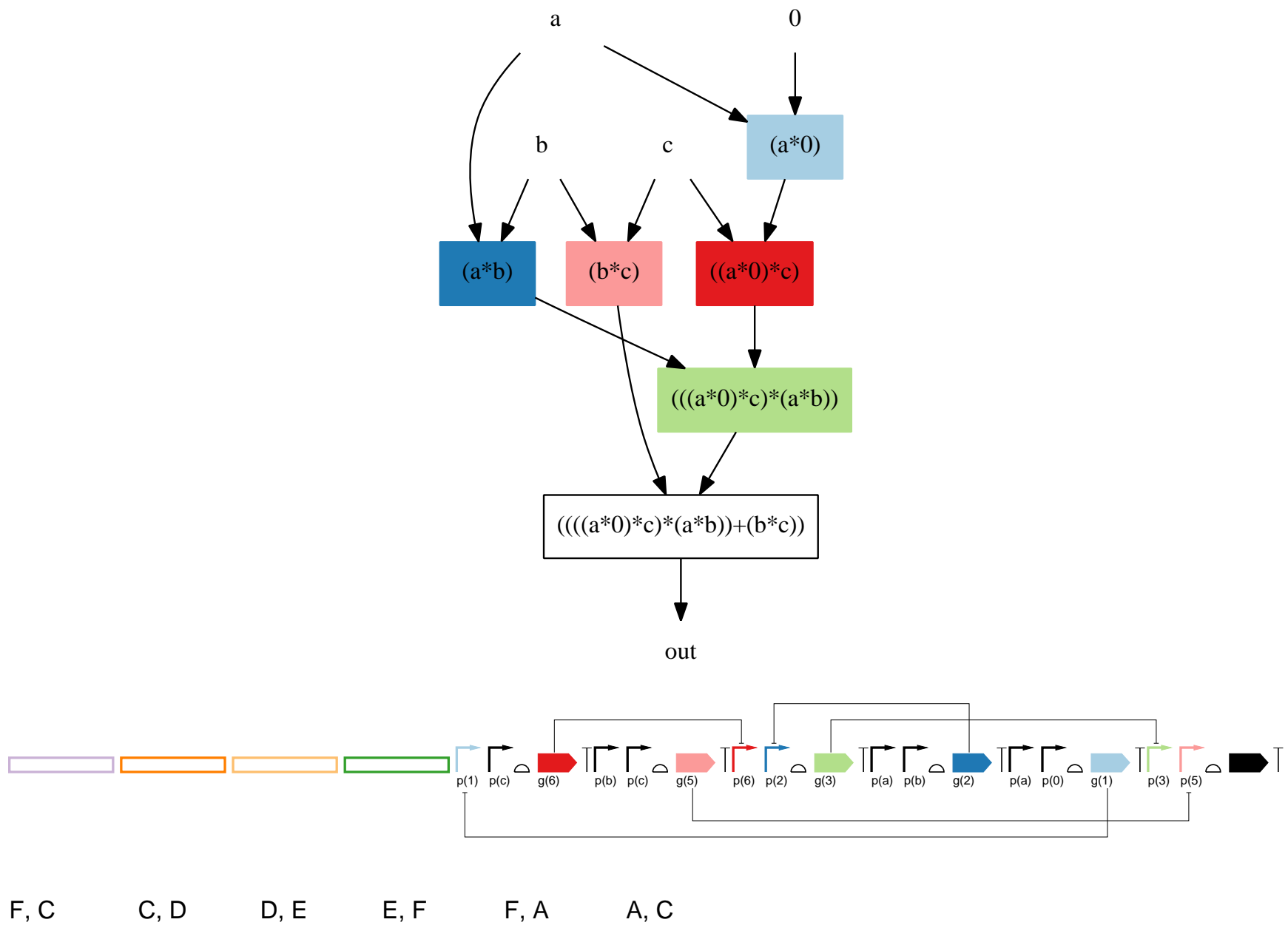


Figure 68: Circuit with truth table 0xBD.

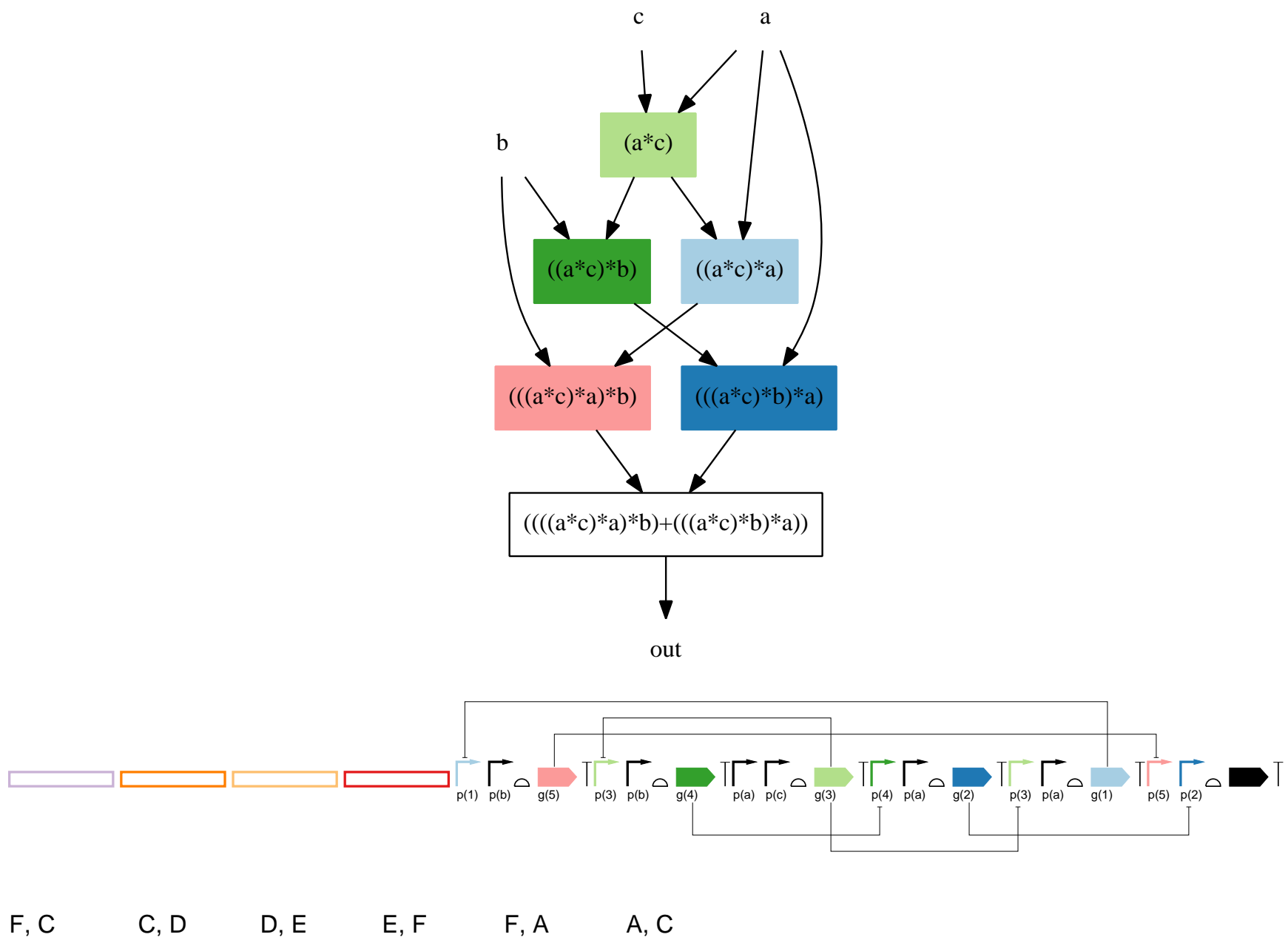


Figure 69: Circuit with truth table 0xBC.

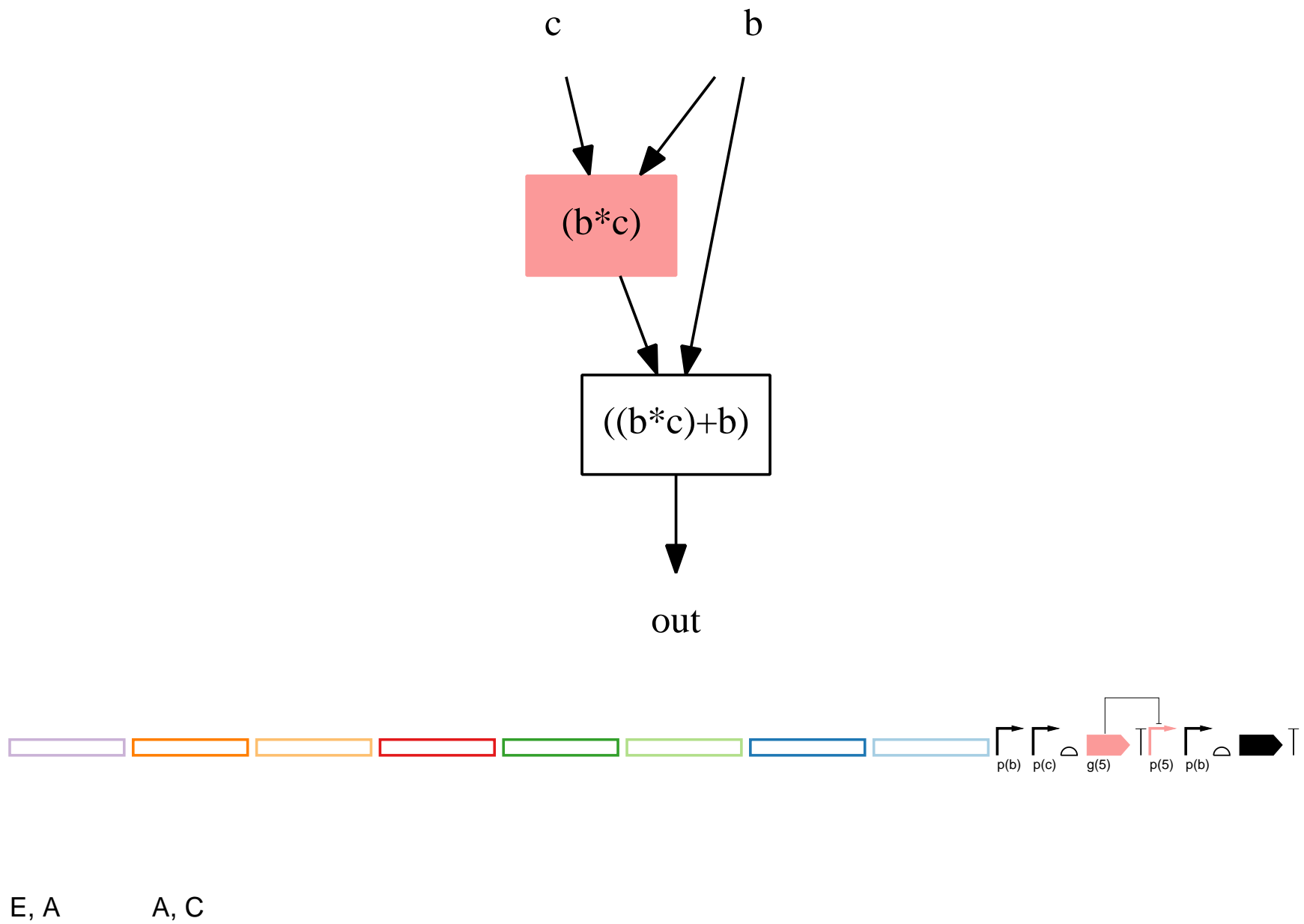


Figure 70: Circuit with truth table 0xBB.

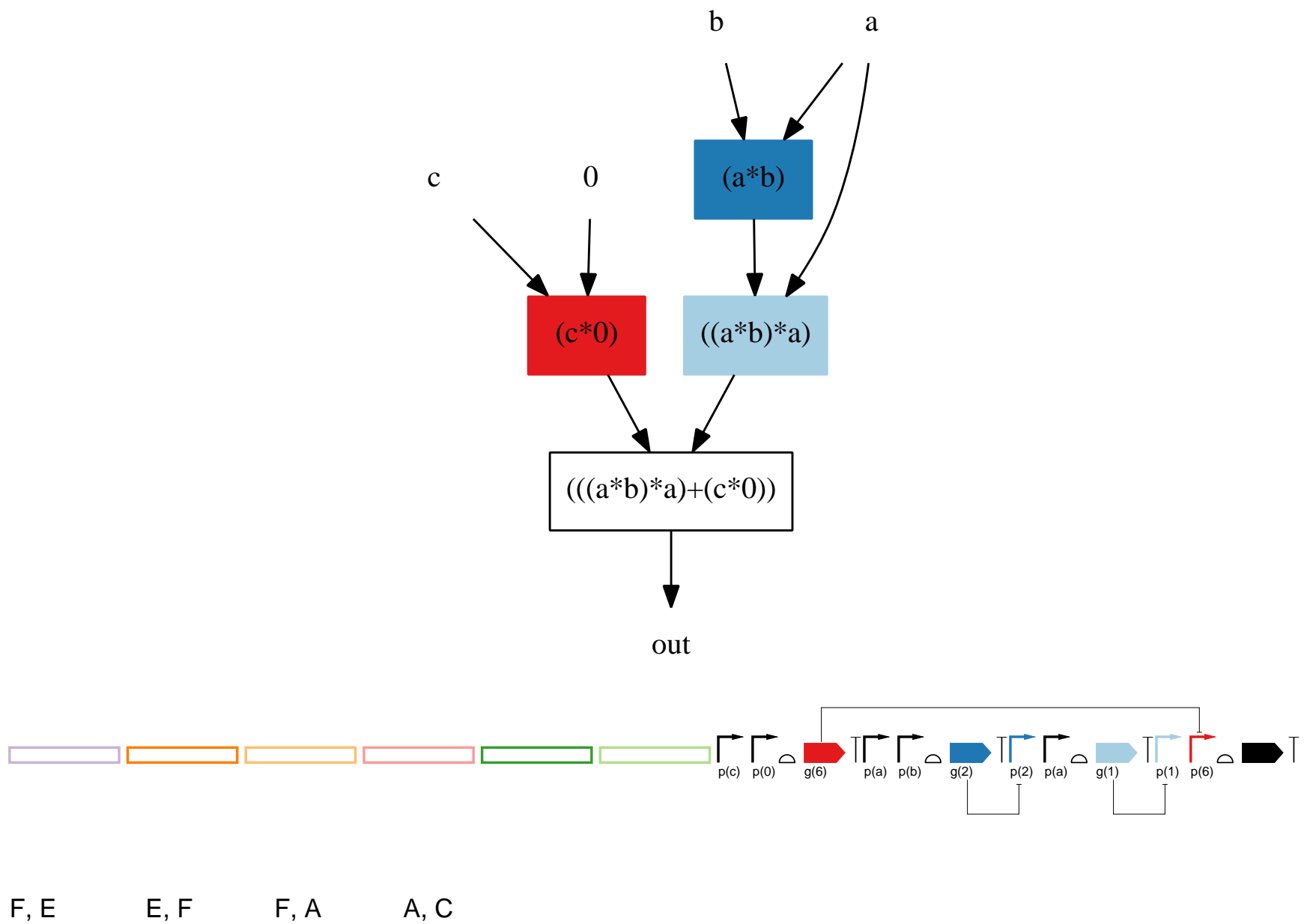


Figure 71: Circuit with truth table 0xBA.

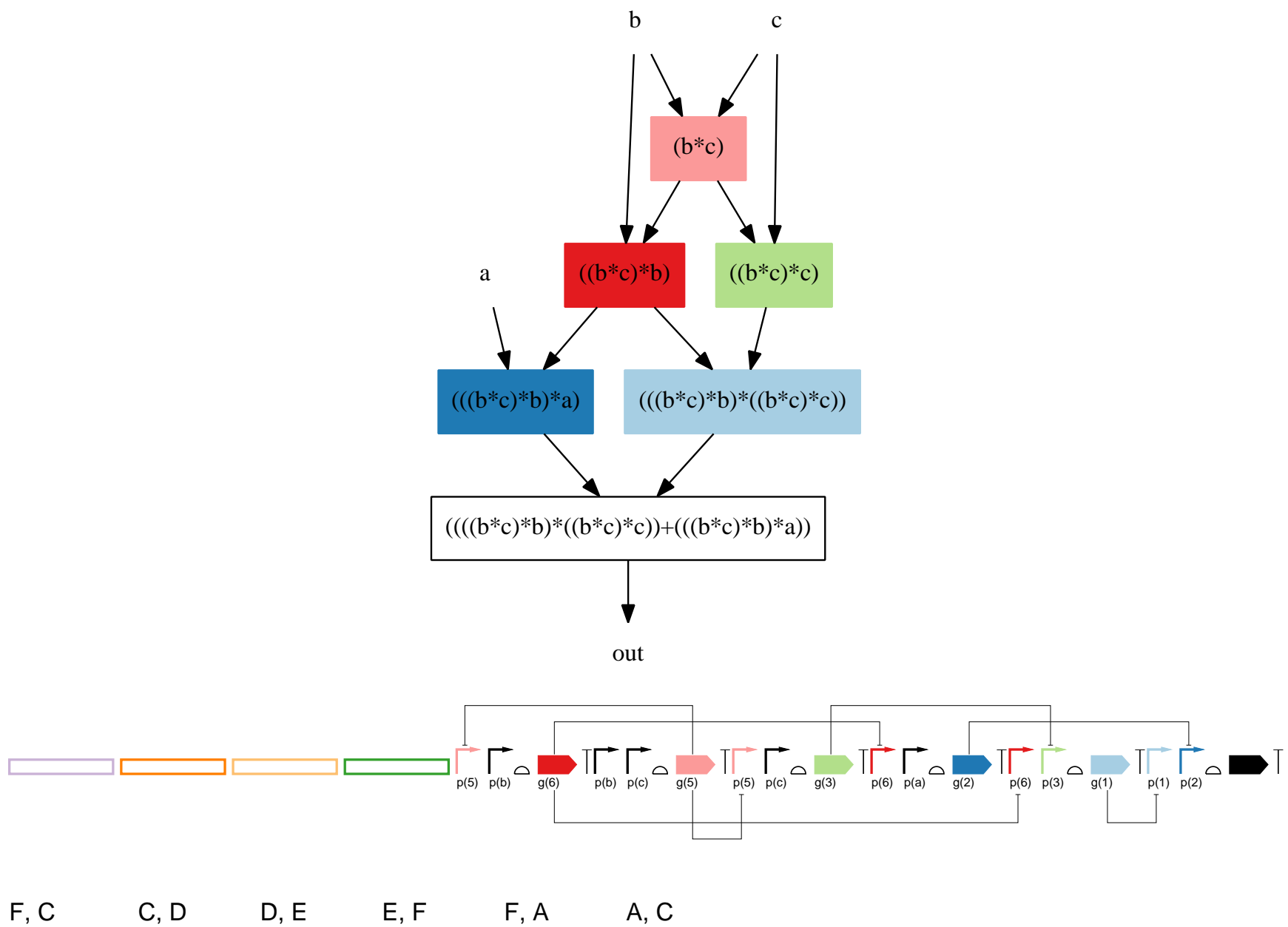


Figure 72: Circuit with truth table 0xB9.

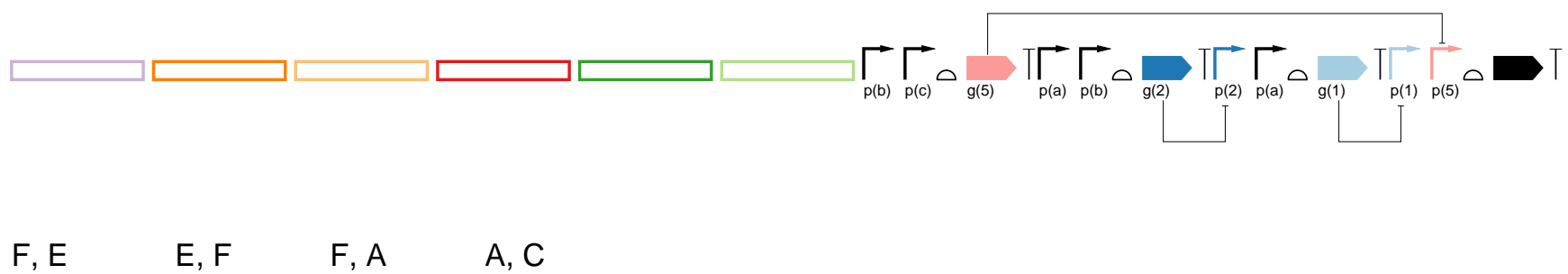
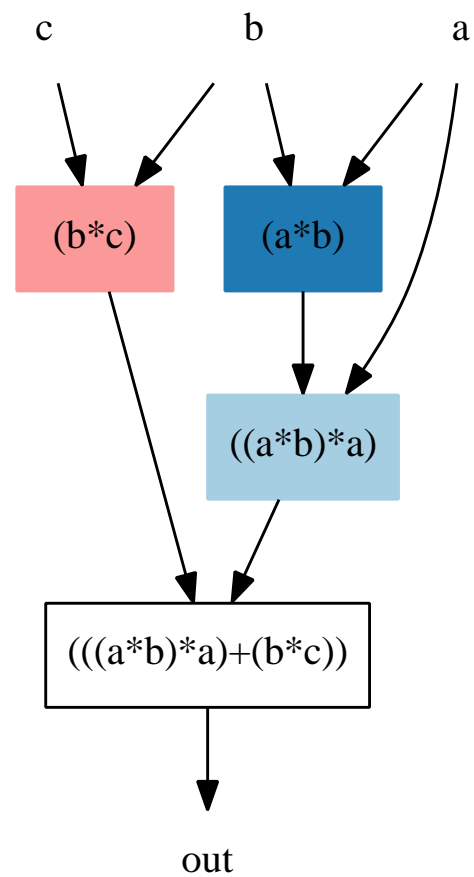


Figure 73: Circuit with truth table 0xB8.

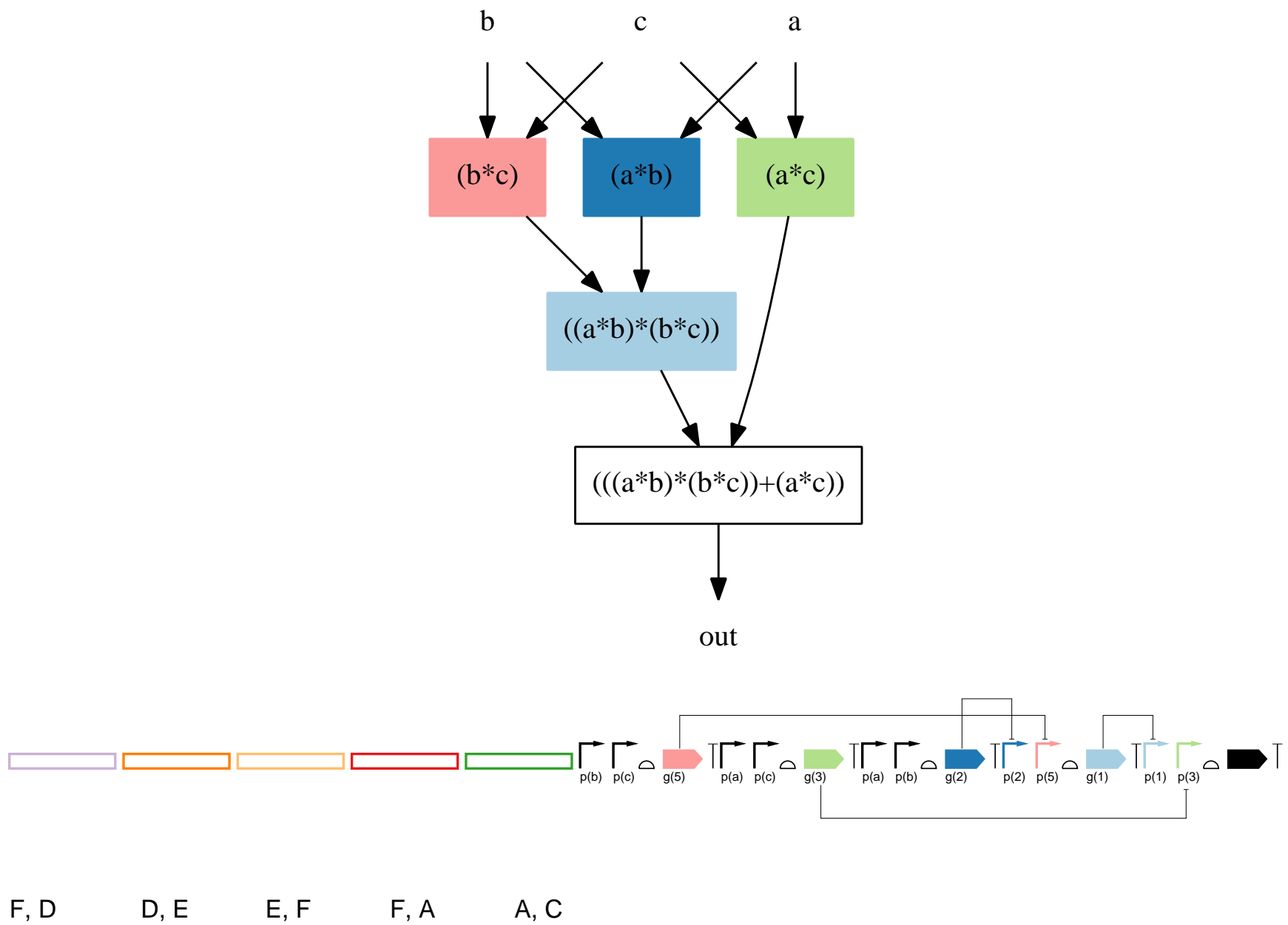


Figure 74: Circuit with truth table 0xB7.

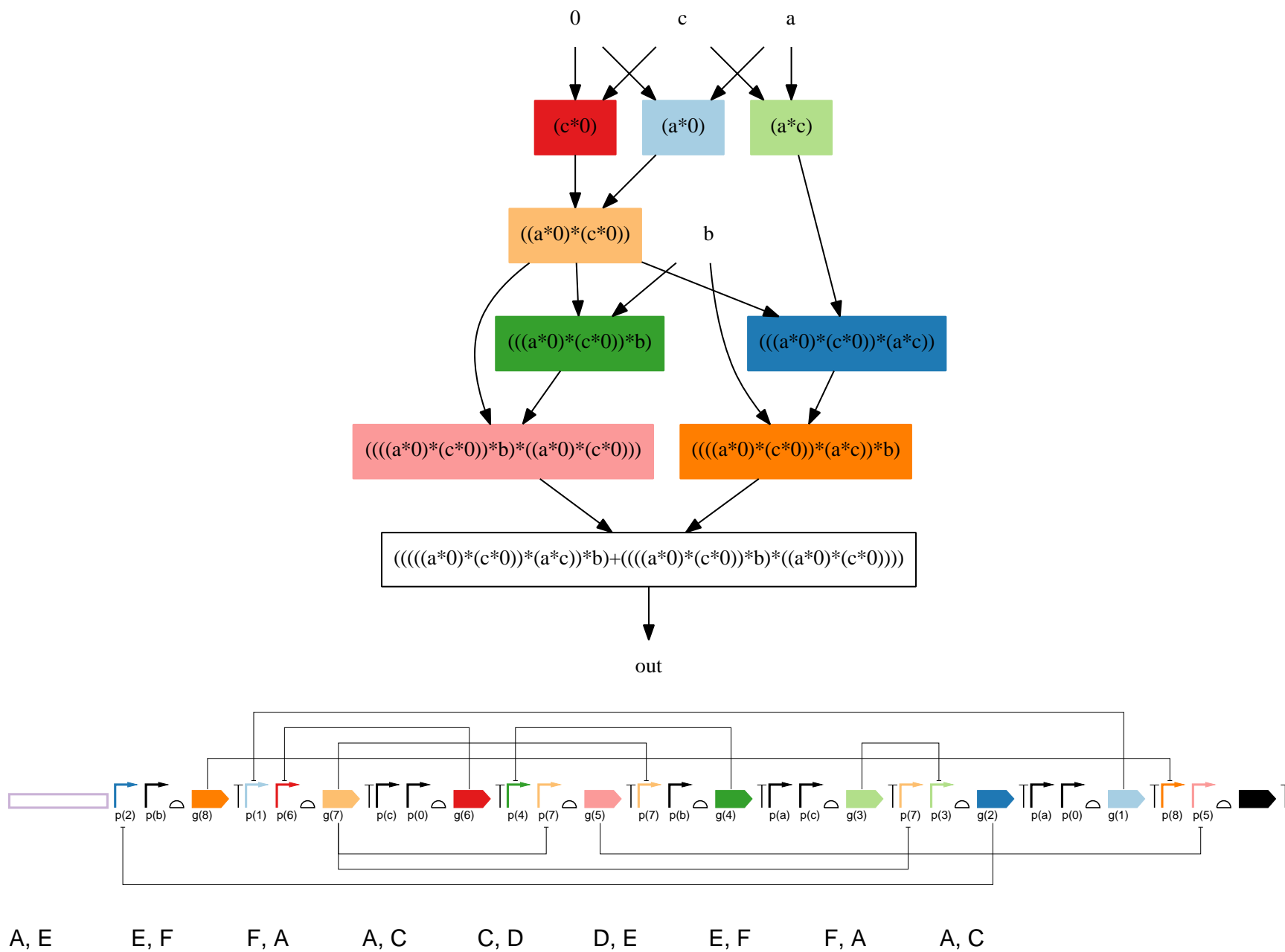
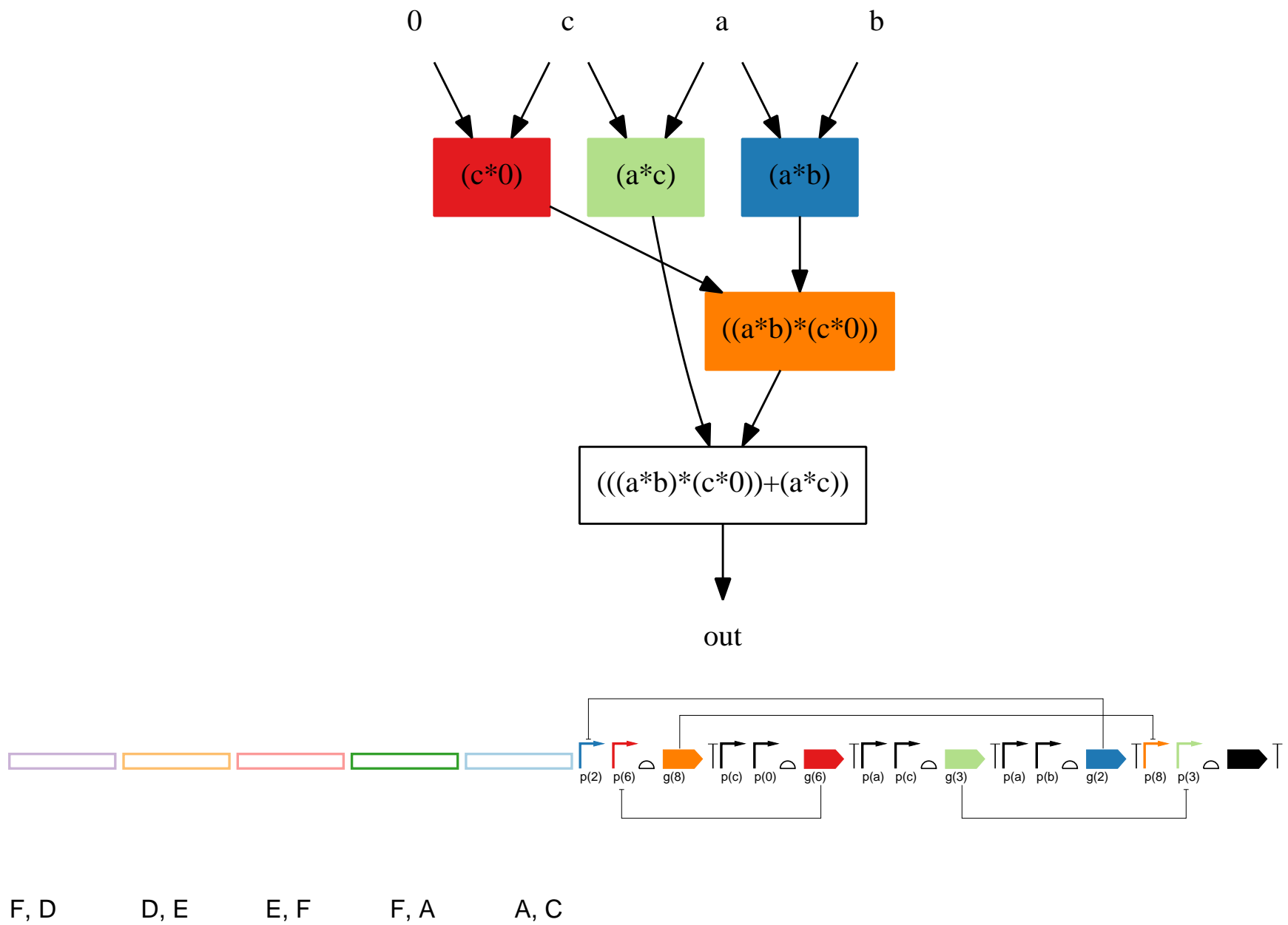


Figure 75: Circuit with truth table 0xB6.



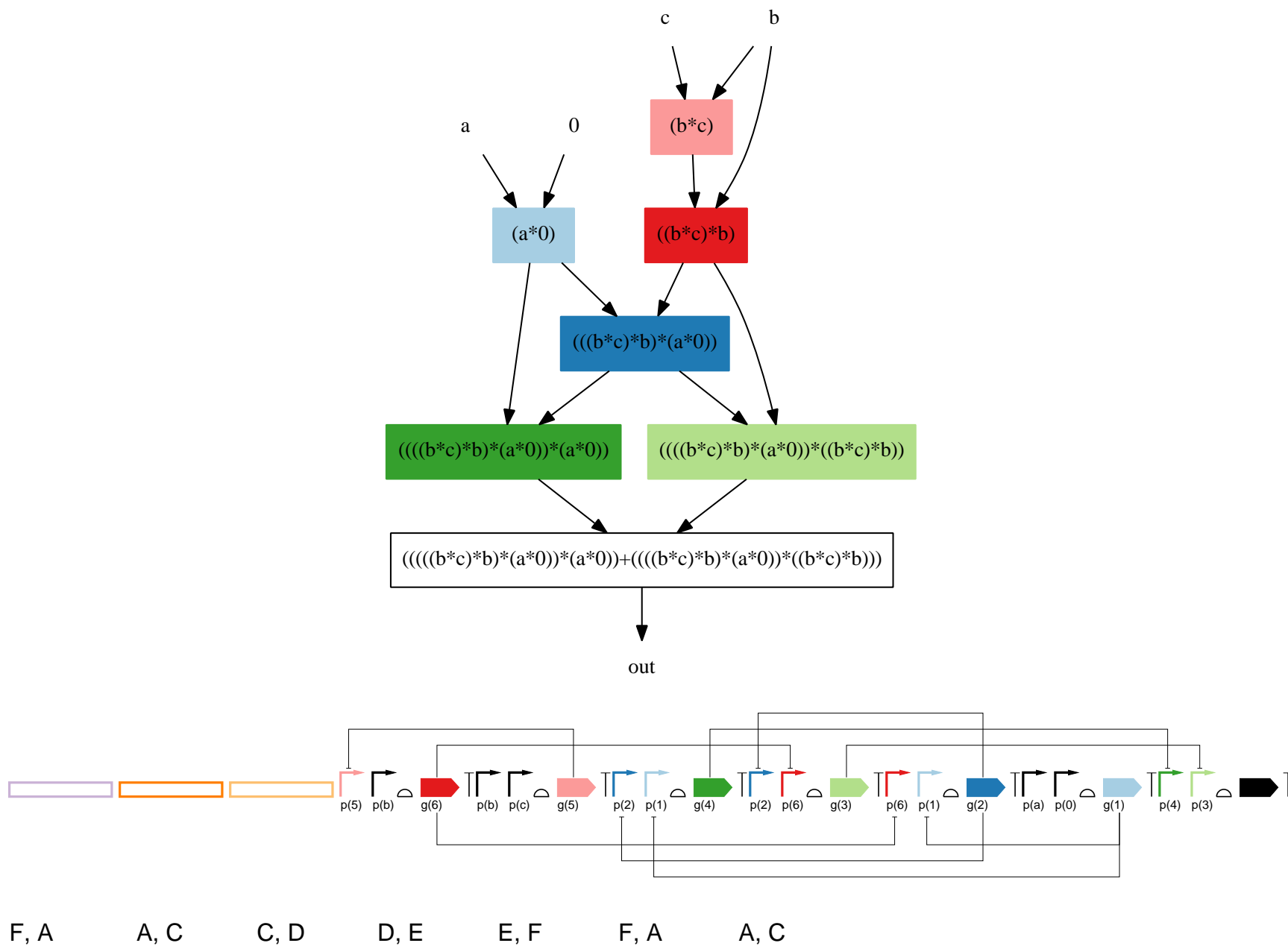
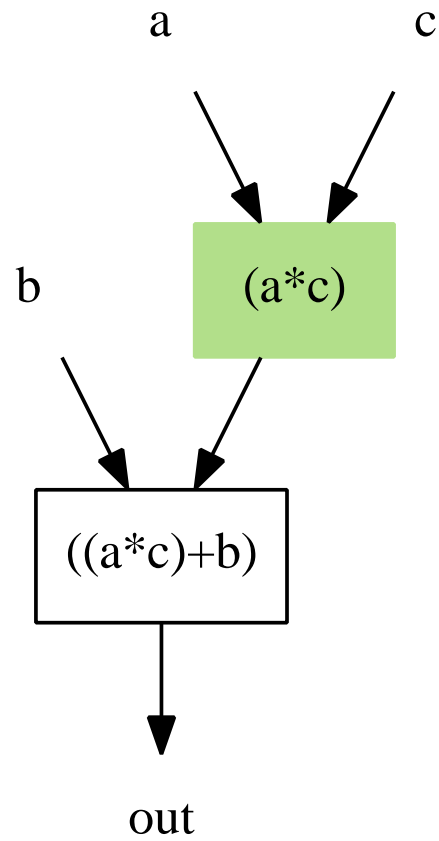


Figure 77: Circuit with truth table 0xB4.



E, A

A, C

Figure 78: Circuit with truth table 0xB3.

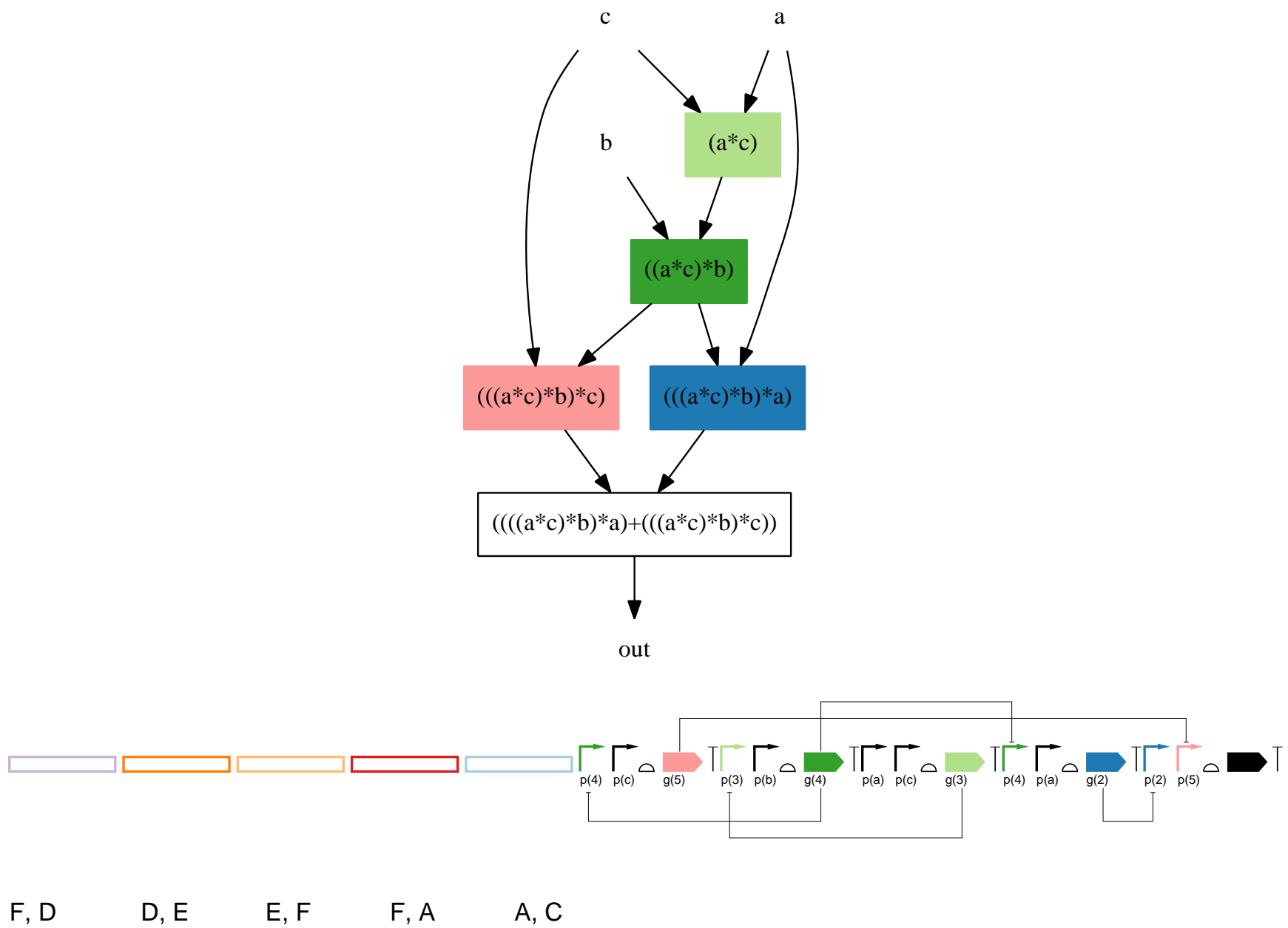


Figure 79: Circuit with truth table 0xB2.

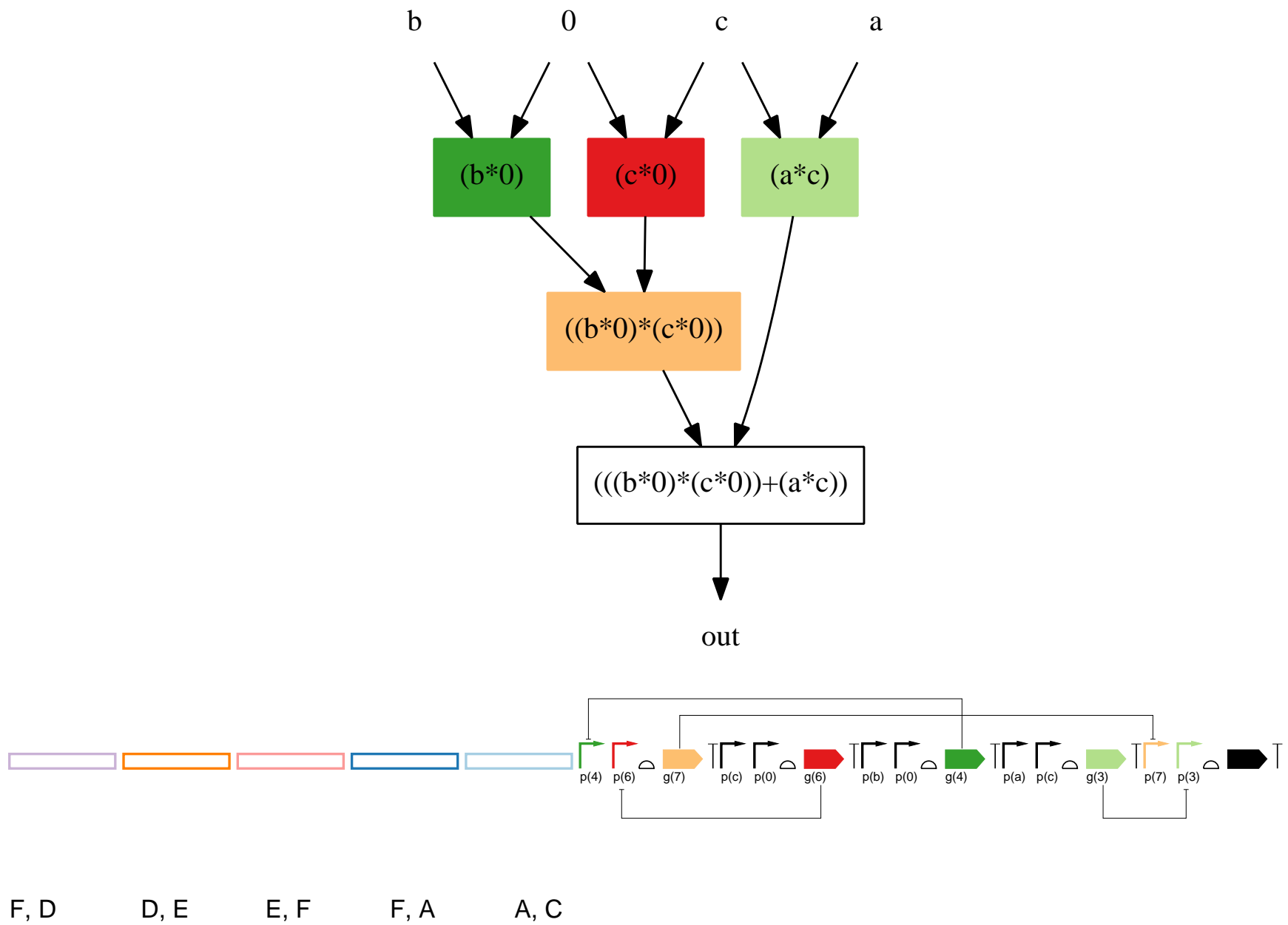


Figure 80: Circuit with truth table 0xB1.

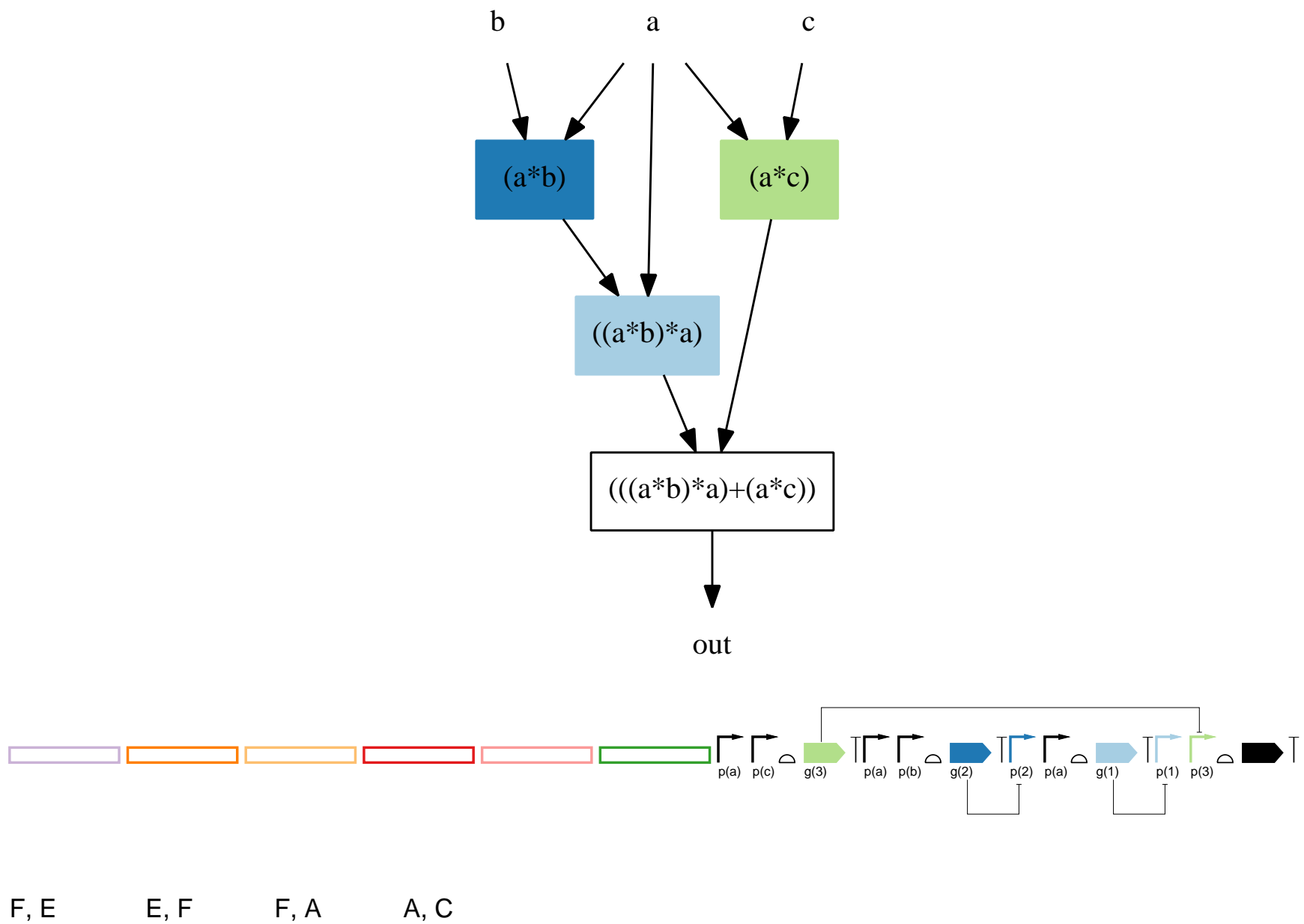
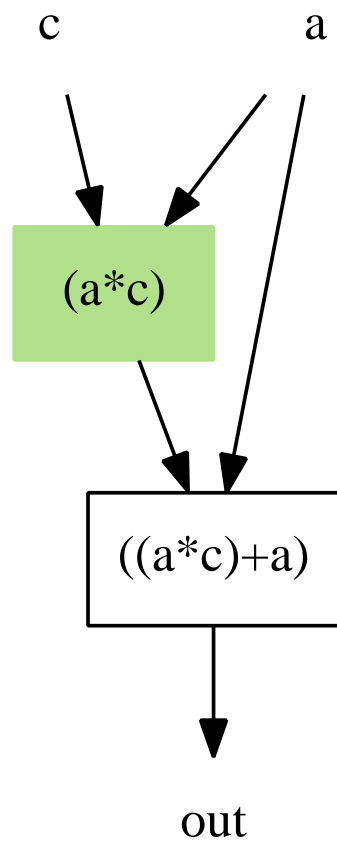


Figure 81: Circuit with truth table 0xB0.



E, A

A, C

Figure 82: Circuit with truth table 0xAF.

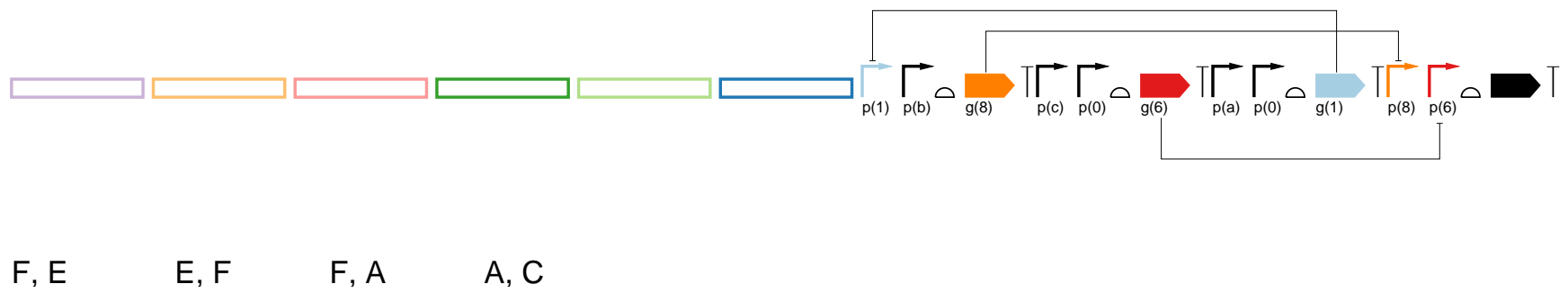
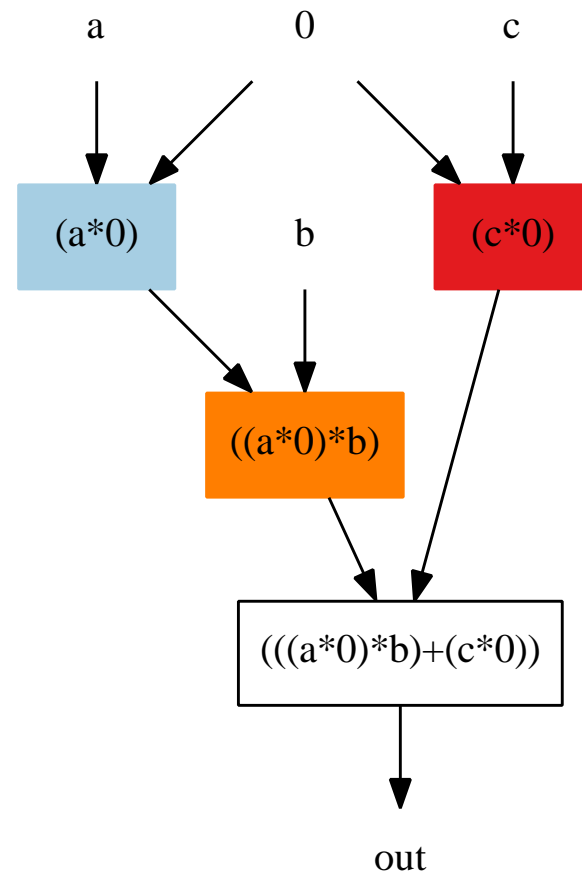


Figure 83: Circuit with truth table 0xAE.

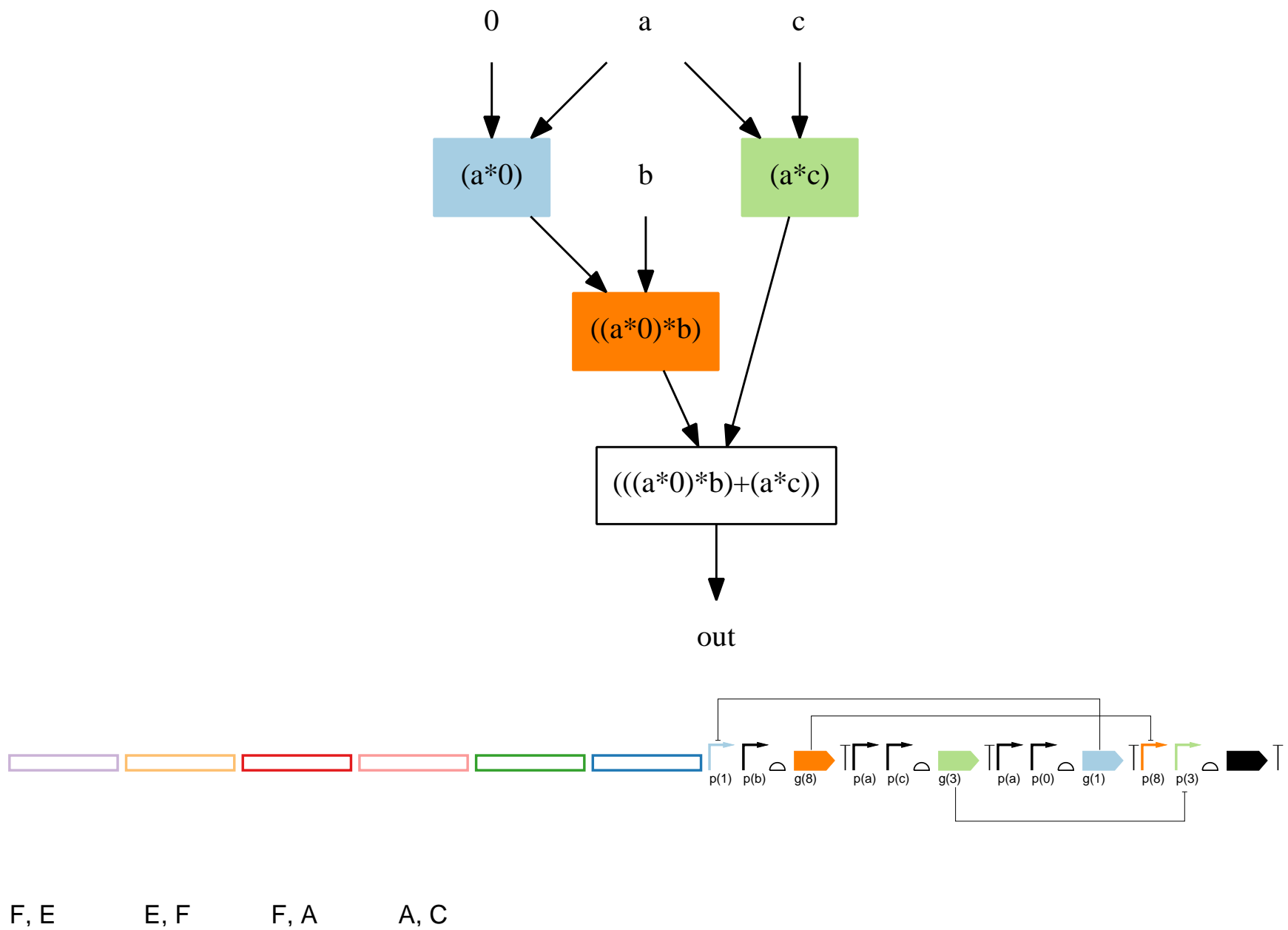


Figure 85: Circuit with truth table 0xAC.

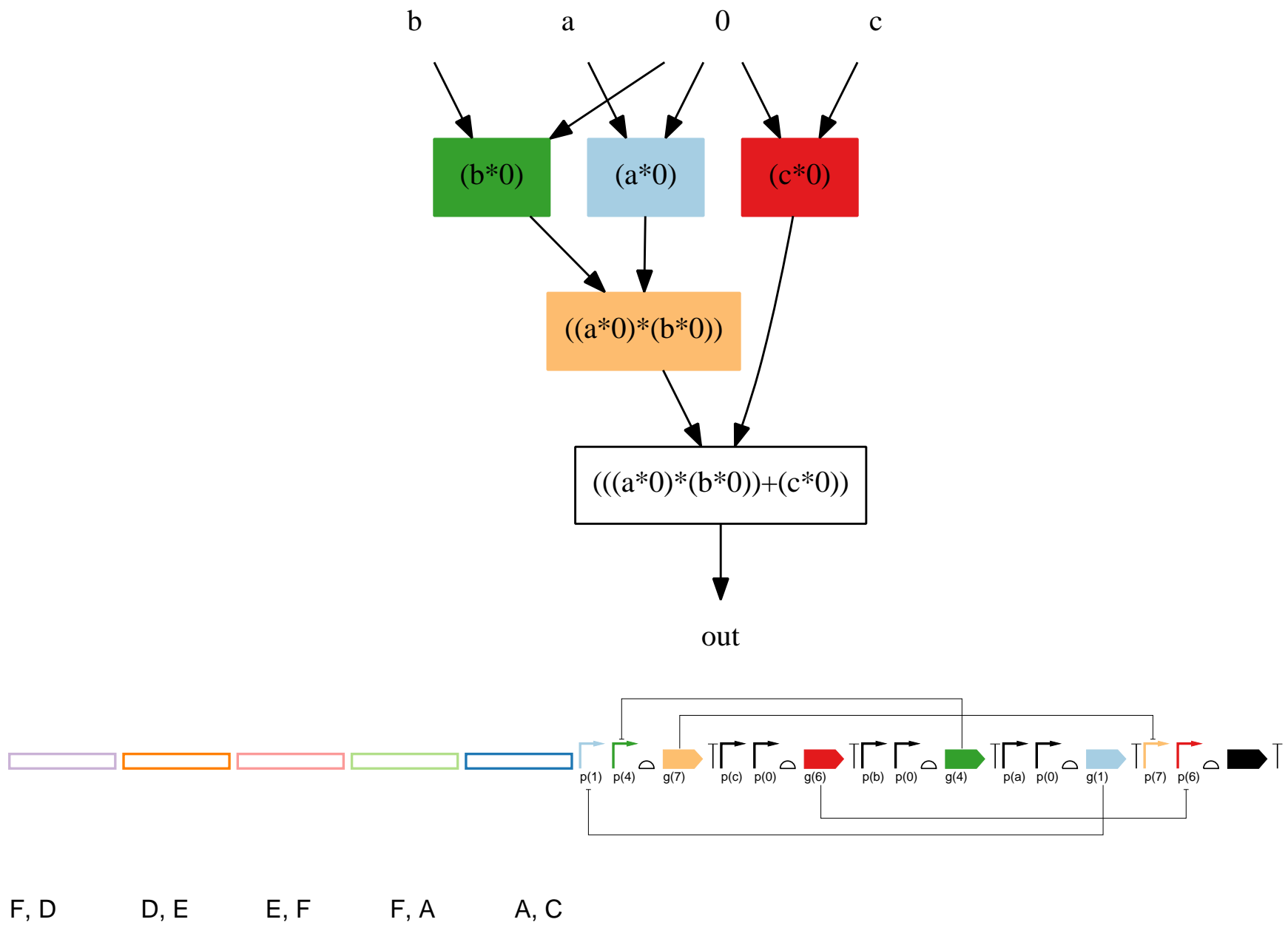


Figure 86: Circuit with truth table 0xAB.

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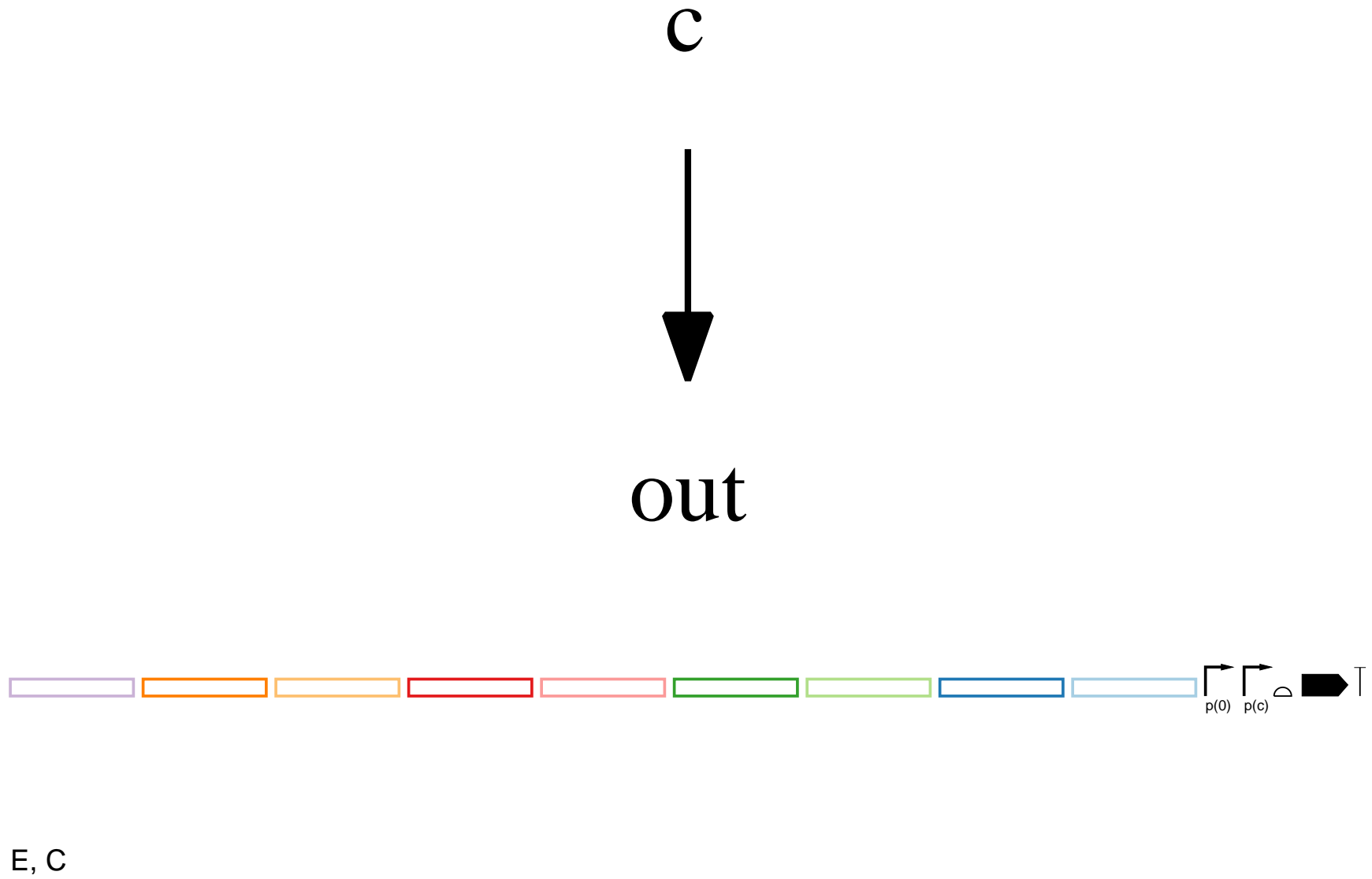


Figure 87: Circuit with truth table 0x55.

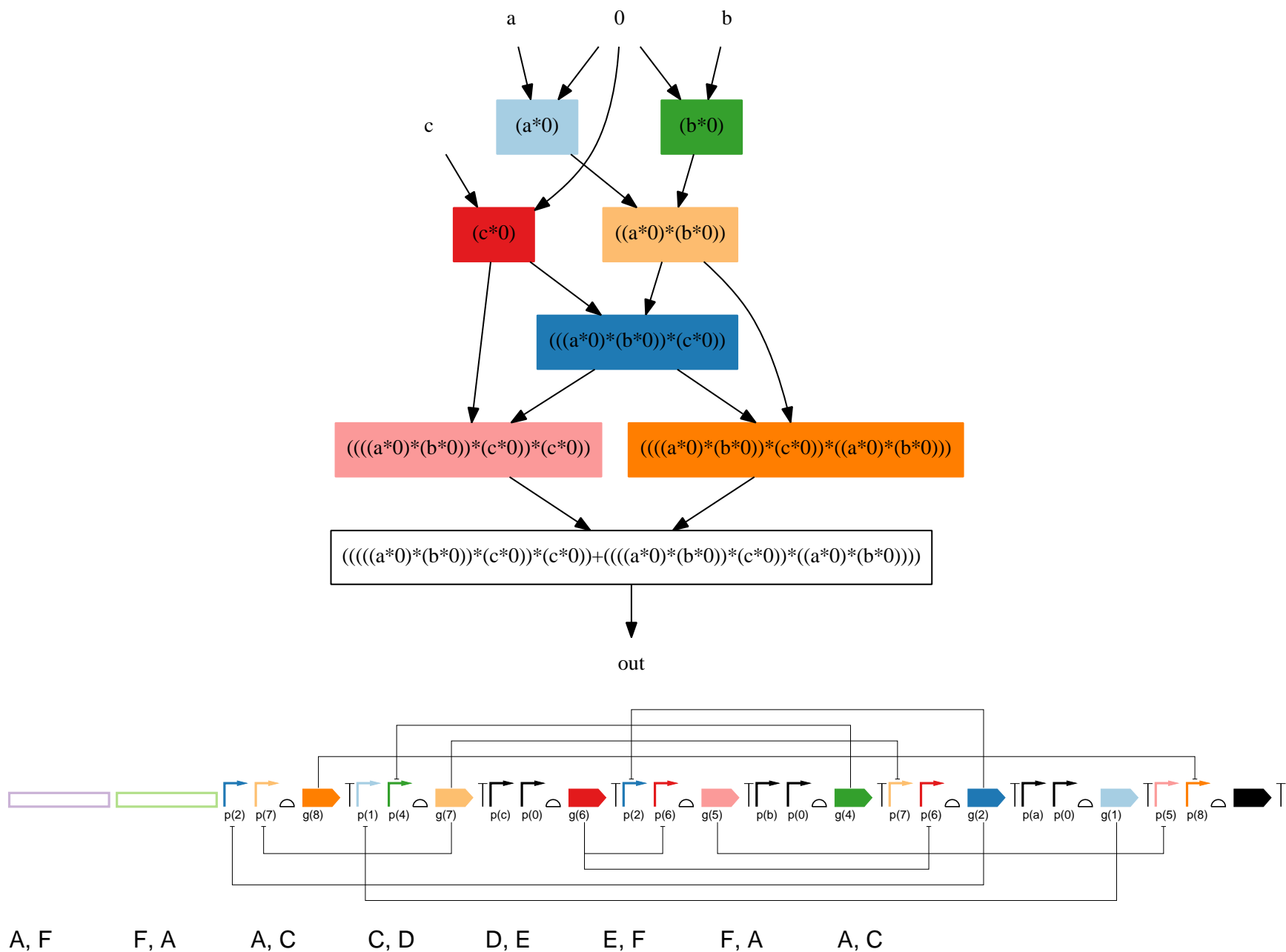


Figure 88: Circuit with truth table 0xA9.

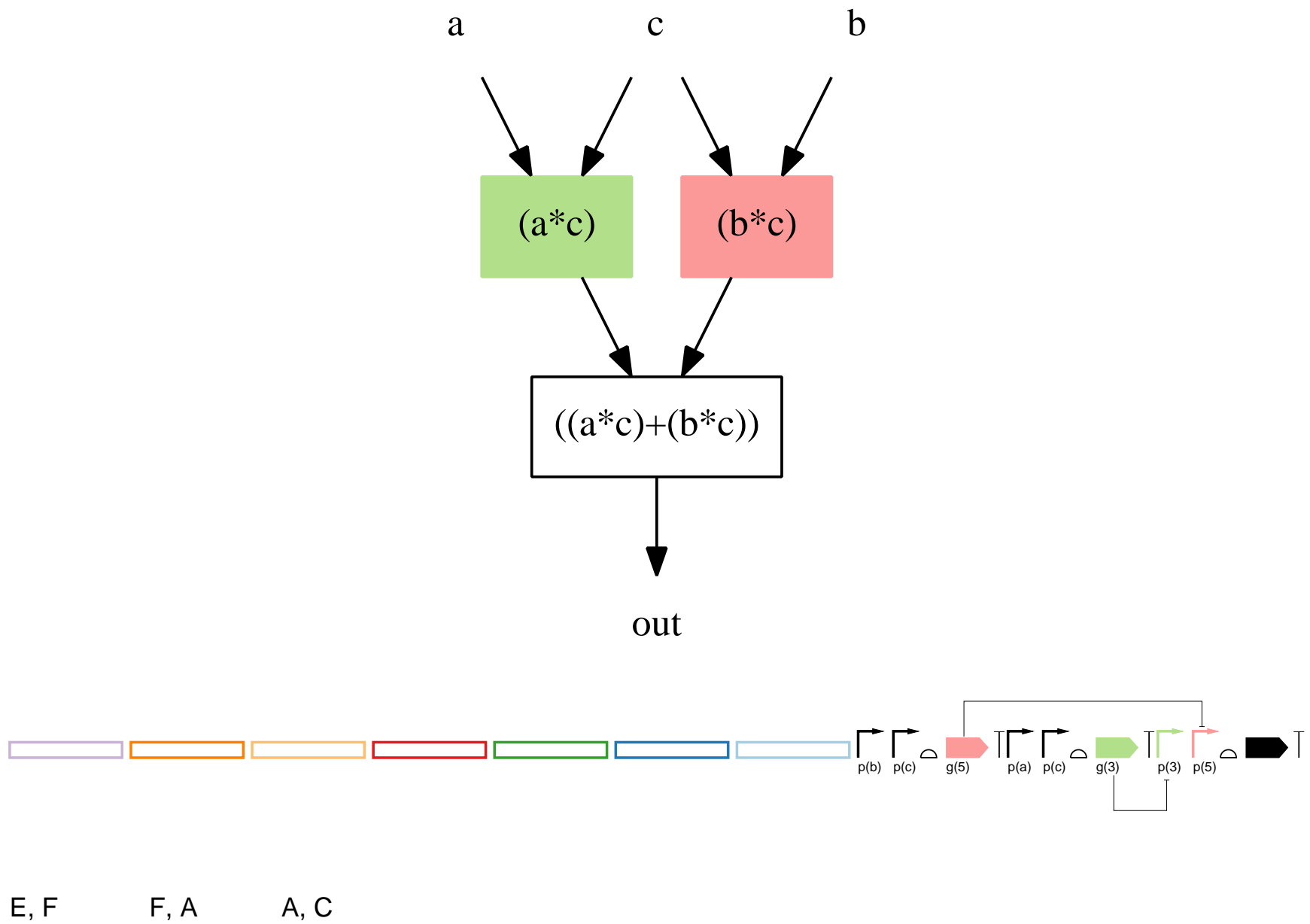


Figure 89: Circuit with truth table 0xA8.

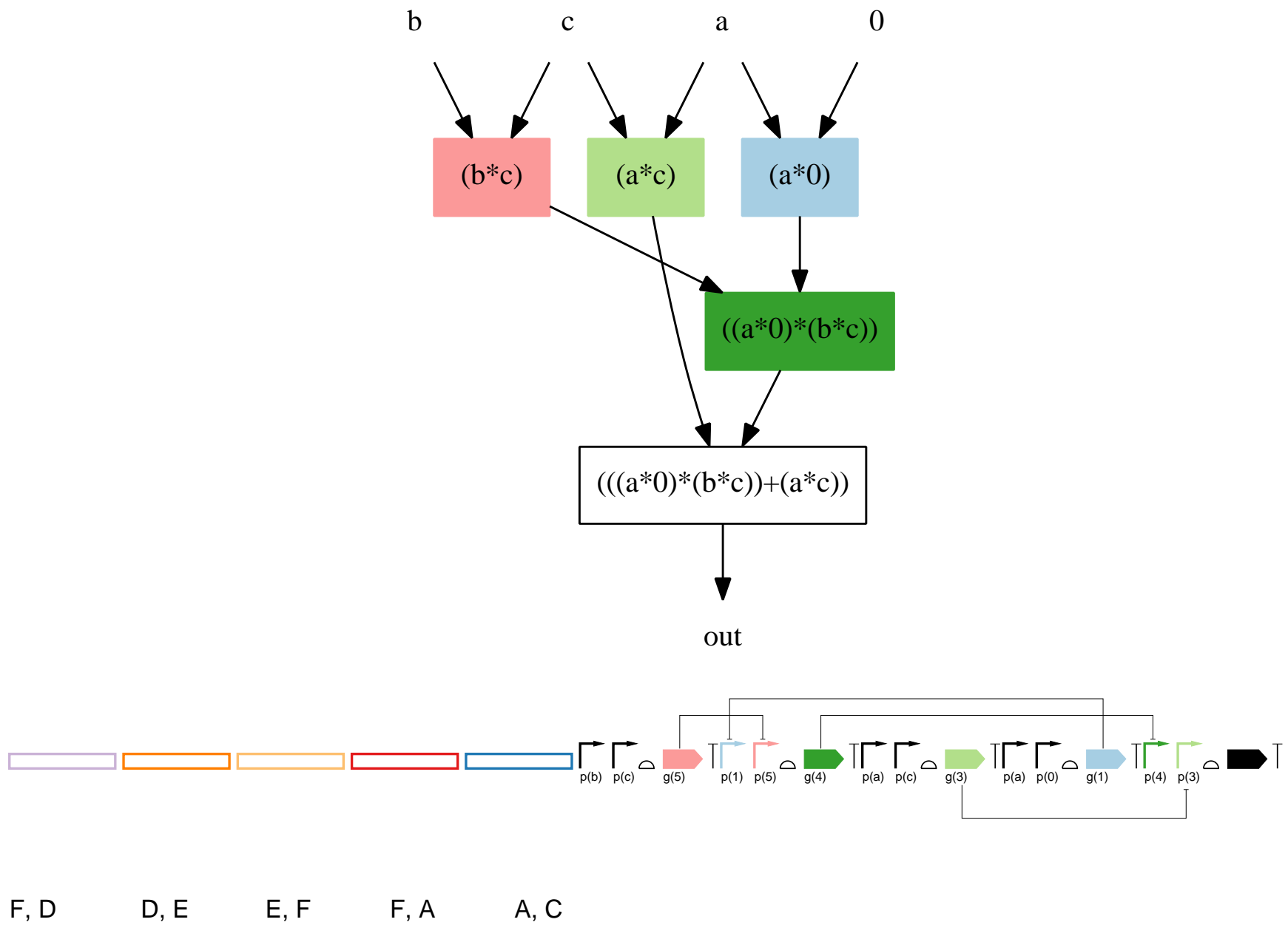


Figure 90: Circuit with truth table 0xA7.

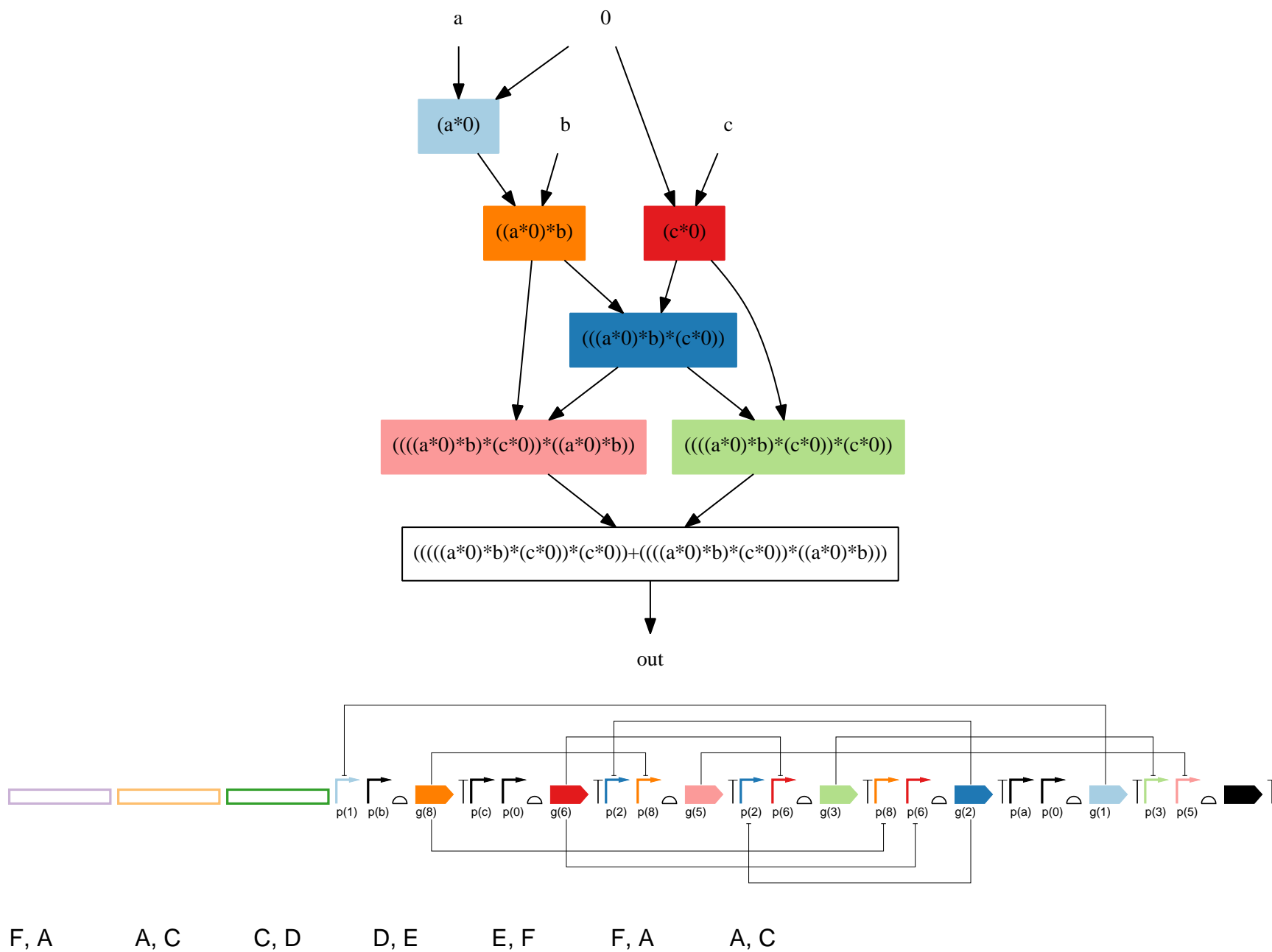


Figure 91: Circuit with truth table 0xA6.

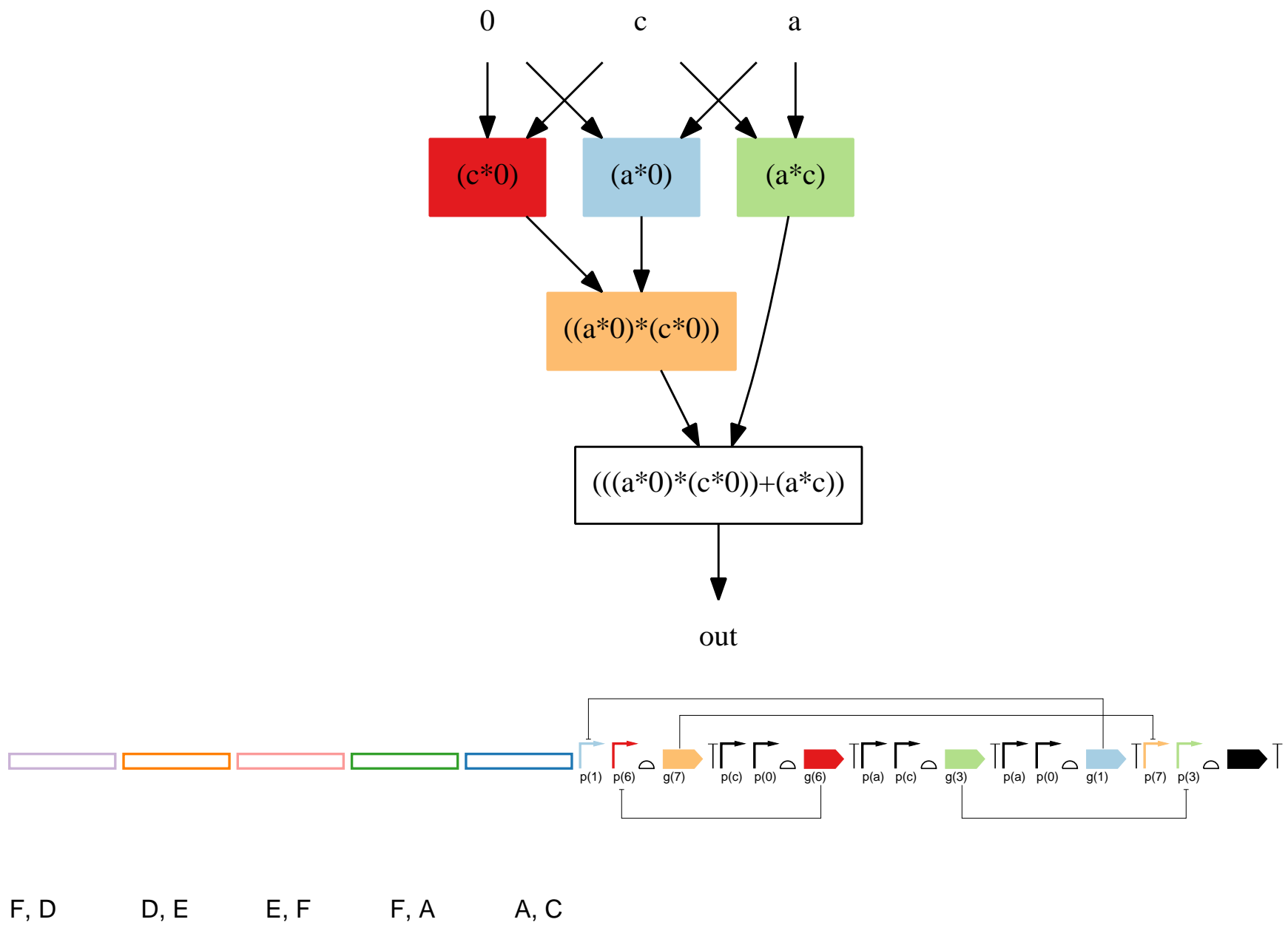
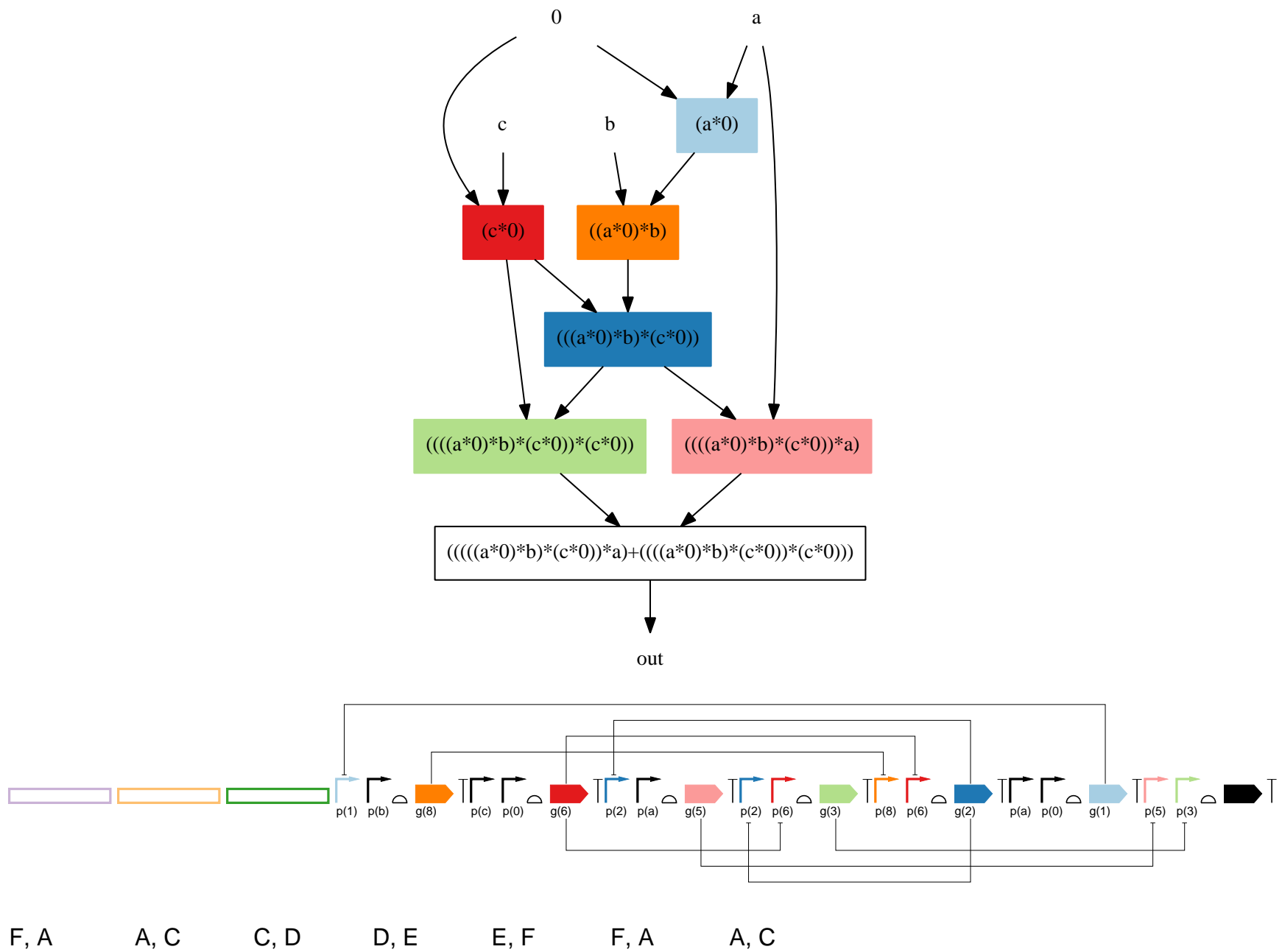


Figure 92: Circuit with truth table 0xA5.



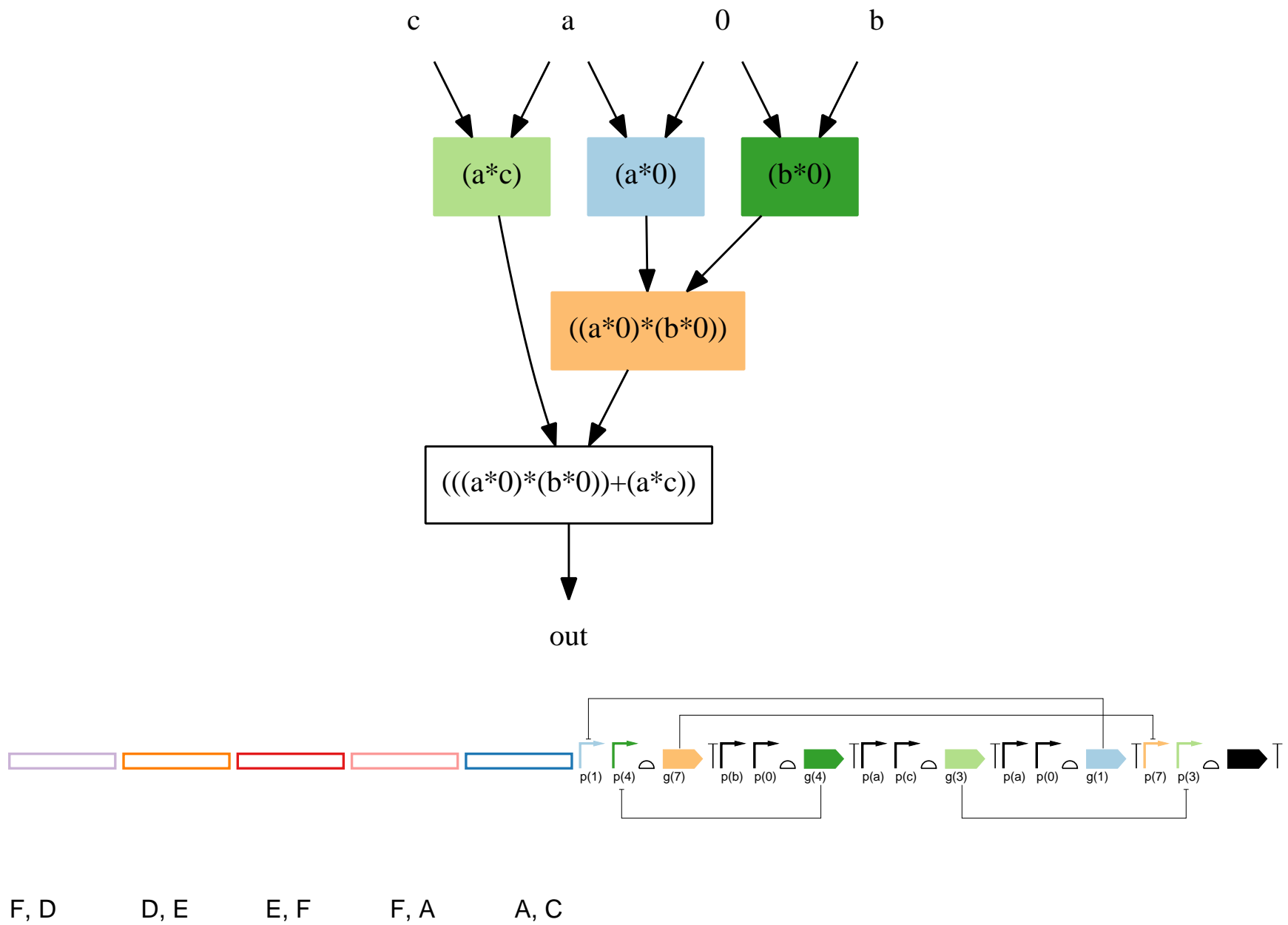


Figure 94: Circuit with truth table 0xA3.

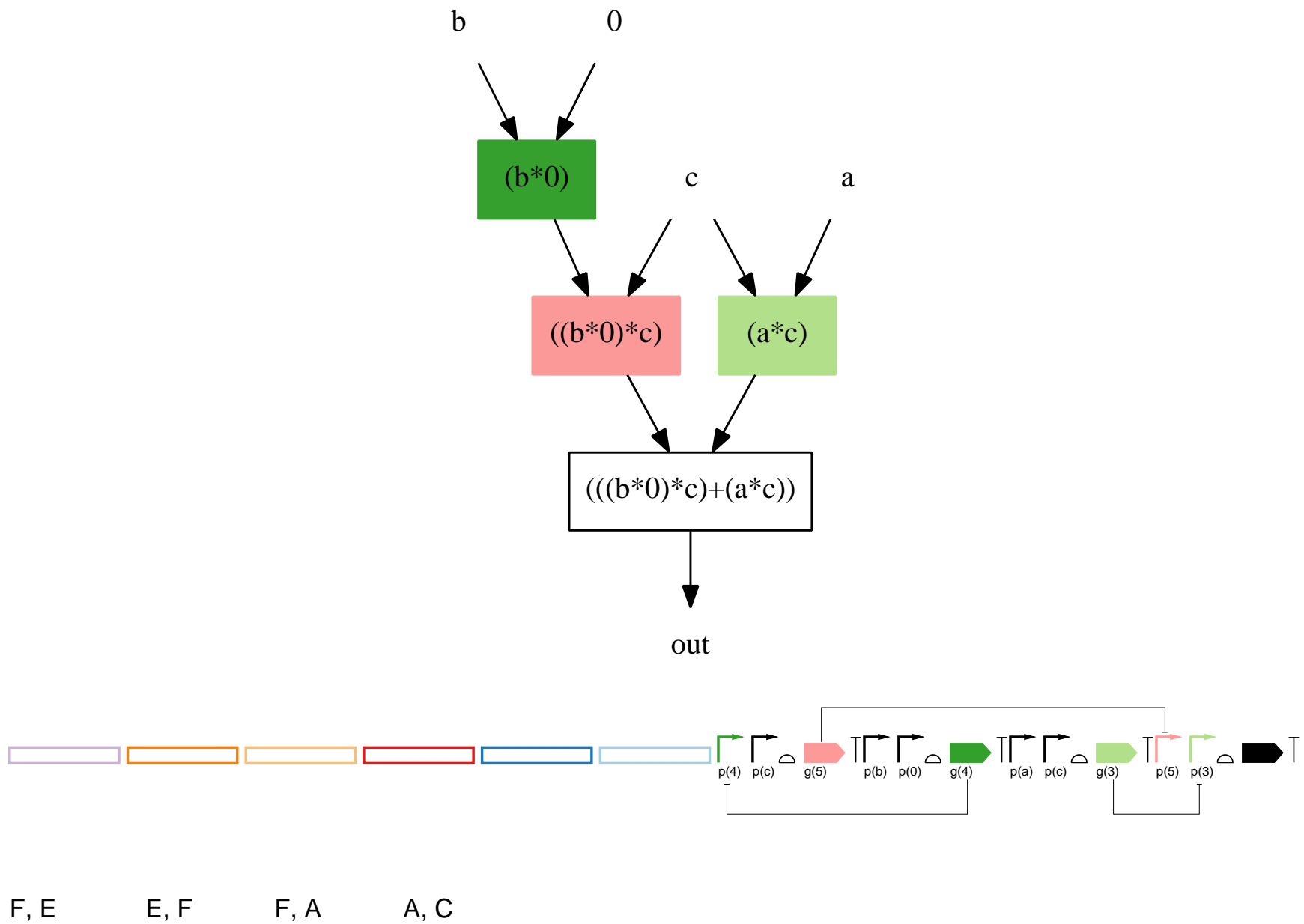


Figure 95: Circuit with truth table 0xA2.

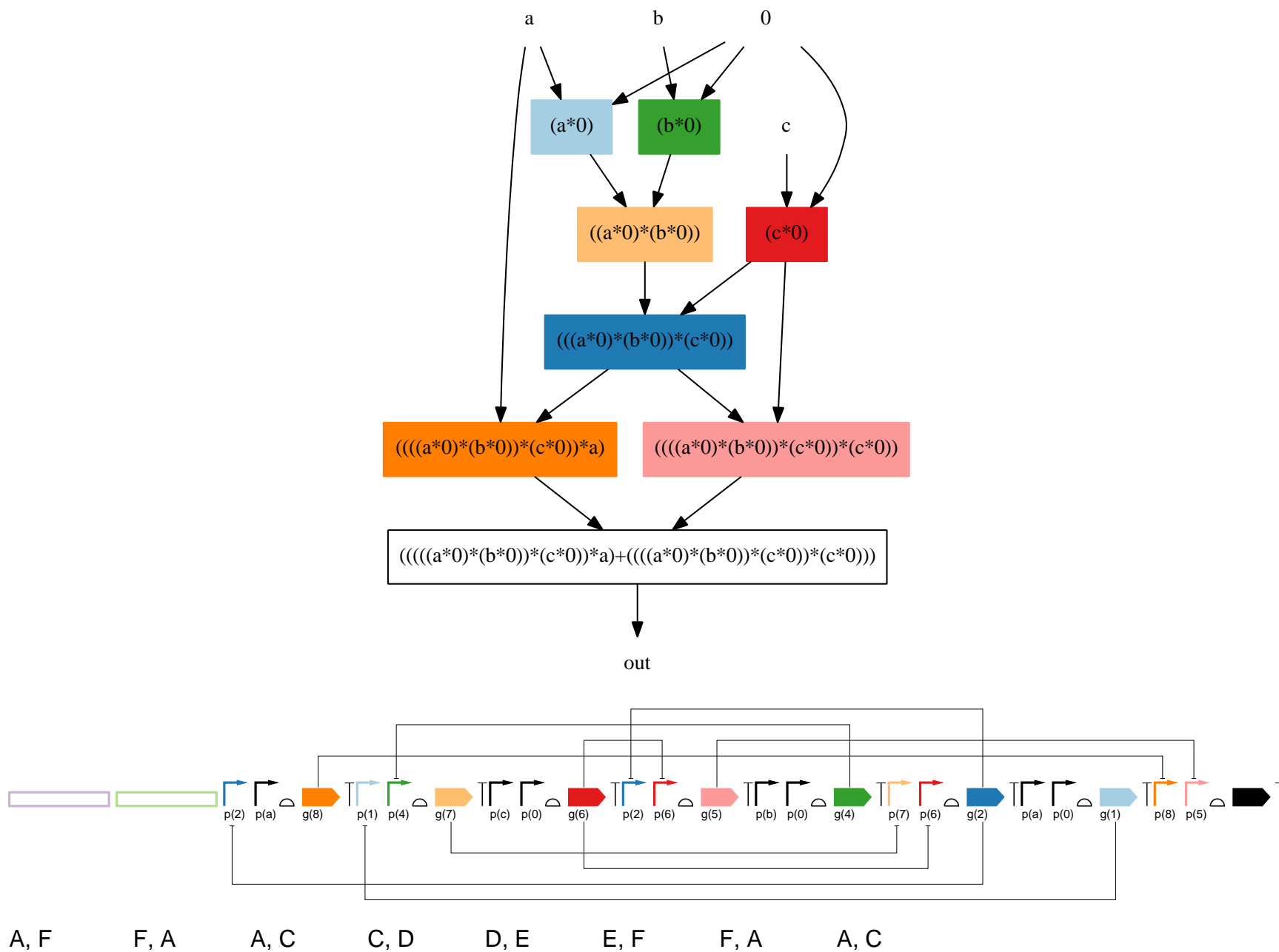
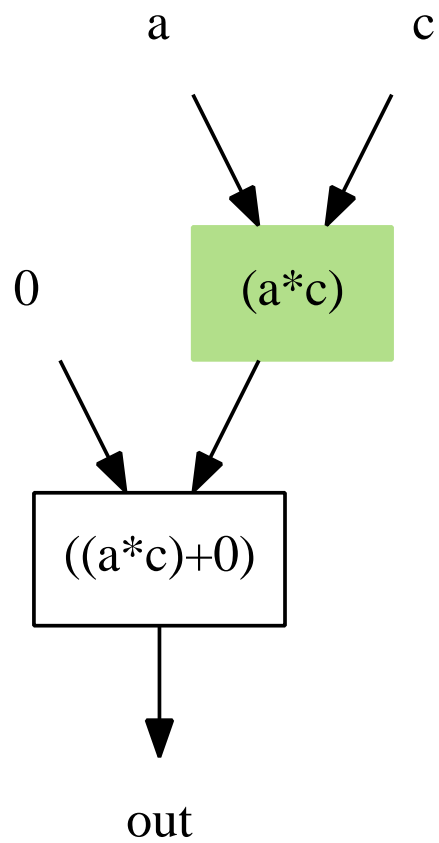


Figure 96: Circuit with truth table 0xA1.



E, A

A, C

Figure 97: Circuit with truth table 0xA0.

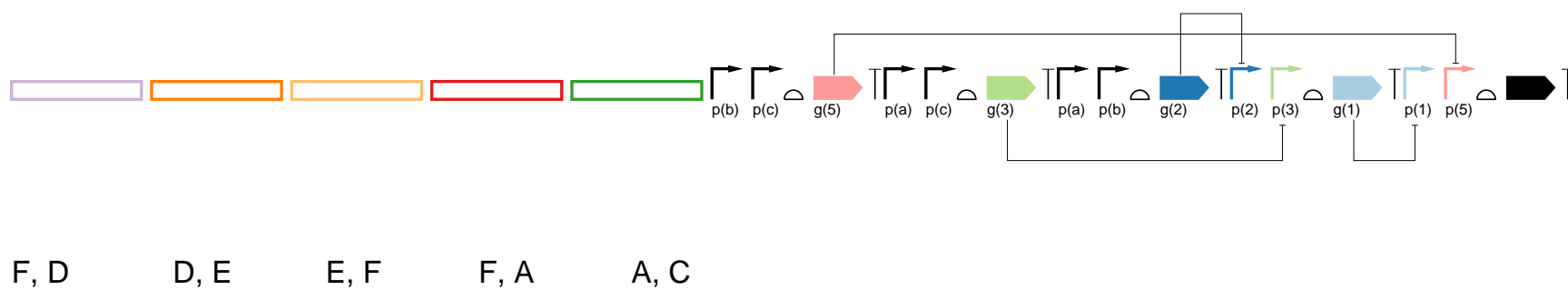
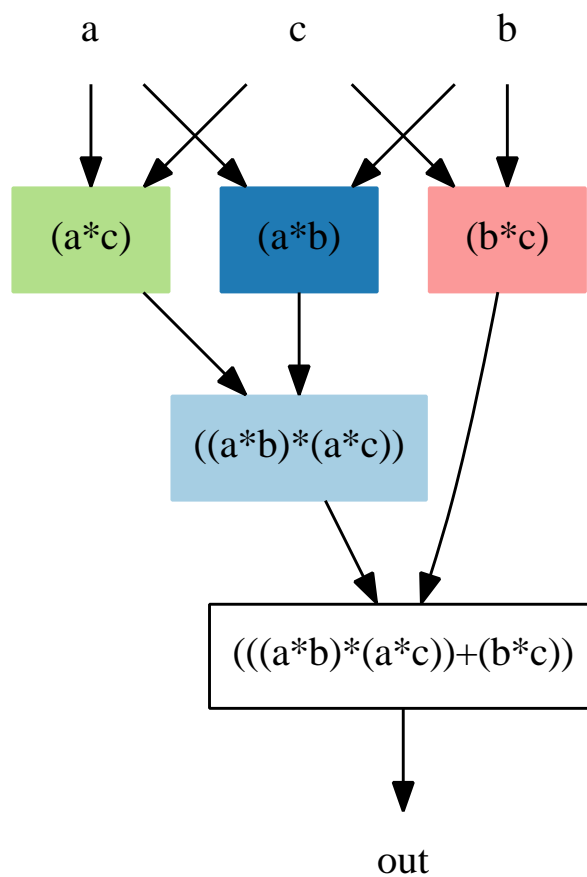


Figure 98: Circuit with truth table 0x9F.

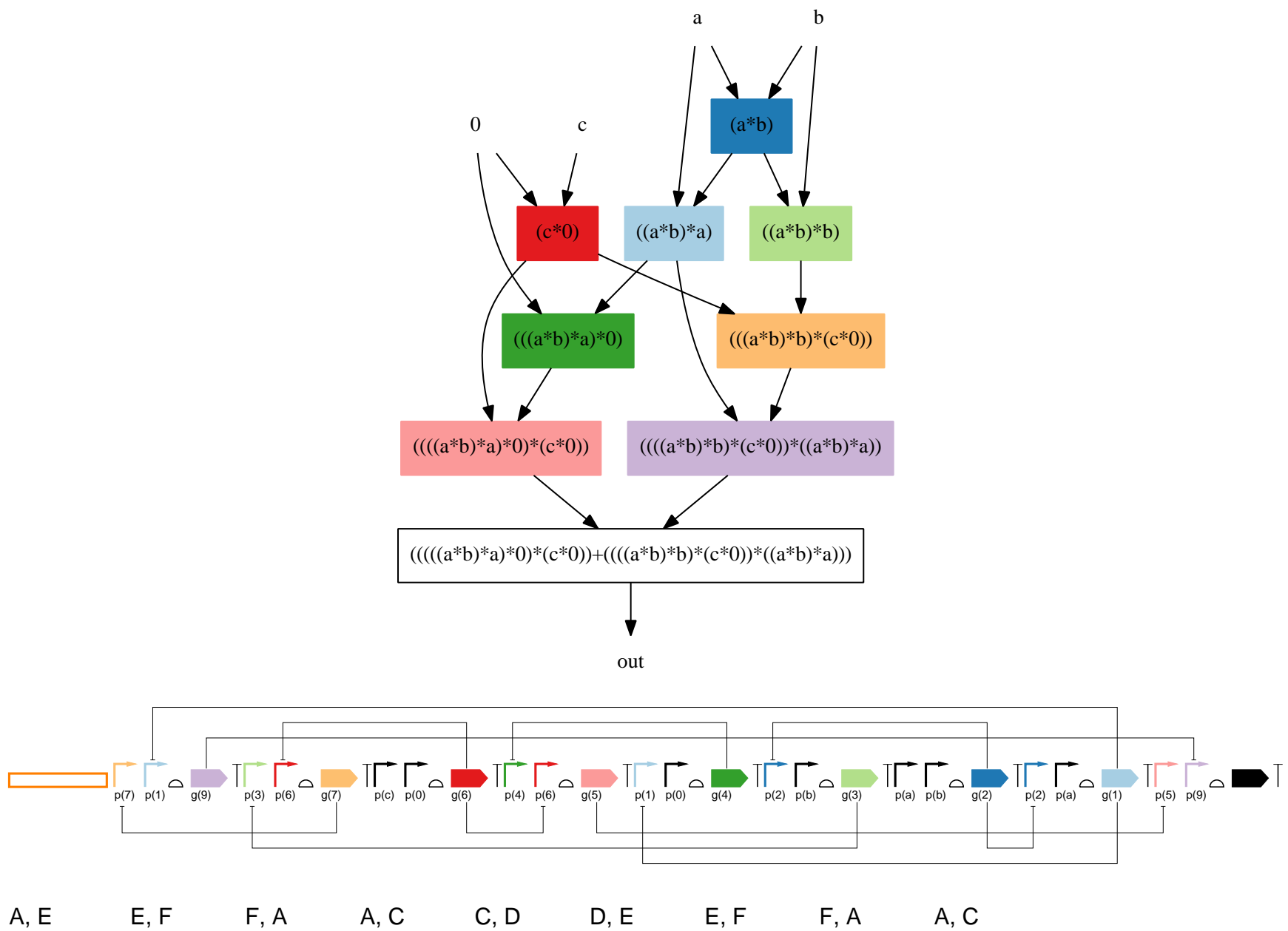
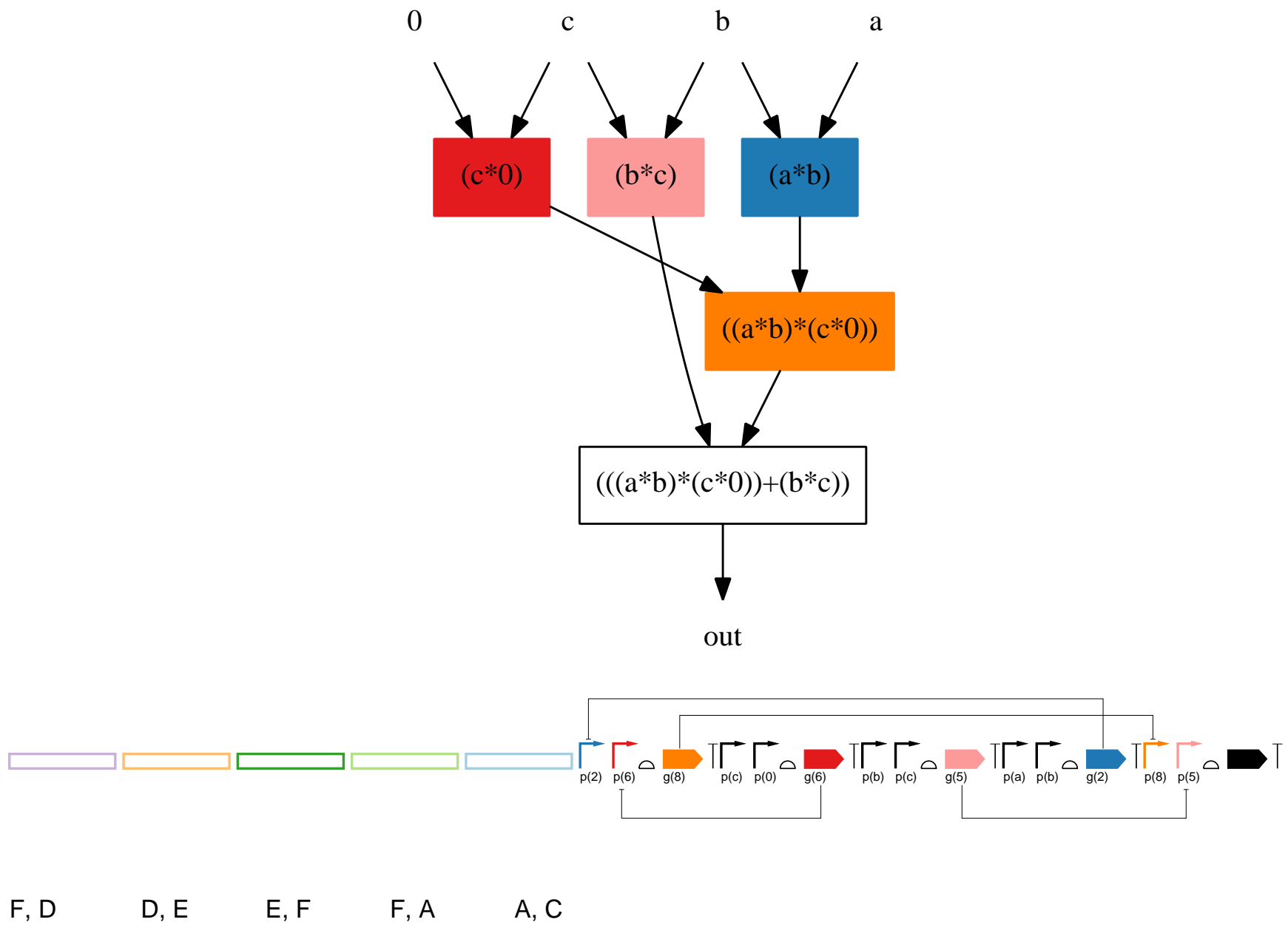


Figure 99: Circuit with truth table 0x9E.



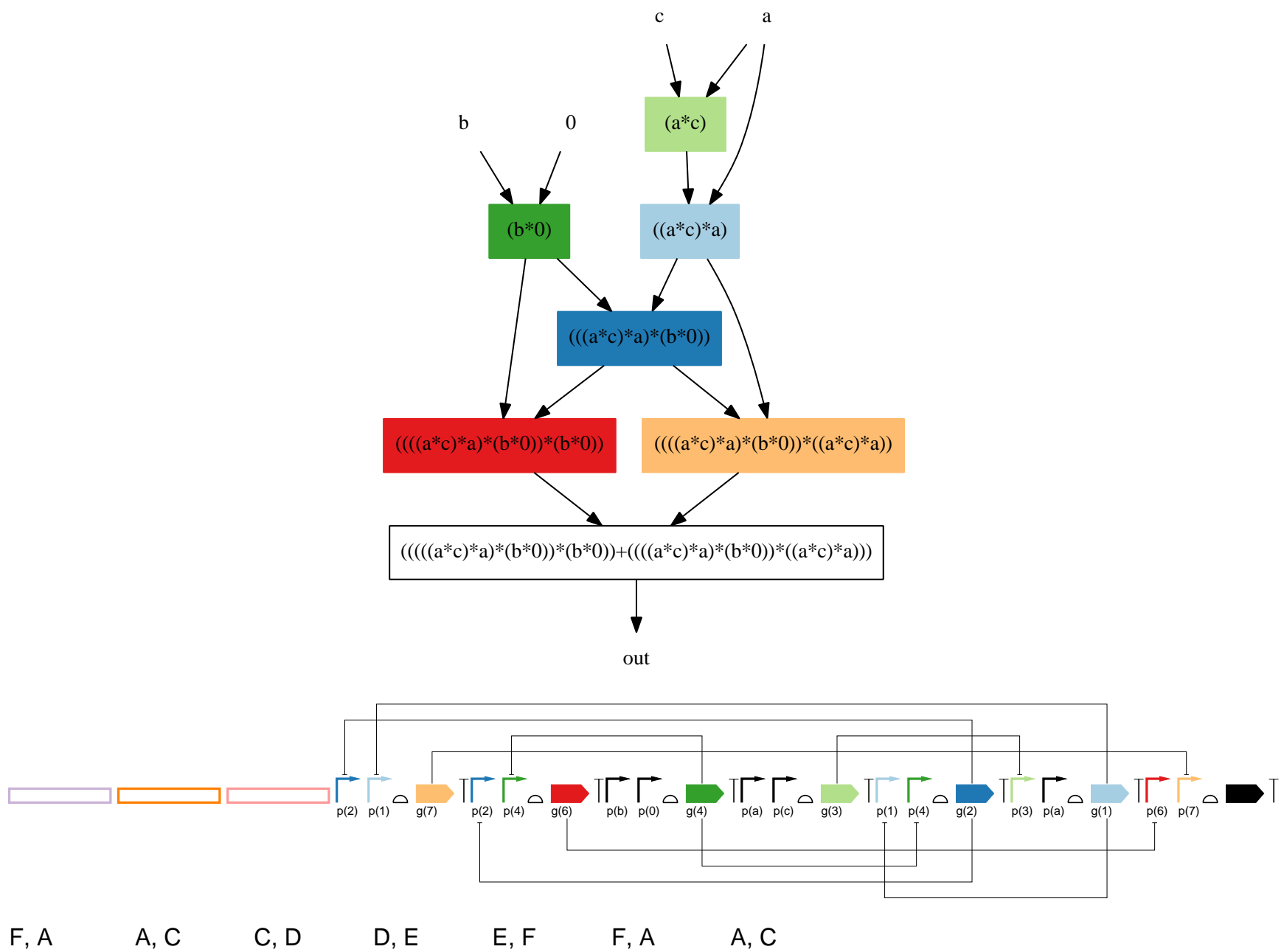


Figure 101: Circuit with truth table 0x9C.

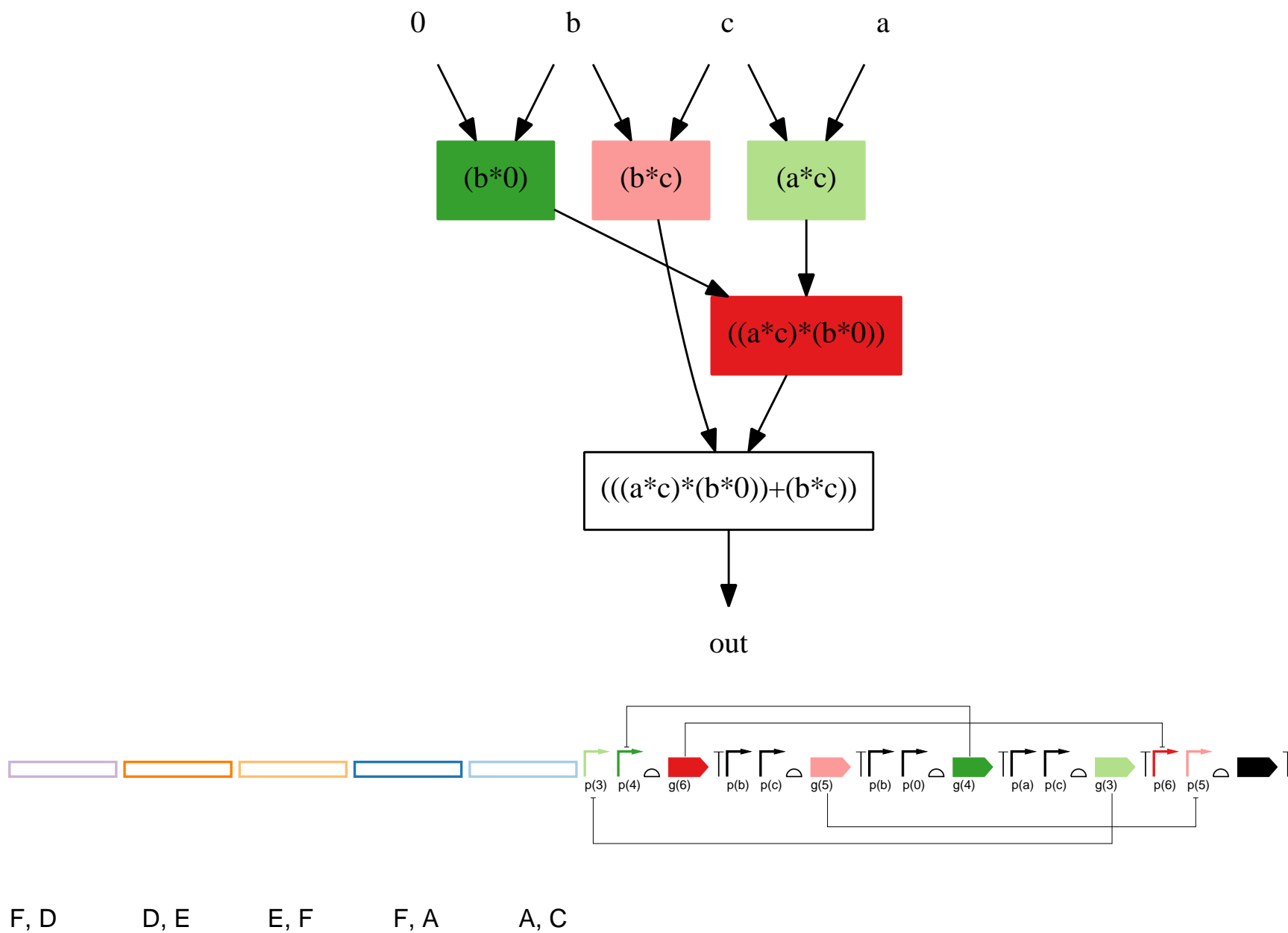


Figure 102: Circuit with truth table 0x9B.

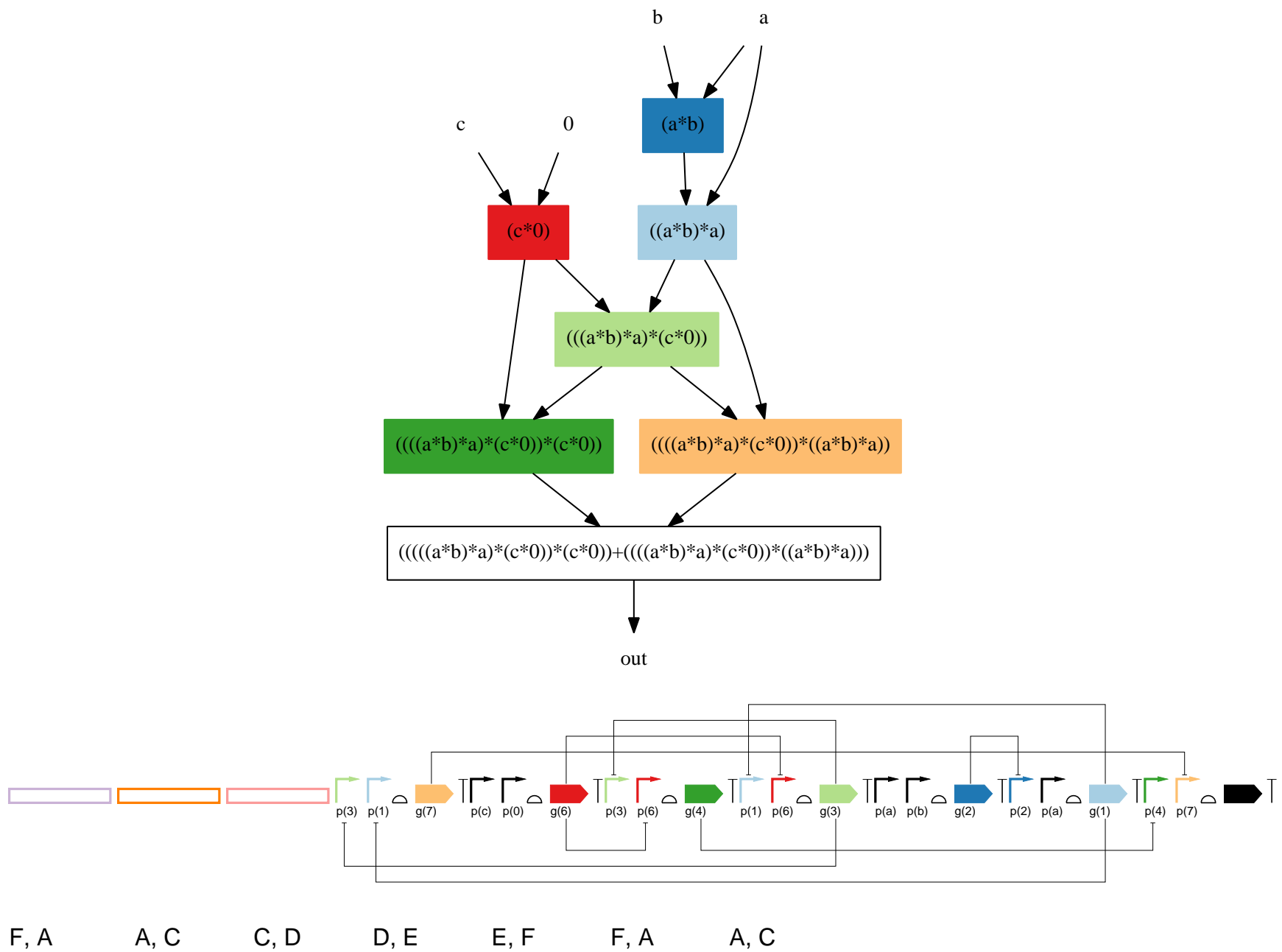


Figure 103: Circuit with truth table 0x9A.

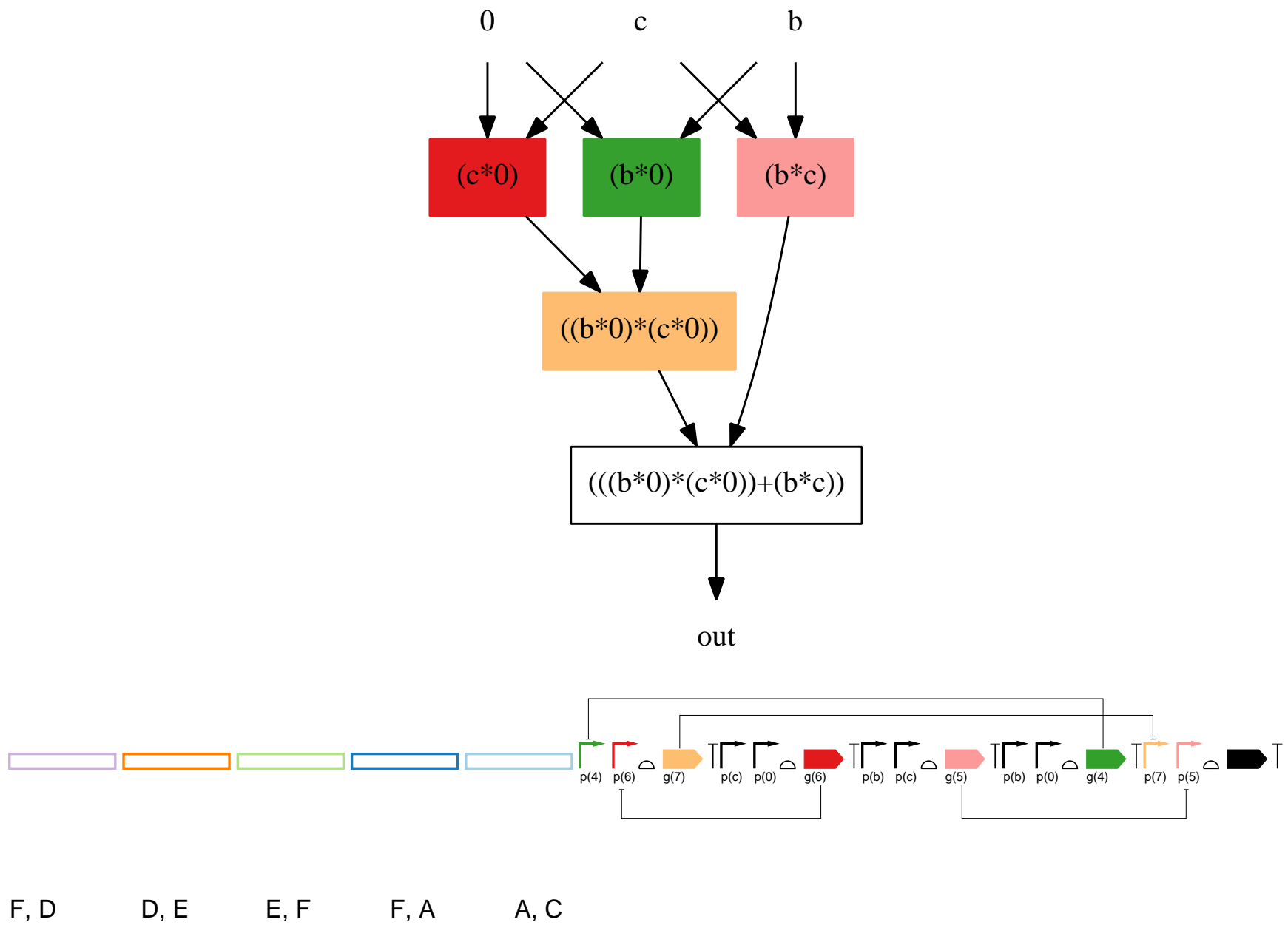


Figure 104: Circuit with truth table 0x99.

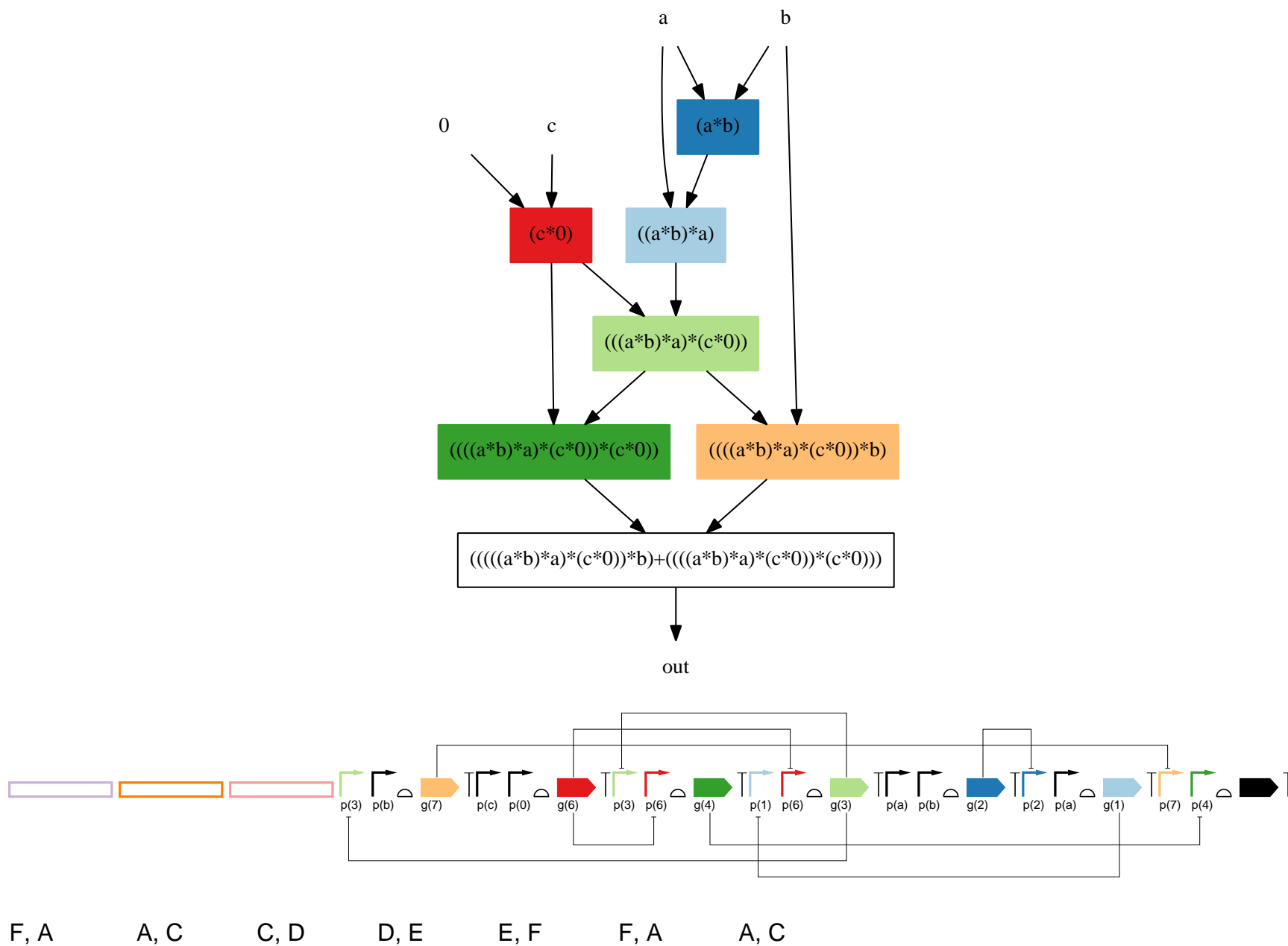


Figure 105: Circuit with truth table 0x98.

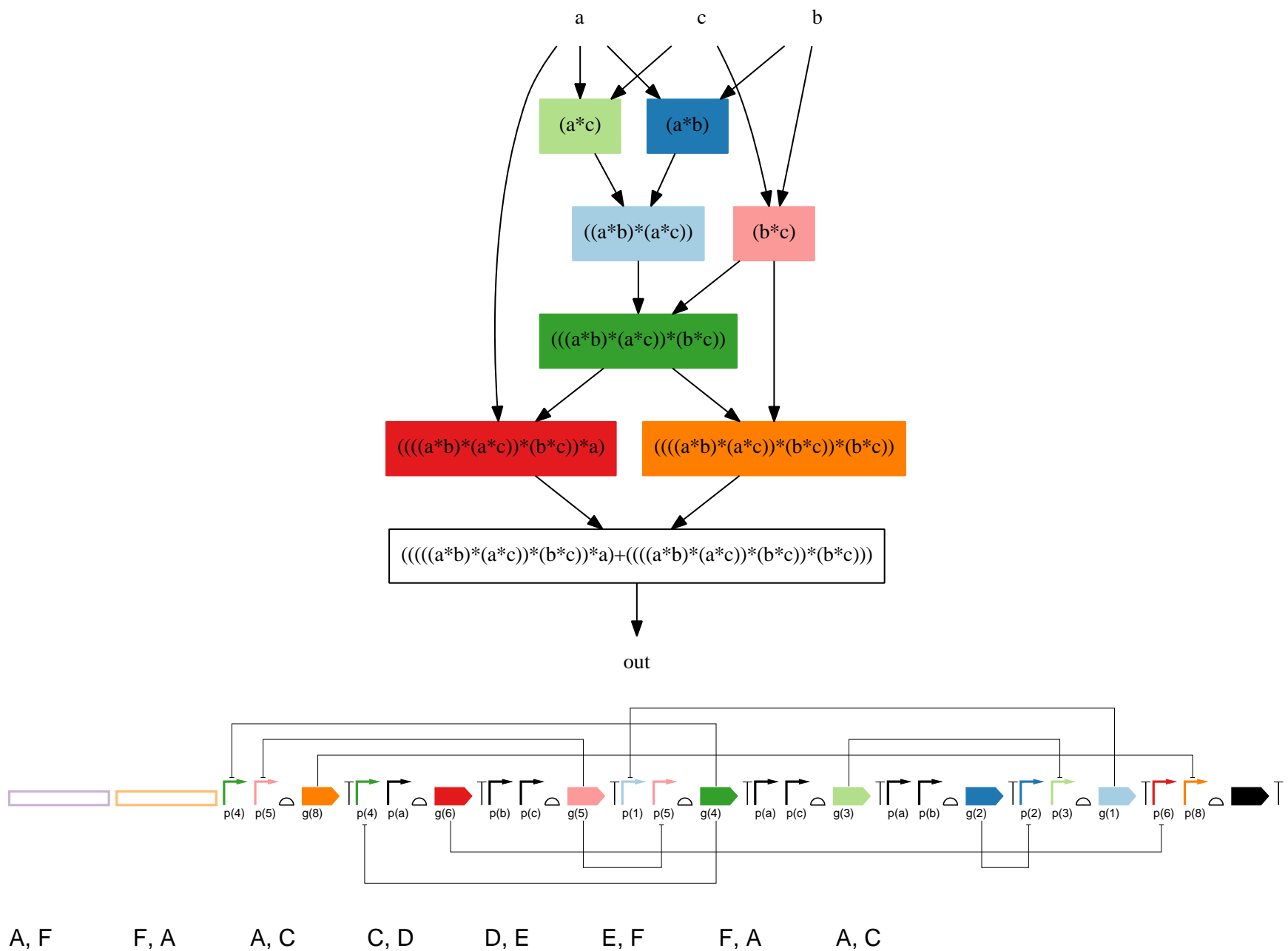


Figure 106: Circuit with truth table 0x97.

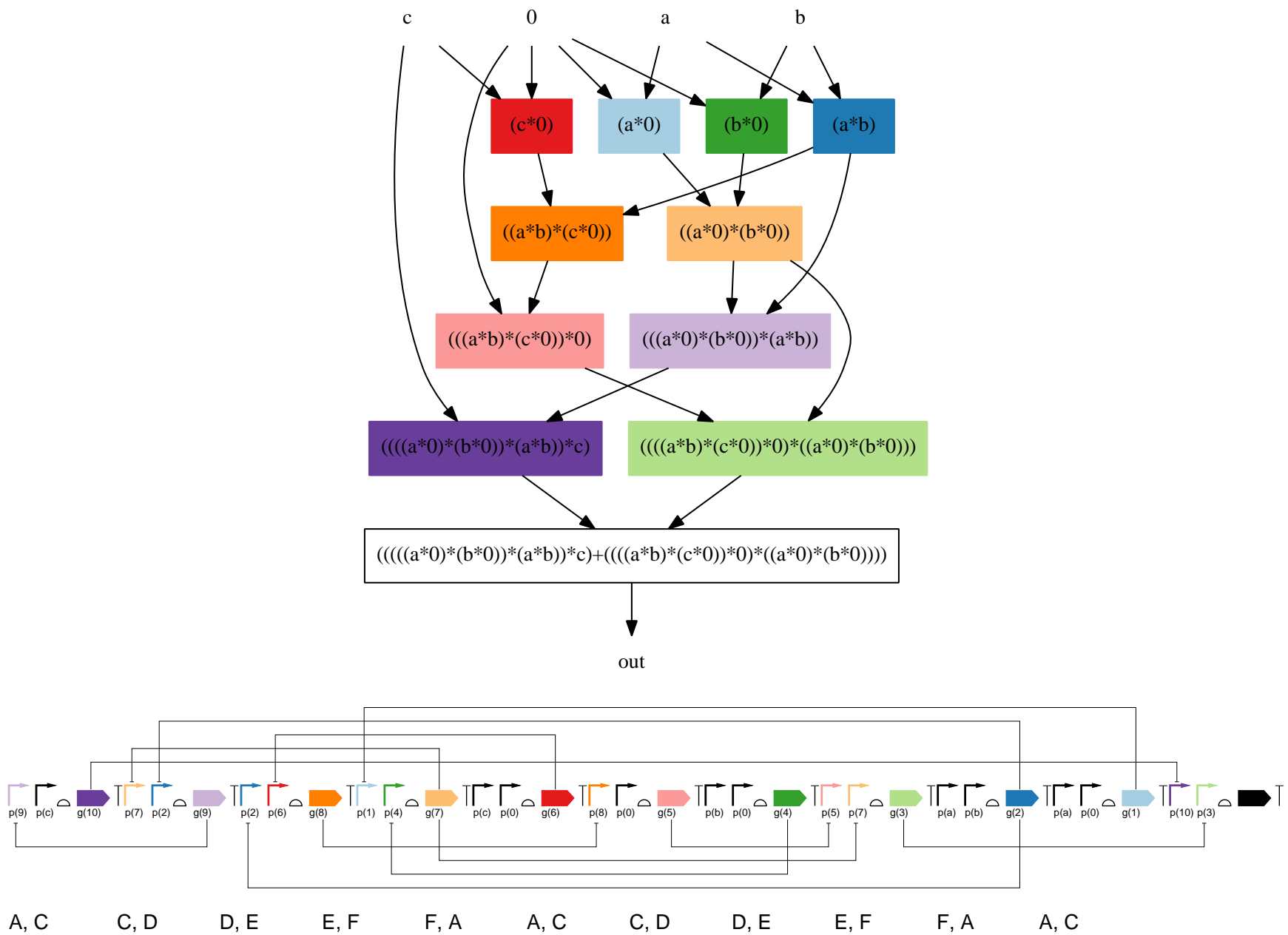


Figure 107: Circuit with truth table 0x96.

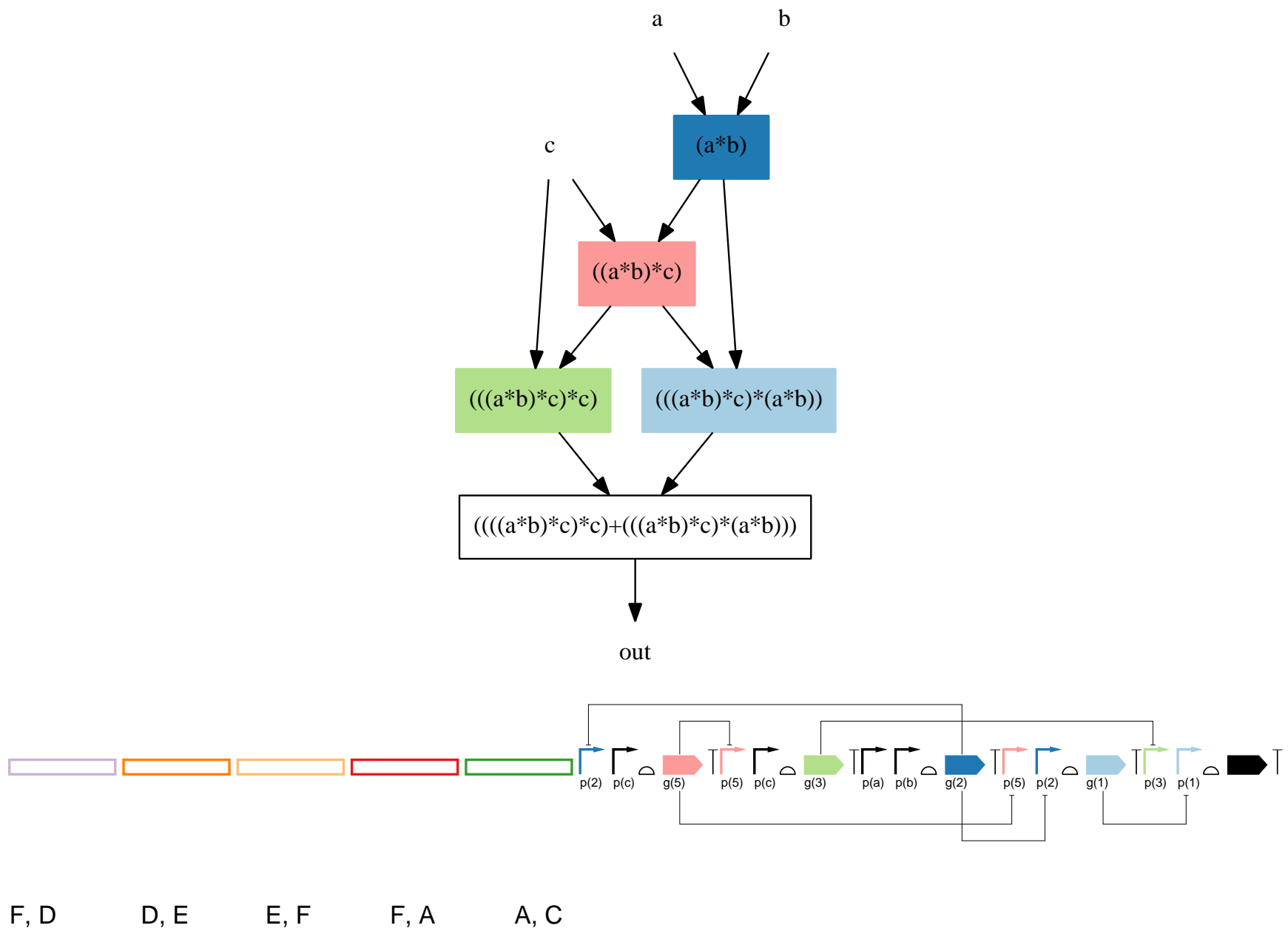


Figure 108: Circuit with truth table 0x95.

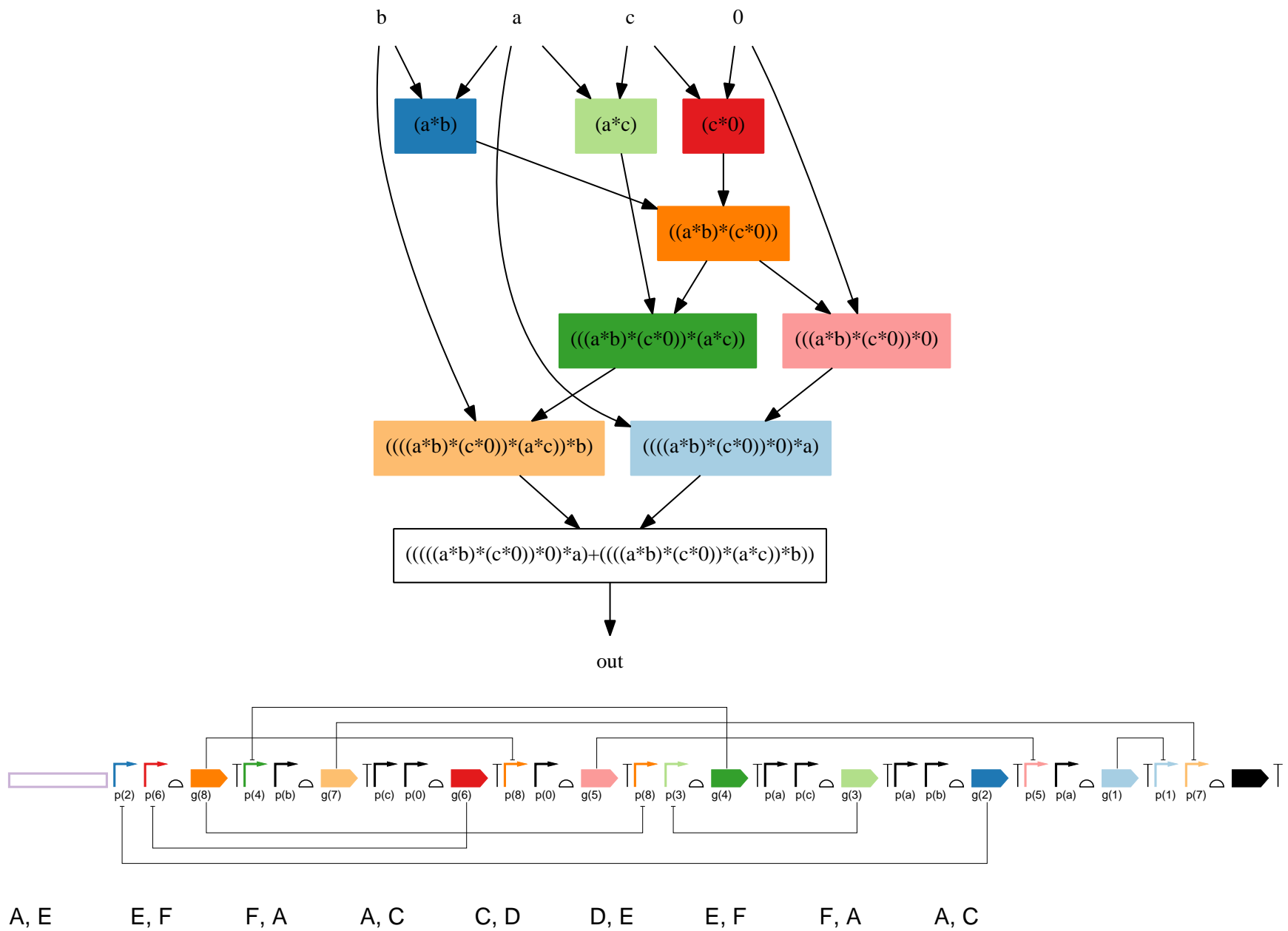


Figure 109: Circuit with truth table 0x94.

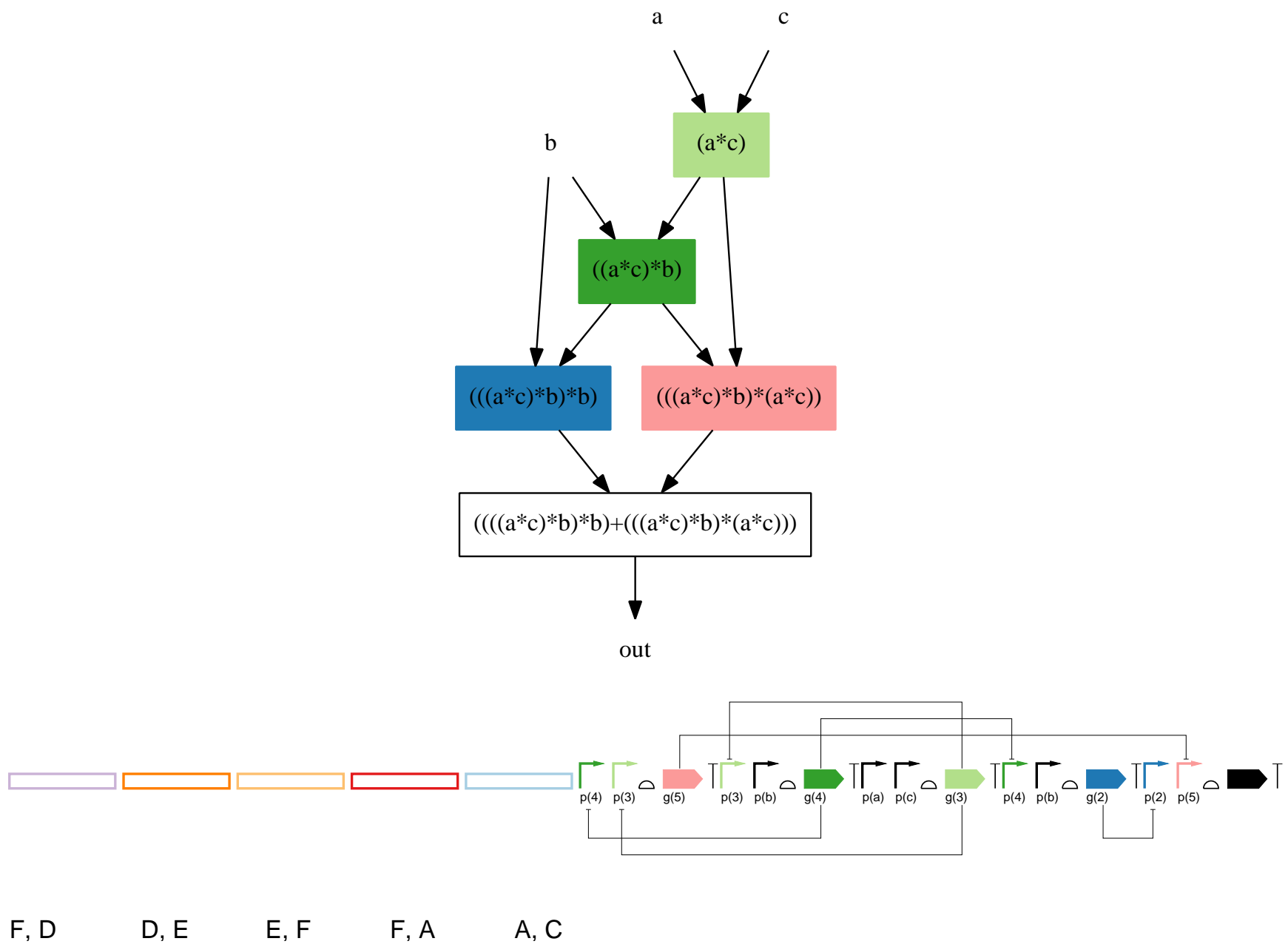


Figure 110: Circuit with truth table 0x93.

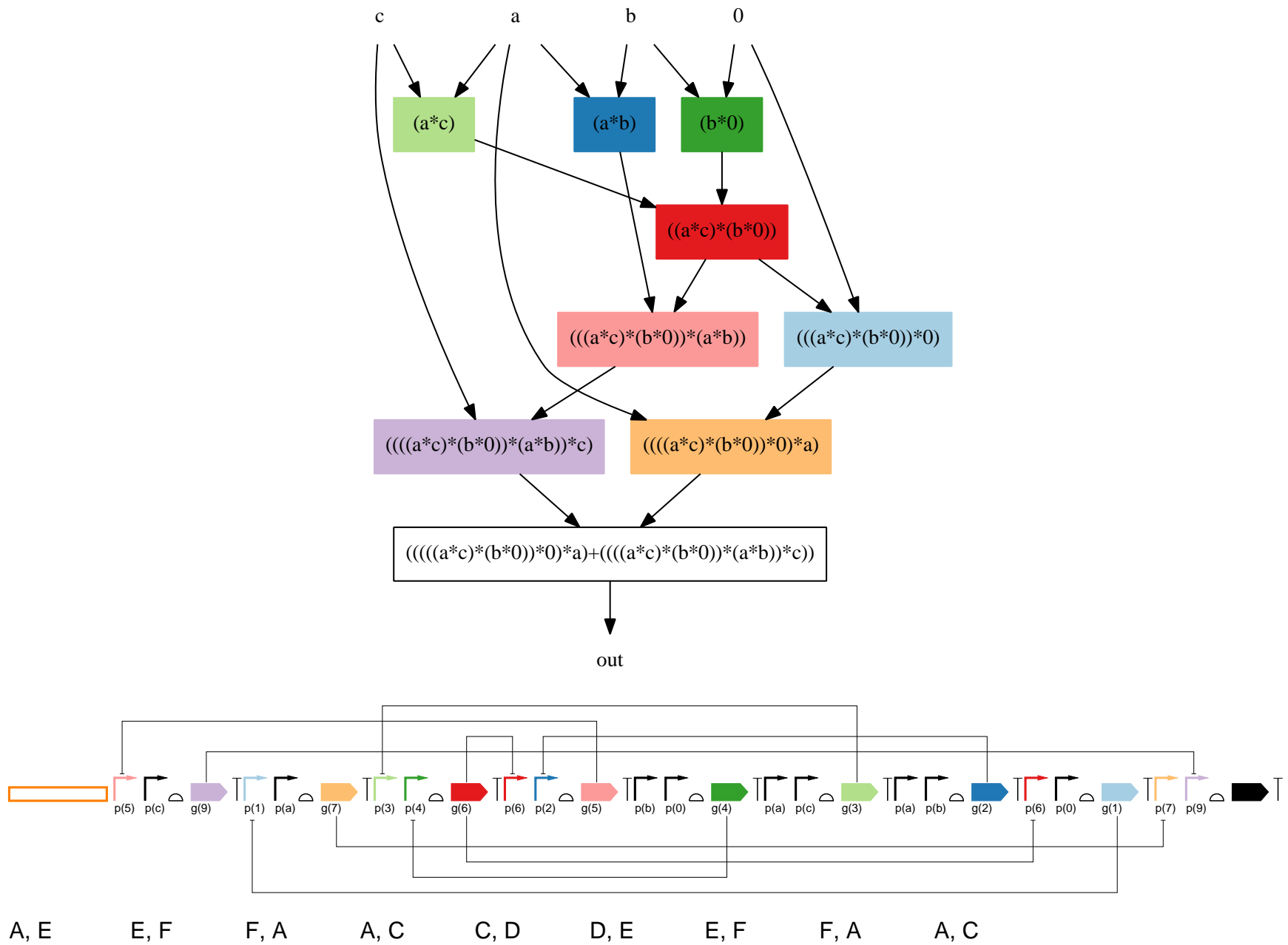


Figure 111: Circuit with truth table 0x92.

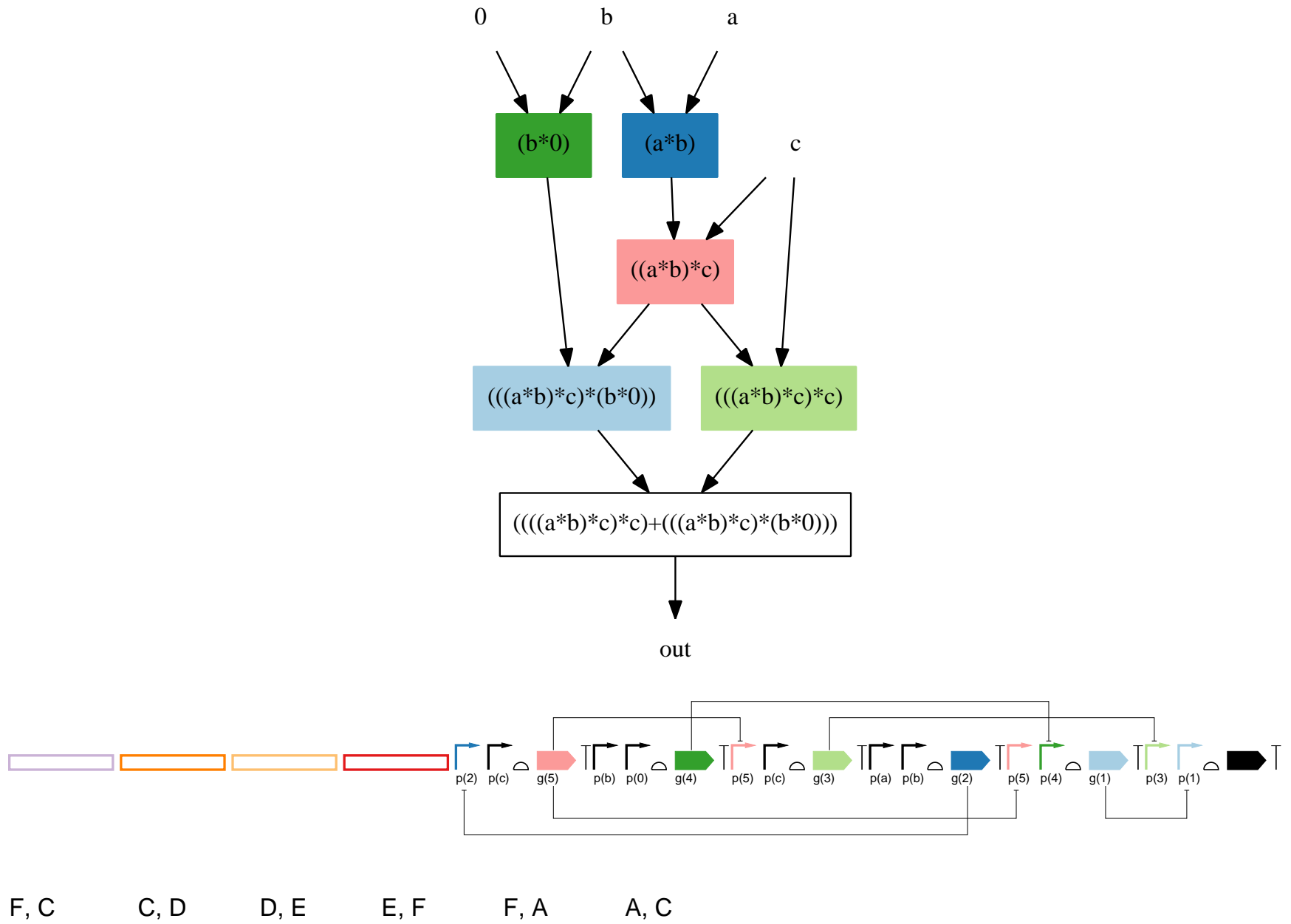


Figure 112: Circuit with truth table 0x91.

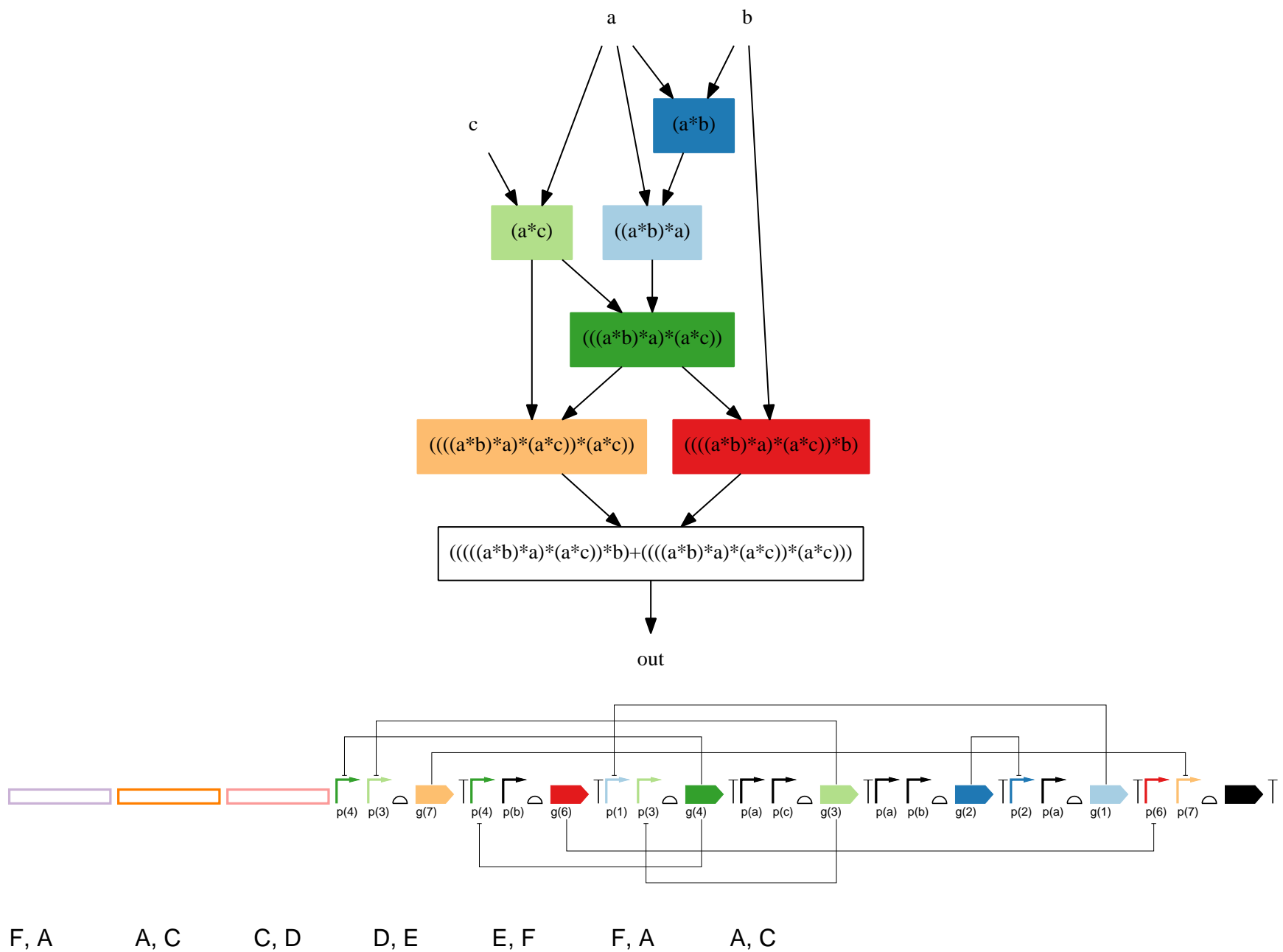
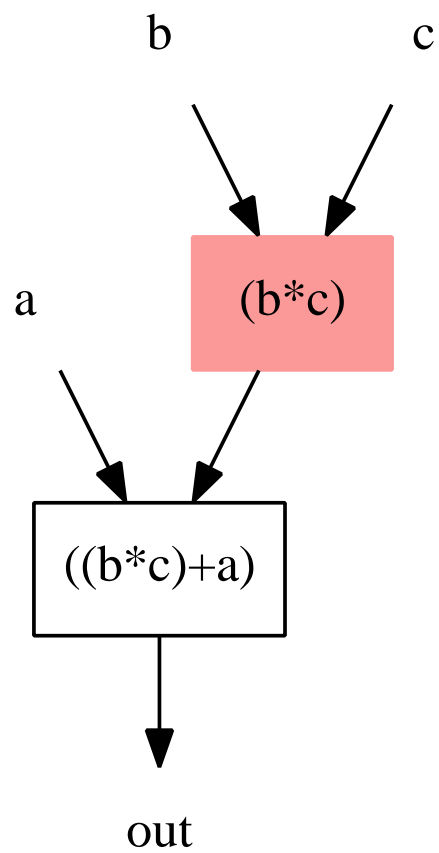


Figure 113: Circuit with truth table 0x90.



E, A

A, C

Figure 114: Circuit with truth table 0x8F.

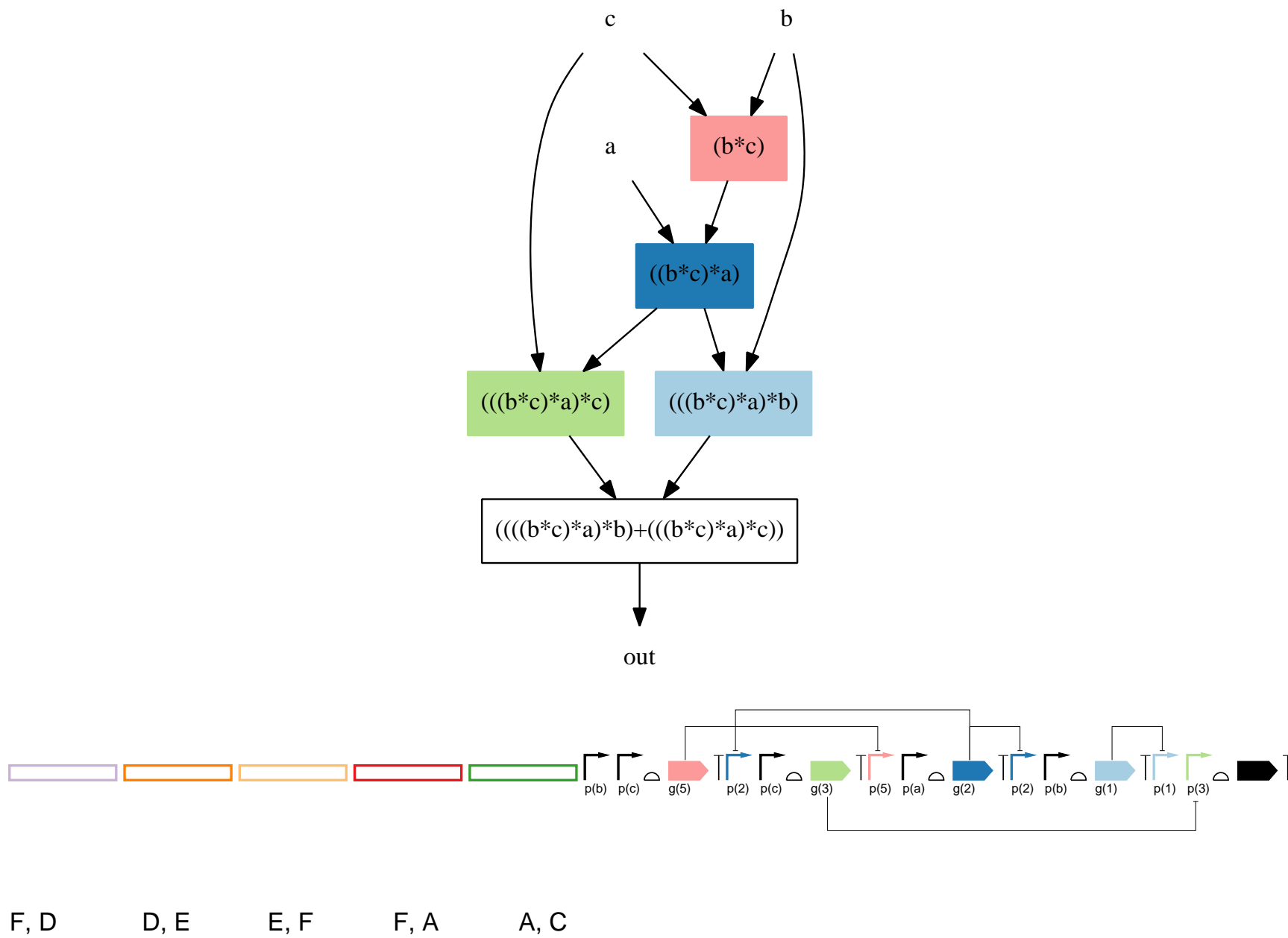


Figure 115: Circuit with truth table 0x8E.

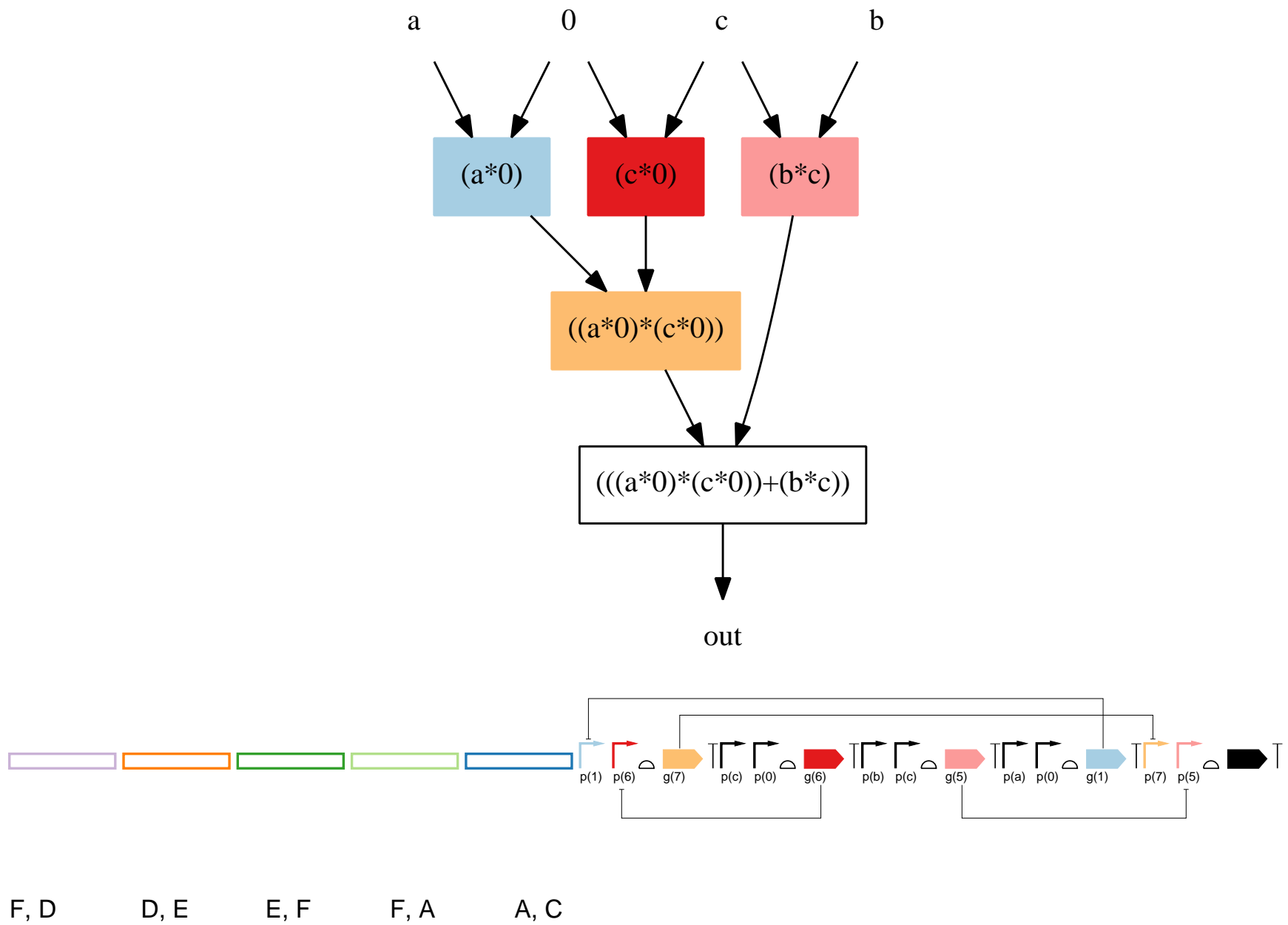


Figure 116: Circuit with truth table 0x8D.

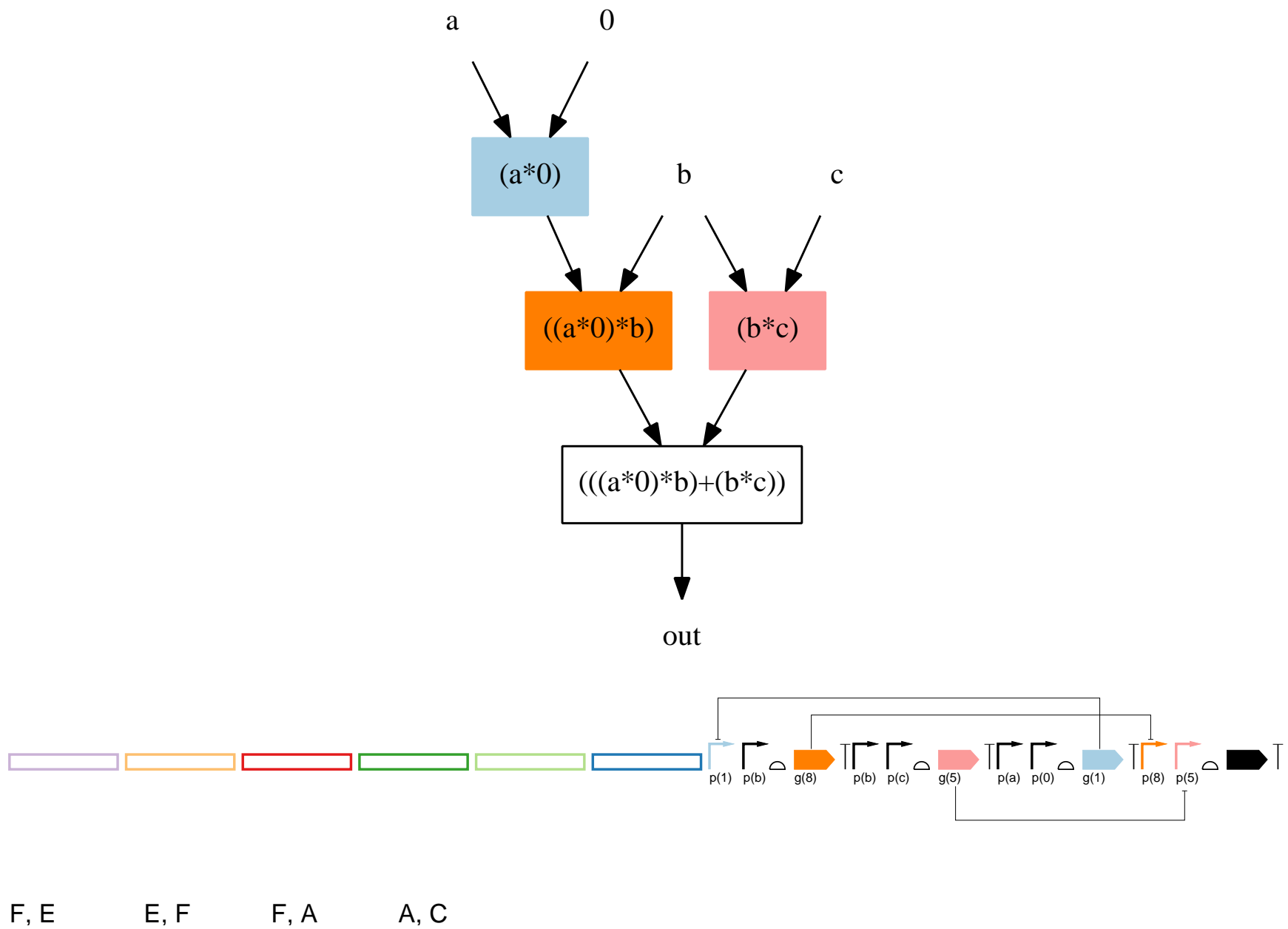


Figure 117: Circuit with truth table 0x8C.

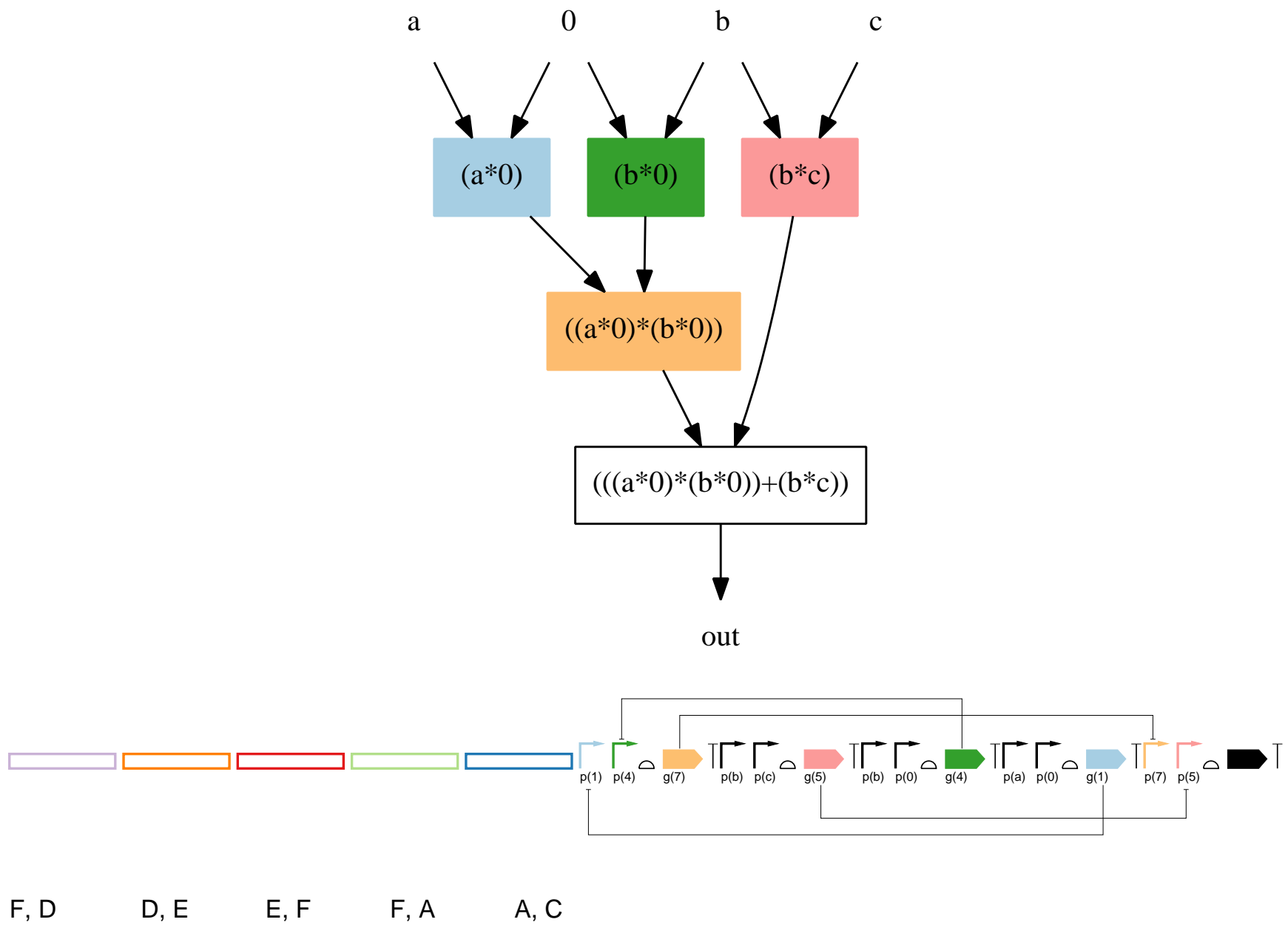


Figure 118: Circuit with truth table 0x8B.

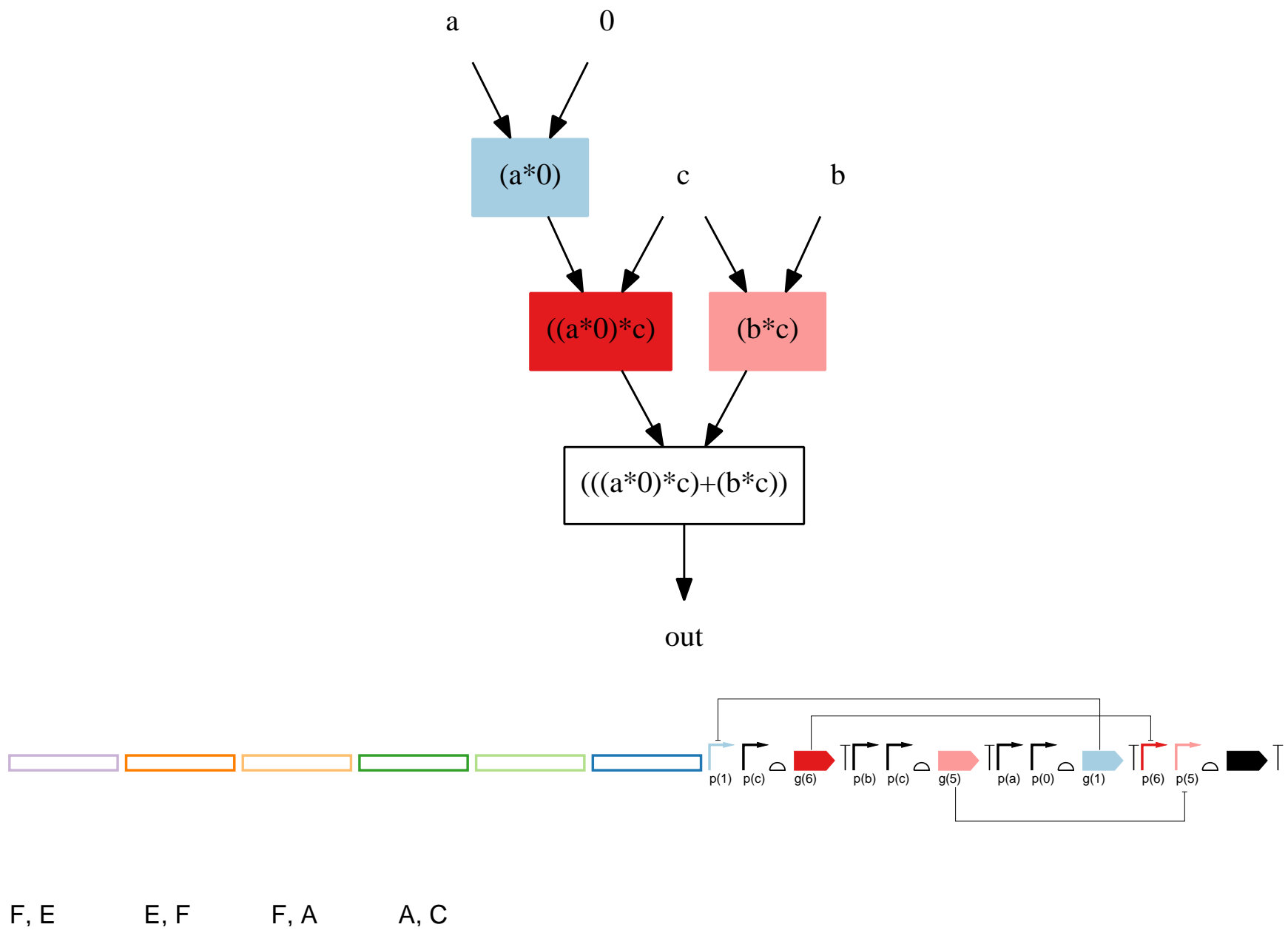


Figure 119: Circuit with truth table 0x8A.

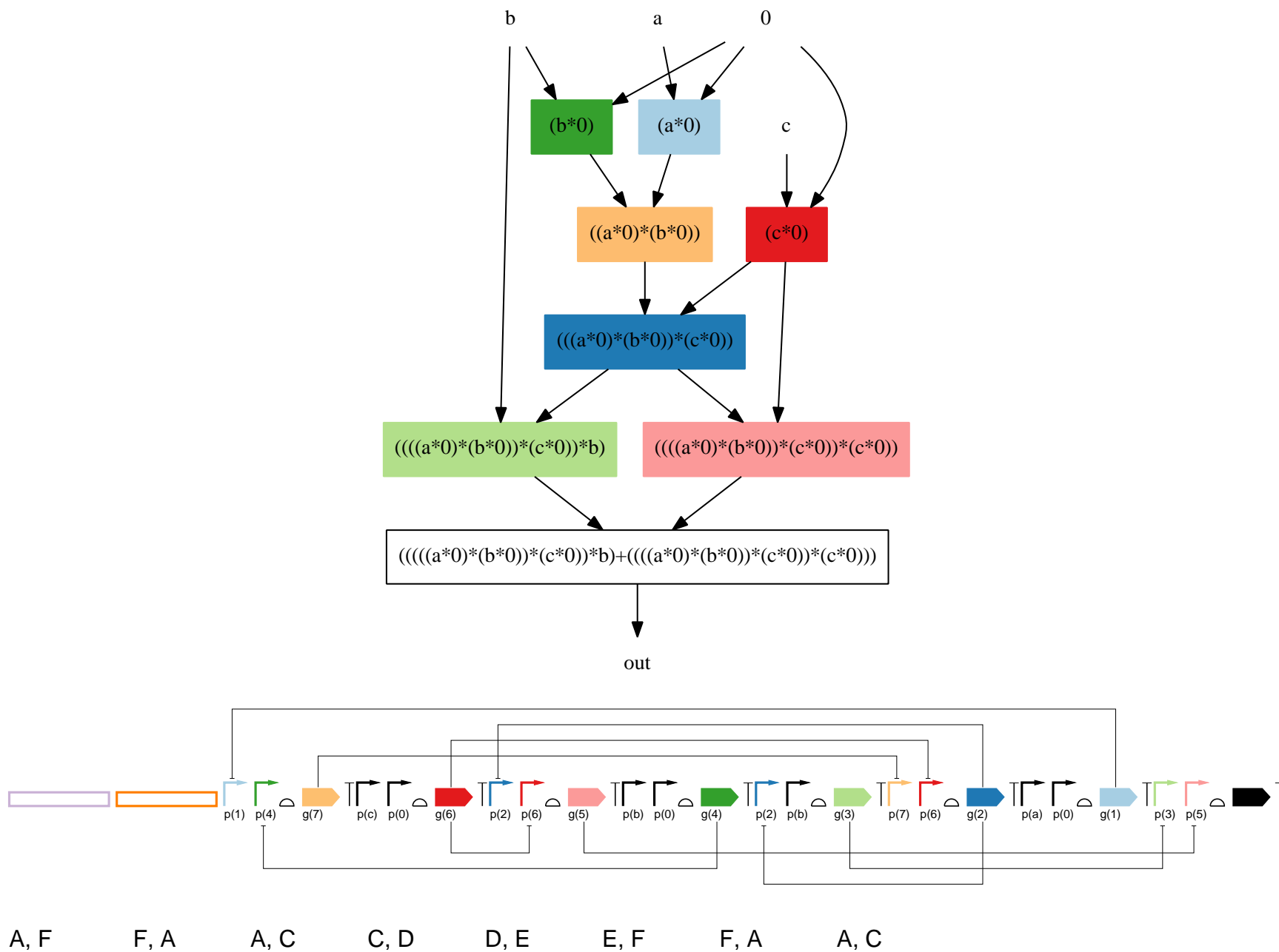
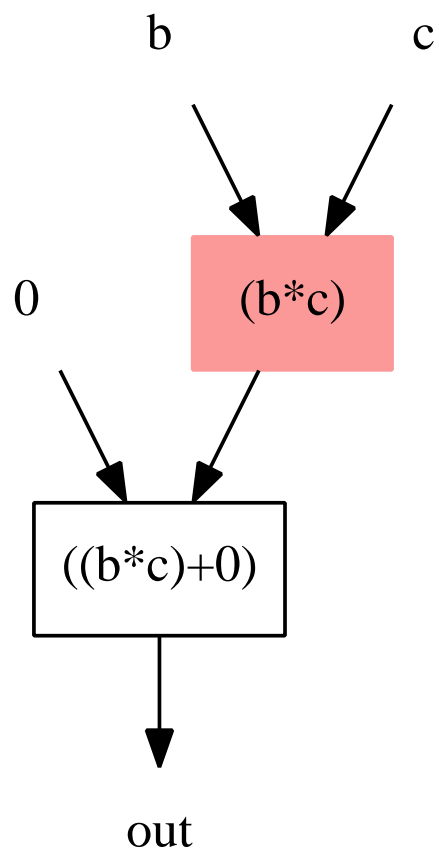


Figure 120: Circuit with truth table 0x89.

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E, A

A, C

Figure 121: Circuit with truth table 0x88.

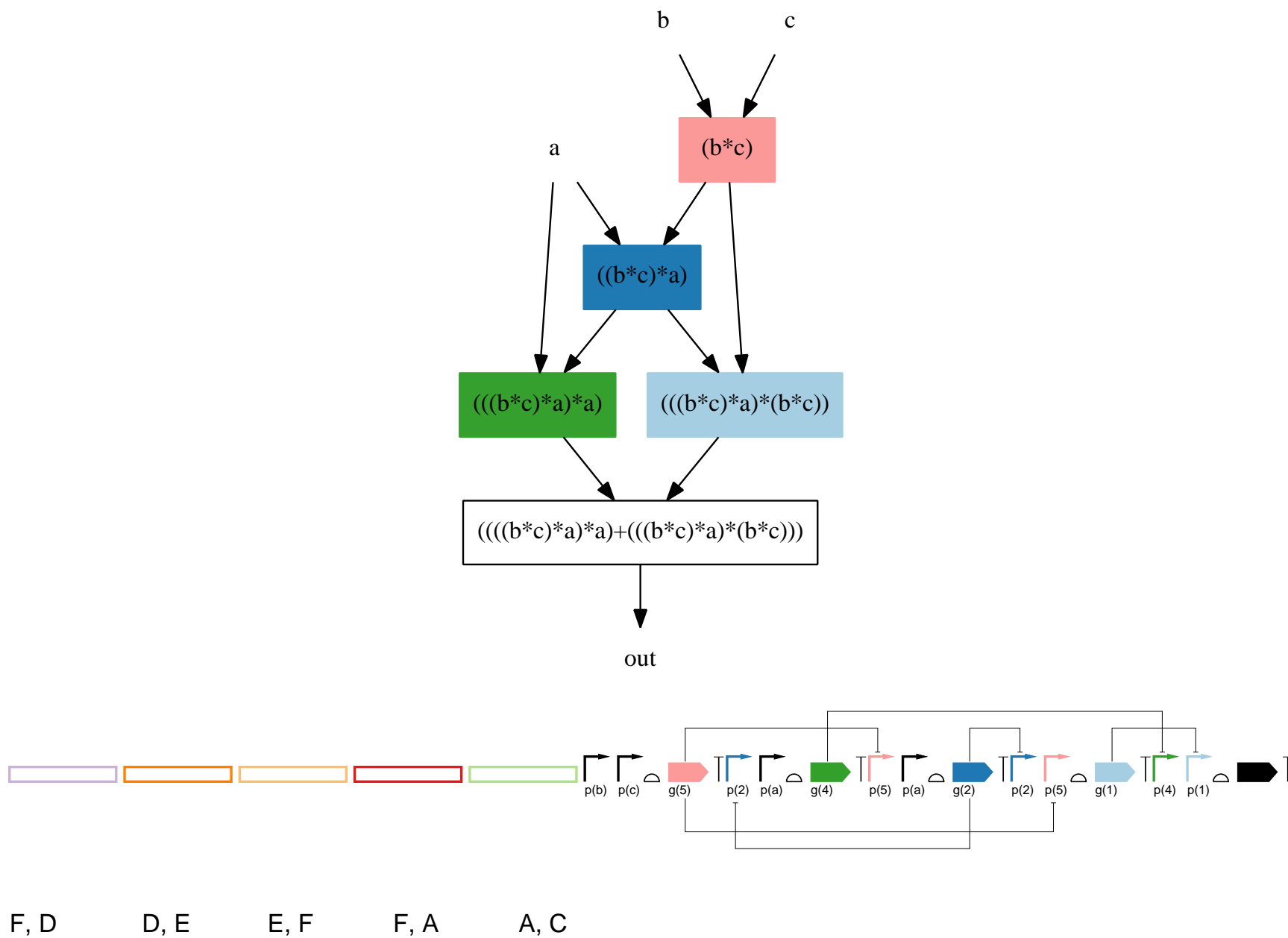


Figure 122: Circuit with truth table 0x87.

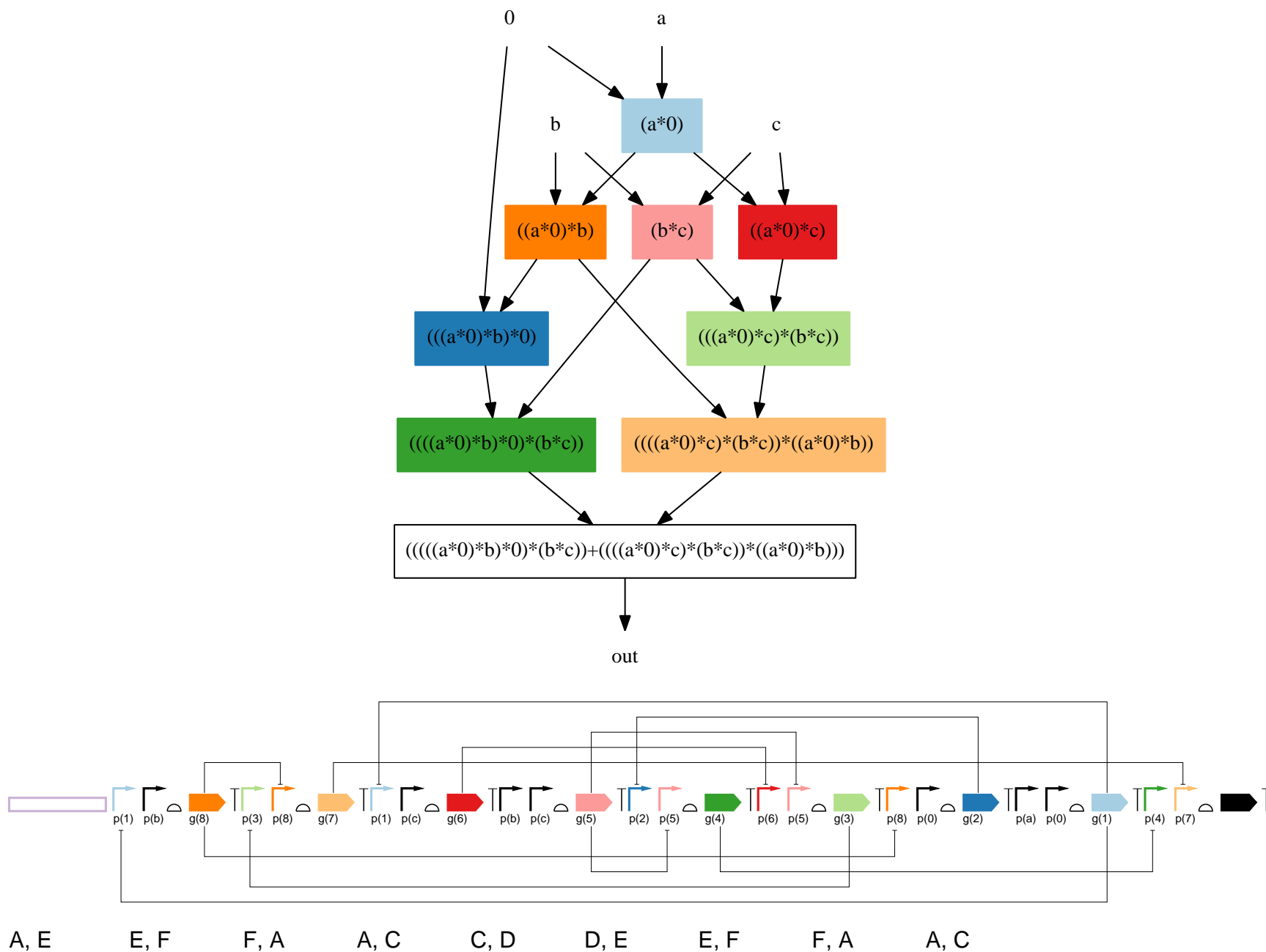


Figure 123: Circuit with truth table 0x86.

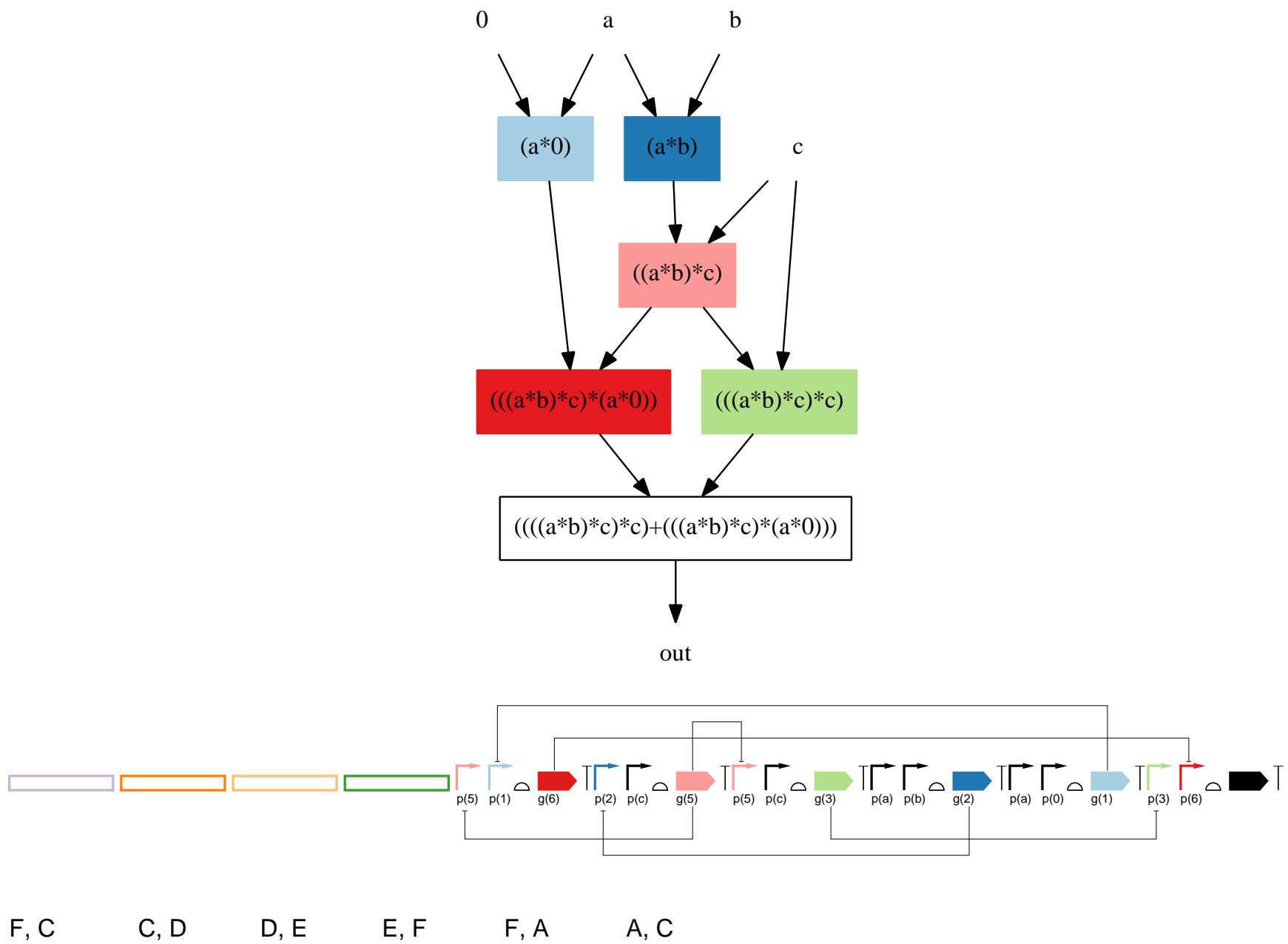


Figure 124: Circuit with truth table 0x85.

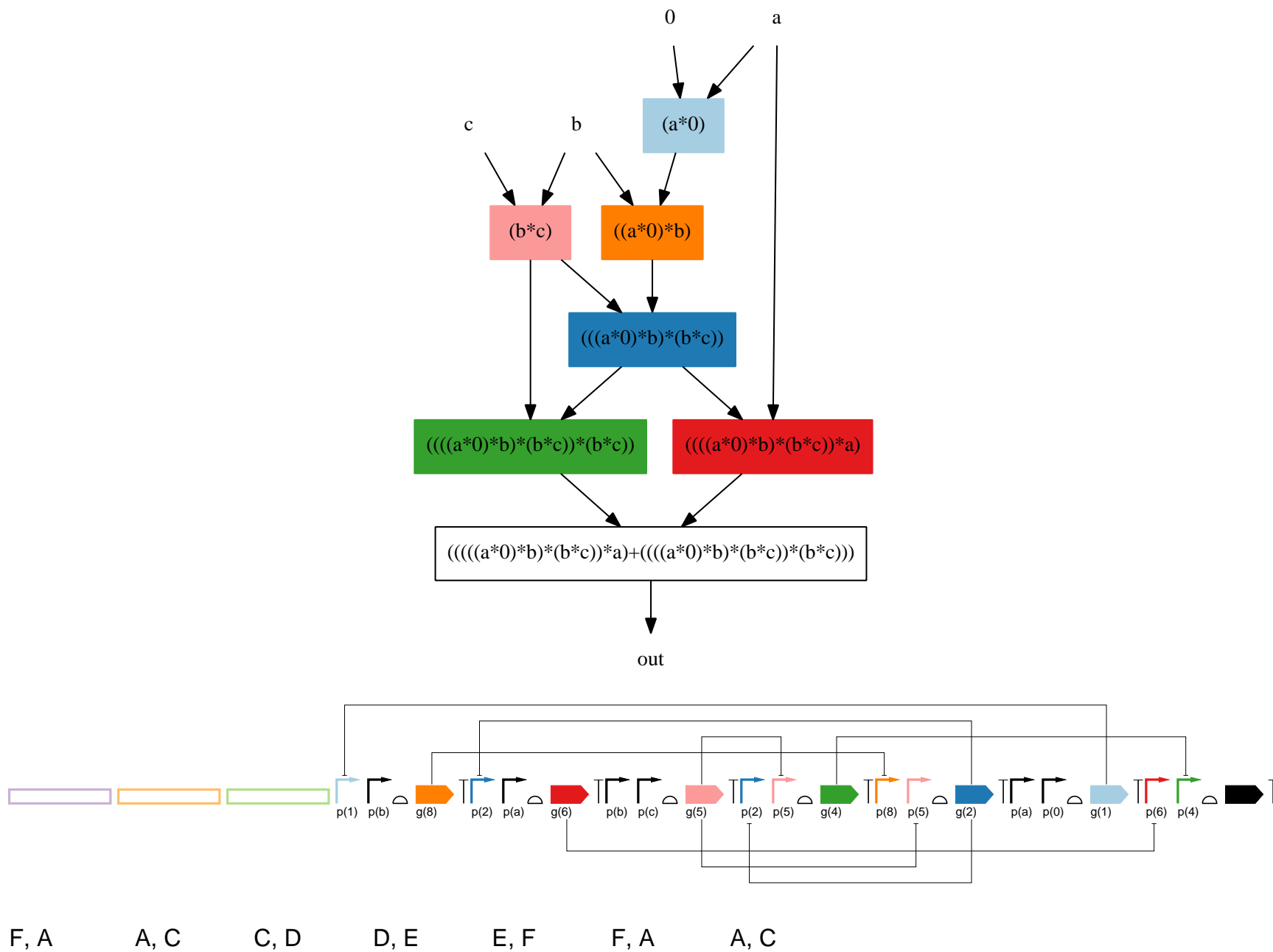


Figure 125: Circuit with truth table 0x84.

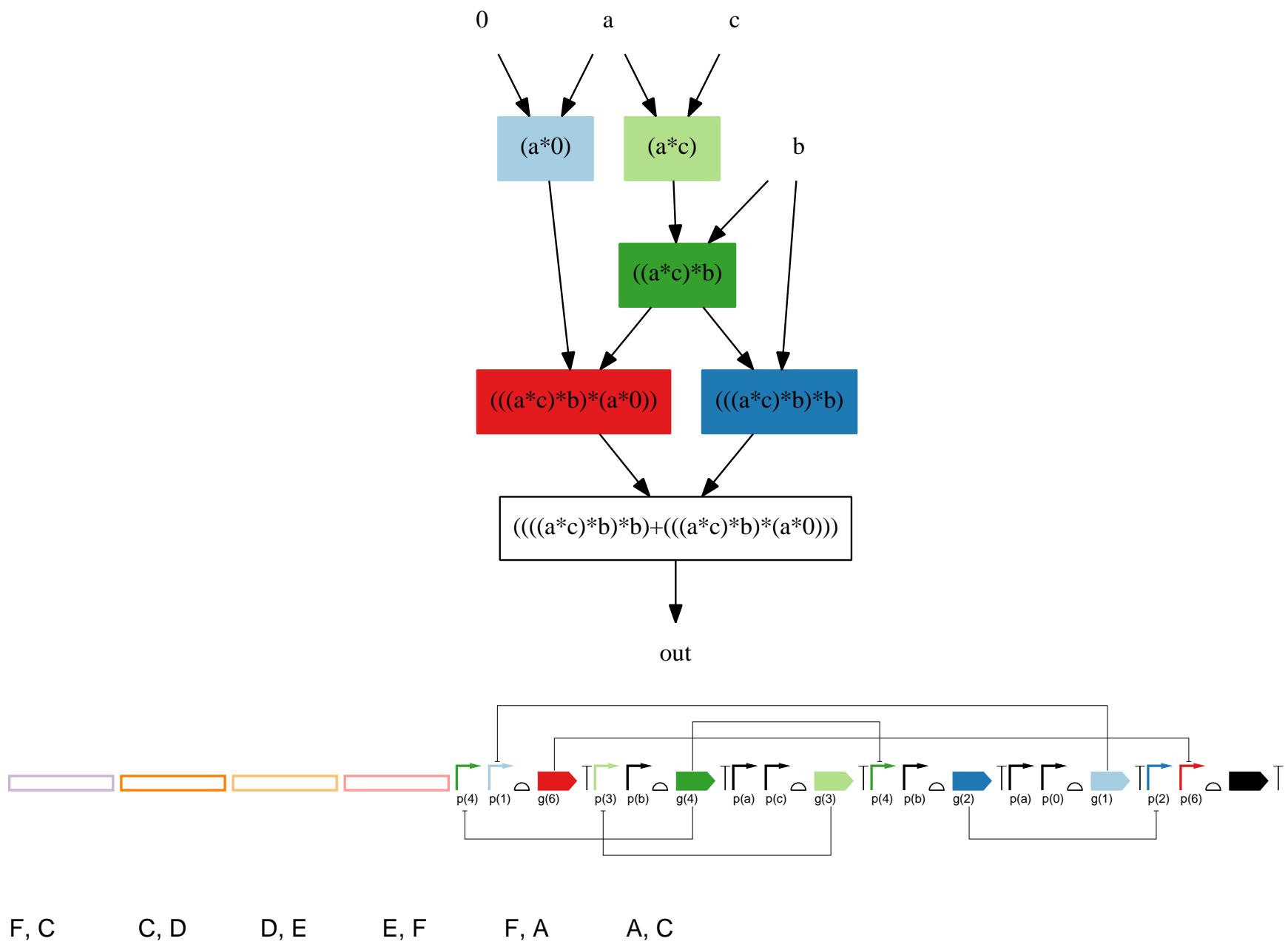


Figure 126: Circuit with truth table 0x83.

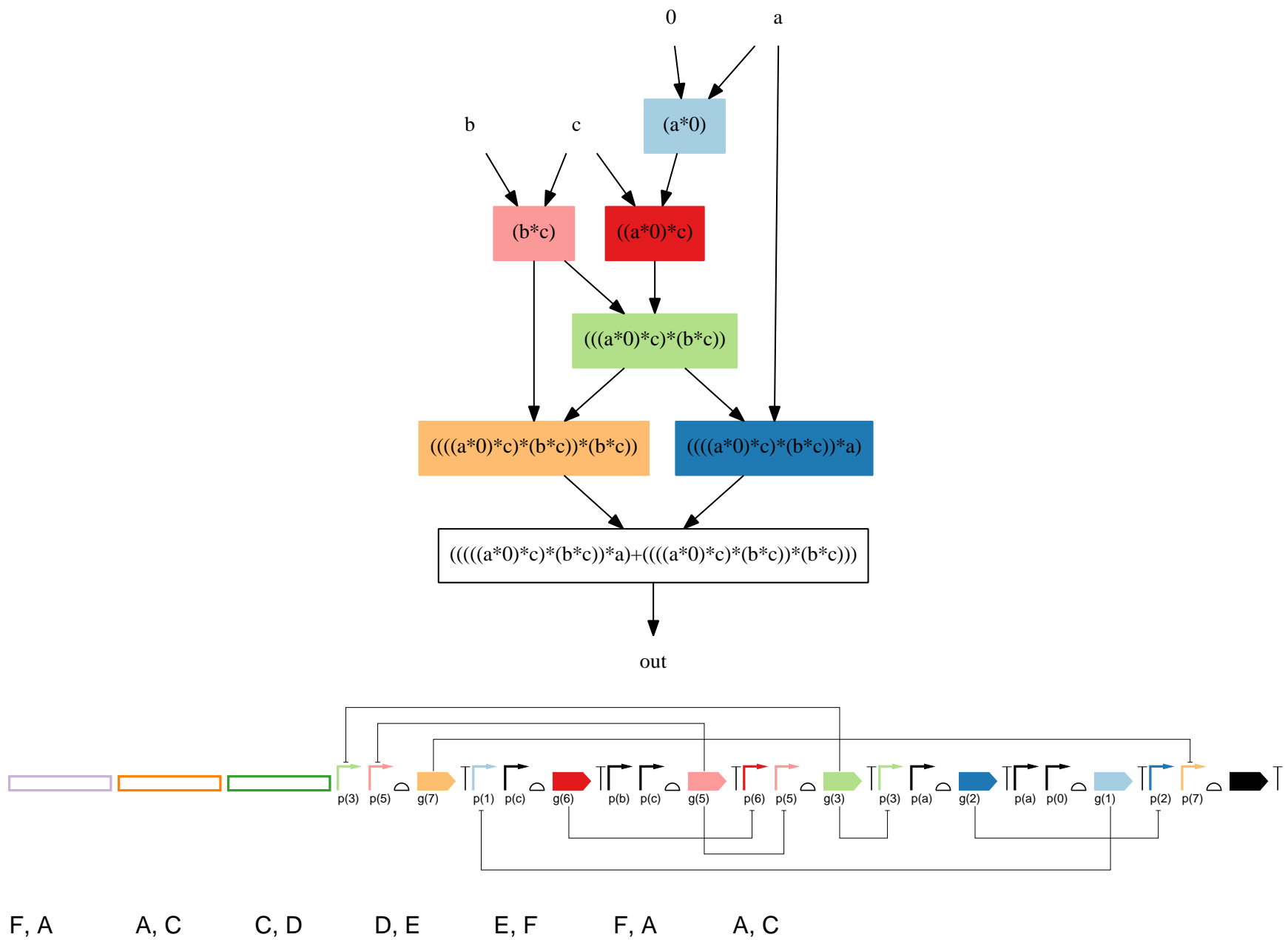


Figure 127: Circuit with truth table 0x82.

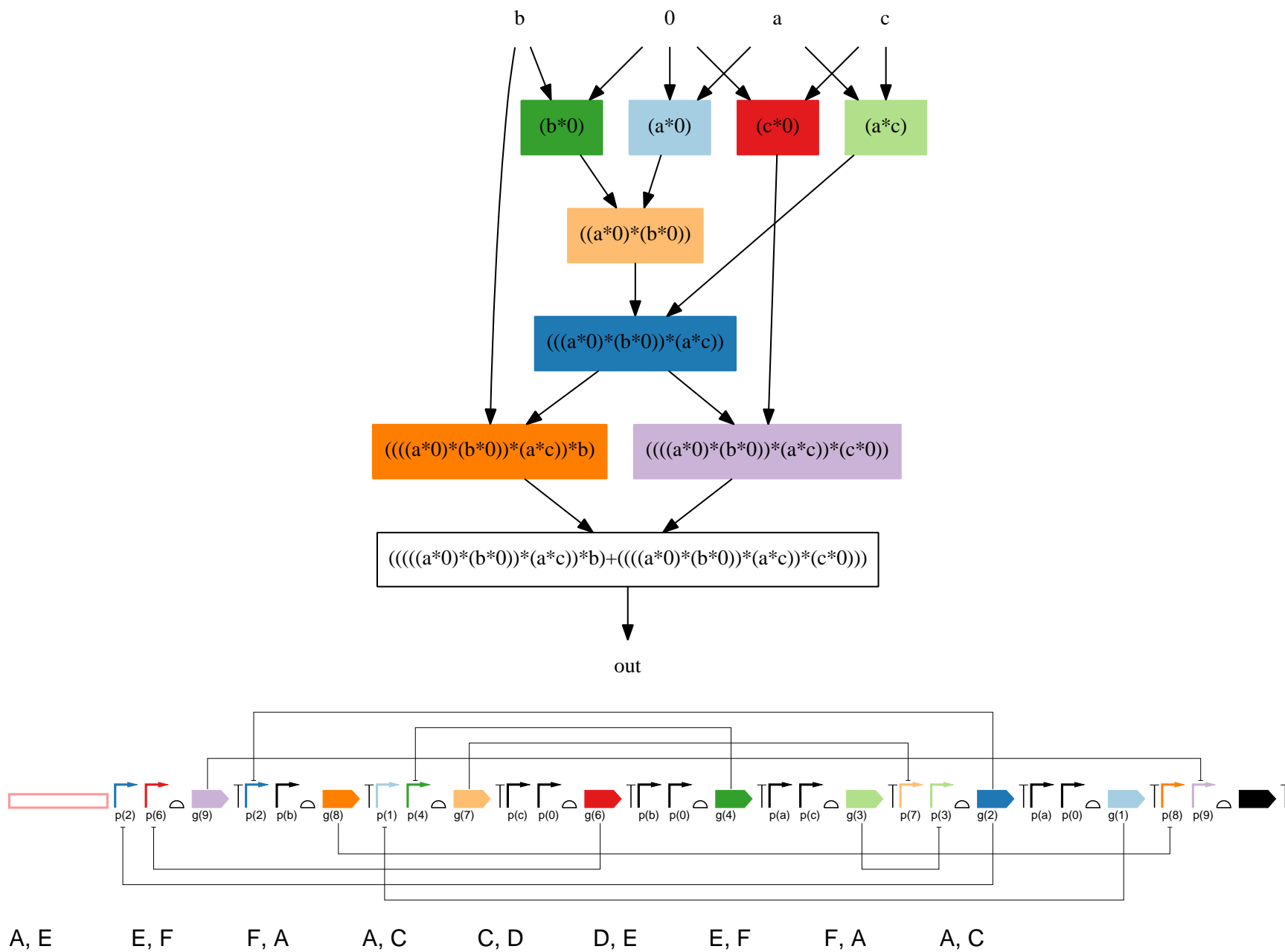
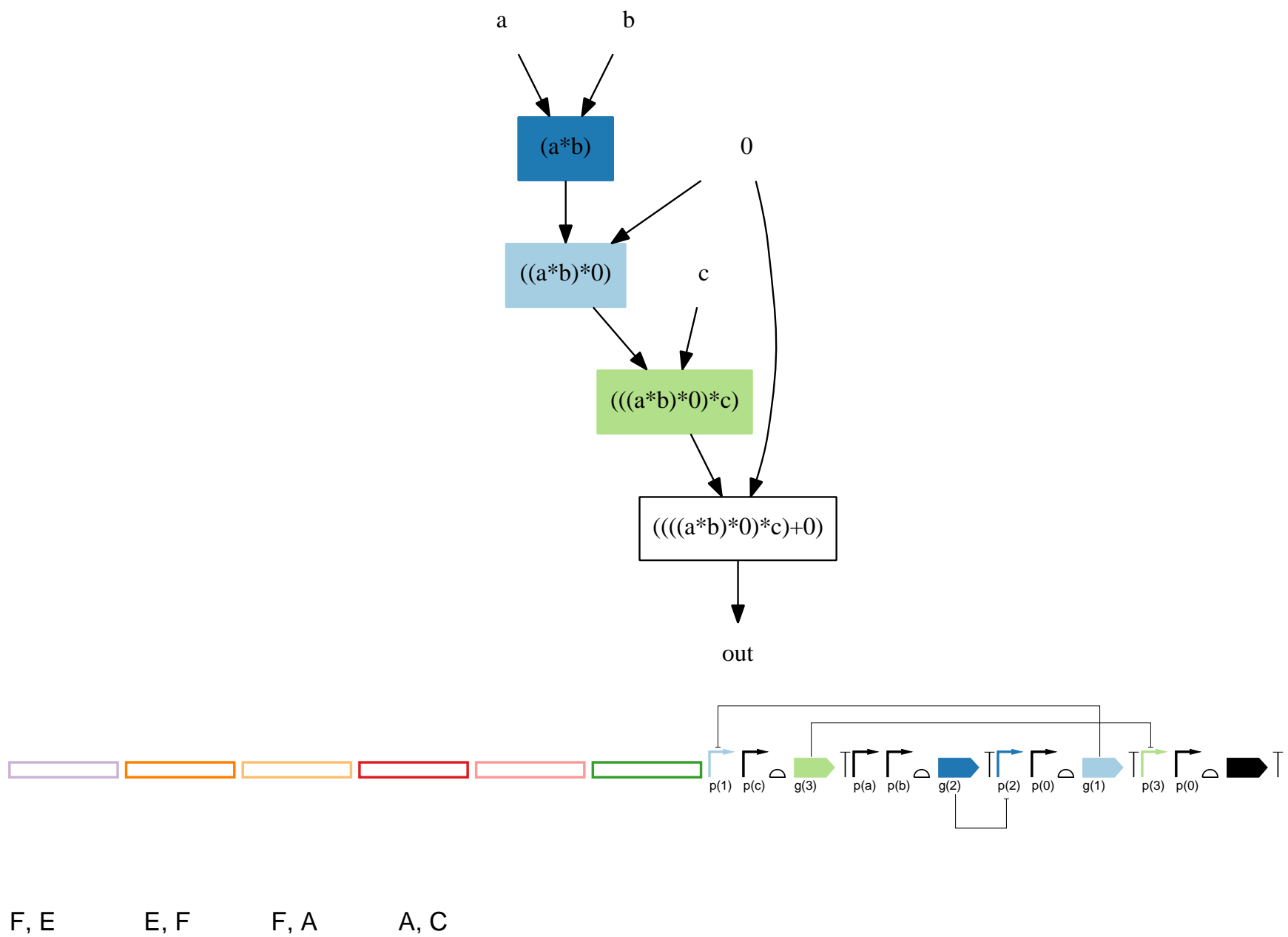


Figure 128: Circuit with truth table 0x81.



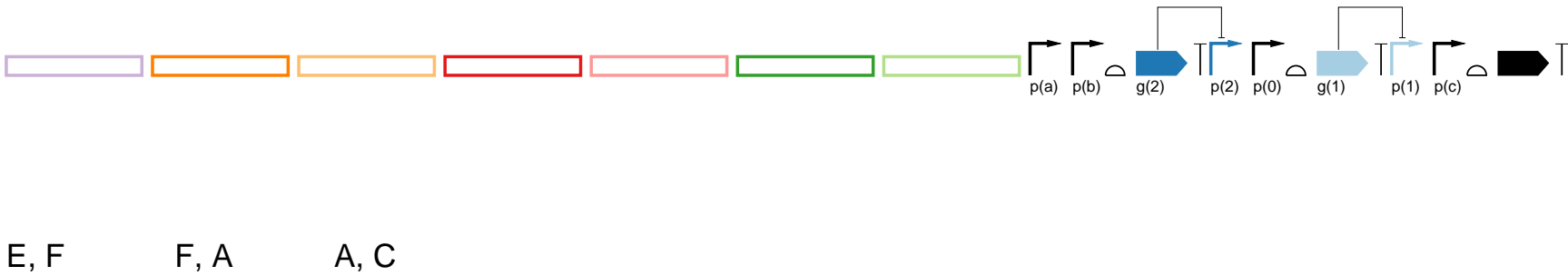
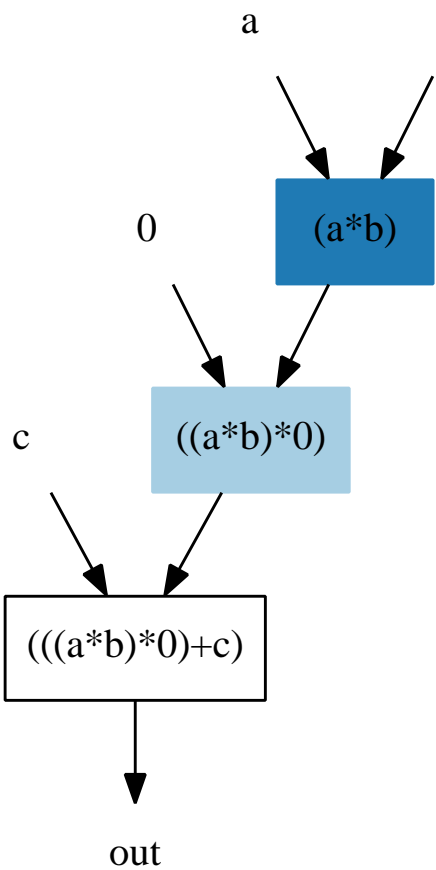


Figure 130: Circuit with truth table 0x7F.

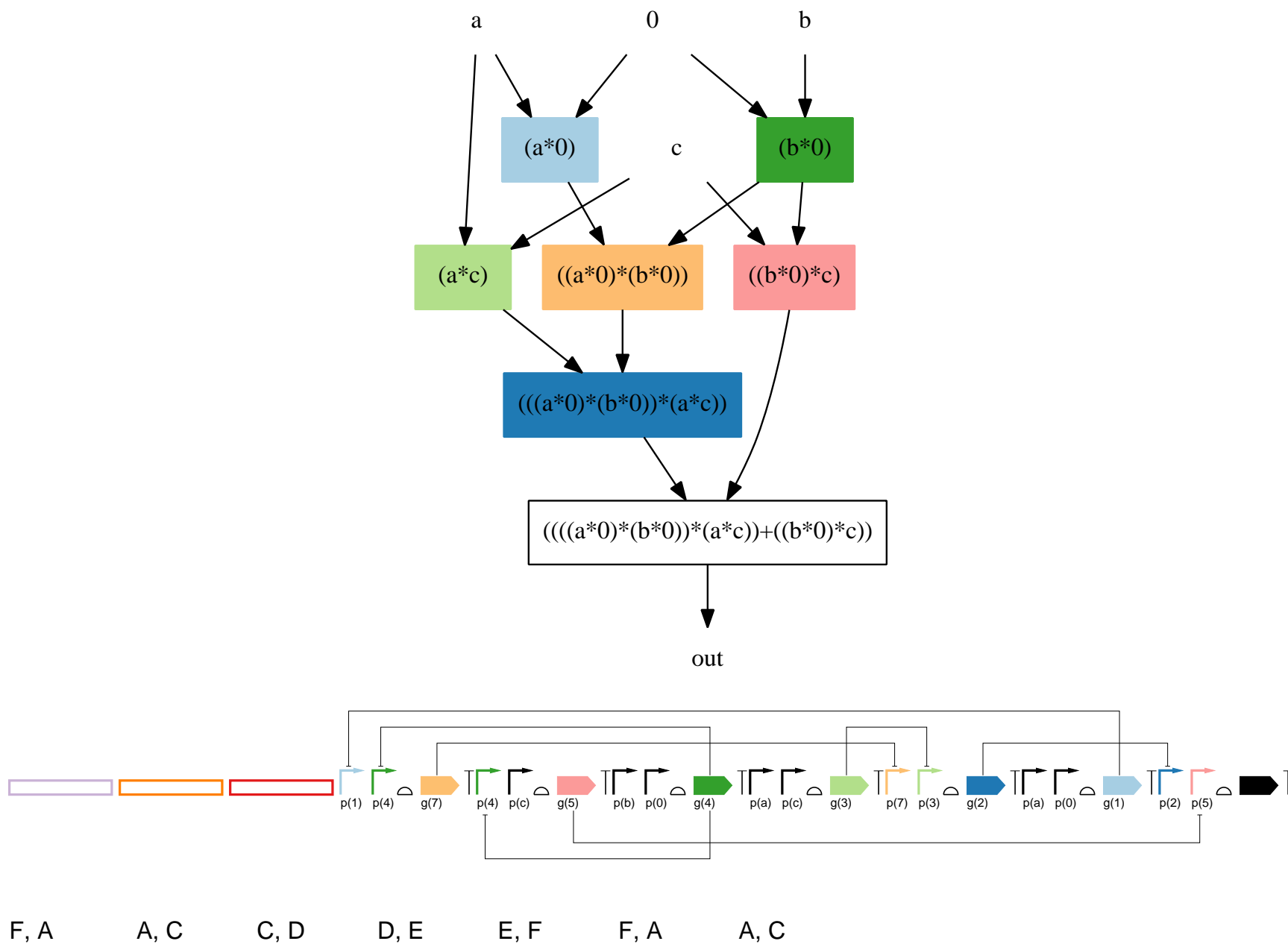


Figure 131: Circuit with truth table 0x7E.

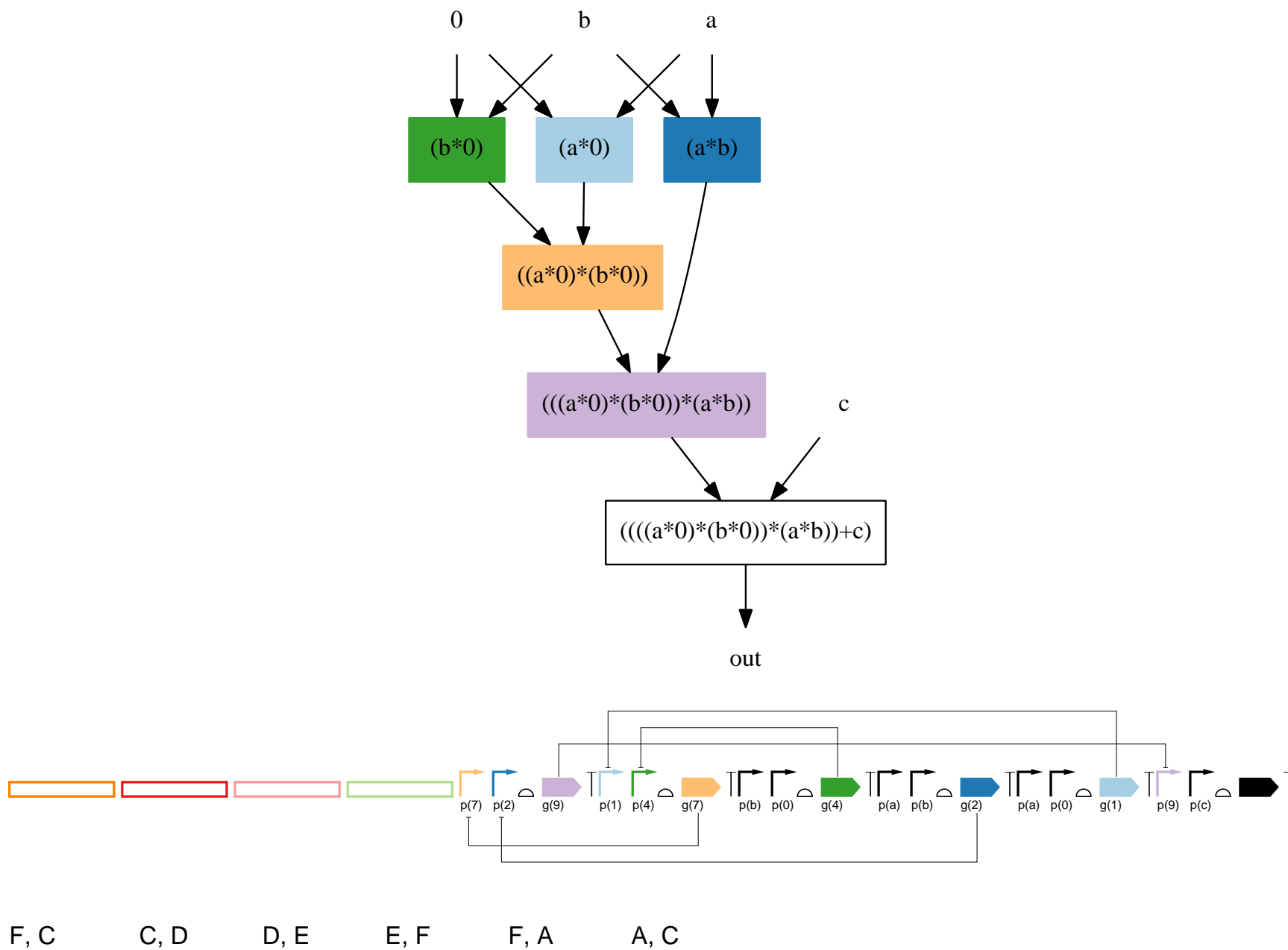


Figure 132: Circuit with truth table 0x7D.

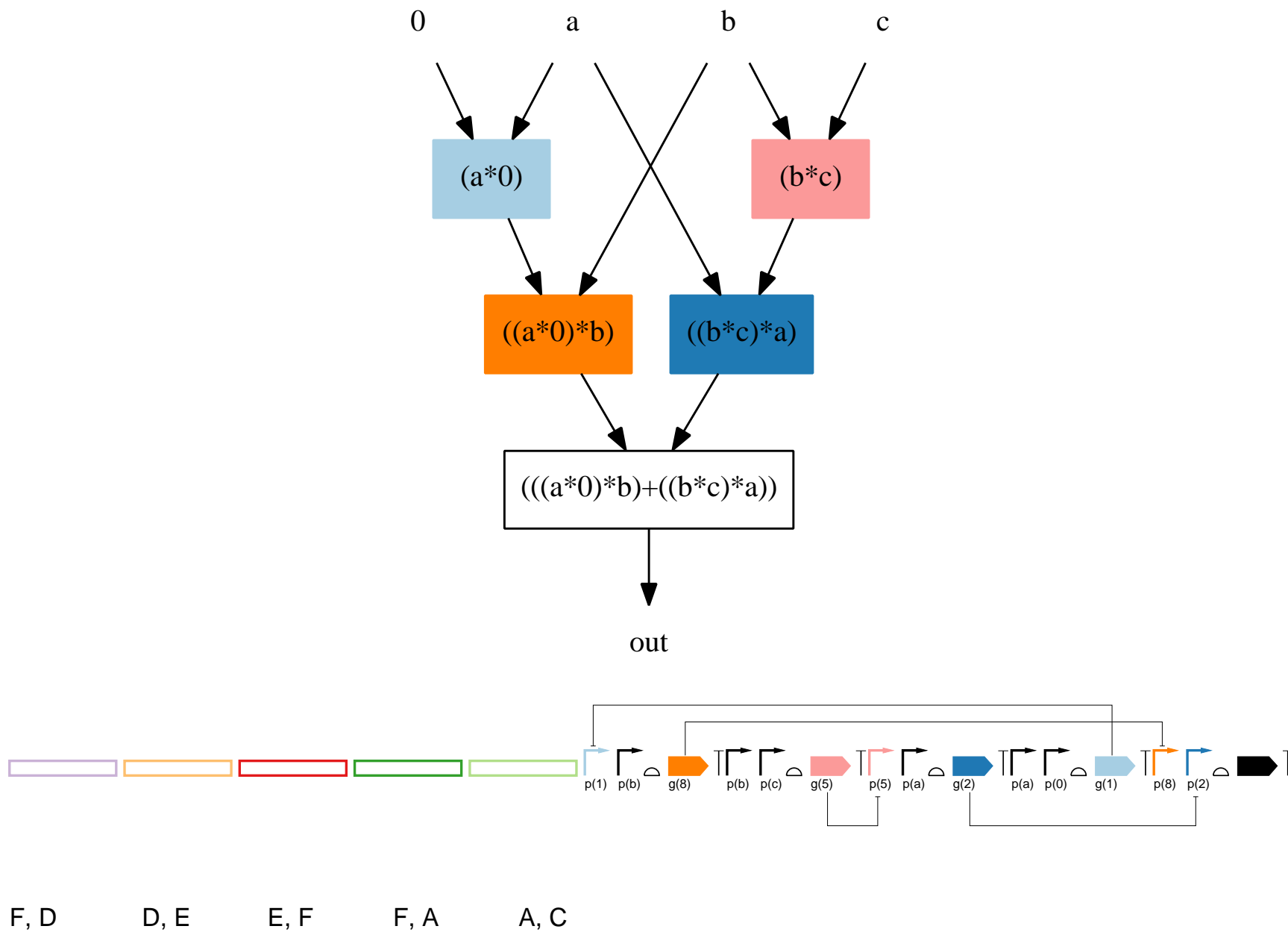


Figure 133: Circuit with truth table 0x7C.

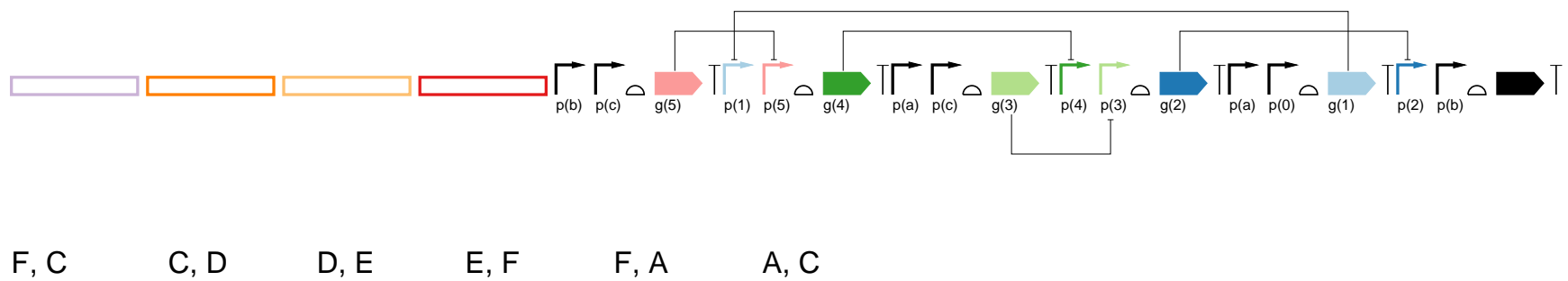


Figure 134: Circuit with truth table 0x7B.

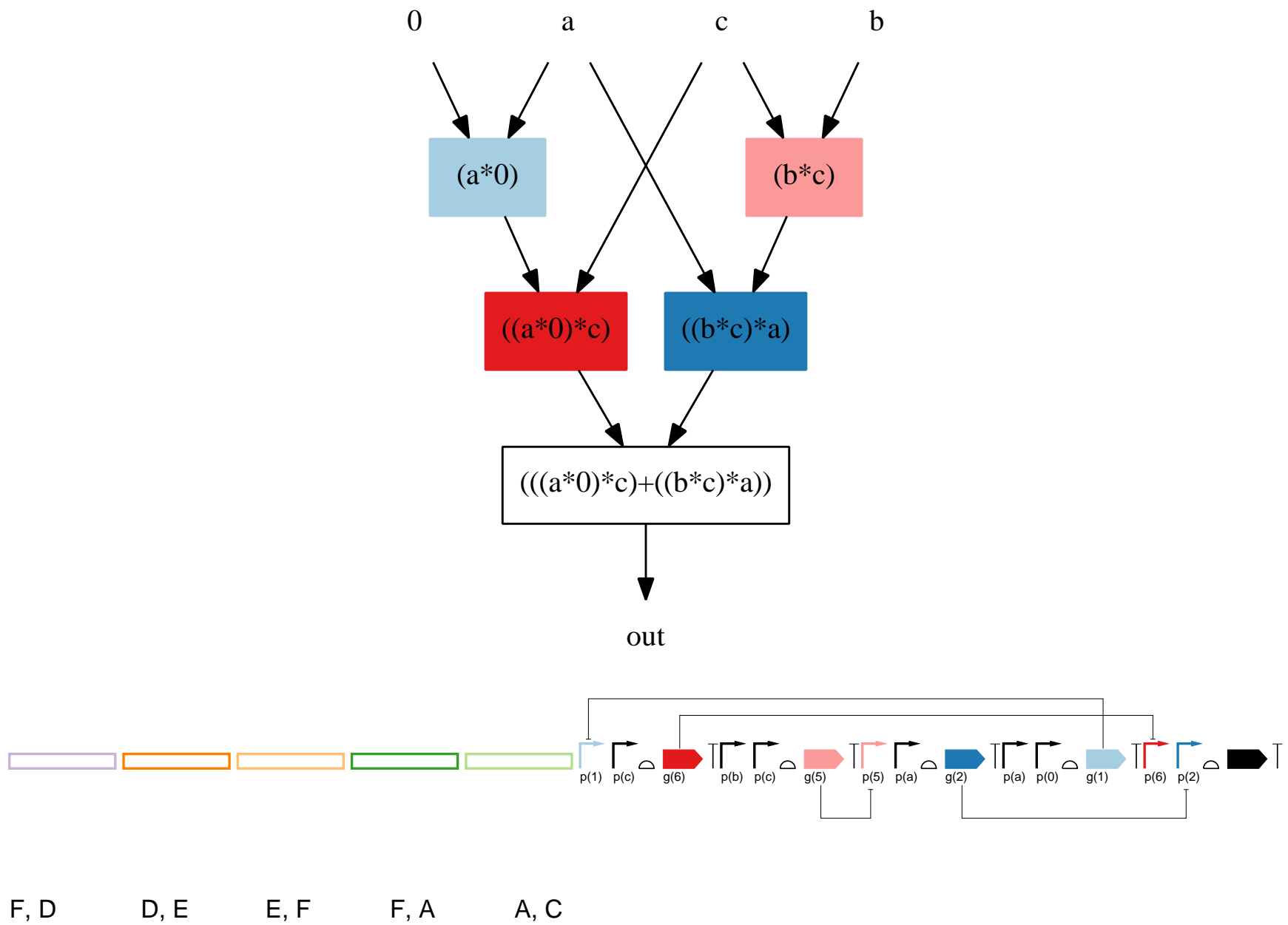


Figure 135: Circuit with truth table 0x7A.

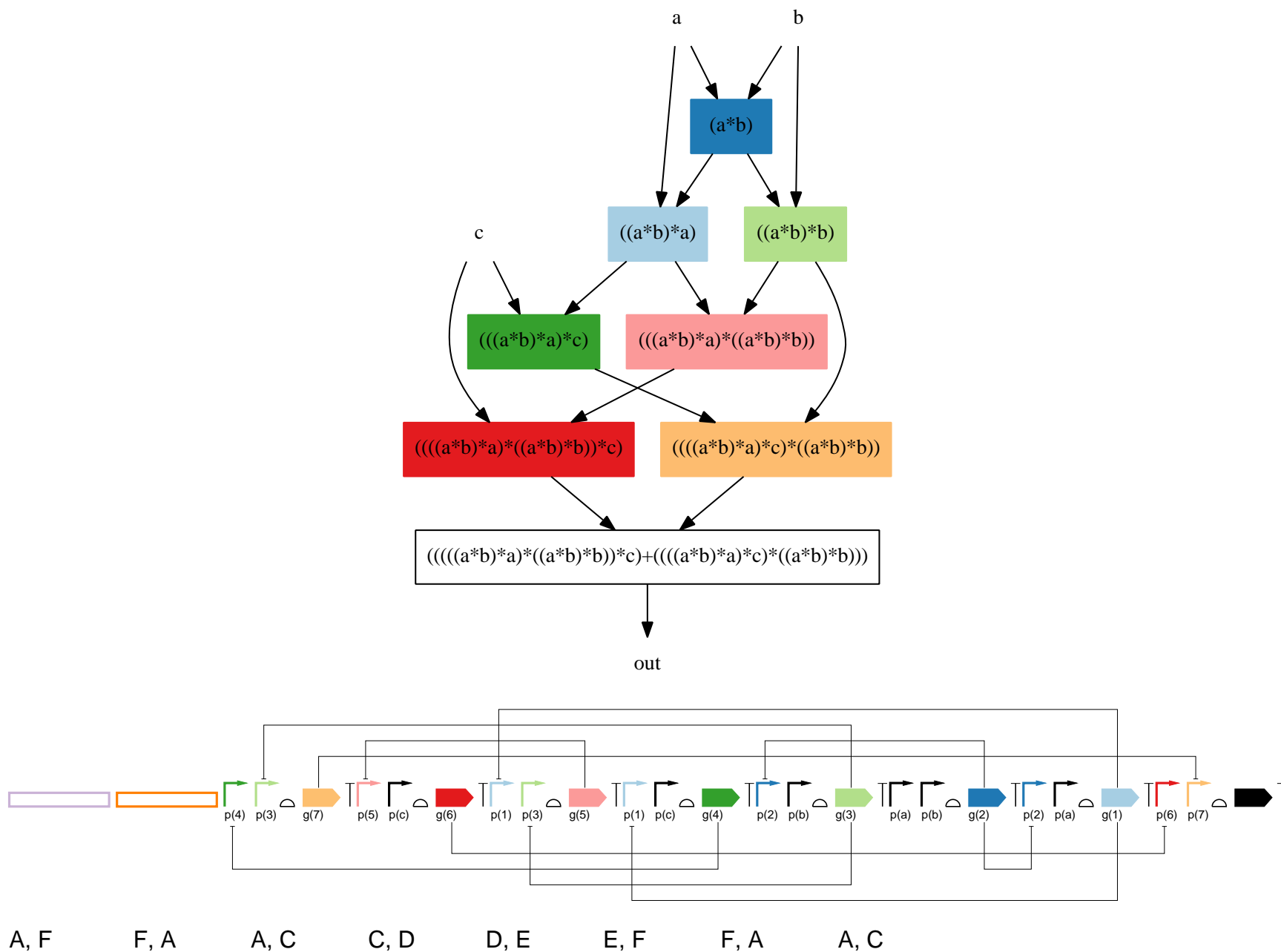


Figure 136: Circuit with truth table 0x79.

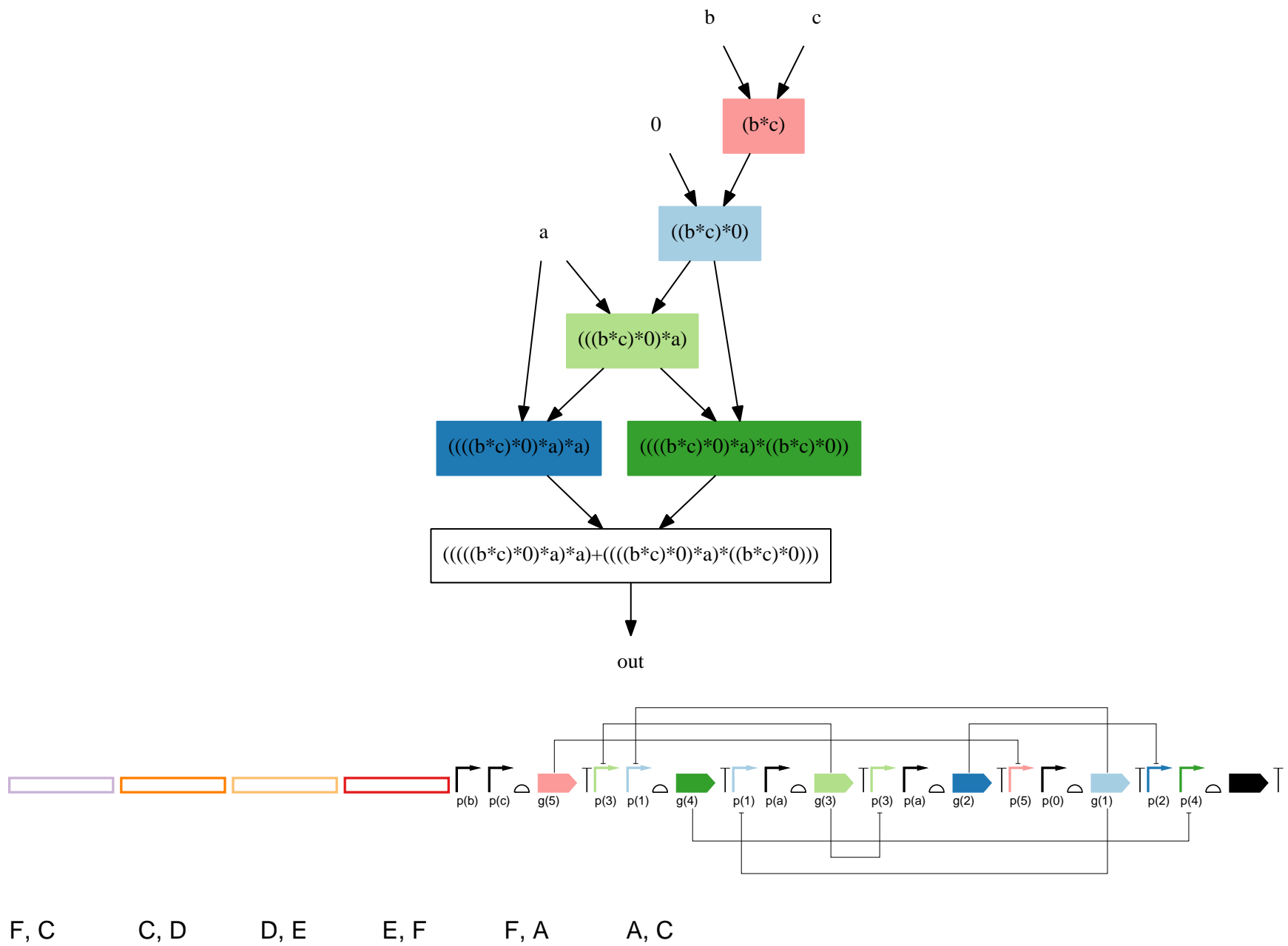
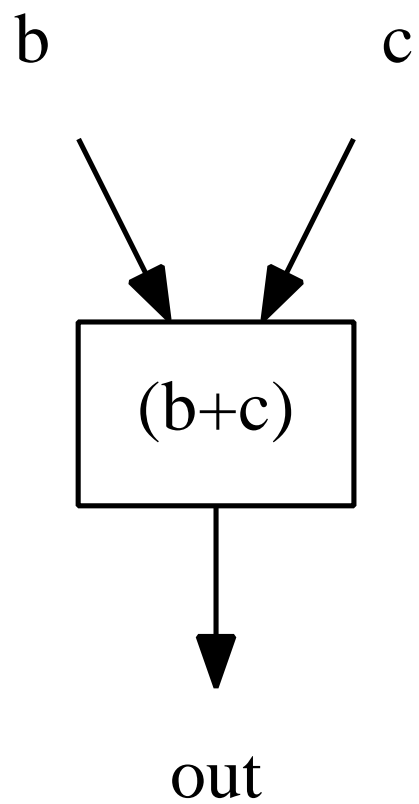


Figure 137: Circuit with truth table 0x78.

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E, C

Figure 138: Circuit with truth table 0x77.

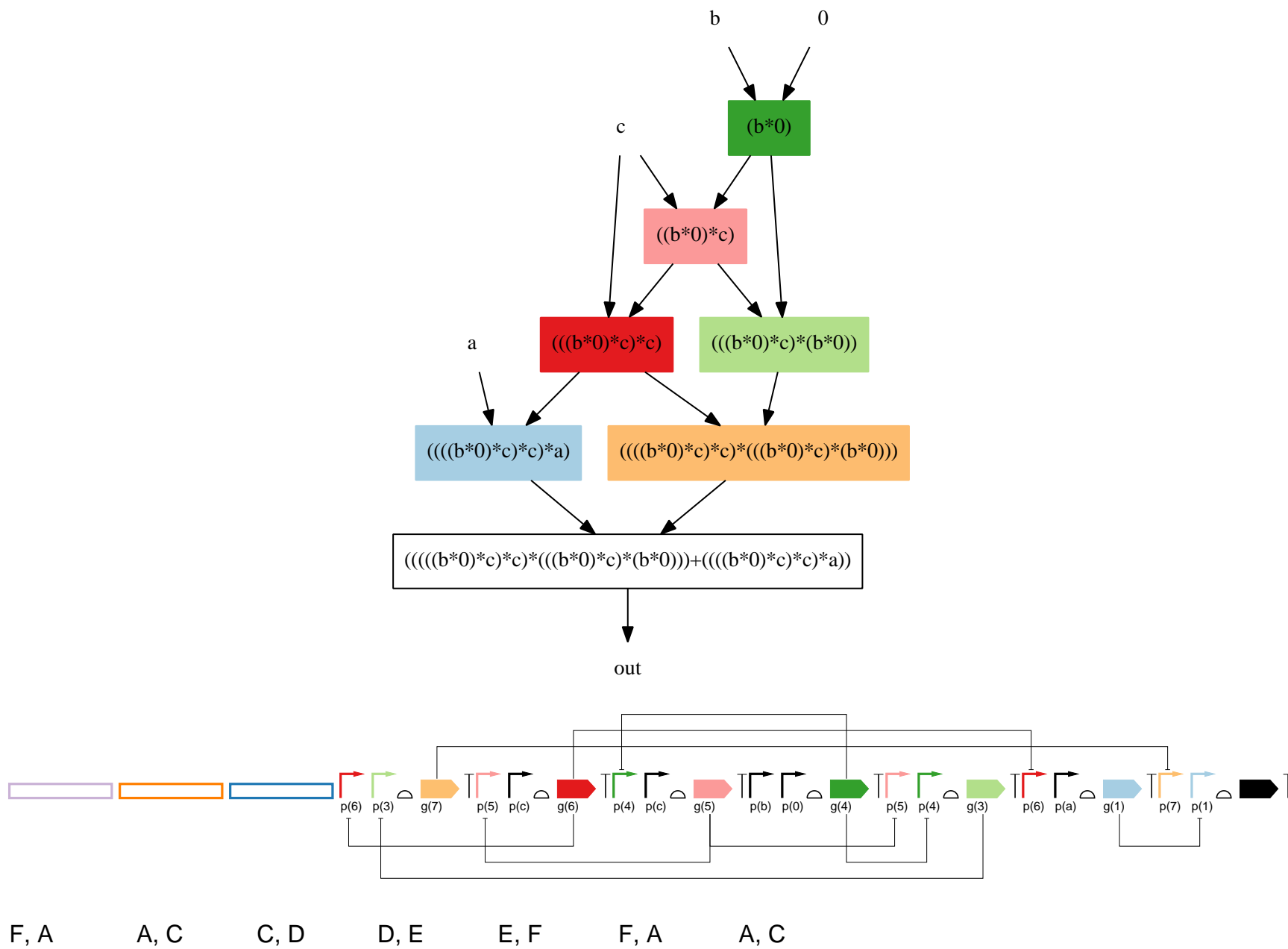
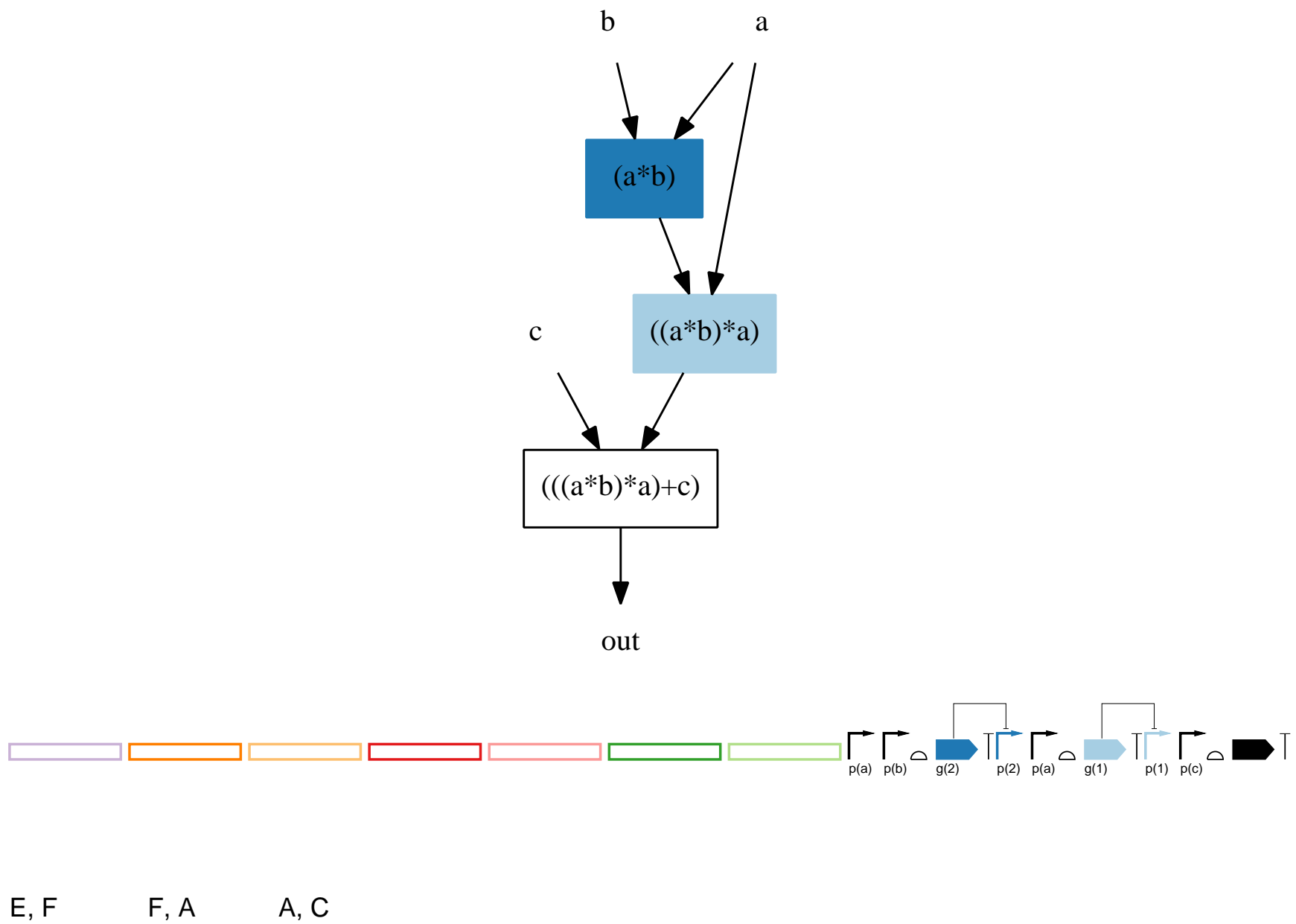


Figure 139: Circuit with truth table 0x76.



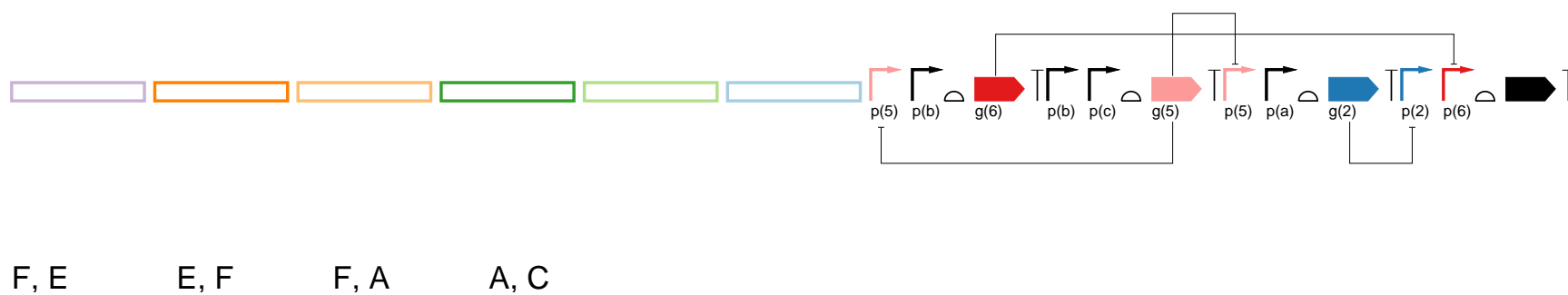
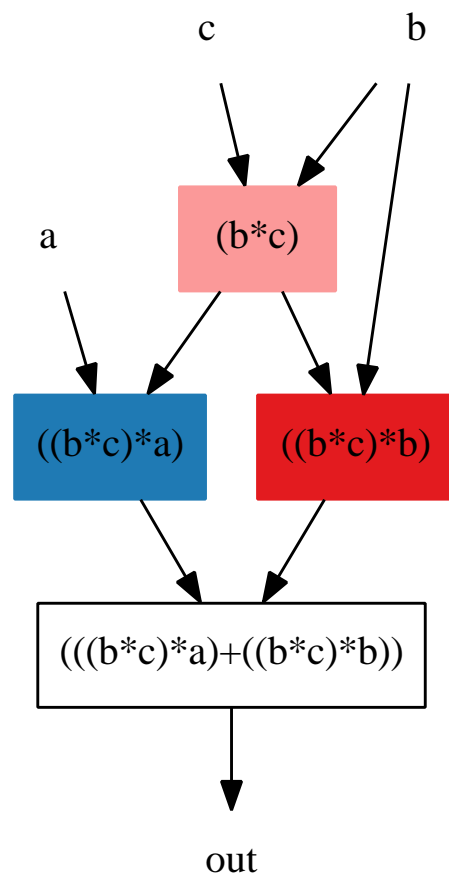


Figure 141: Circuit with truth table 0x74.

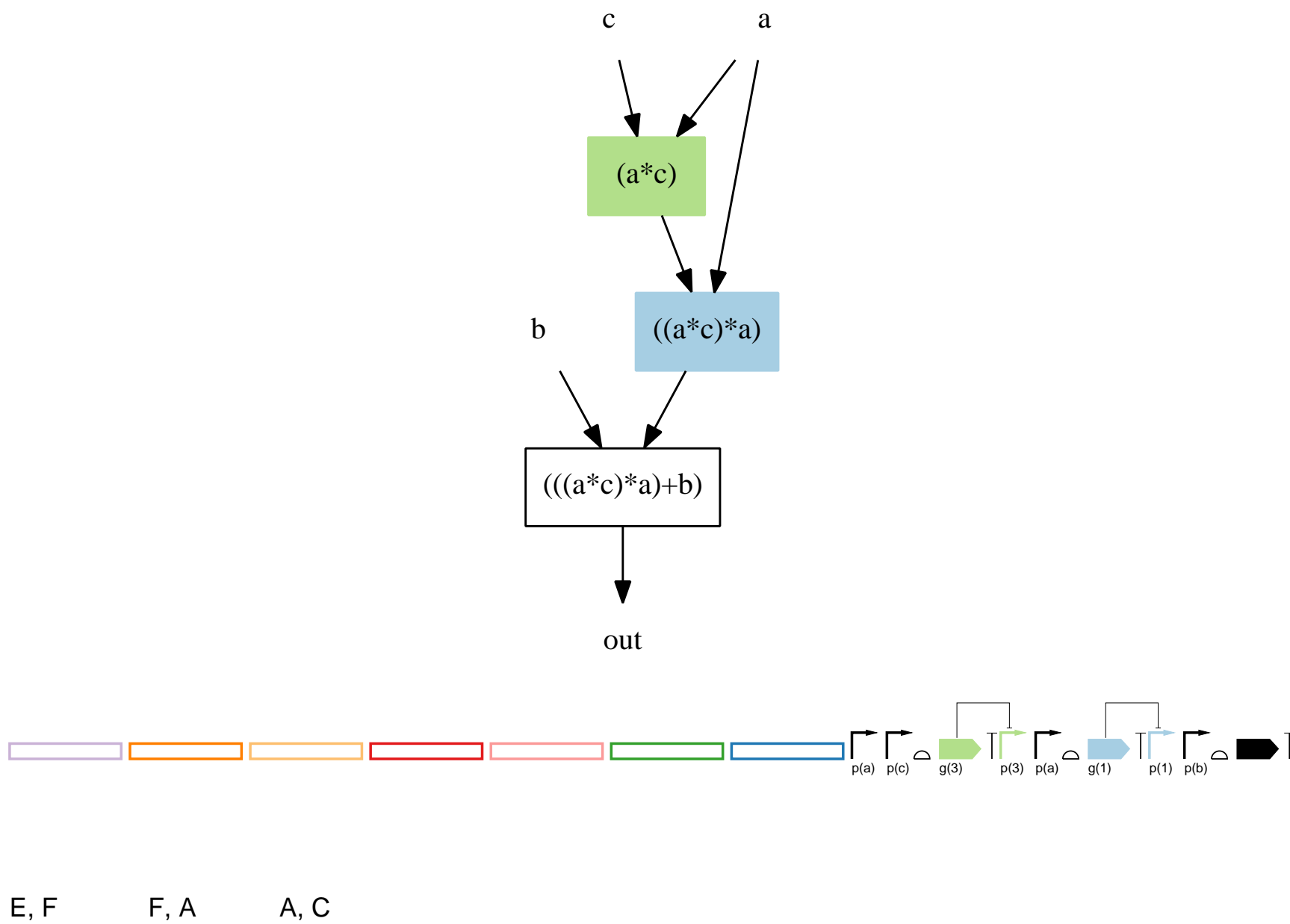


Figure 142: Circuit with truth table 0x73.

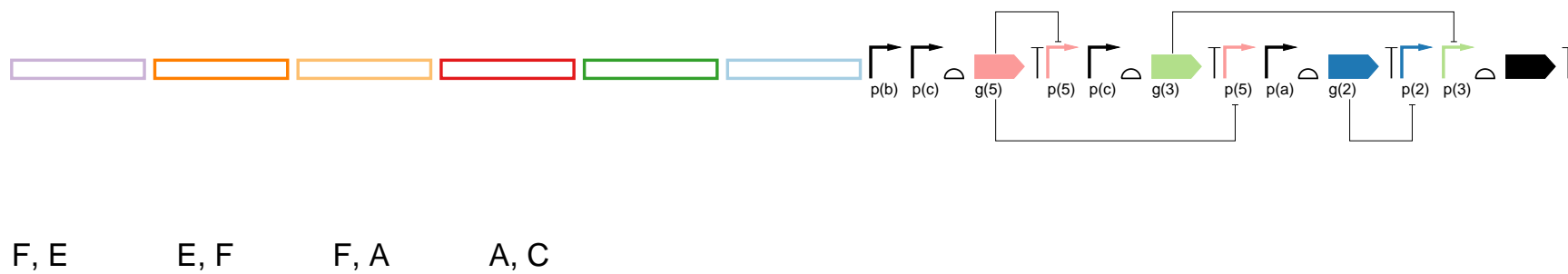
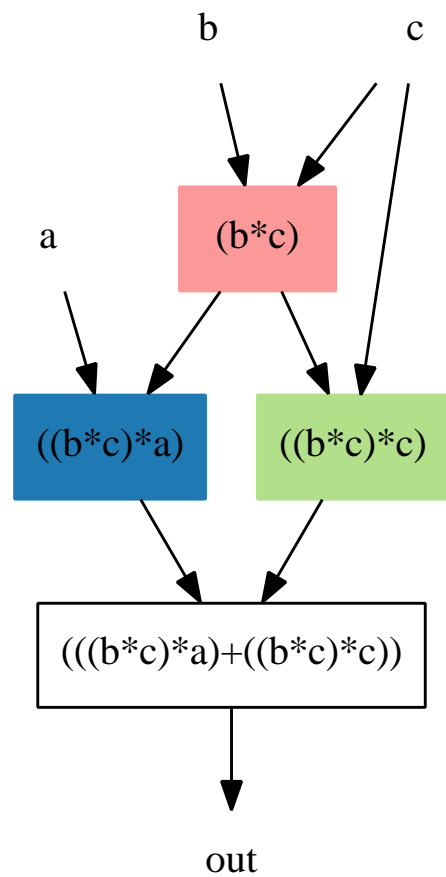


Figure 143: Circuit with truth table 0x72.

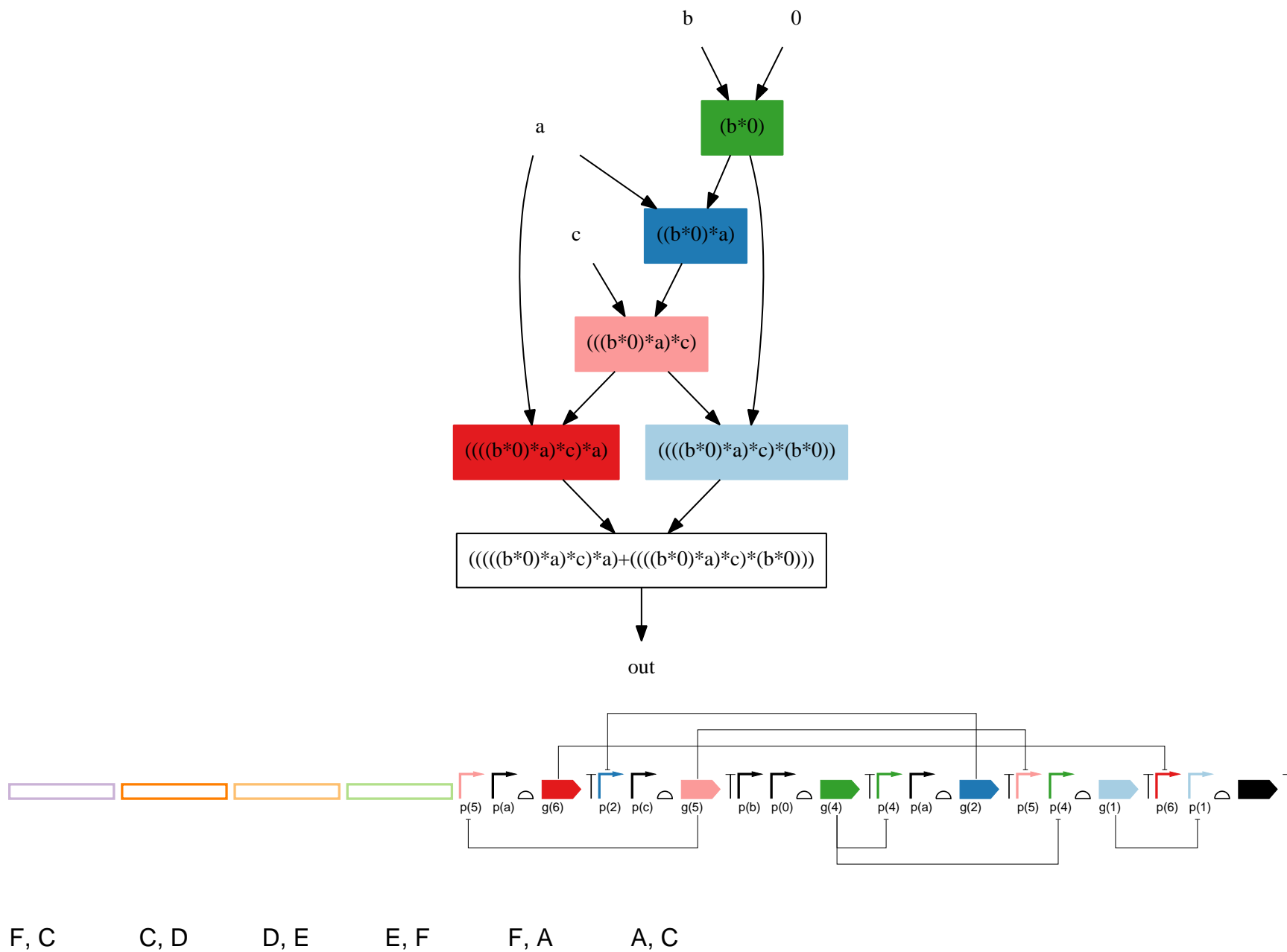


Figure 144: Circuit with truth table 0x71.

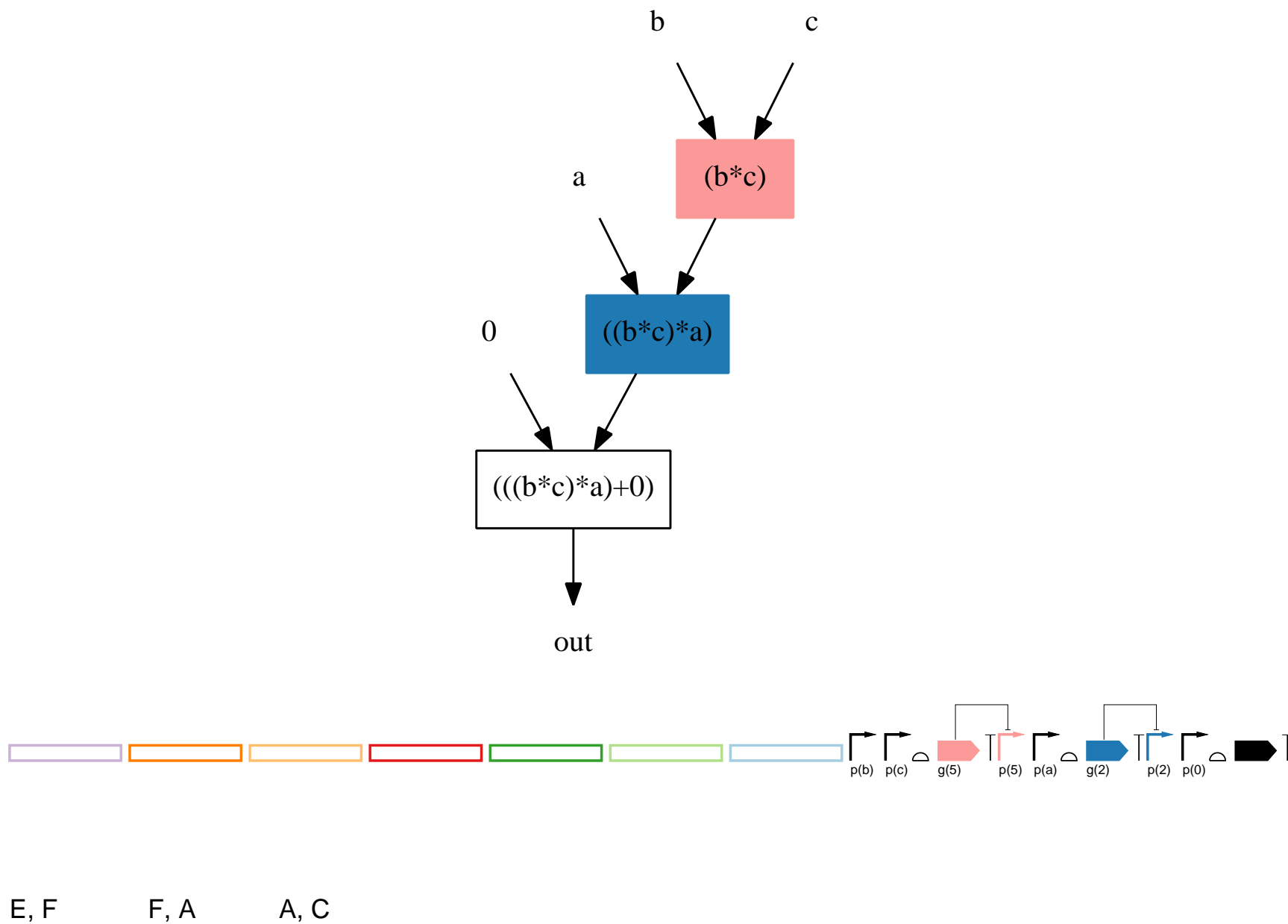


Figure 145: Circuit with truth table 0x70.

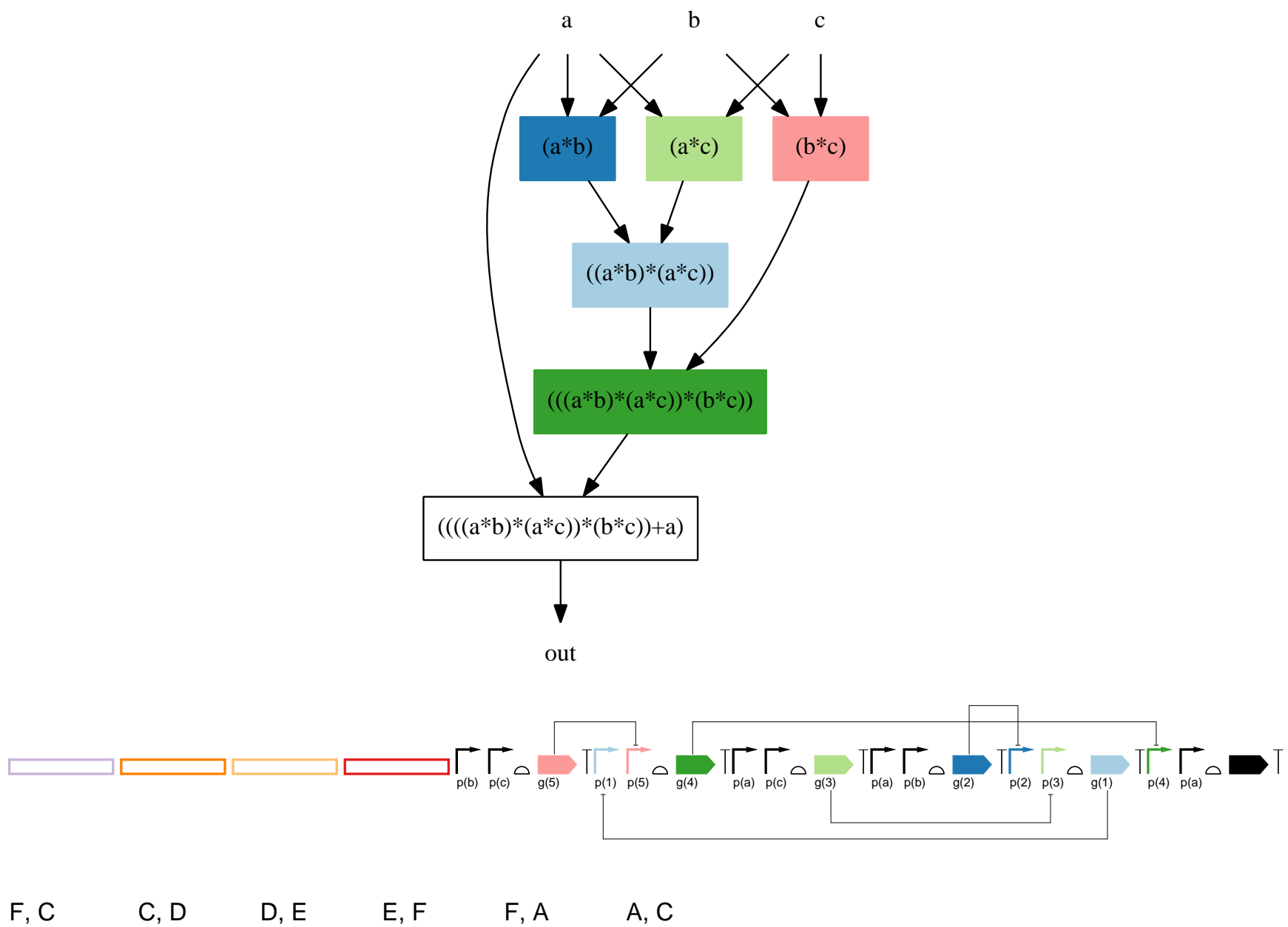


Figure 146: Circuit with truth table 0x6F.

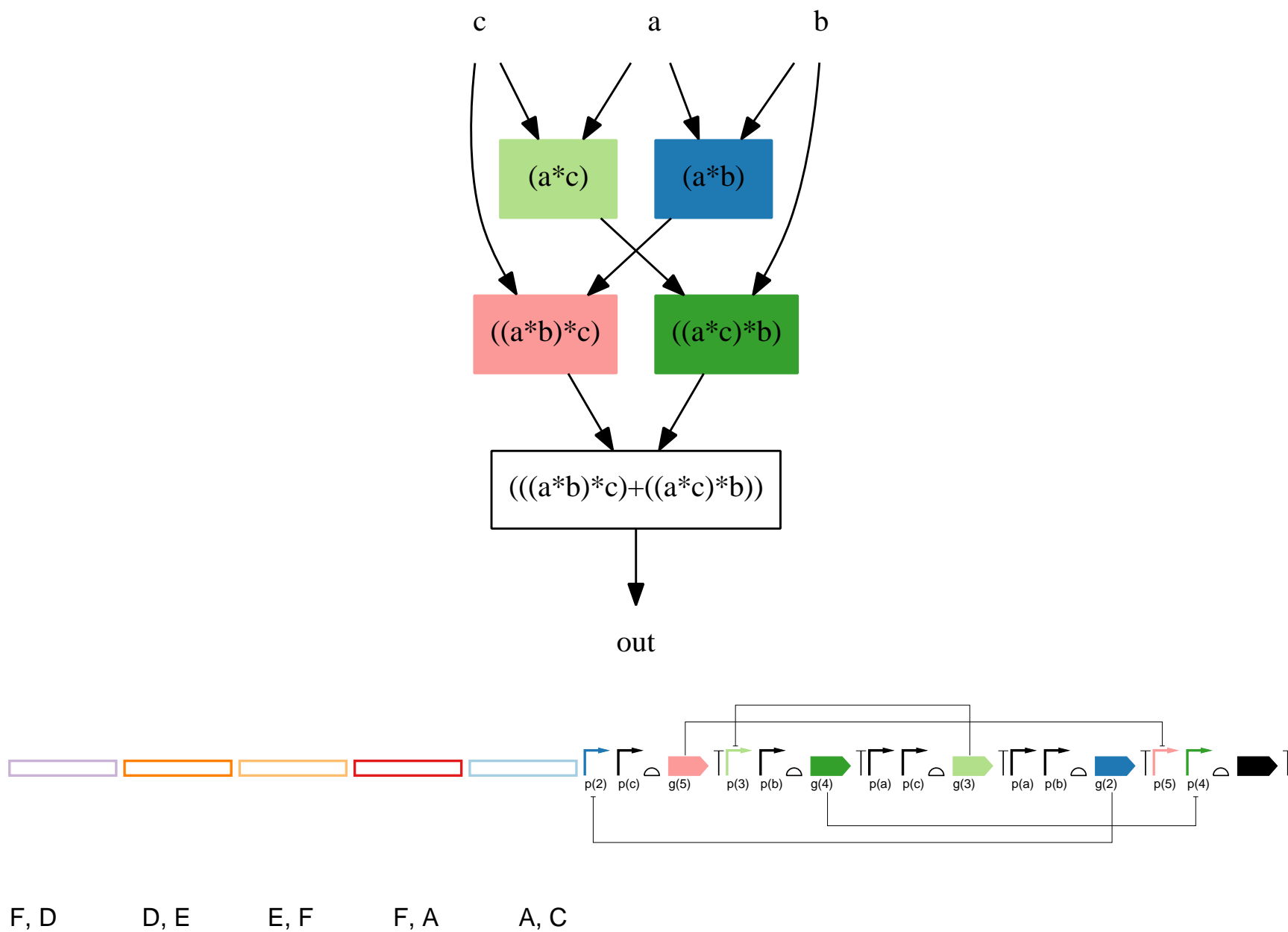


Figure 147: Circuit with truth table 0x6E.

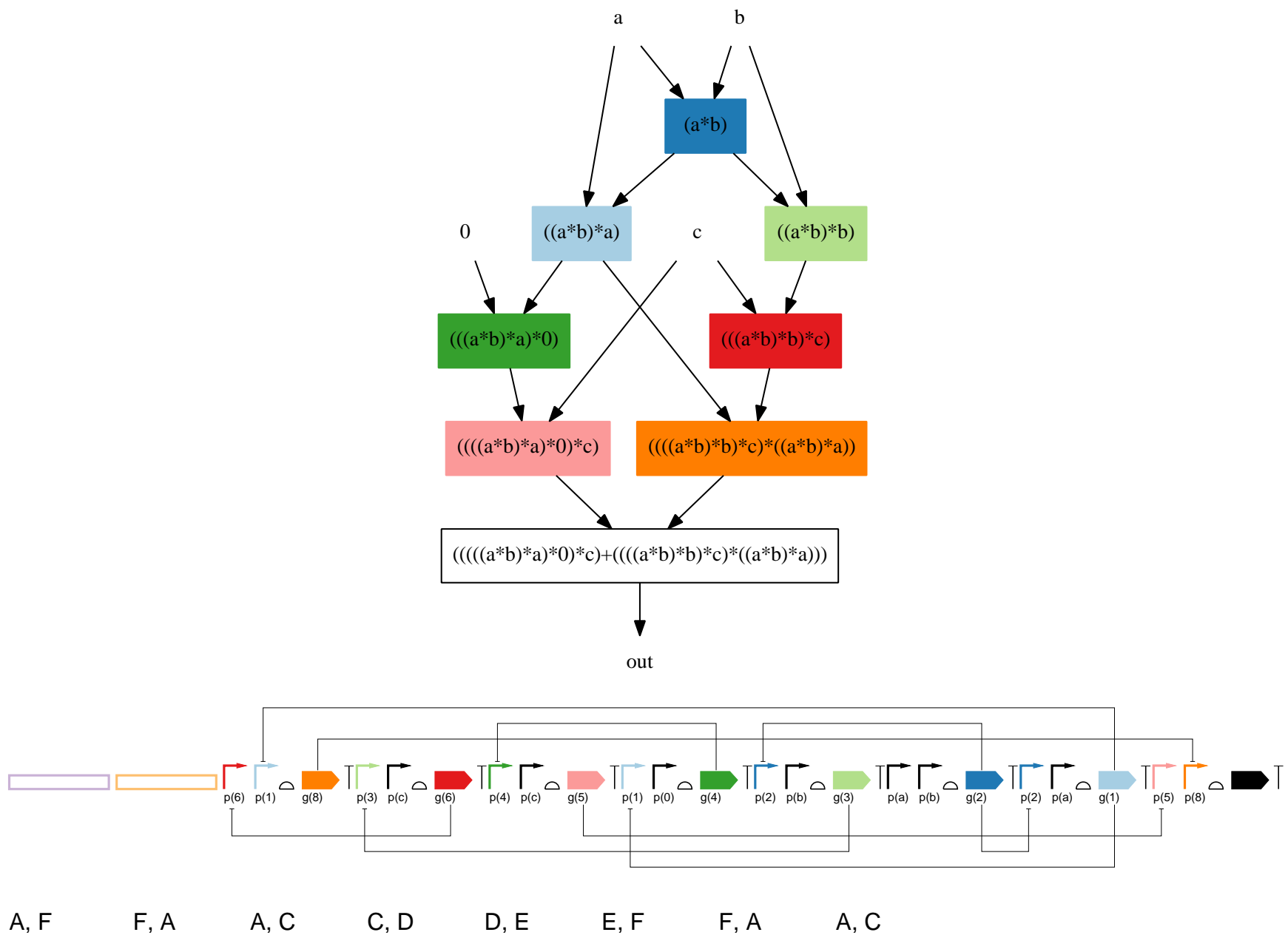


Figure 148: Circuit with truth table 0x6D.

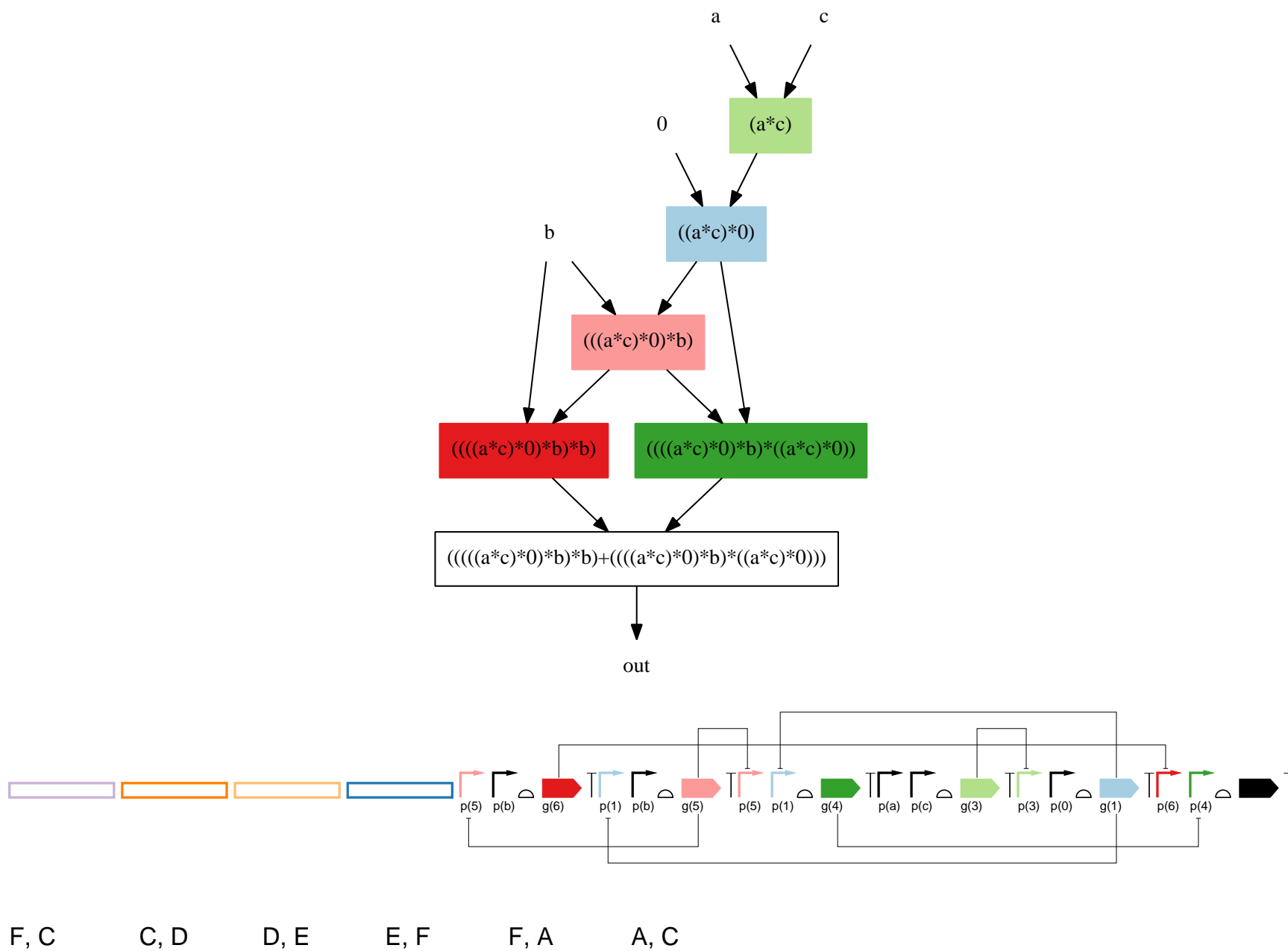


Figure 149: Circuit with truth table 0x6C.

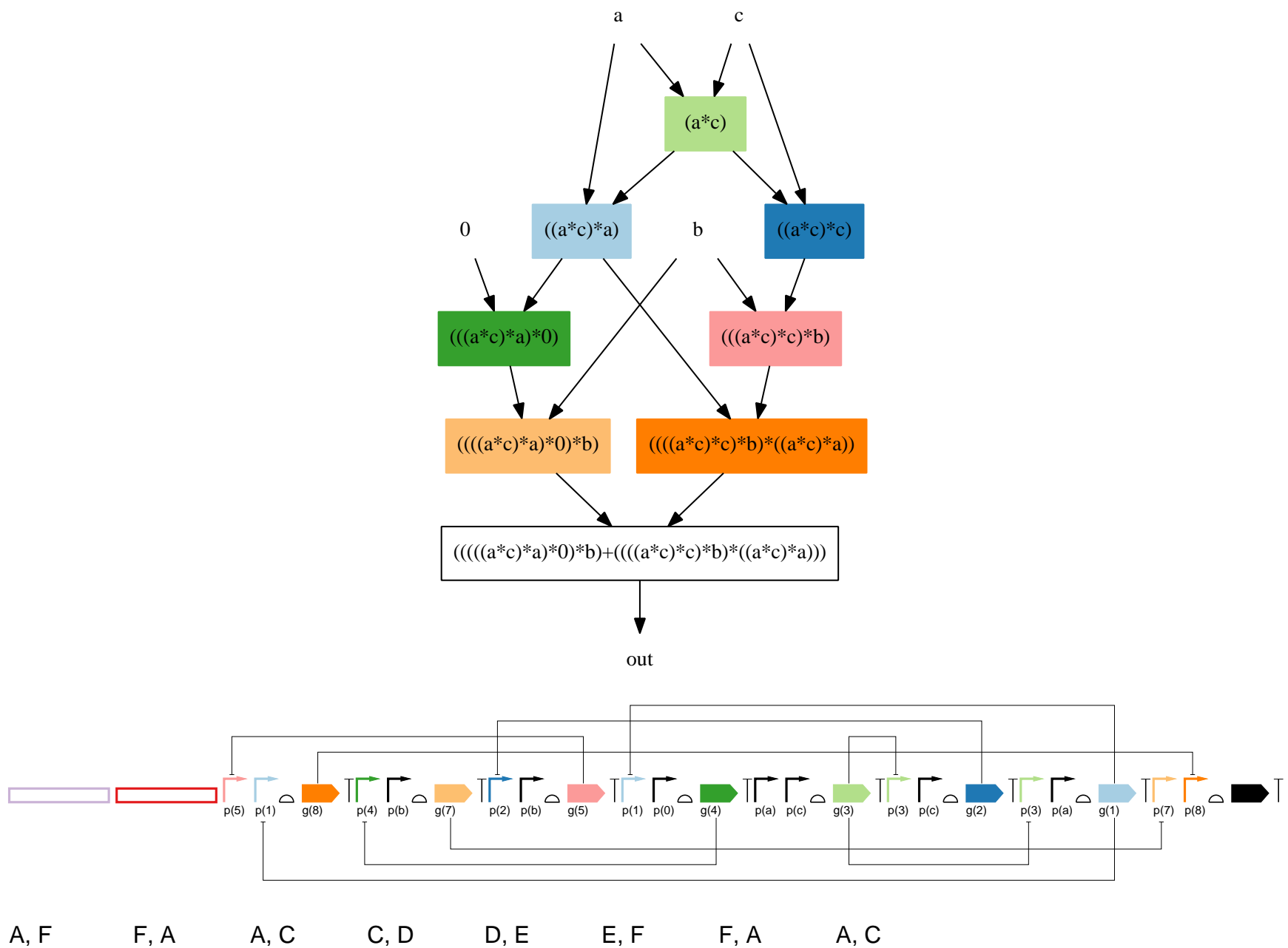


Figure 150: Circuit with truth table 0x6B.

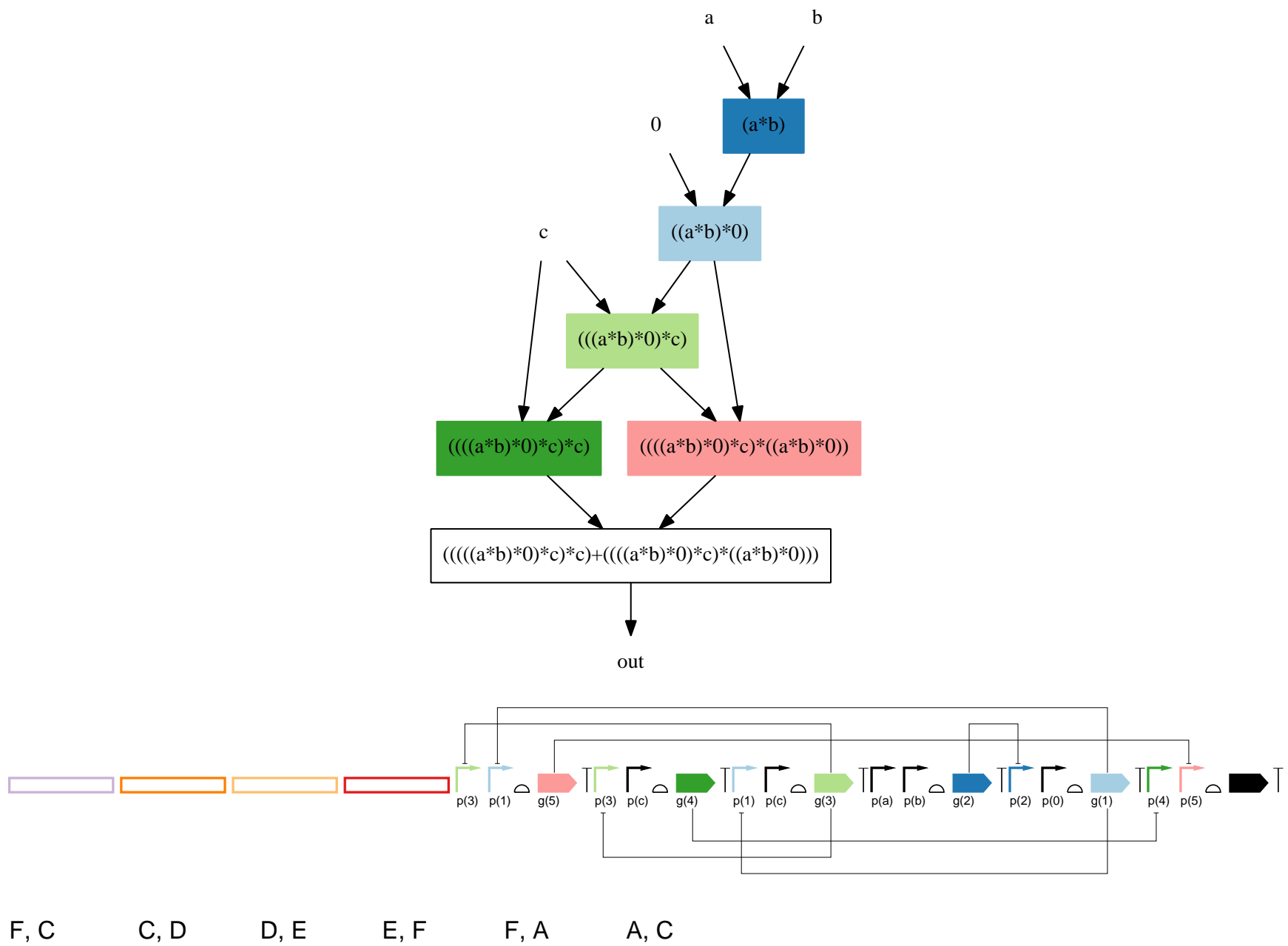


Figure 151: Circuit with truth table 0x6A.

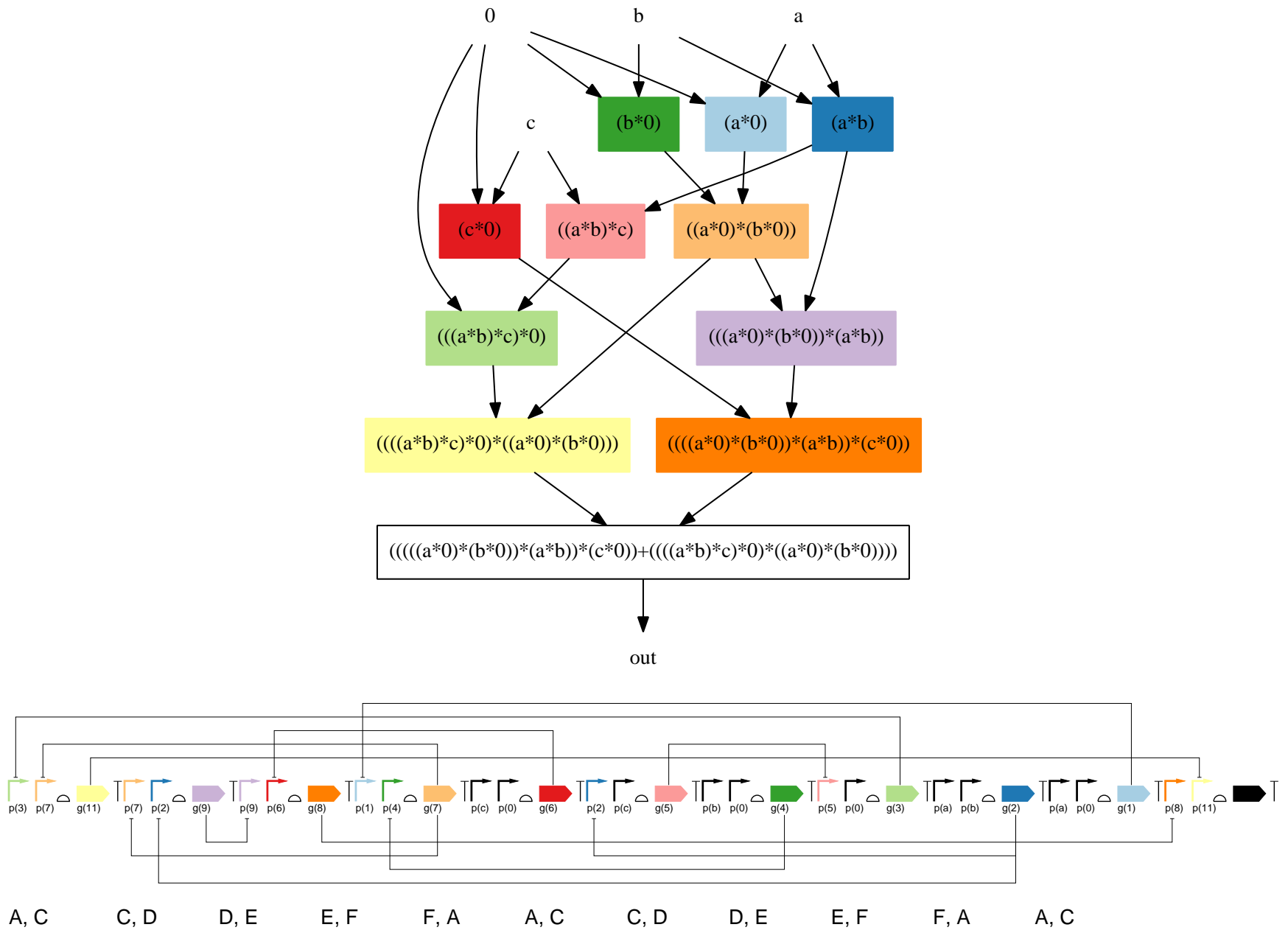


Figure 152: Circuit with truth table 0x69.

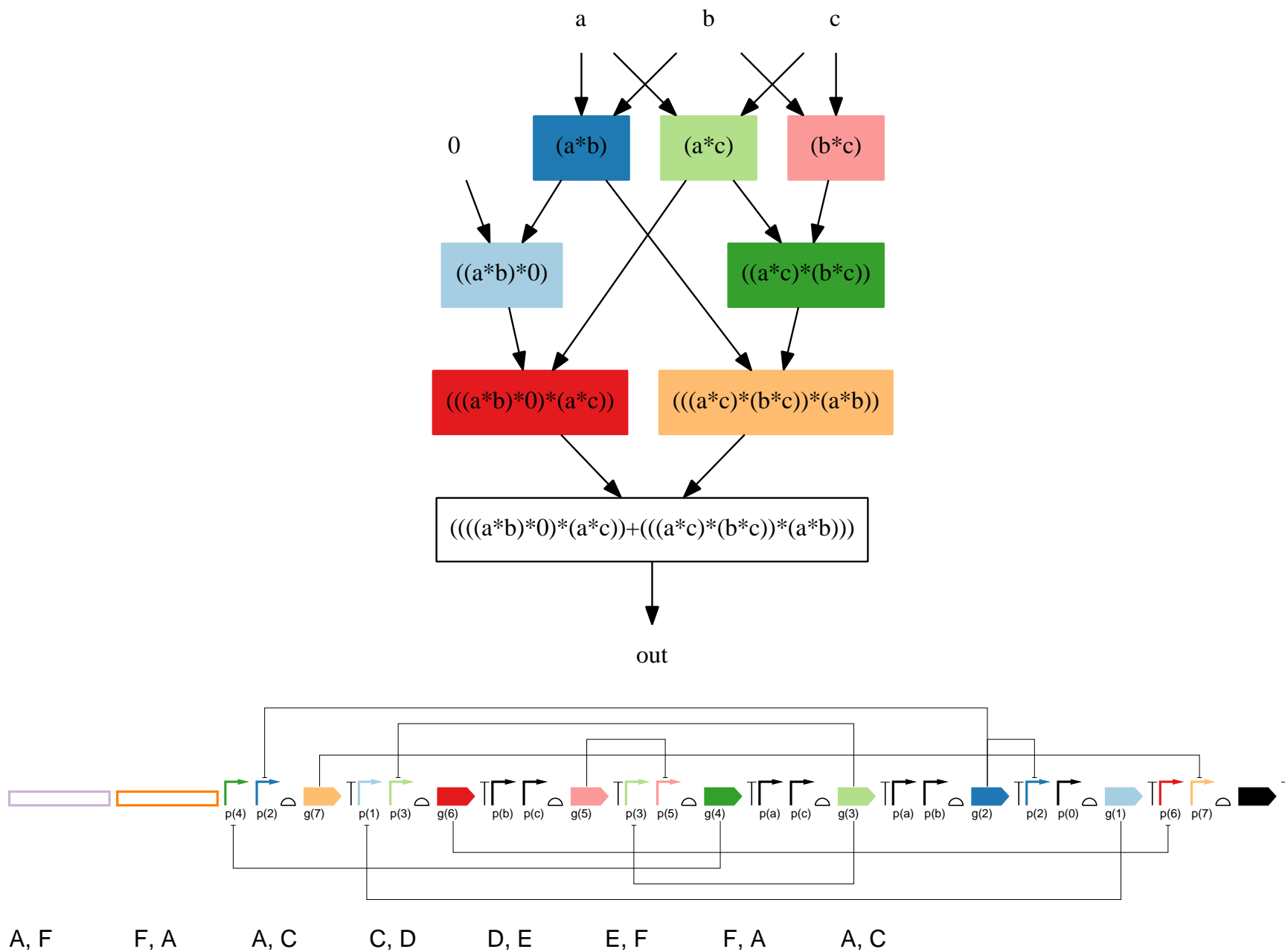


Figure 153: Circuit with truth table 0x68.

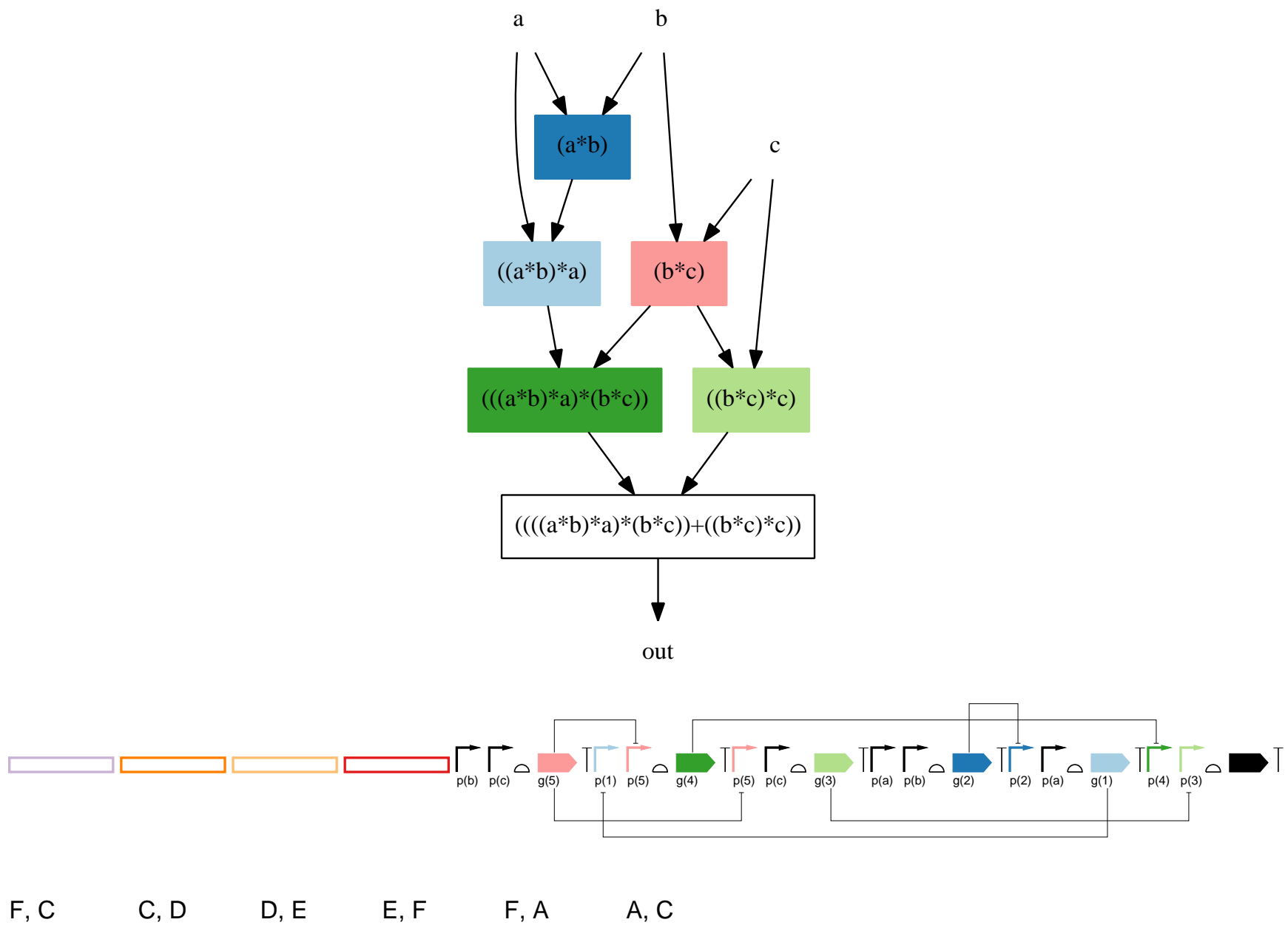


Figure 154: Circuit with truth table 0x67.

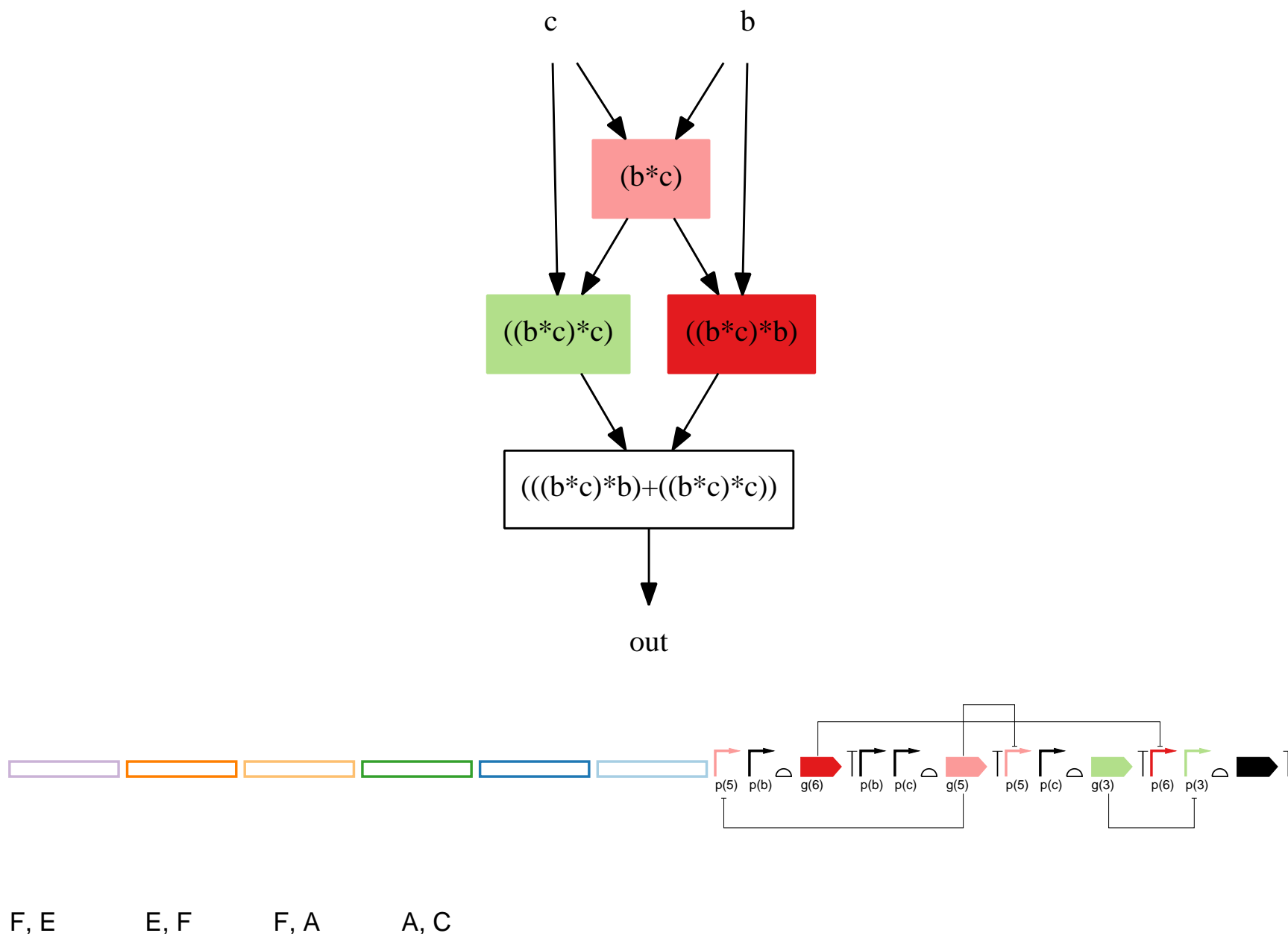


Figure 155: Circuit with truth table 0x66.

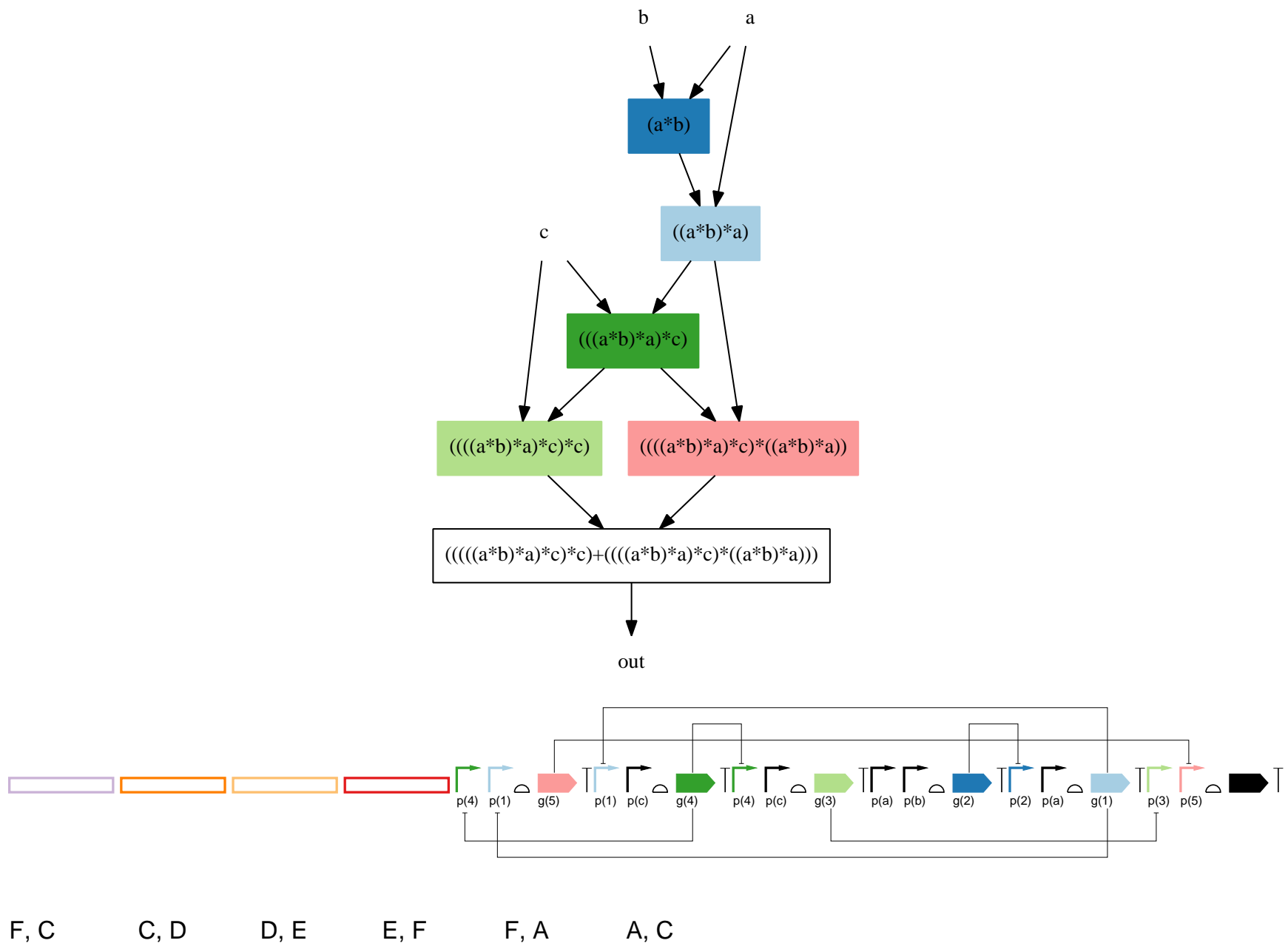


Figure 156: Circuit with truth table 0x65.

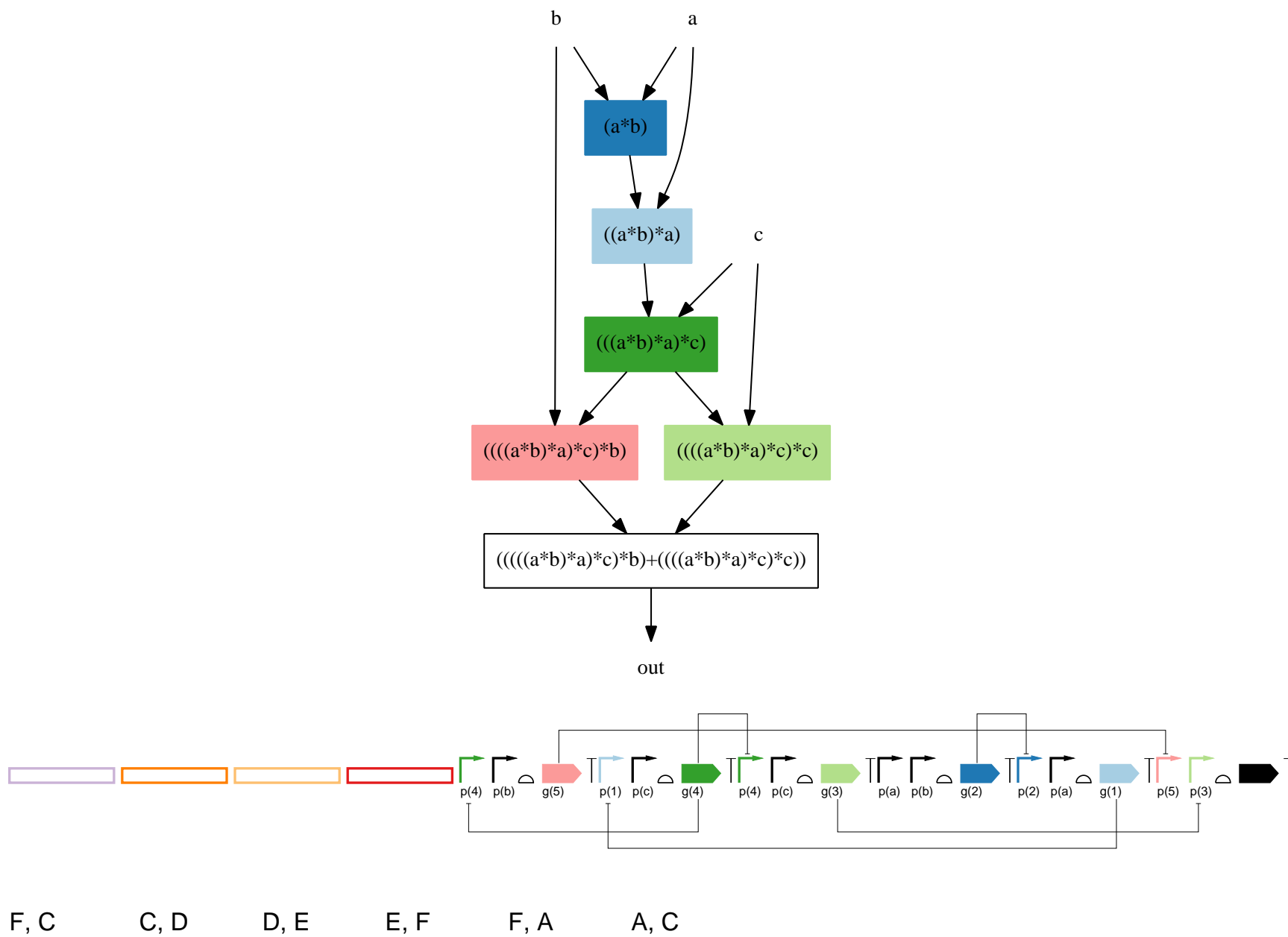


Figure 157: Circuit with truth table 0x64.

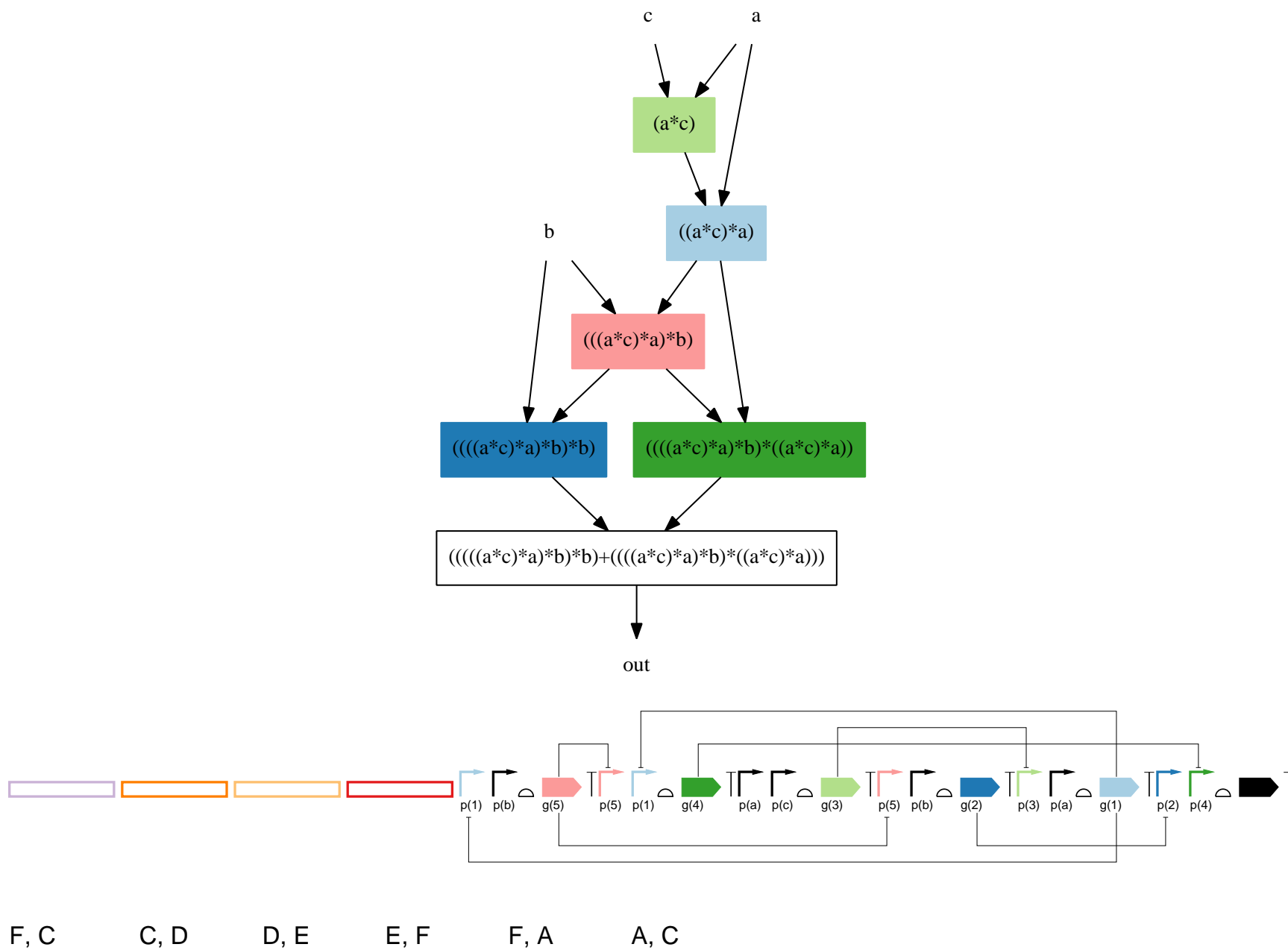


Figure 158: Circuit with truth table 0x63.

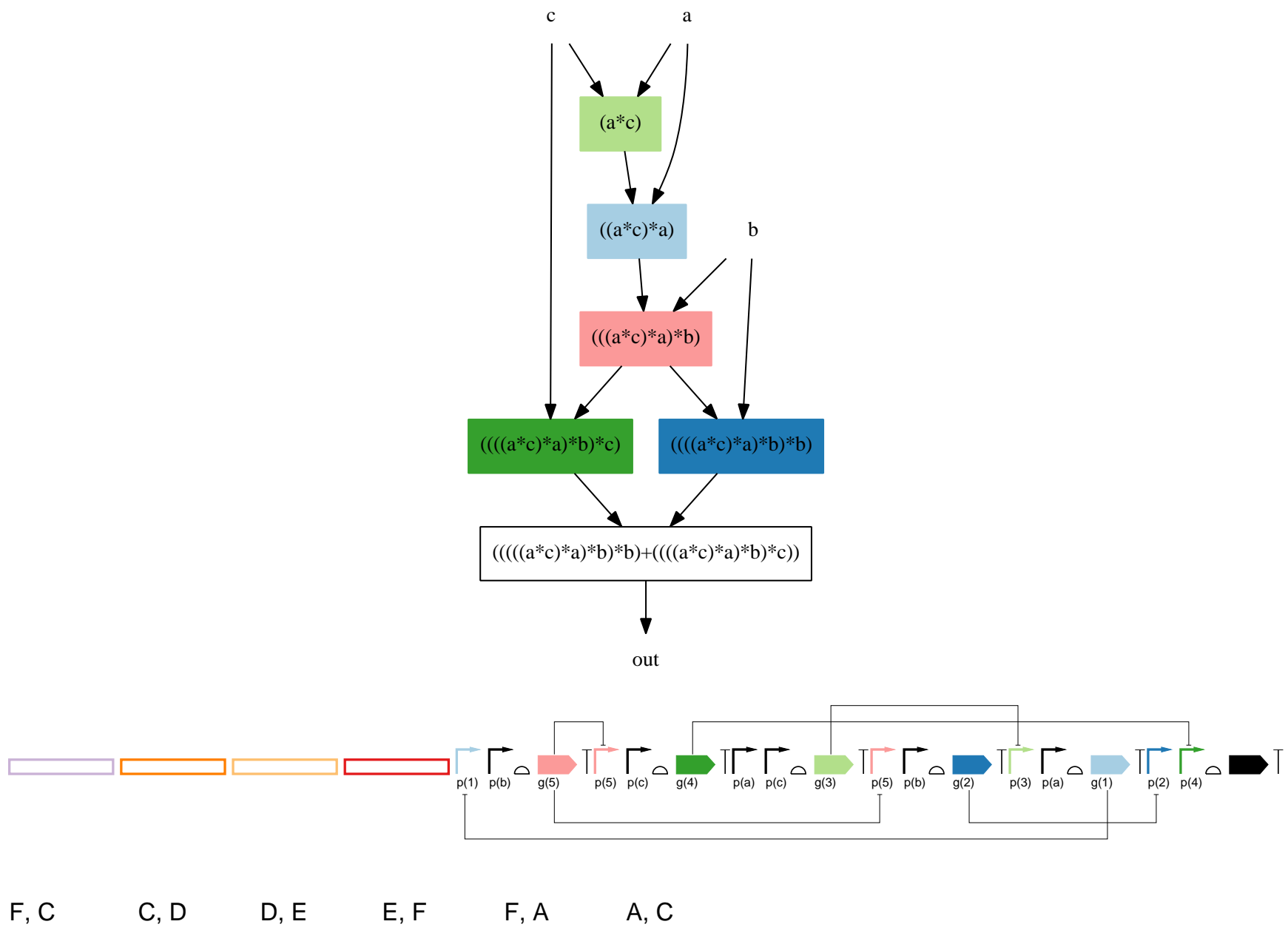


Figure 159: Circuit with truth table 0x62.

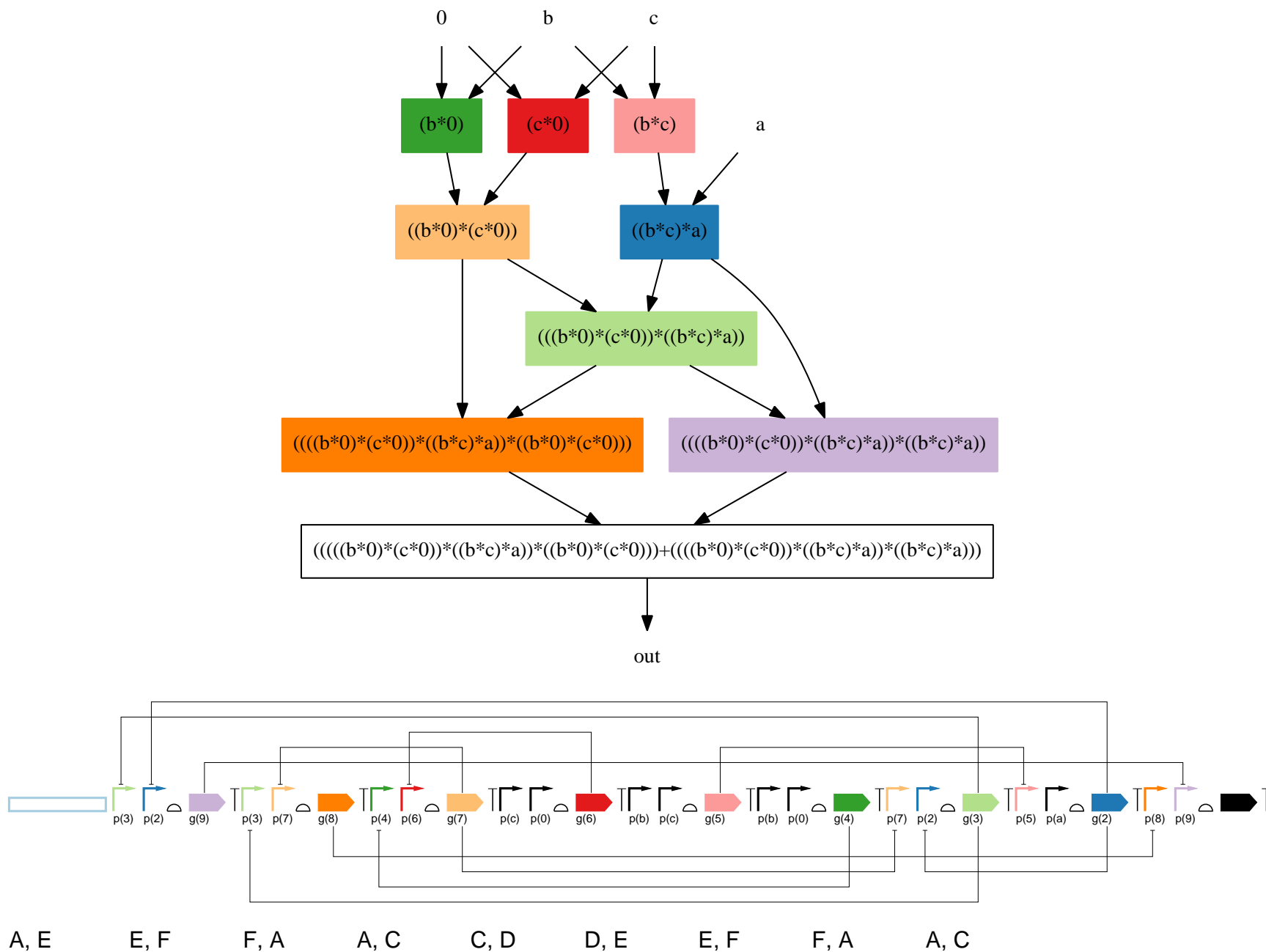


Figure 160: Circuit with truth table 0x61.

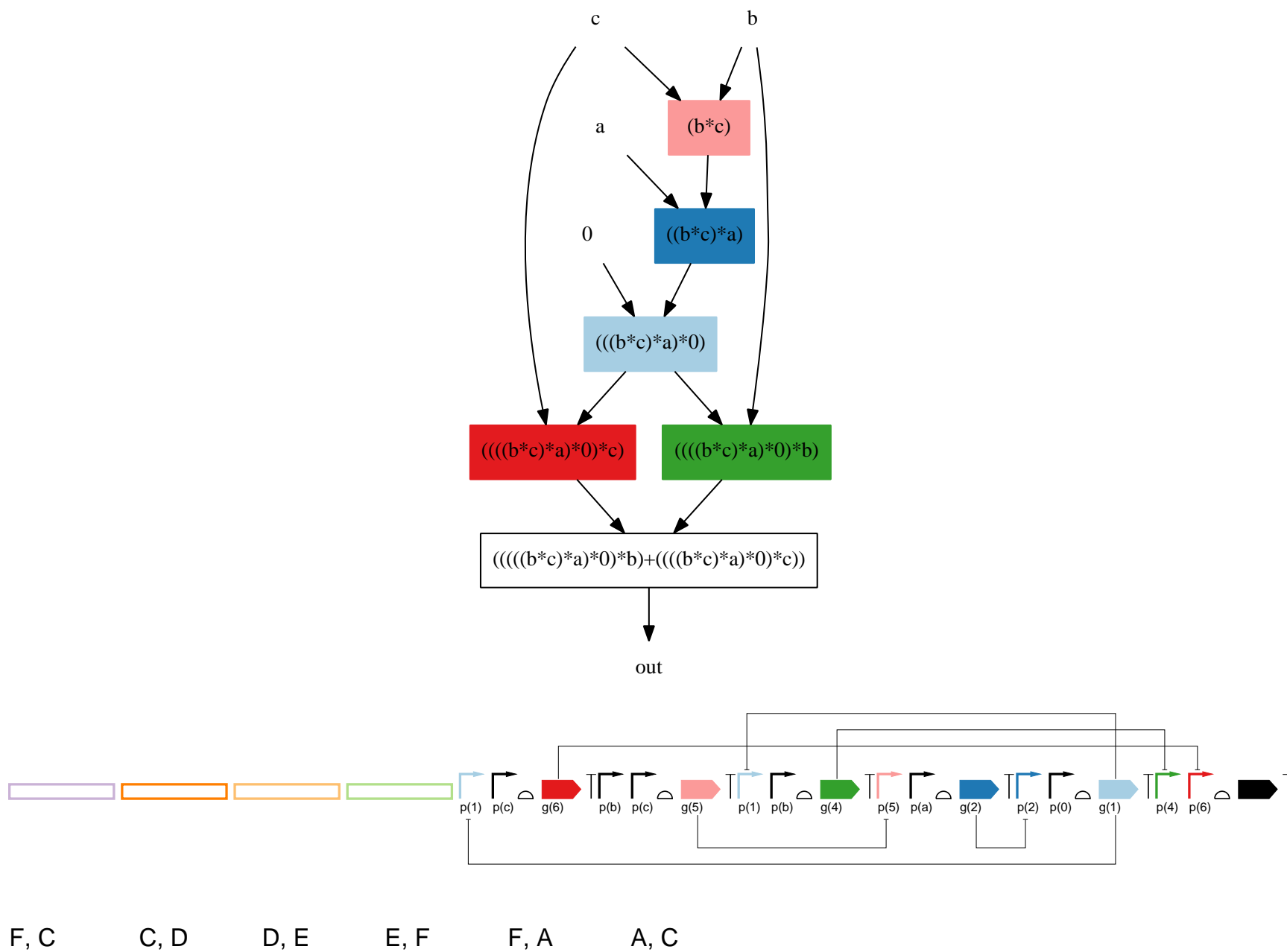
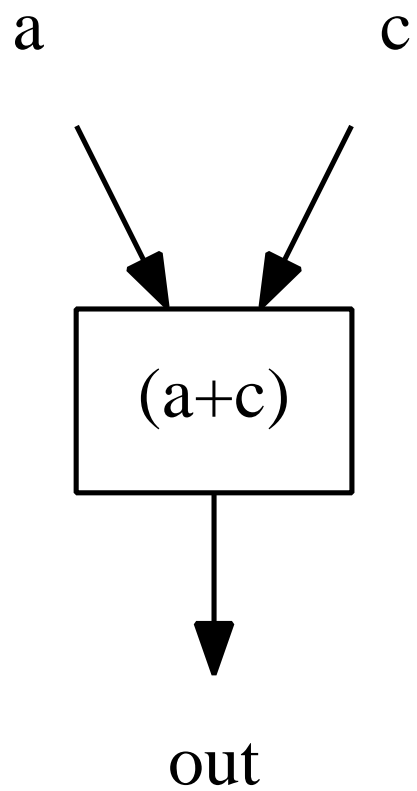


Figure 161: Circuit with truth table 0x60.

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E, C

Figure 162: Circuit with truth table 0x5F.

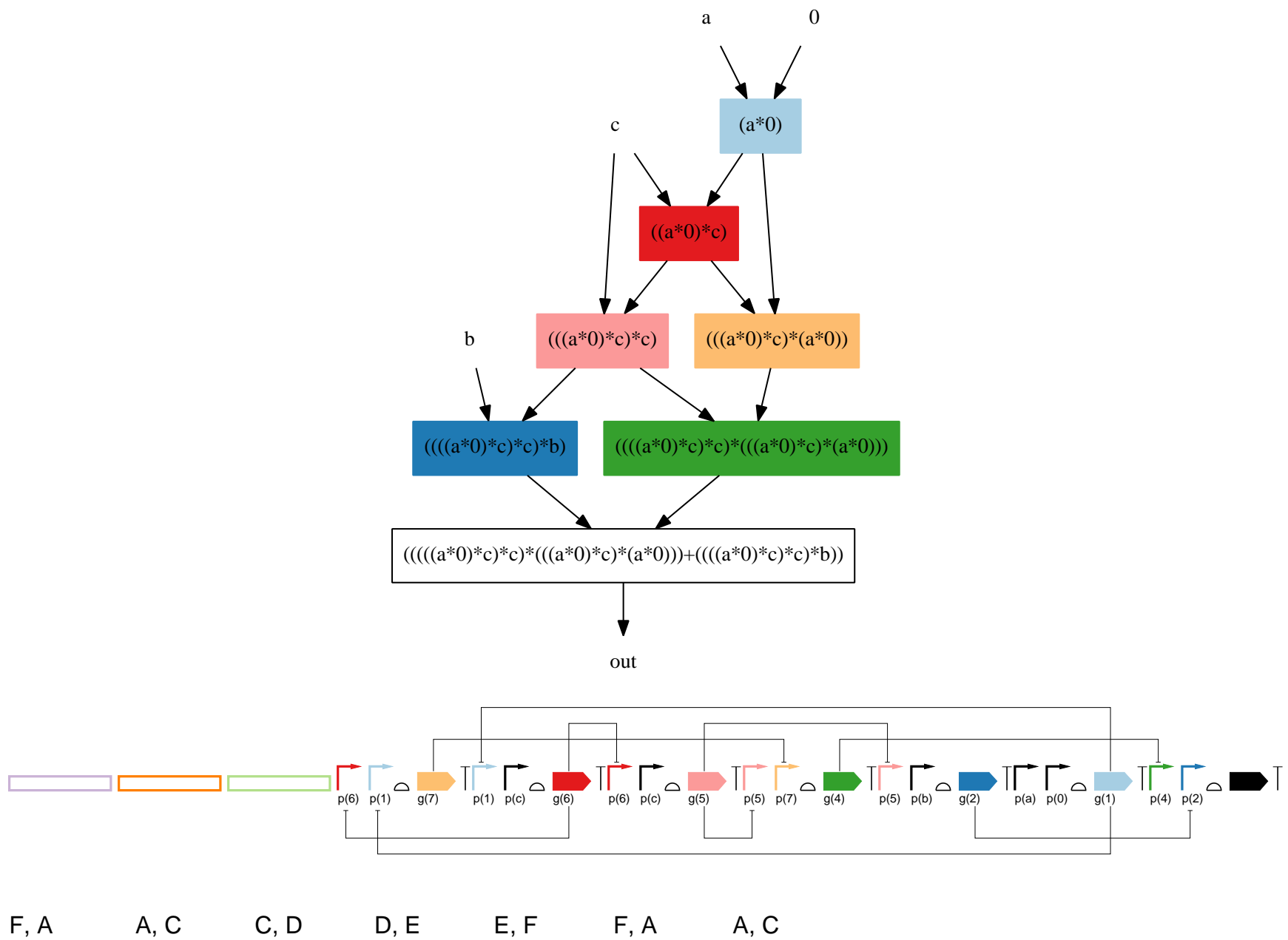


Figure 163: Circuit with truth table 0x5E.

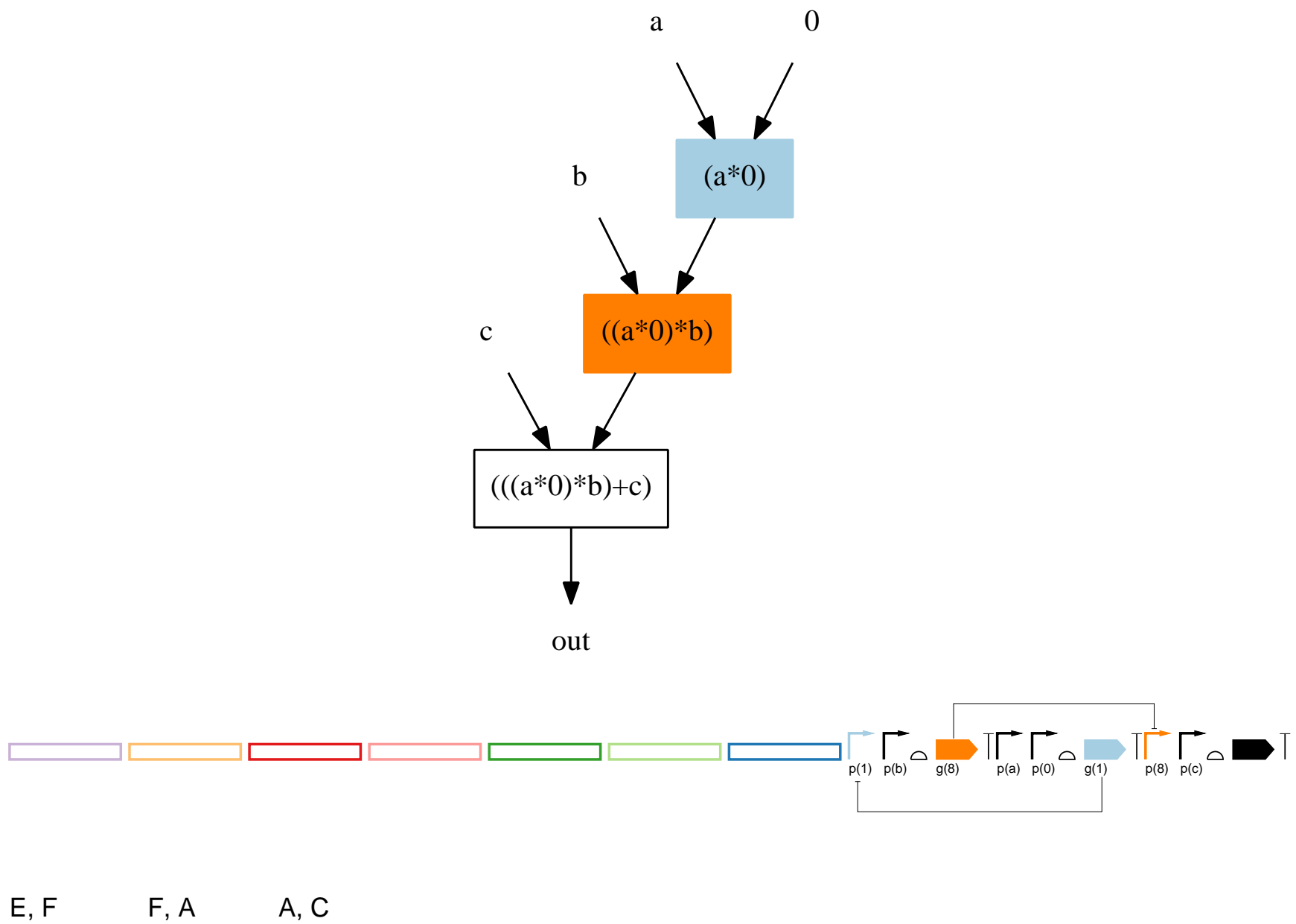


Figure 164: Circuit with truth table 0x5D.

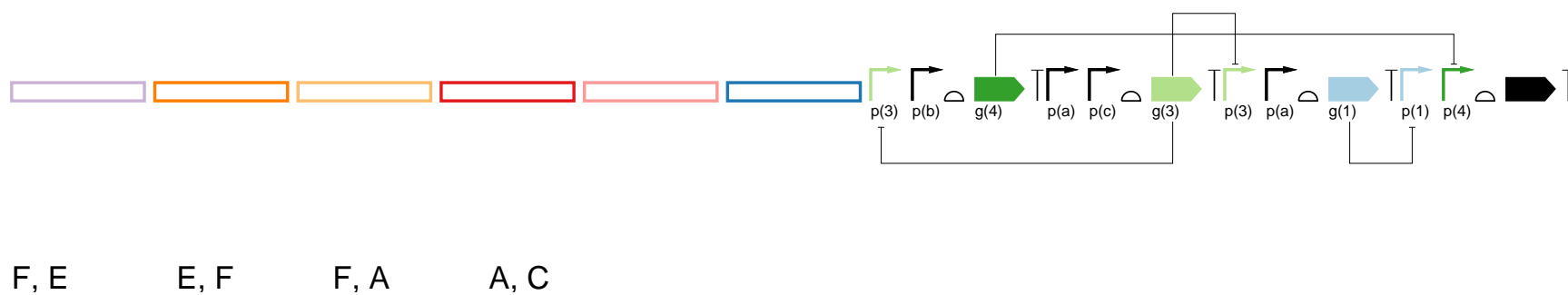
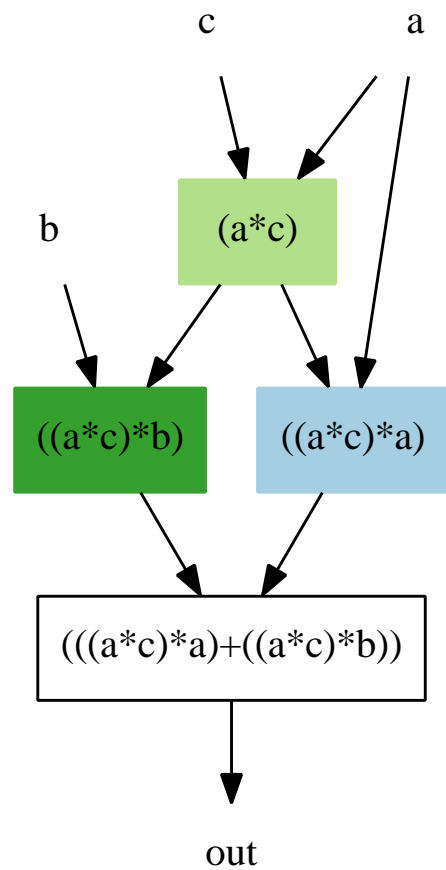


Figure 165: Circuit with truth table 0x5C.

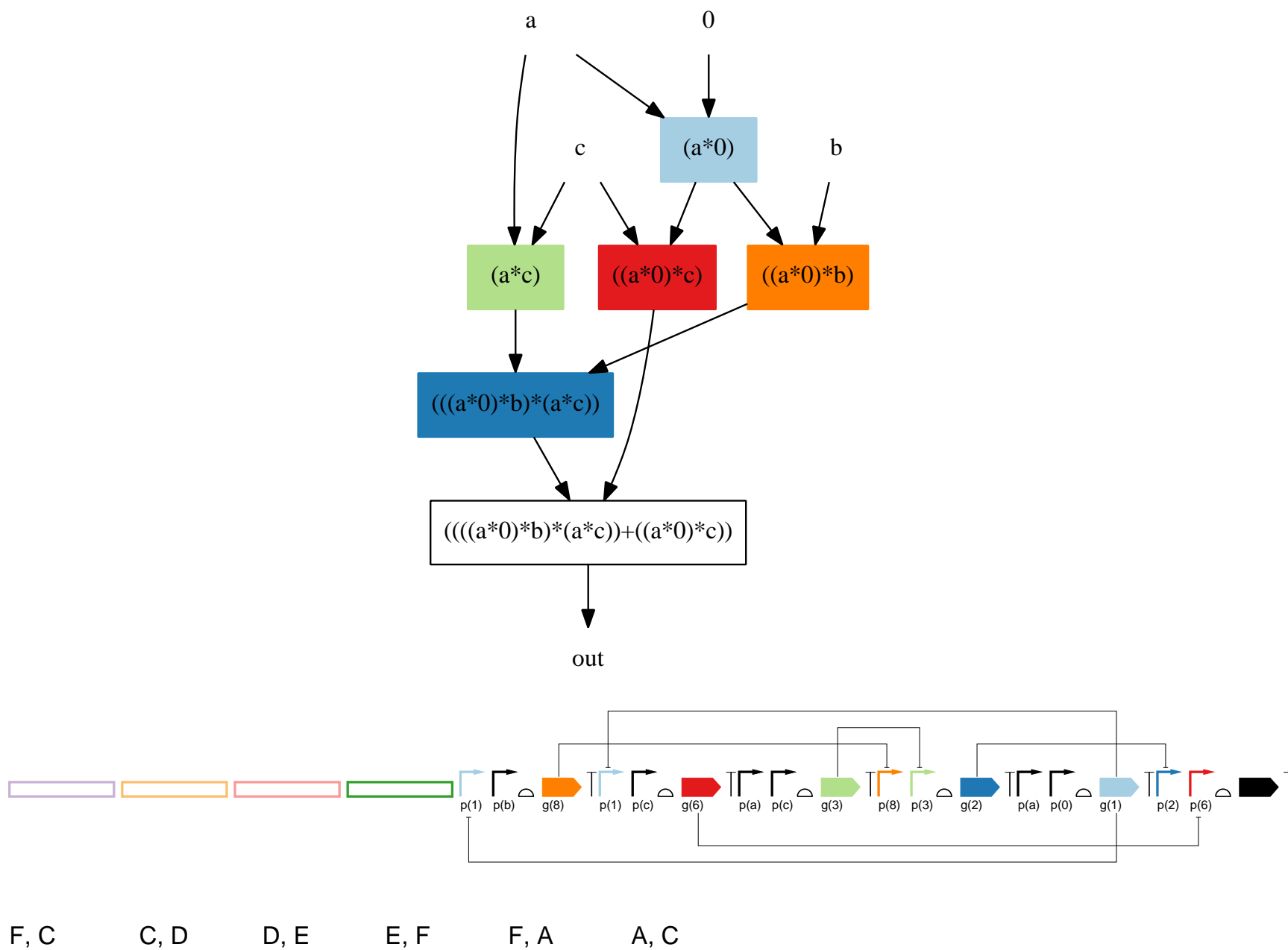


Figure 166: Circuit with truth table 0x5B.

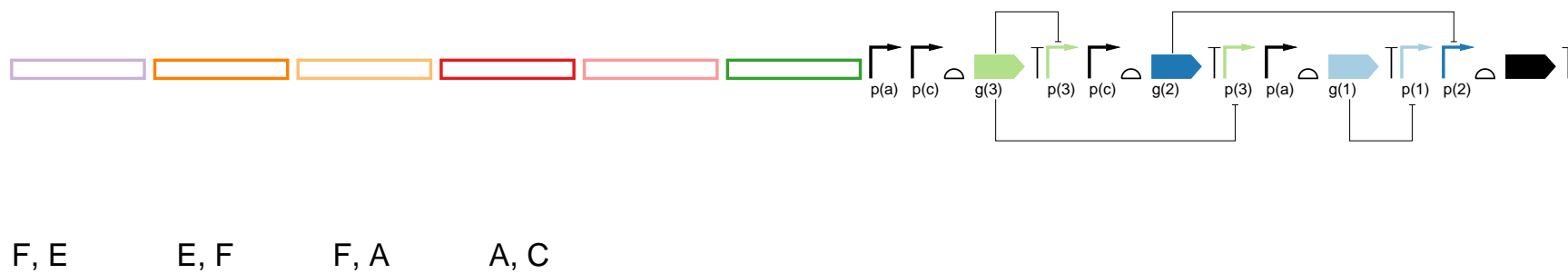
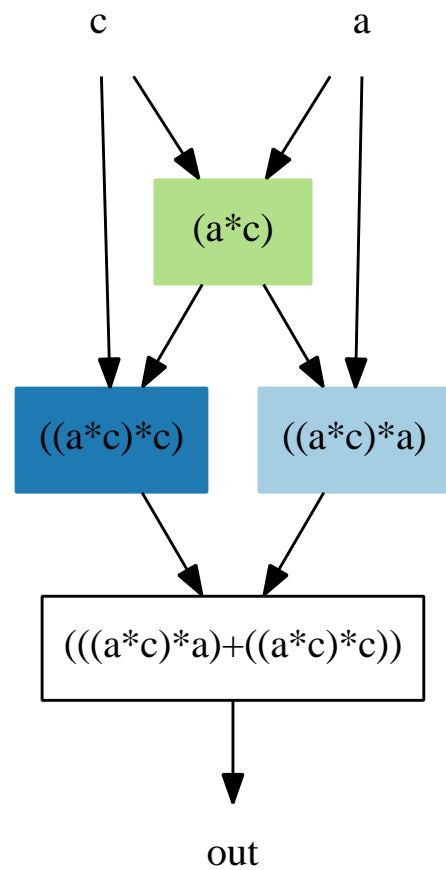


Figure 167: Circuit with truth table 0x5A.

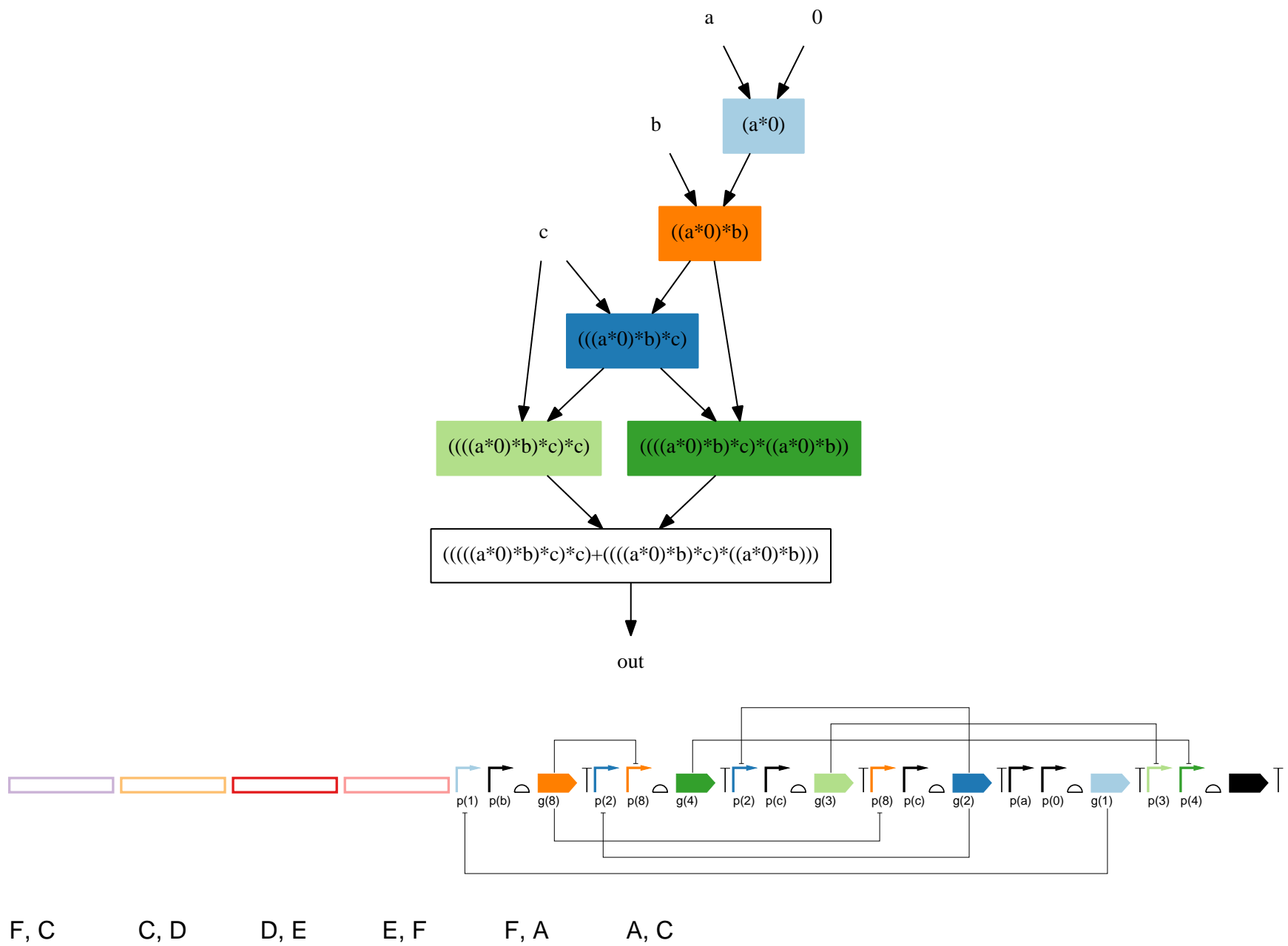


Figure 168: Circuit with truth table 0x59.

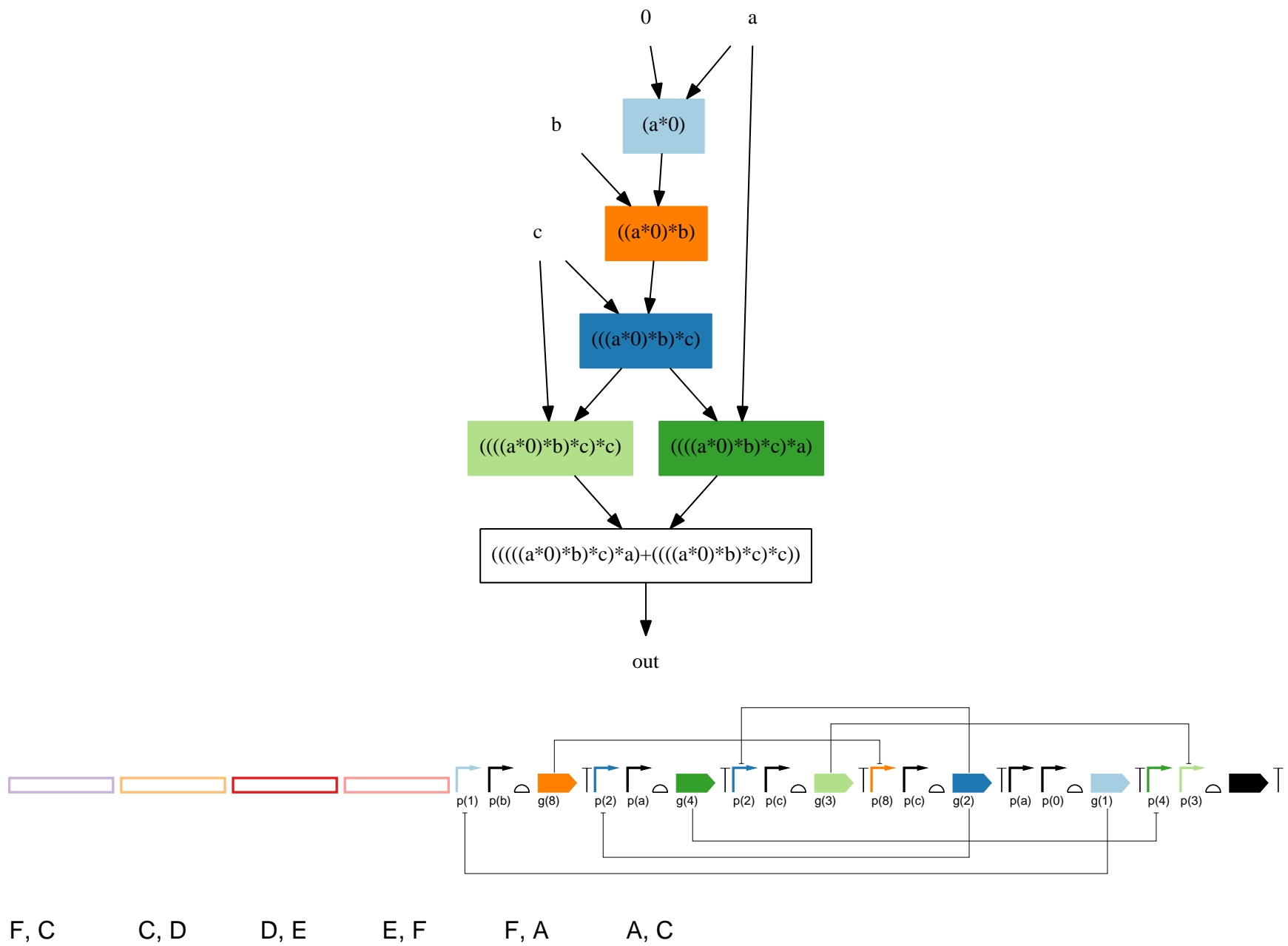


Figure 169: Circuit with truth table 0x58.

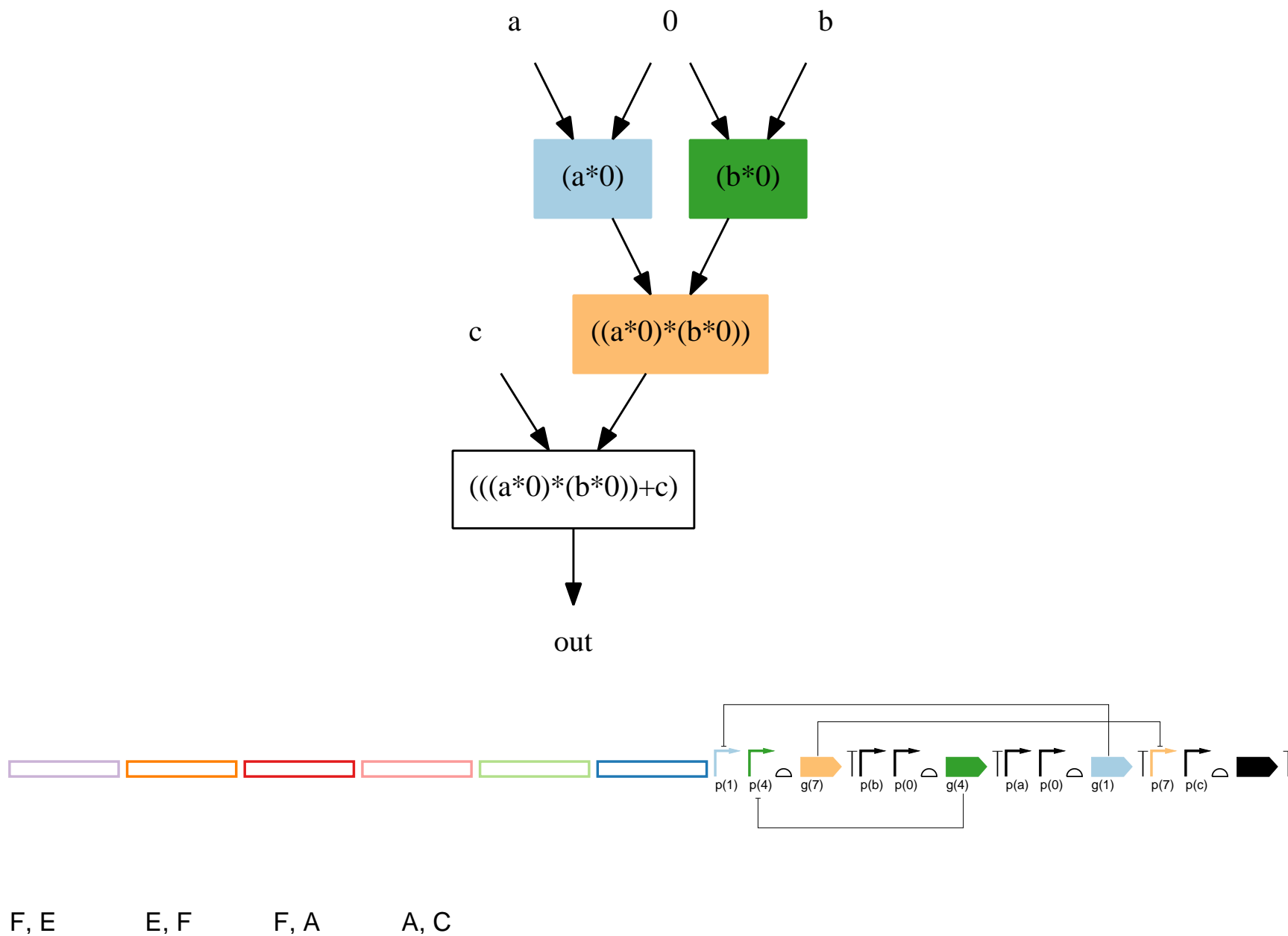


Figure 170: Circuit with truth table 0x57.

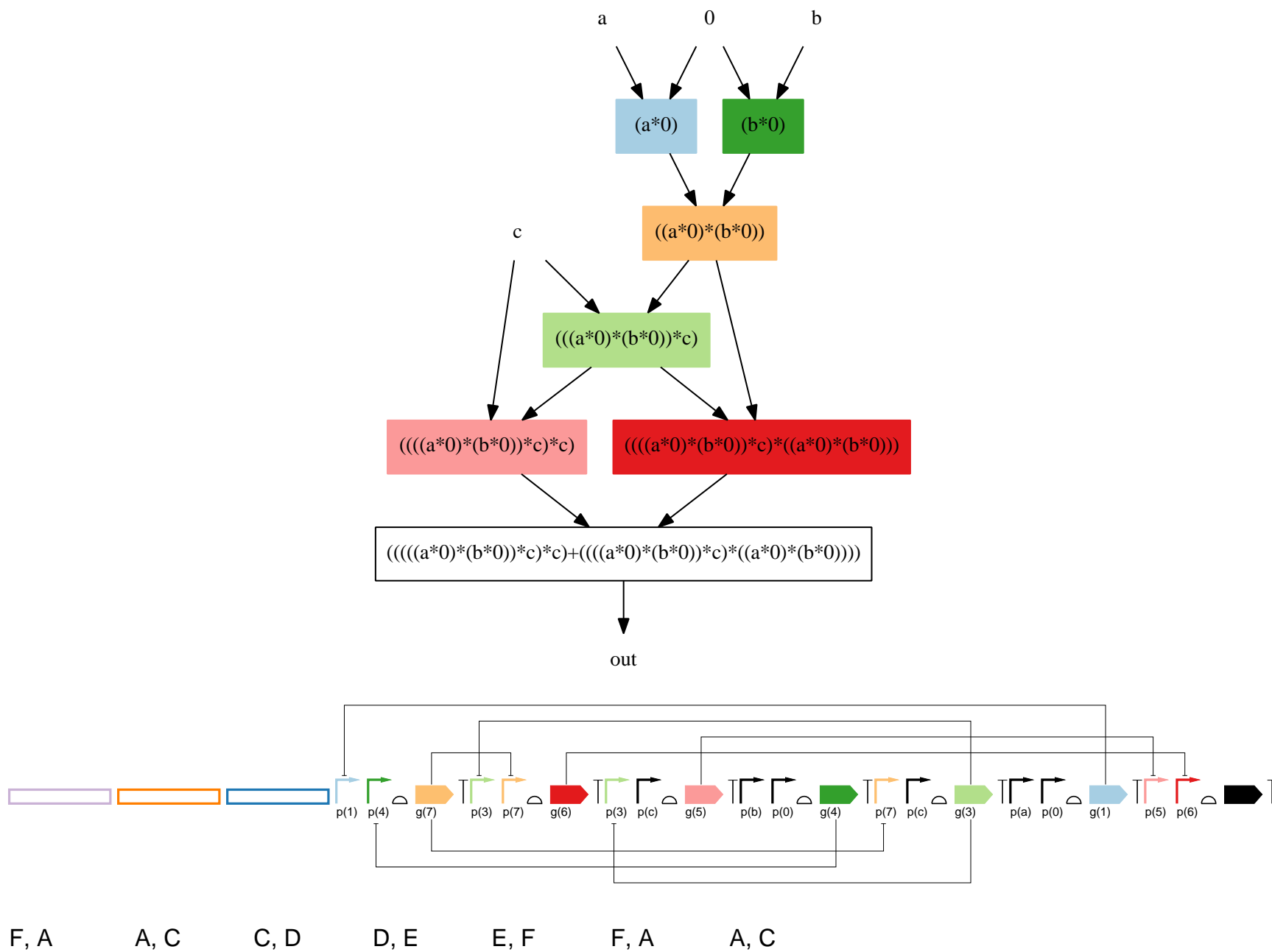


Figure 171: Circuit with truth table 0x56.

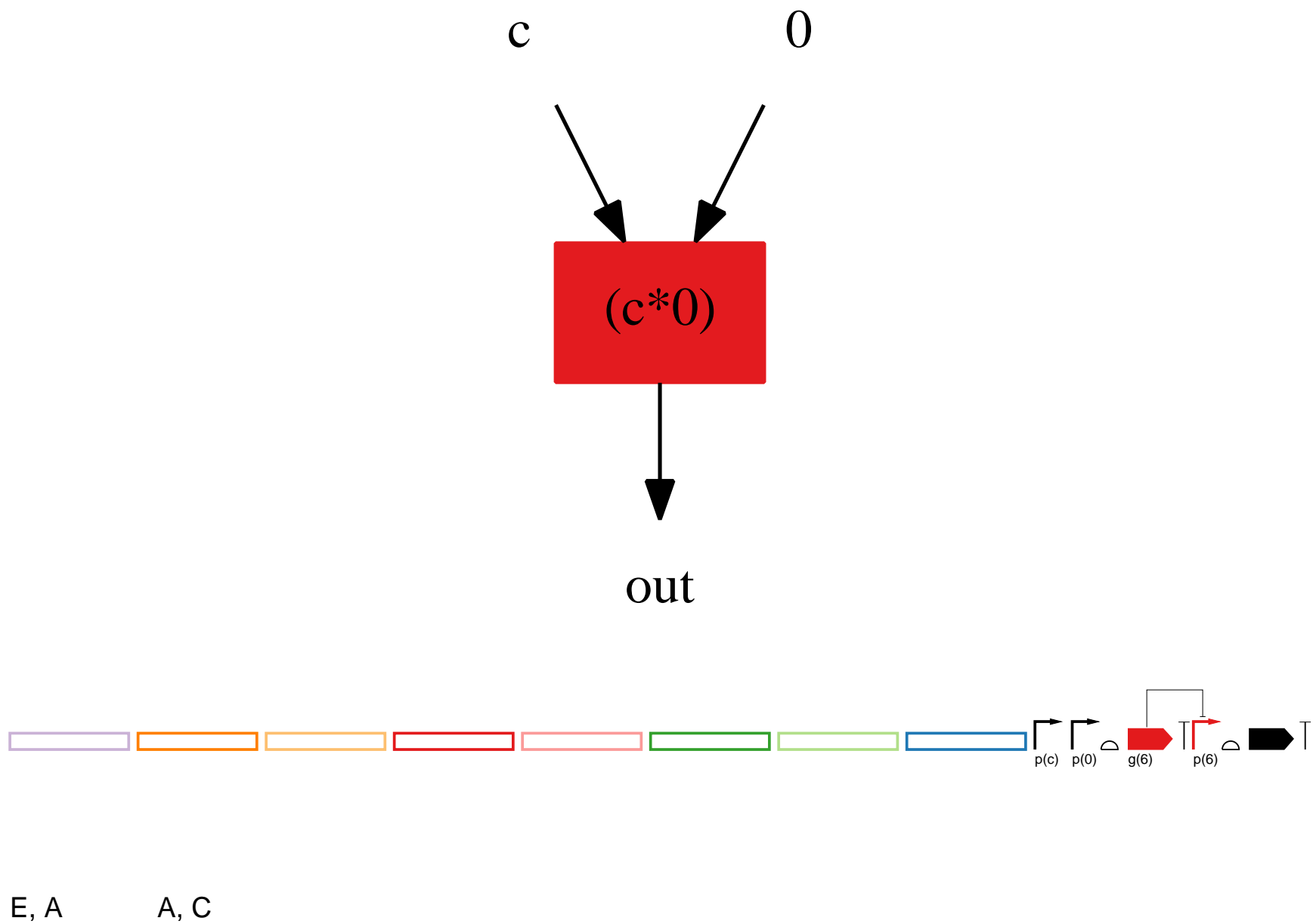


Figure 172: Circuit with truth table 0xAA.

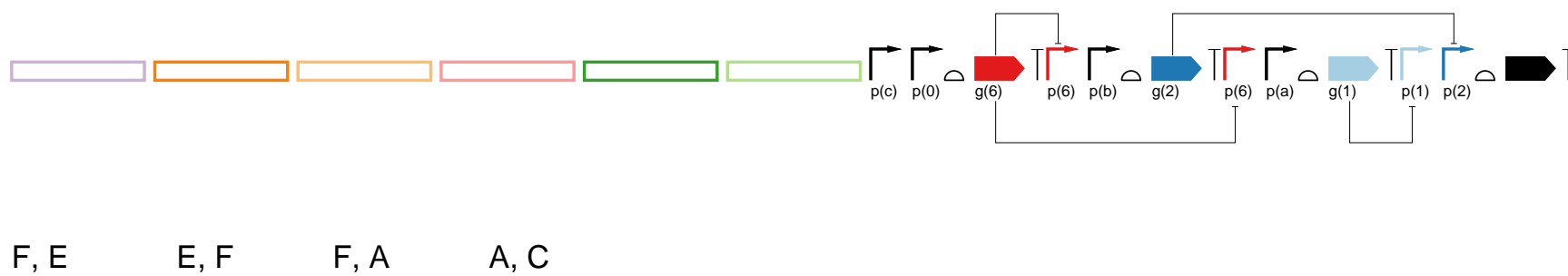
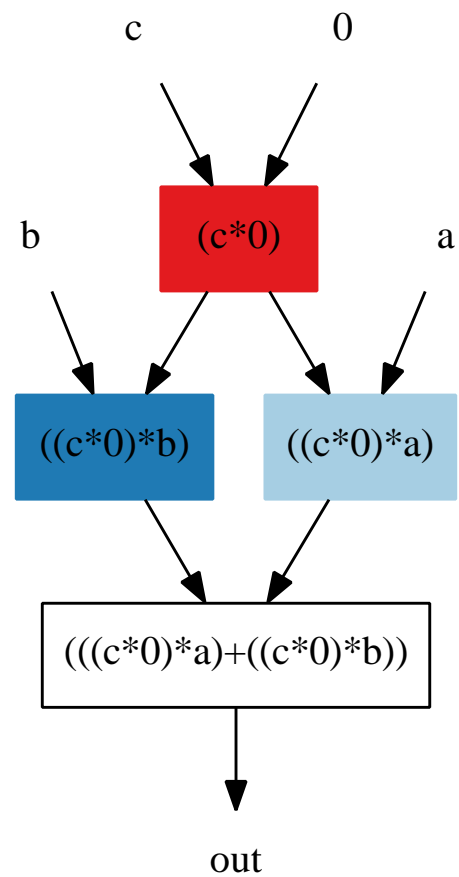


Figure 173: Circuit with truth table 0x54.

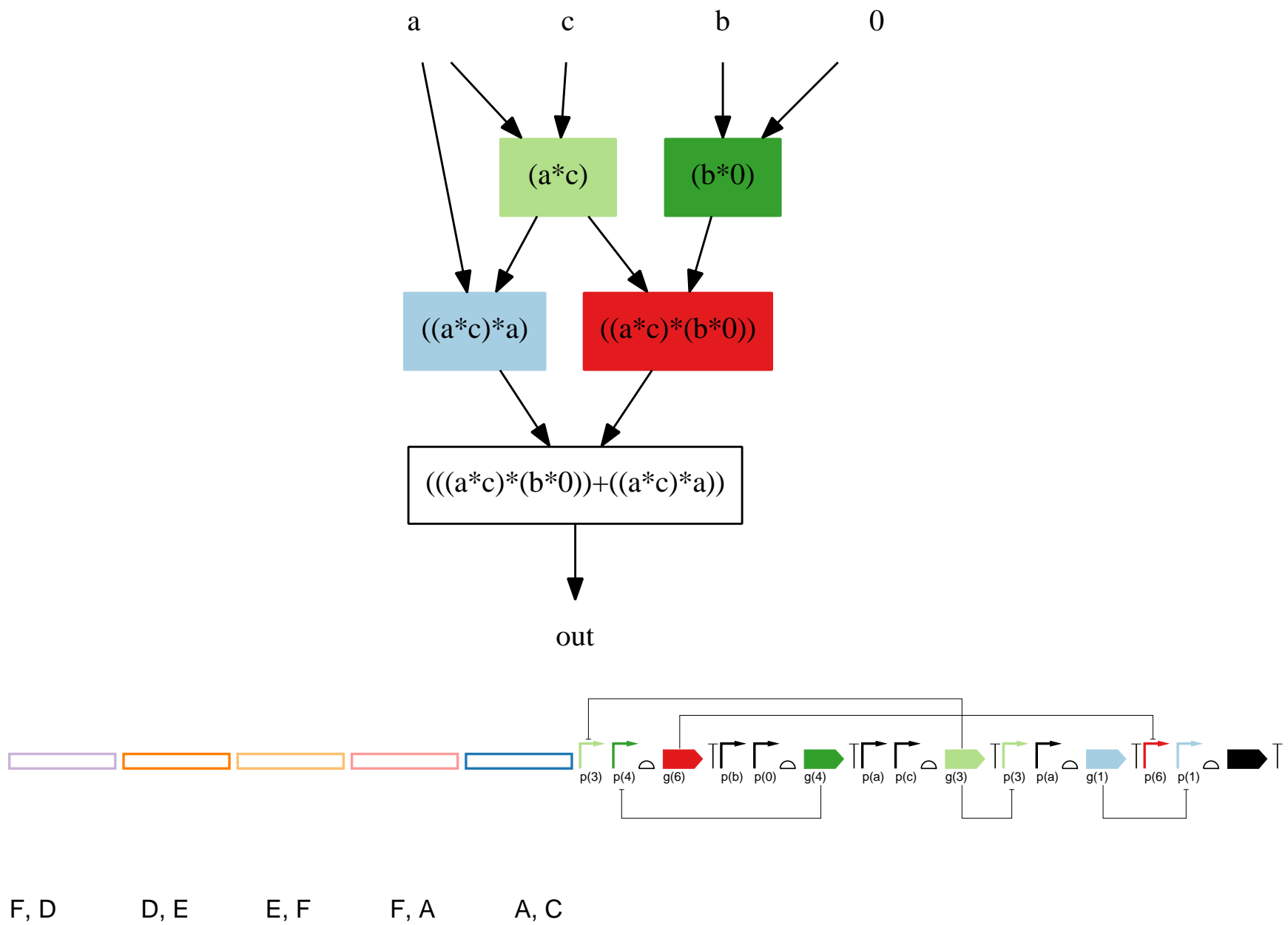


Figure 174: Circuit with truth table 0x53.

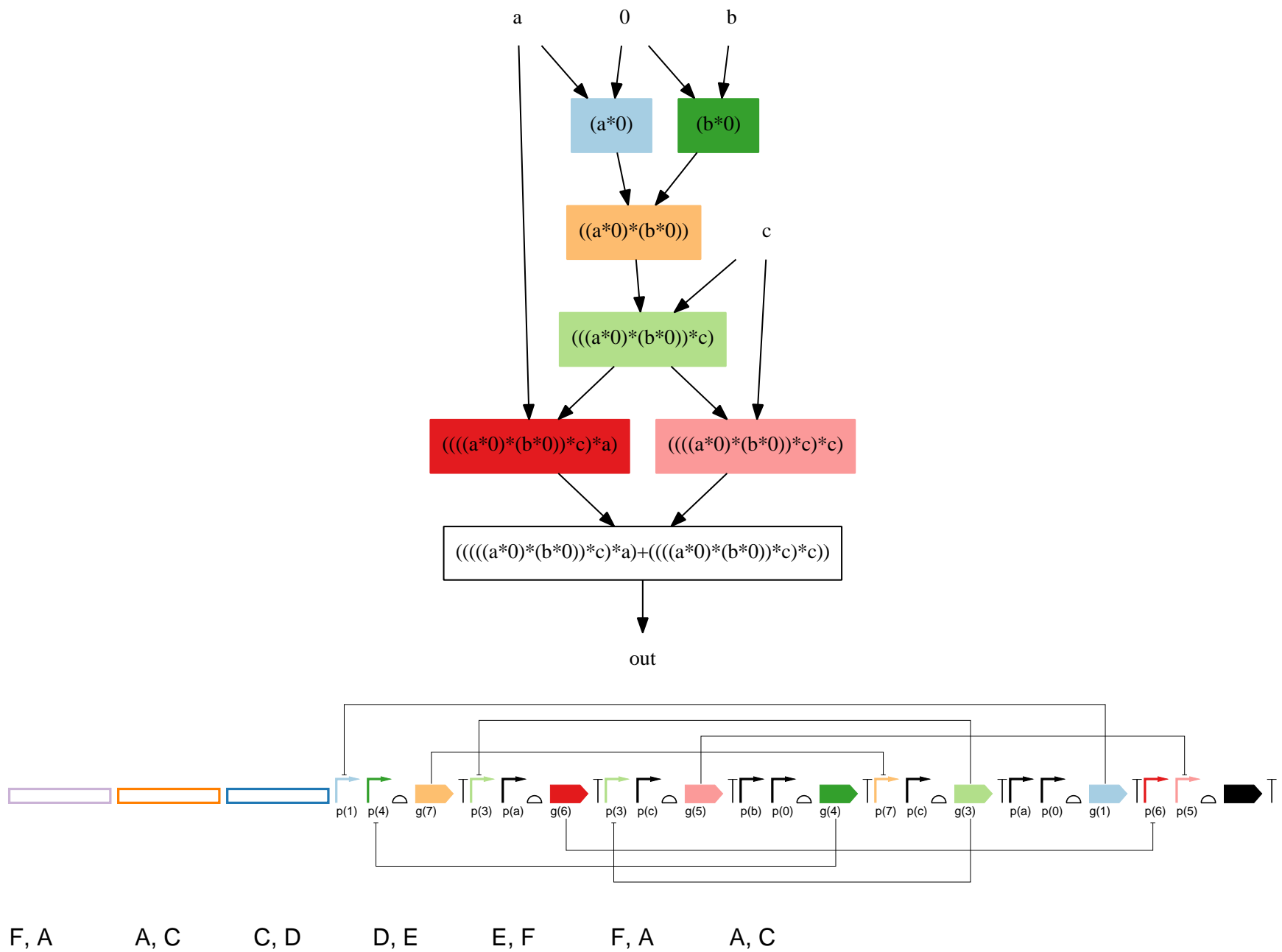


Figure 175: Circuit with truth table 0x52.

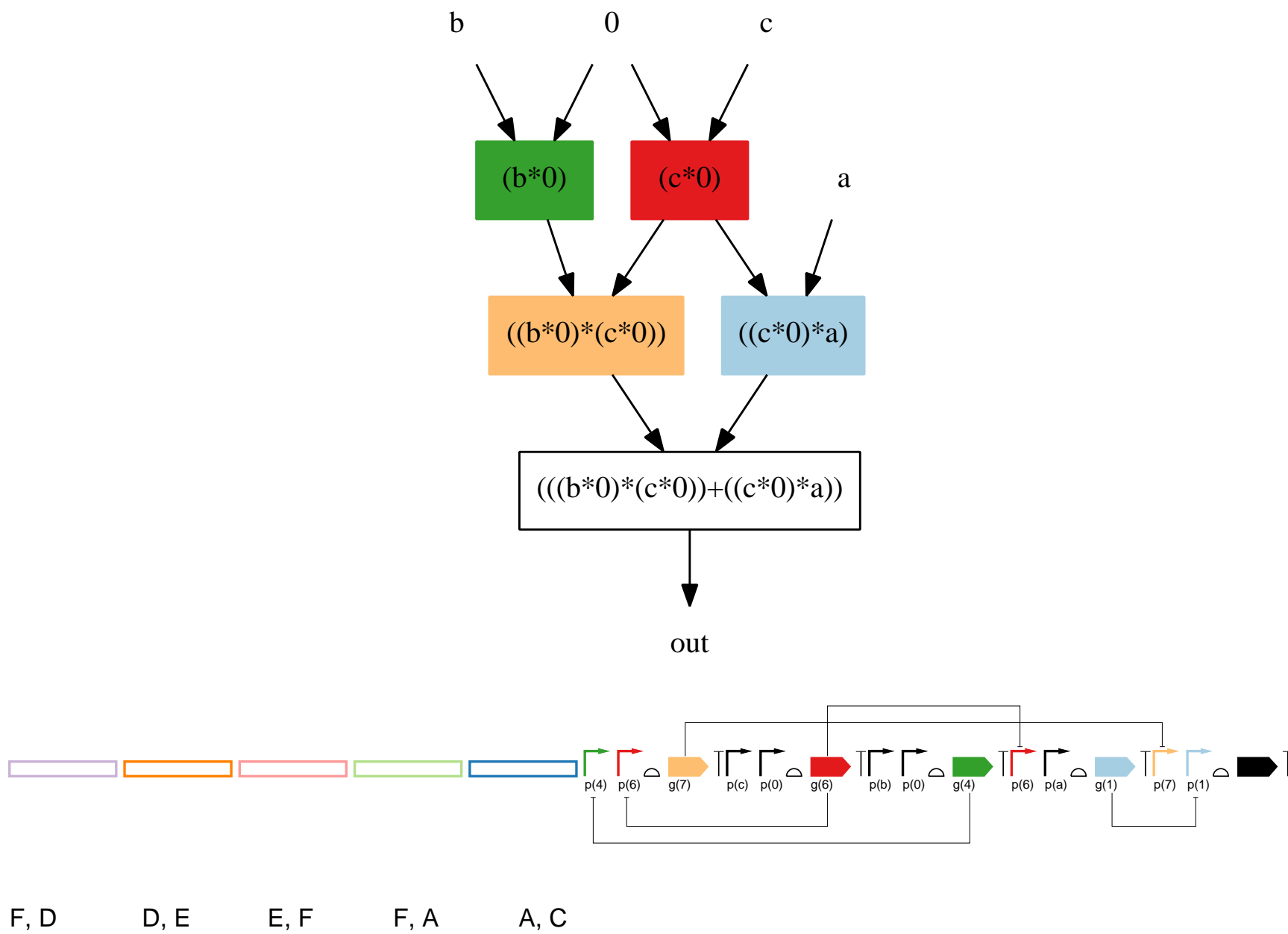


Figure 176: Circuit with truth table 0x51.

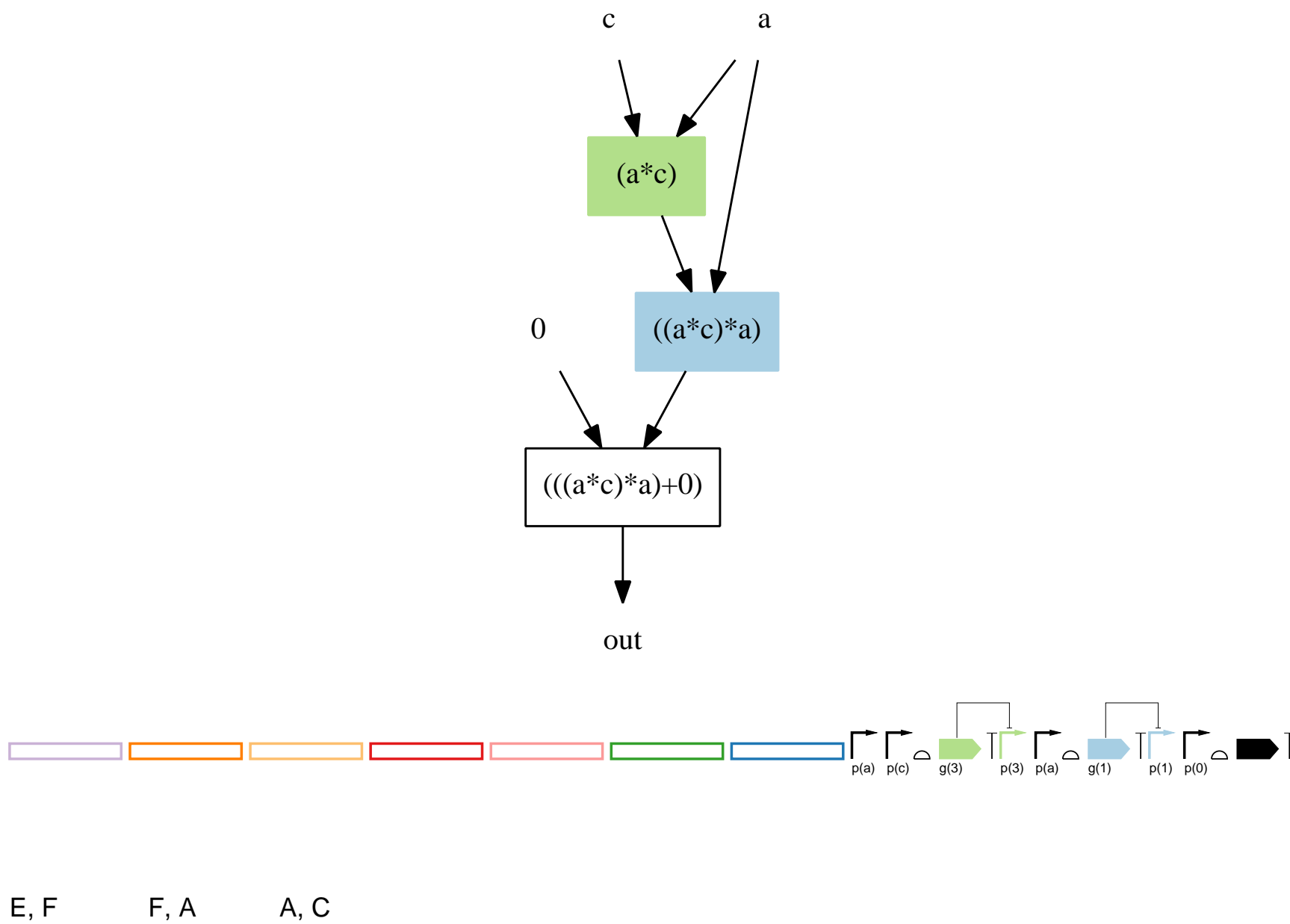


Figure 177: Circuit with truth table 0x50.

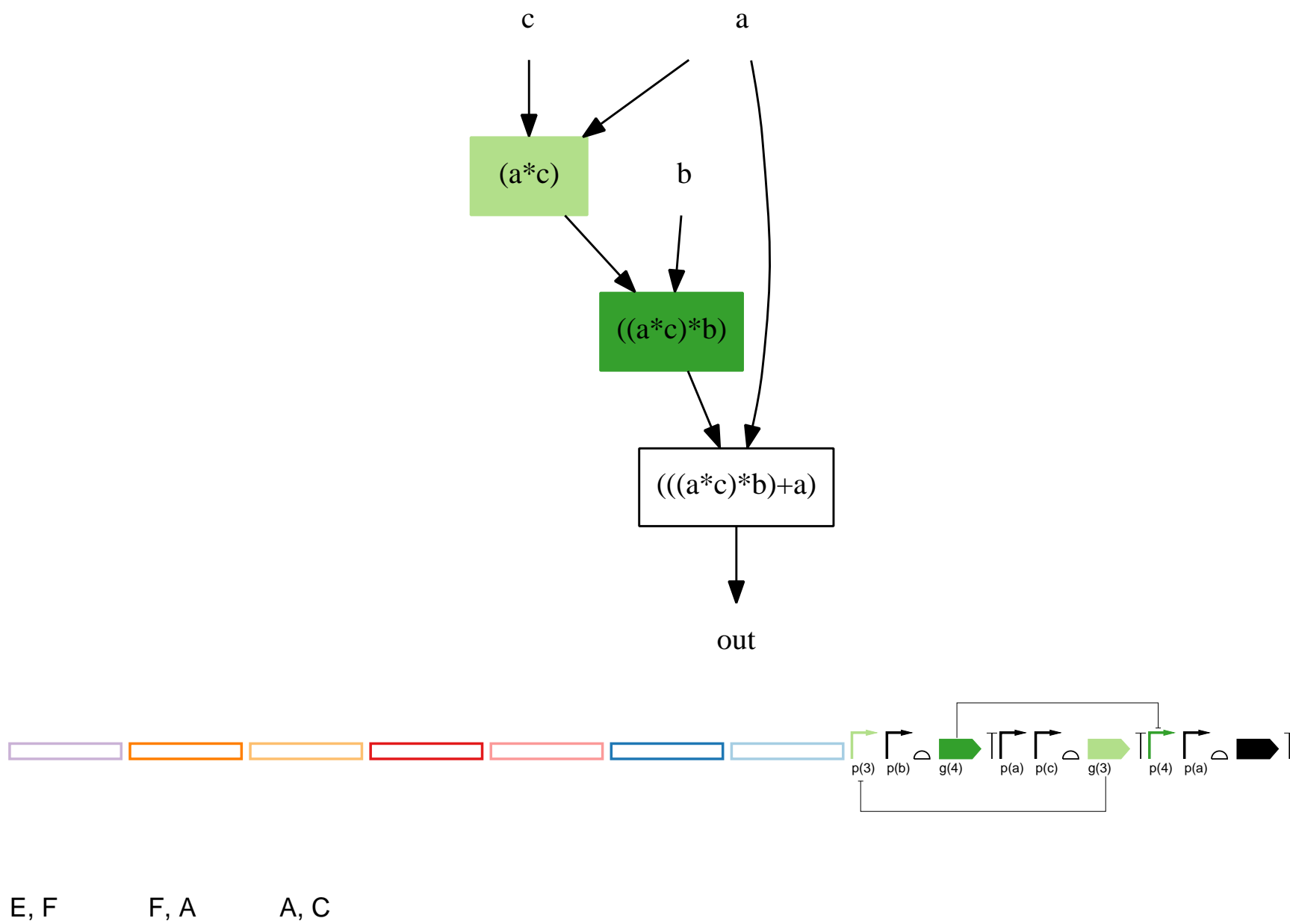


Figure 178: Circuit with truth table 0x4F.

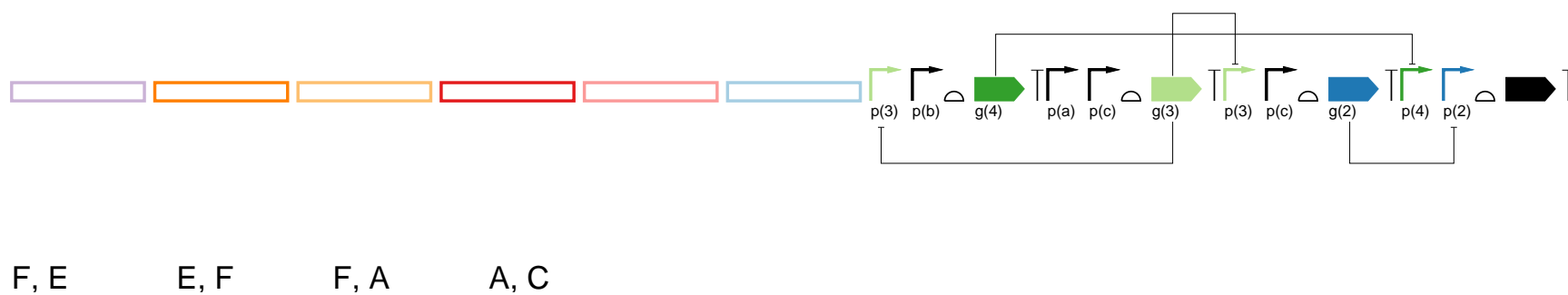
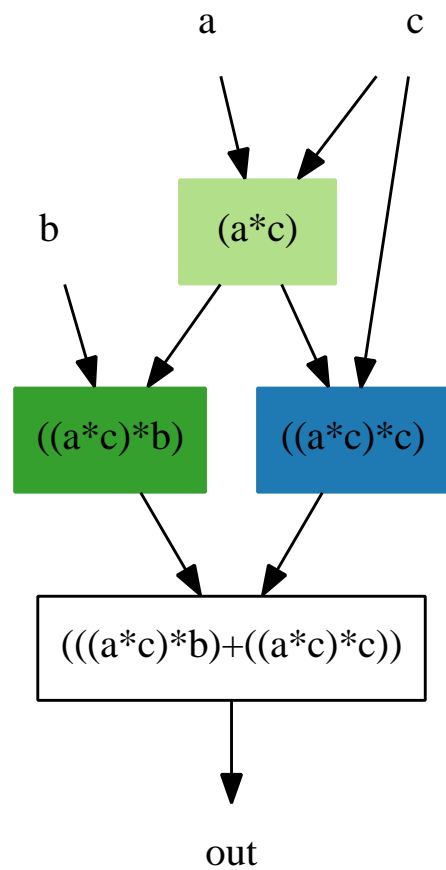


Figure 179: Circuit with truth table 0x4E.

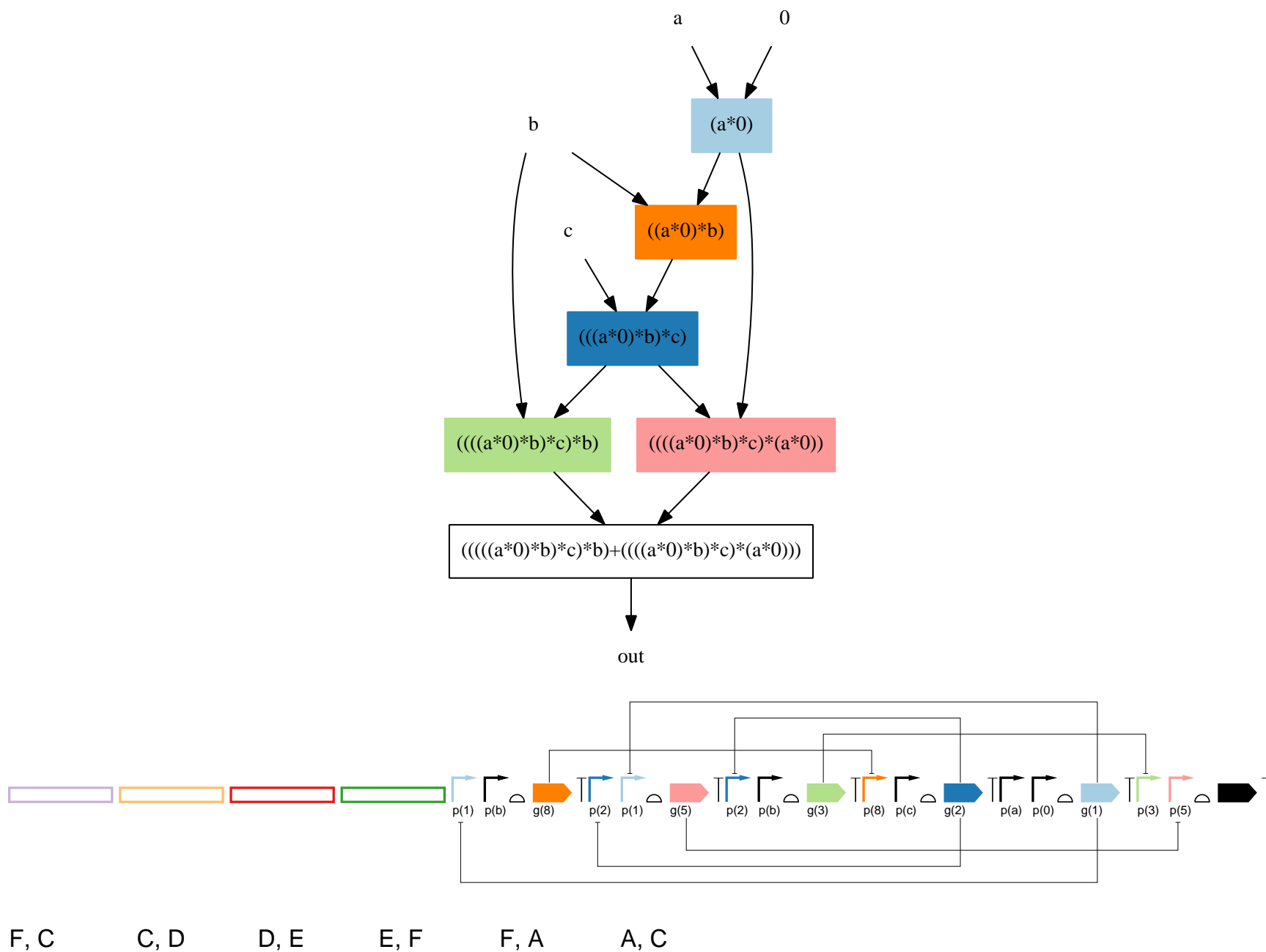


Figure 180: Circuit with truth table 0x4D.

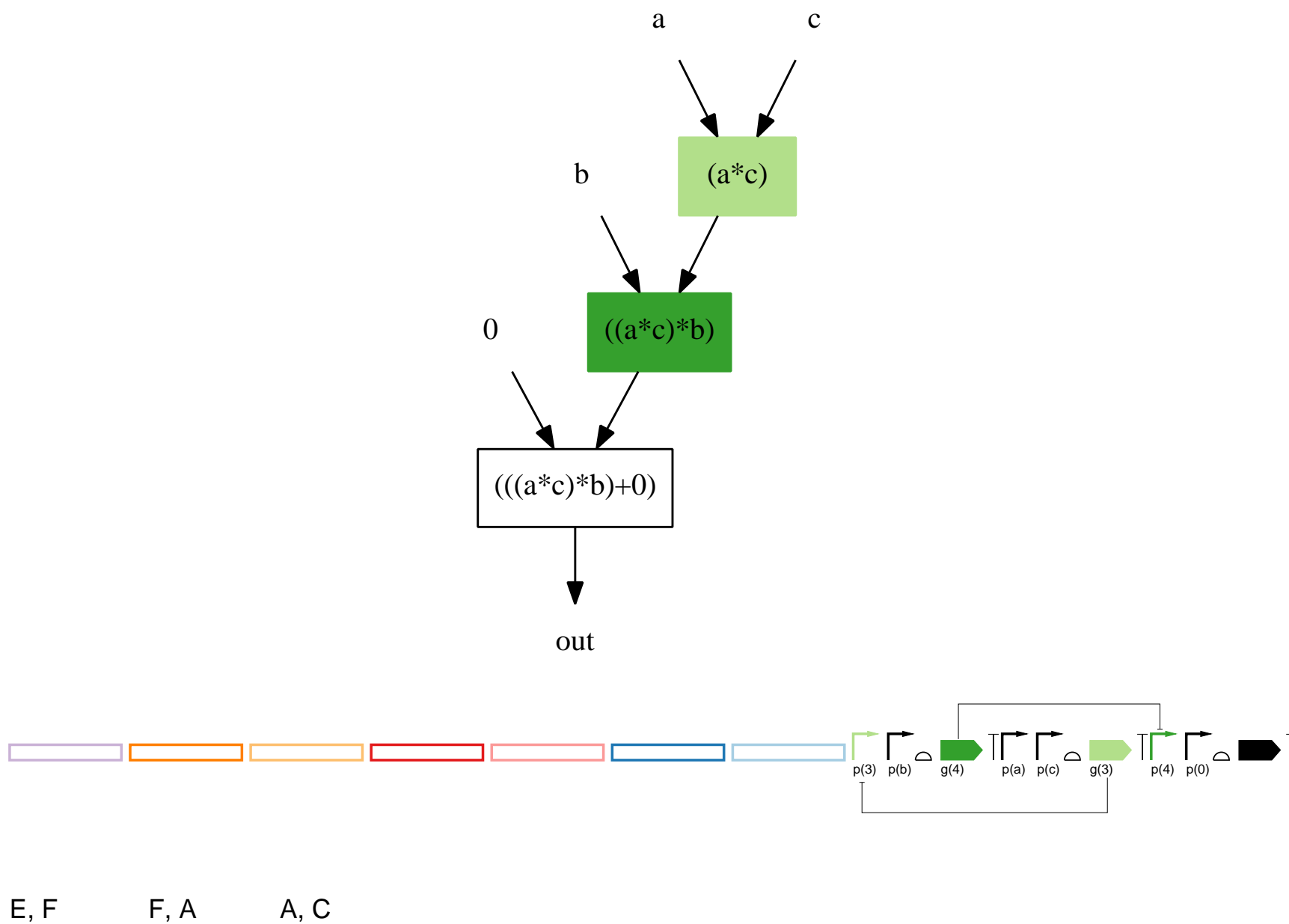


Figure 181: Circuit with truth table 0x4C.

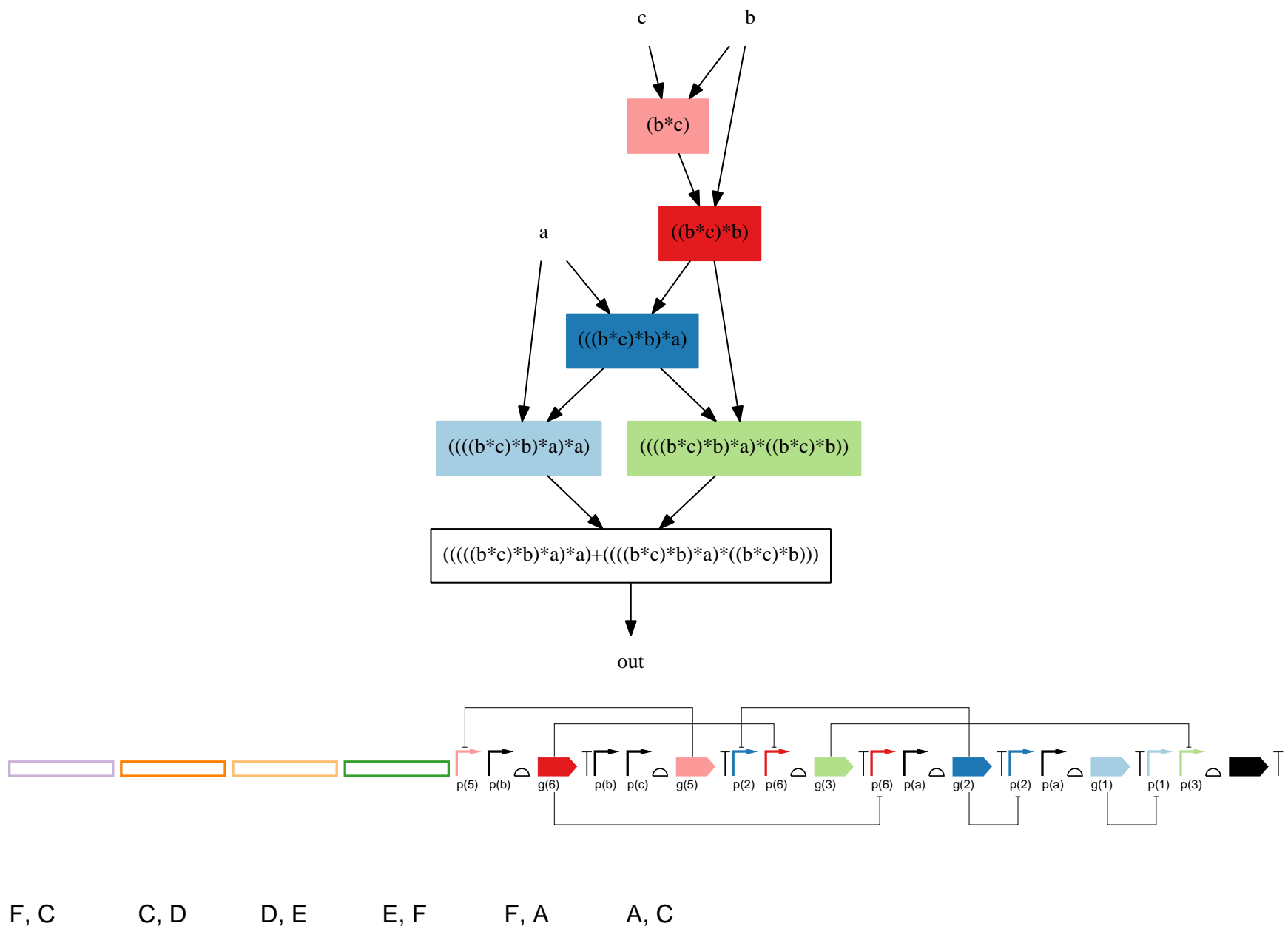


Figure 182: Circuit with truth table 0x4B.

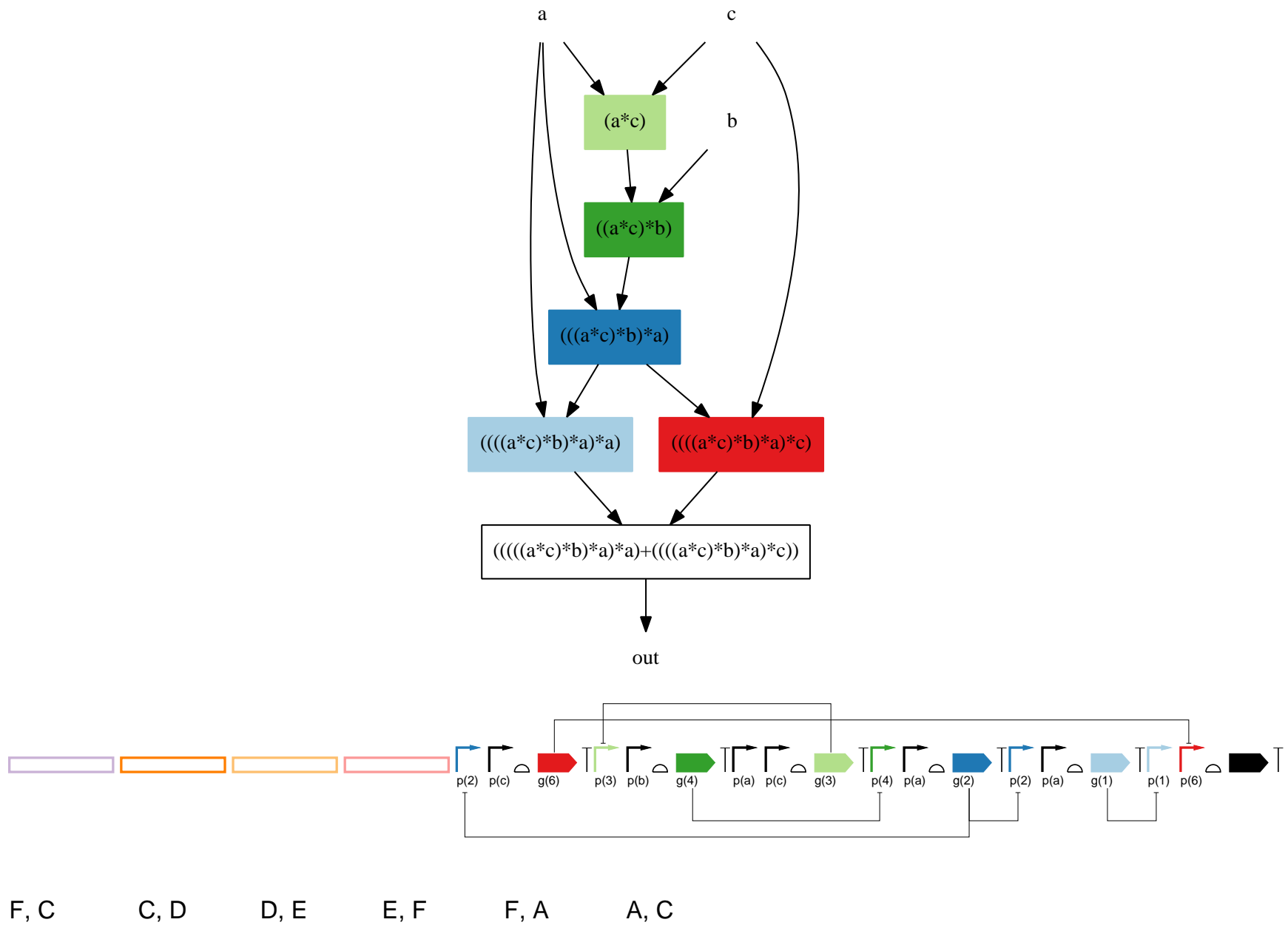


Figure 183: Circuit with truth table 0x4A.

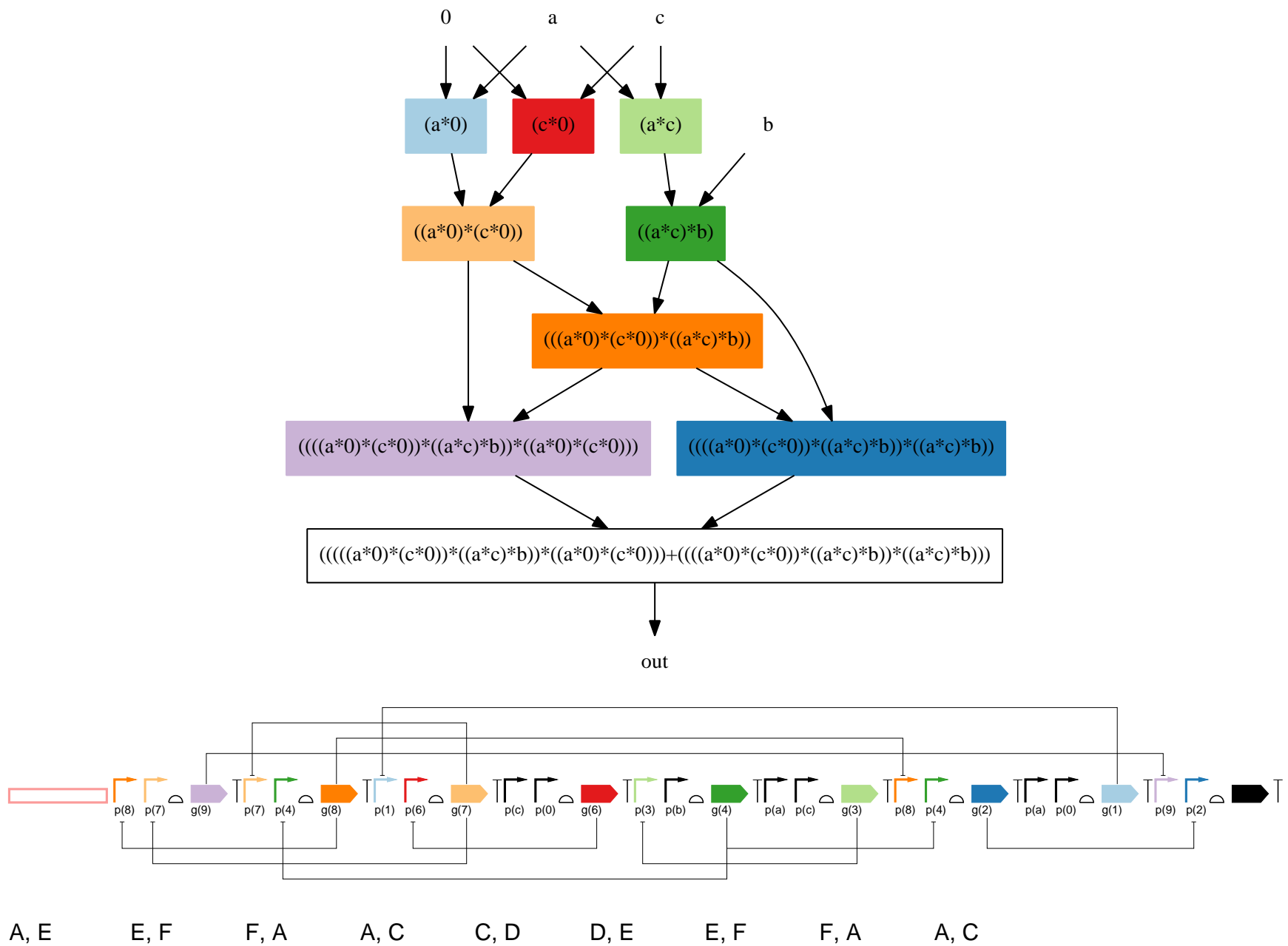


Figure 184: Circuit with truth table 0x49.

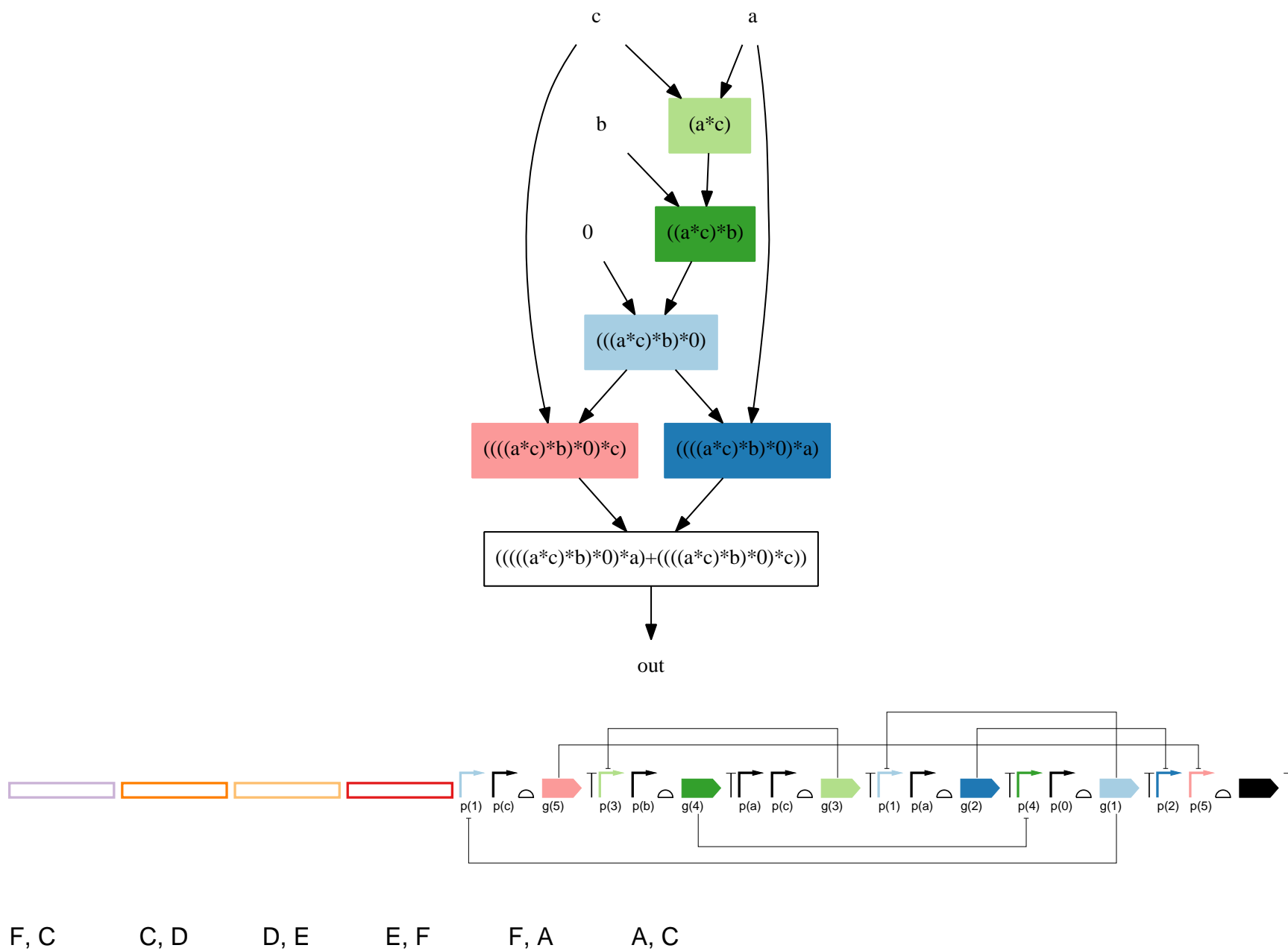


Figure 185: Circuit with truth table 0x48.

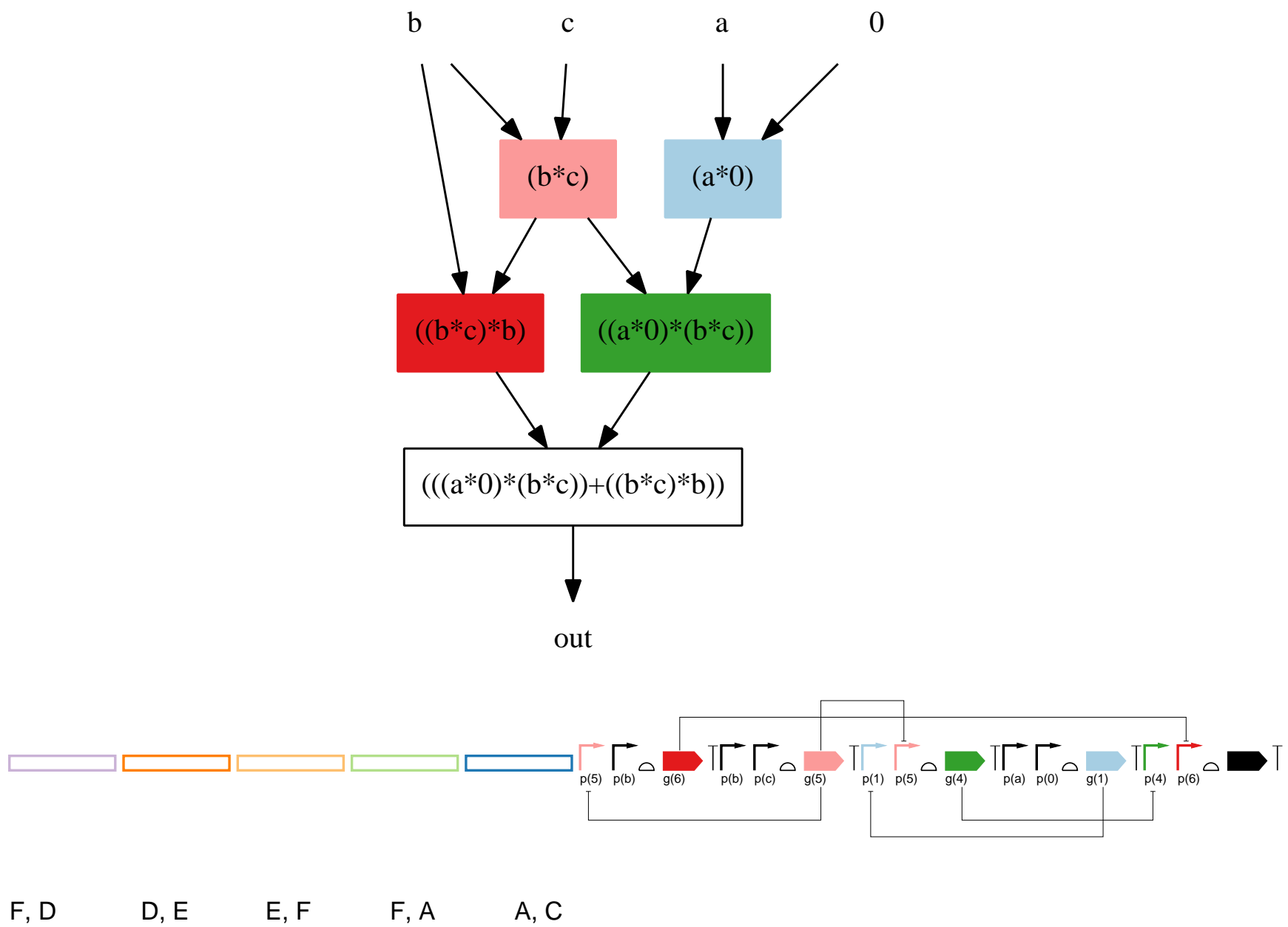


Figure 186: Circuit with truth table 0x47.

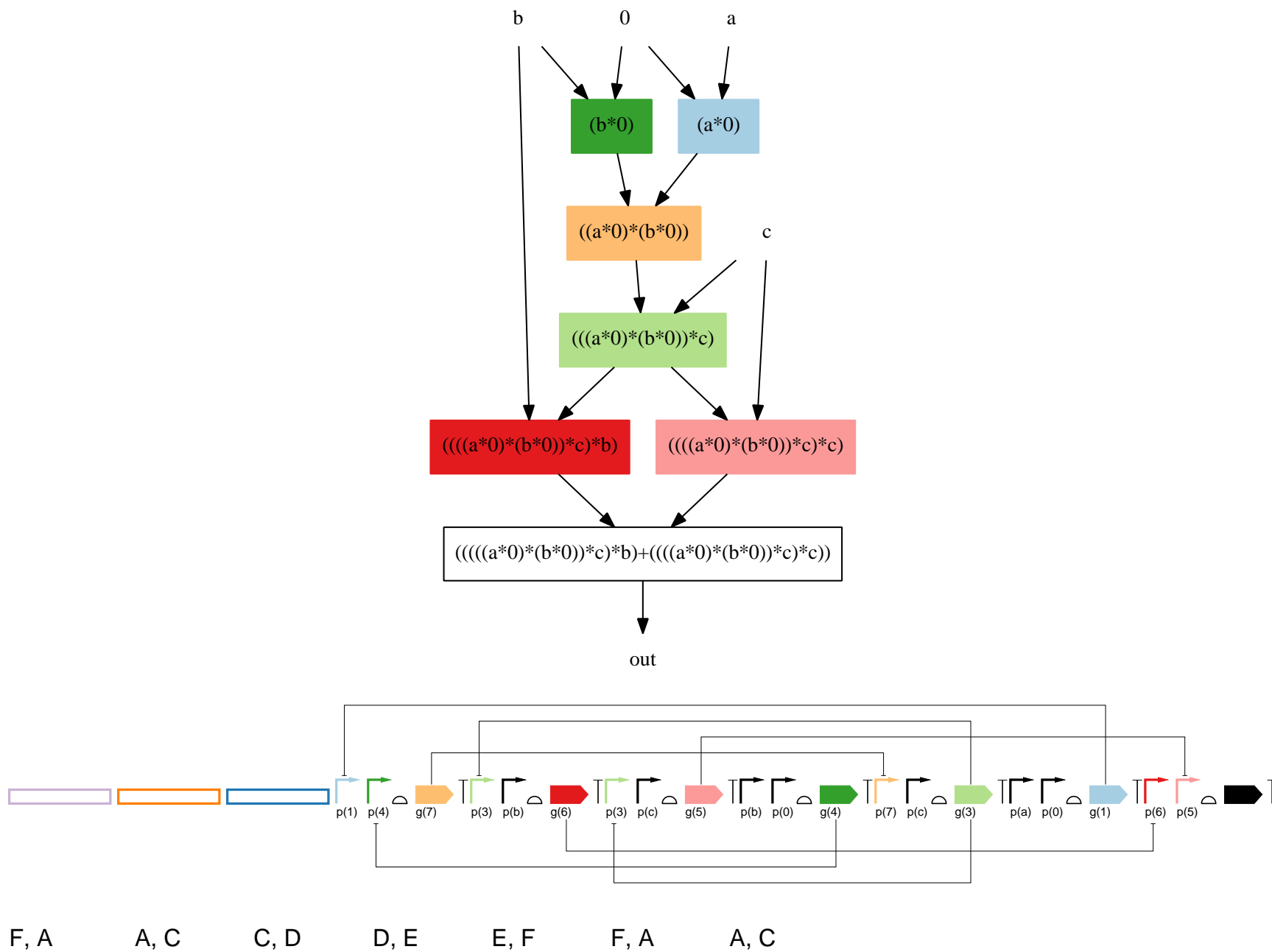


Figure 187: Circuit with truth table 0x46.

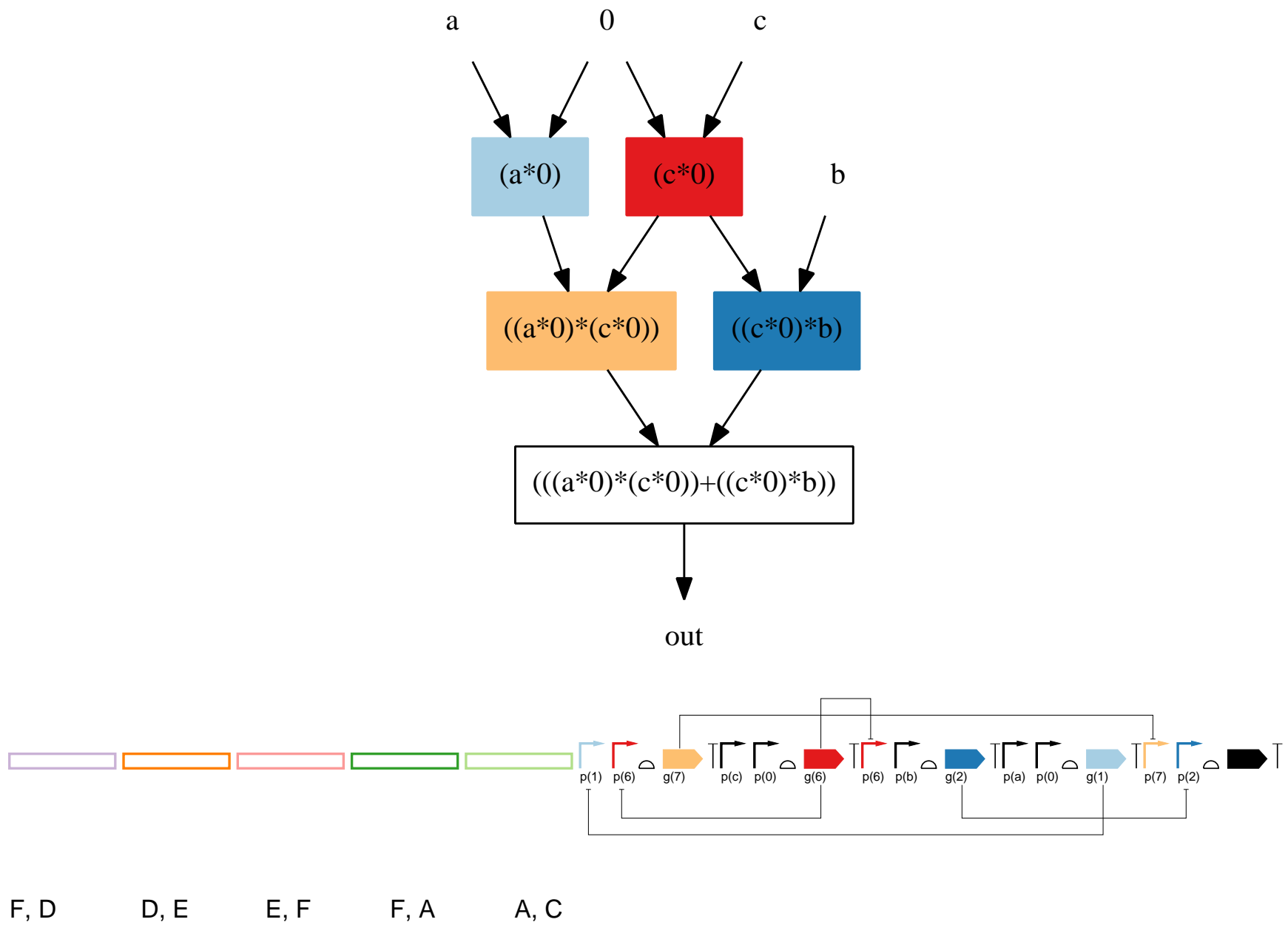


Figure 188: Circuit with truth table 0x45.

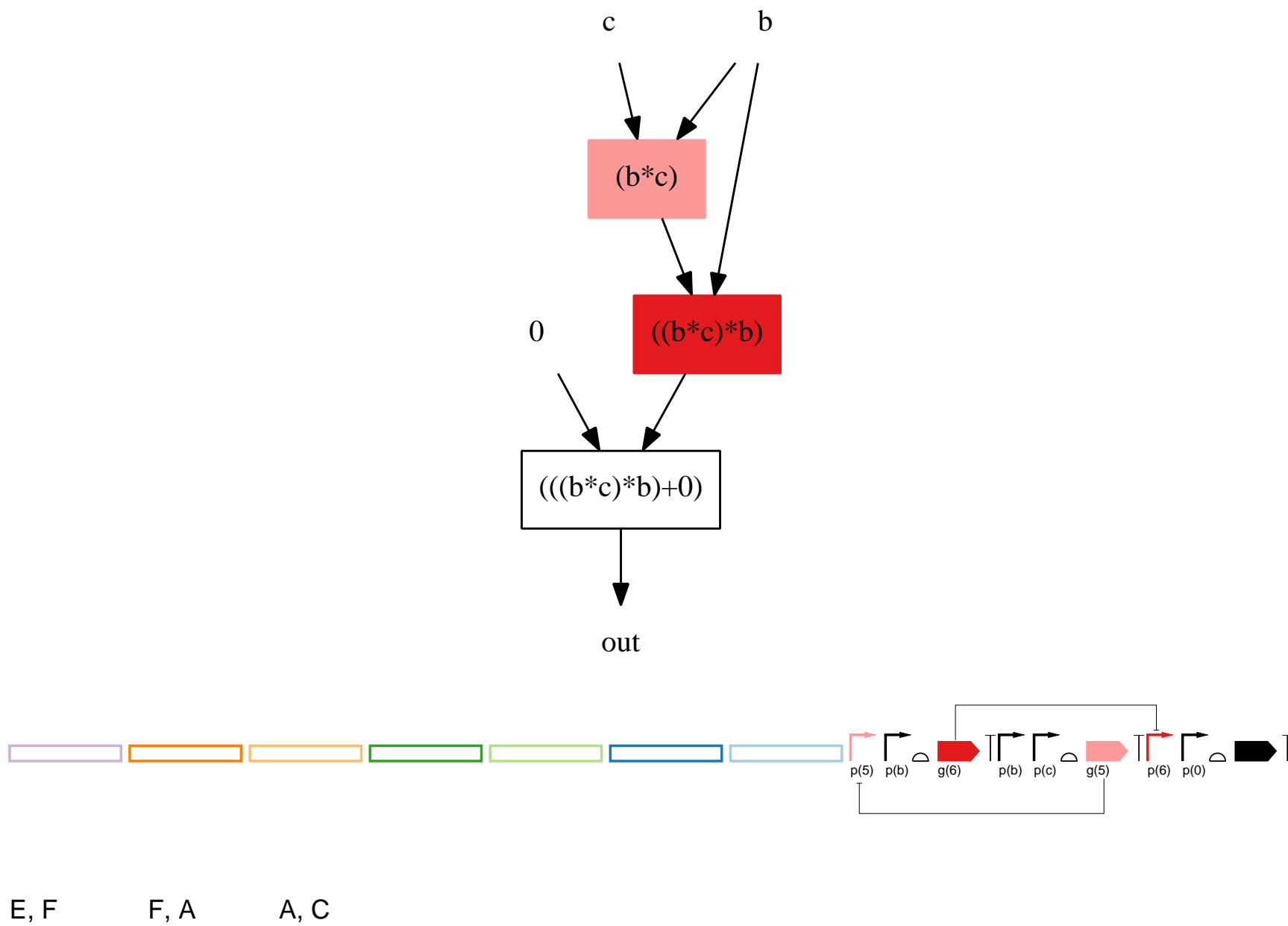


Figure 189: Circuit with truth table 0x44.

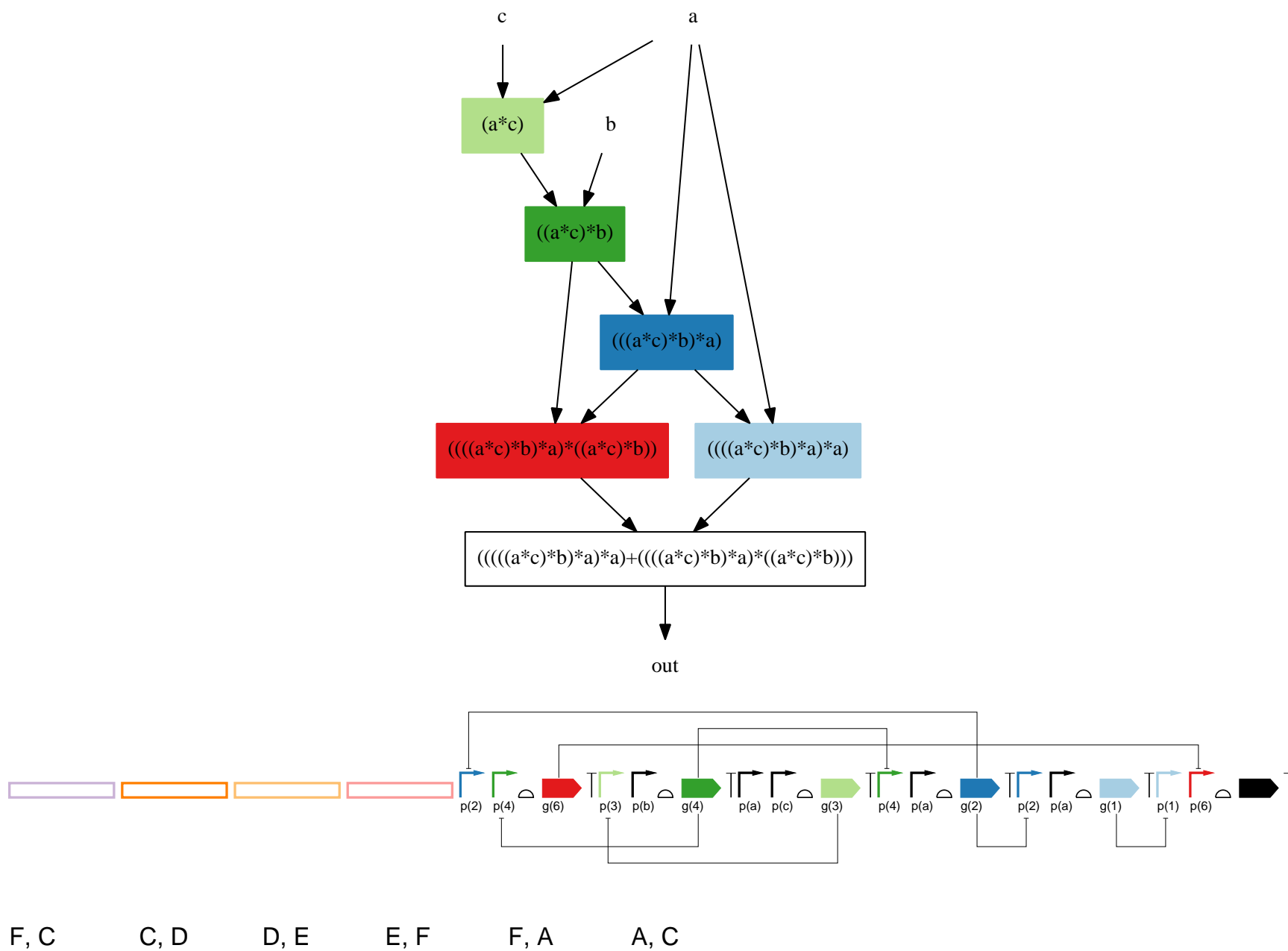


Figure 190: Circuit with truth table 0x43.

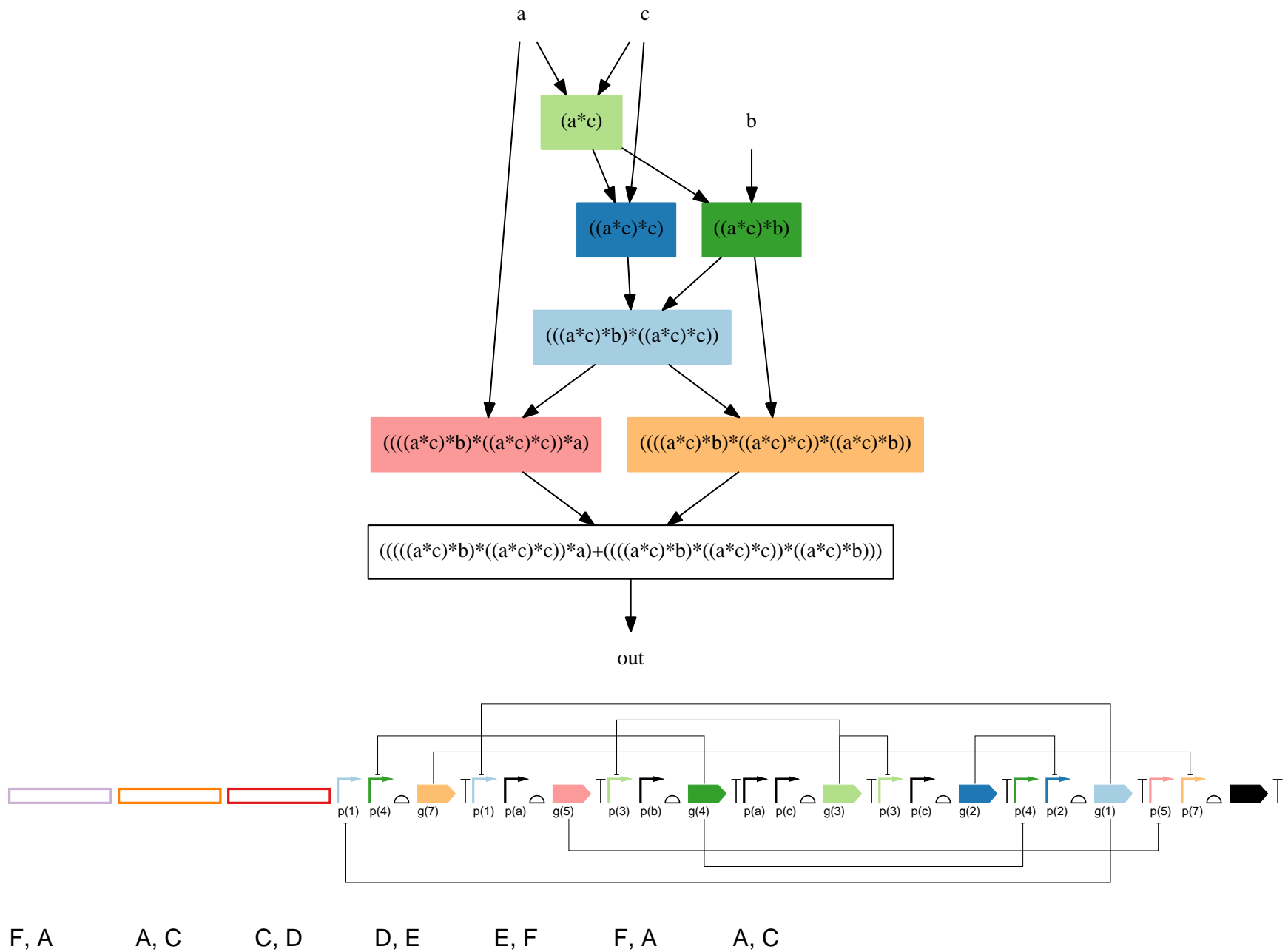


Figure 191: Circuit with truth table 0x42.

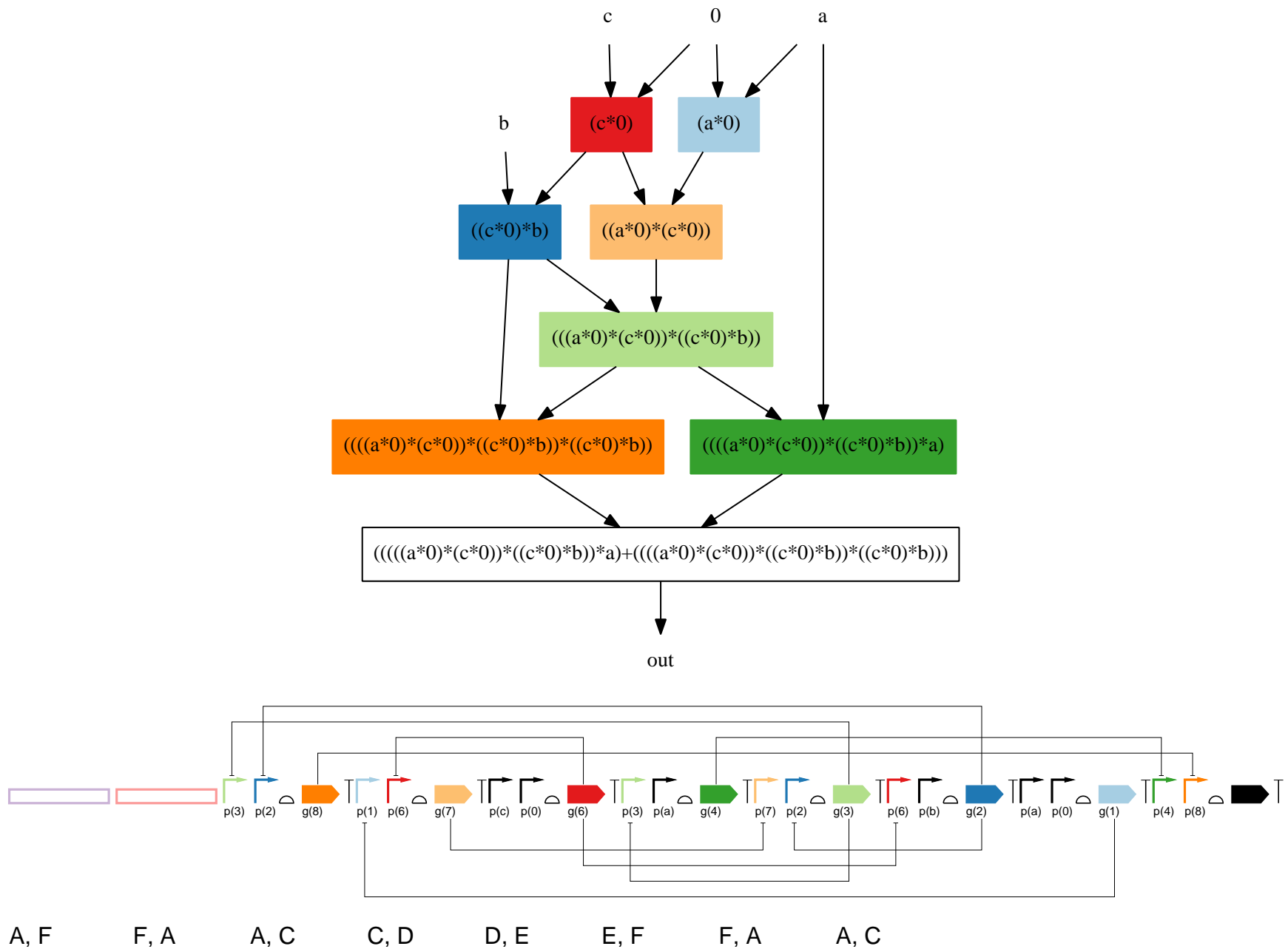


Figure 192: Circuit with truth table 0x41.

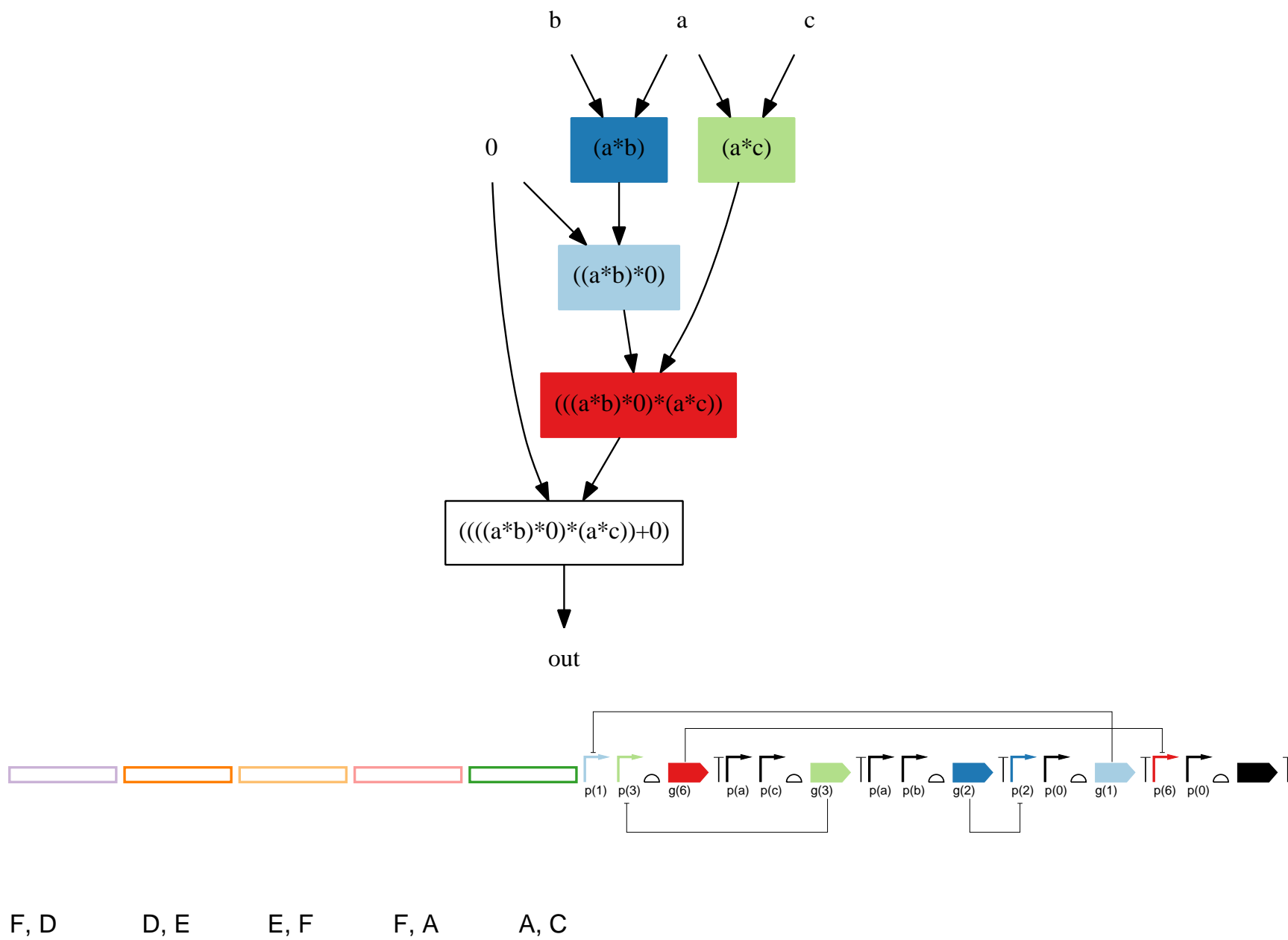


Figure 193: Circuit with truth table 0x40.

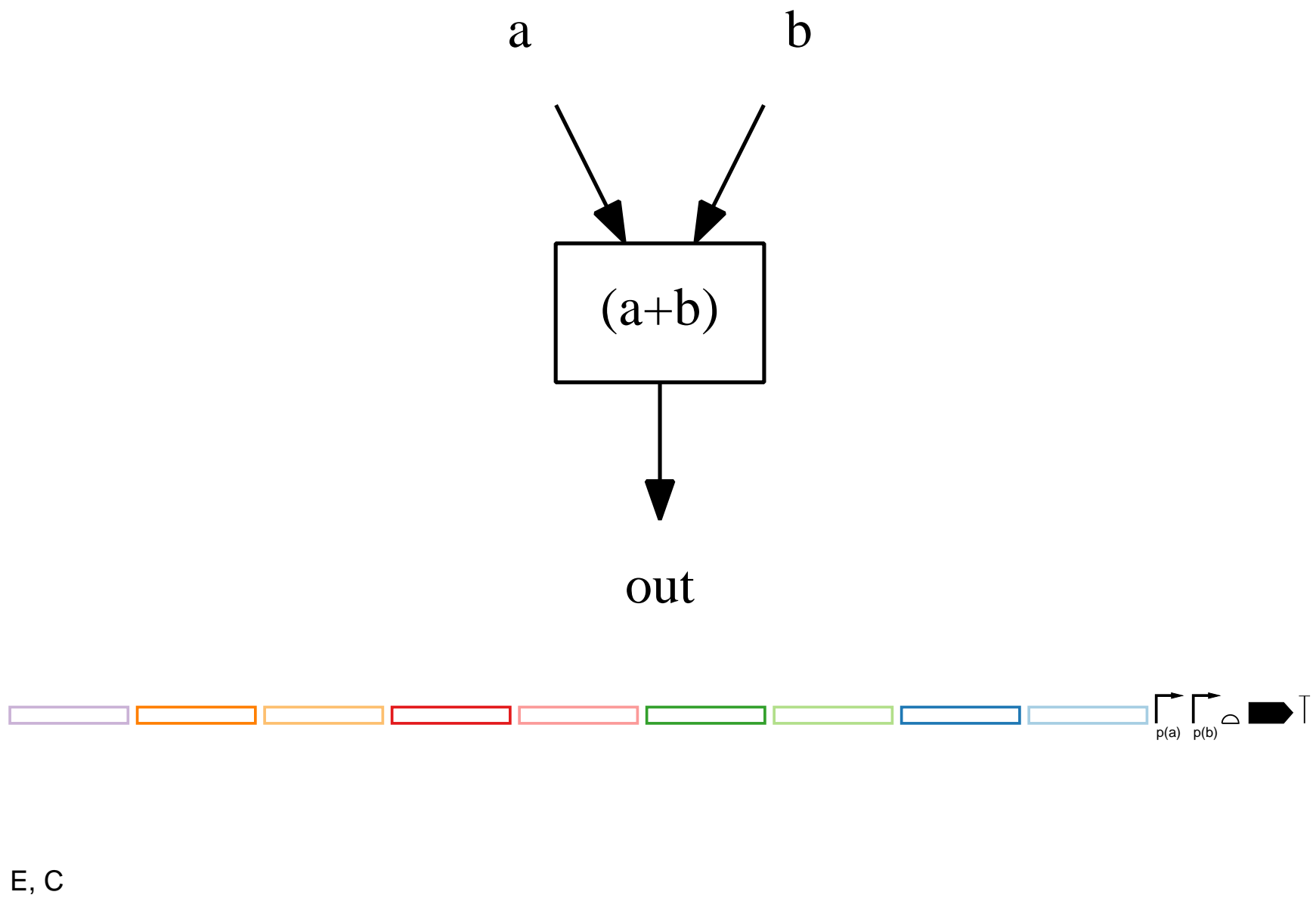


Figure 194: Circuit with truth table 0x3F.

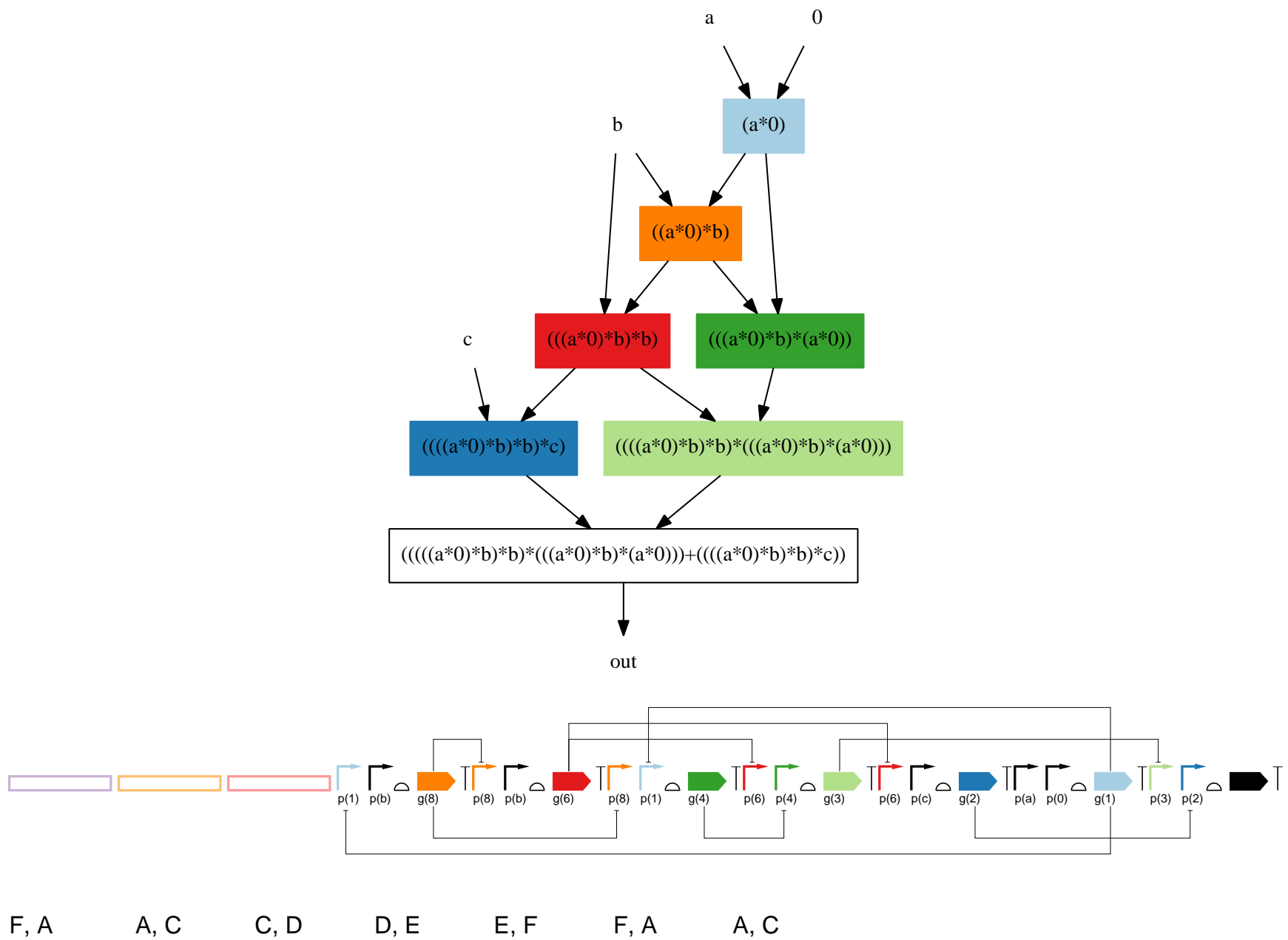


Figure 195: Circuit with truth table 0x3E.

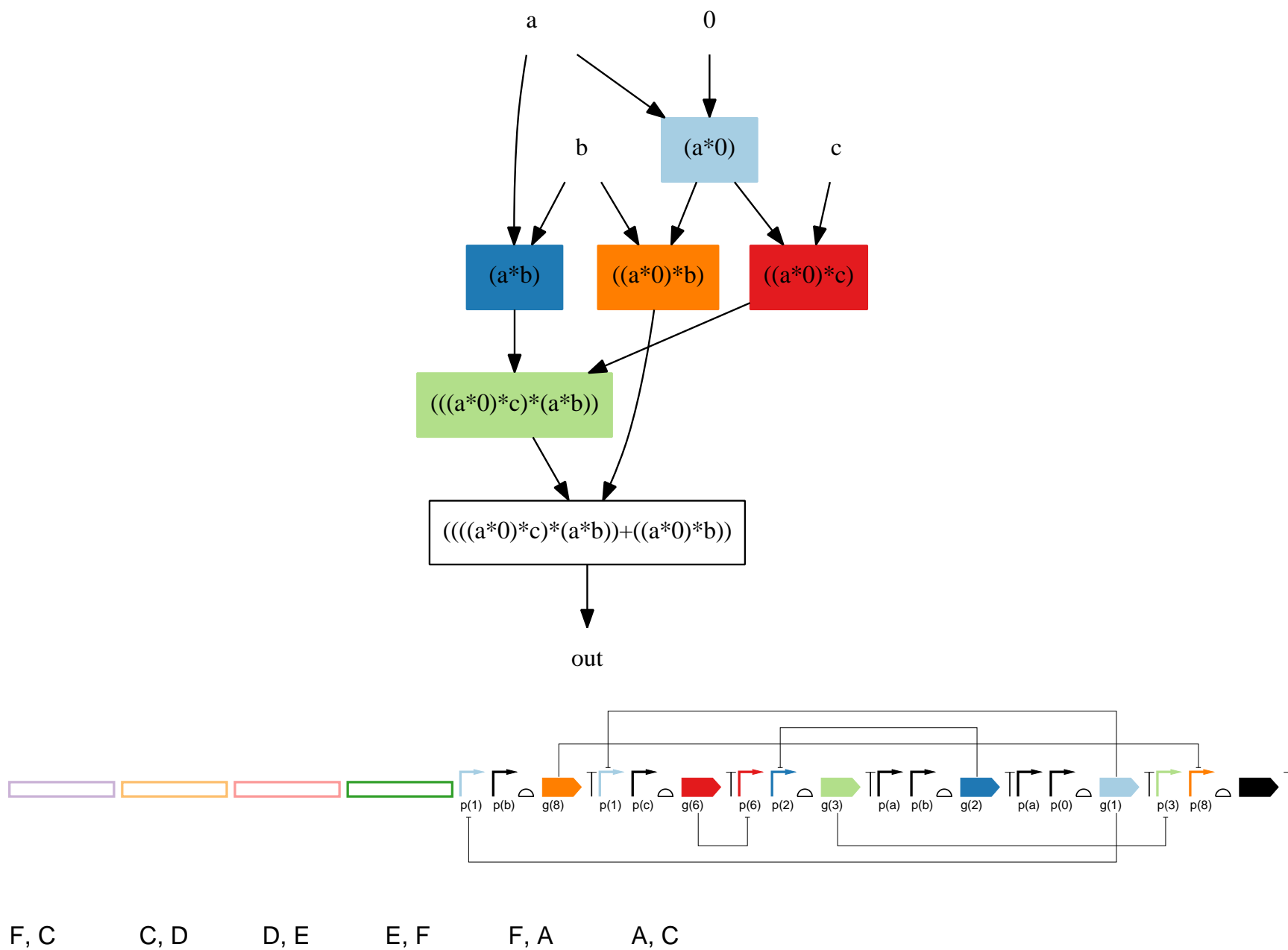


Figure 196: Circuit with truth table 0x3D.

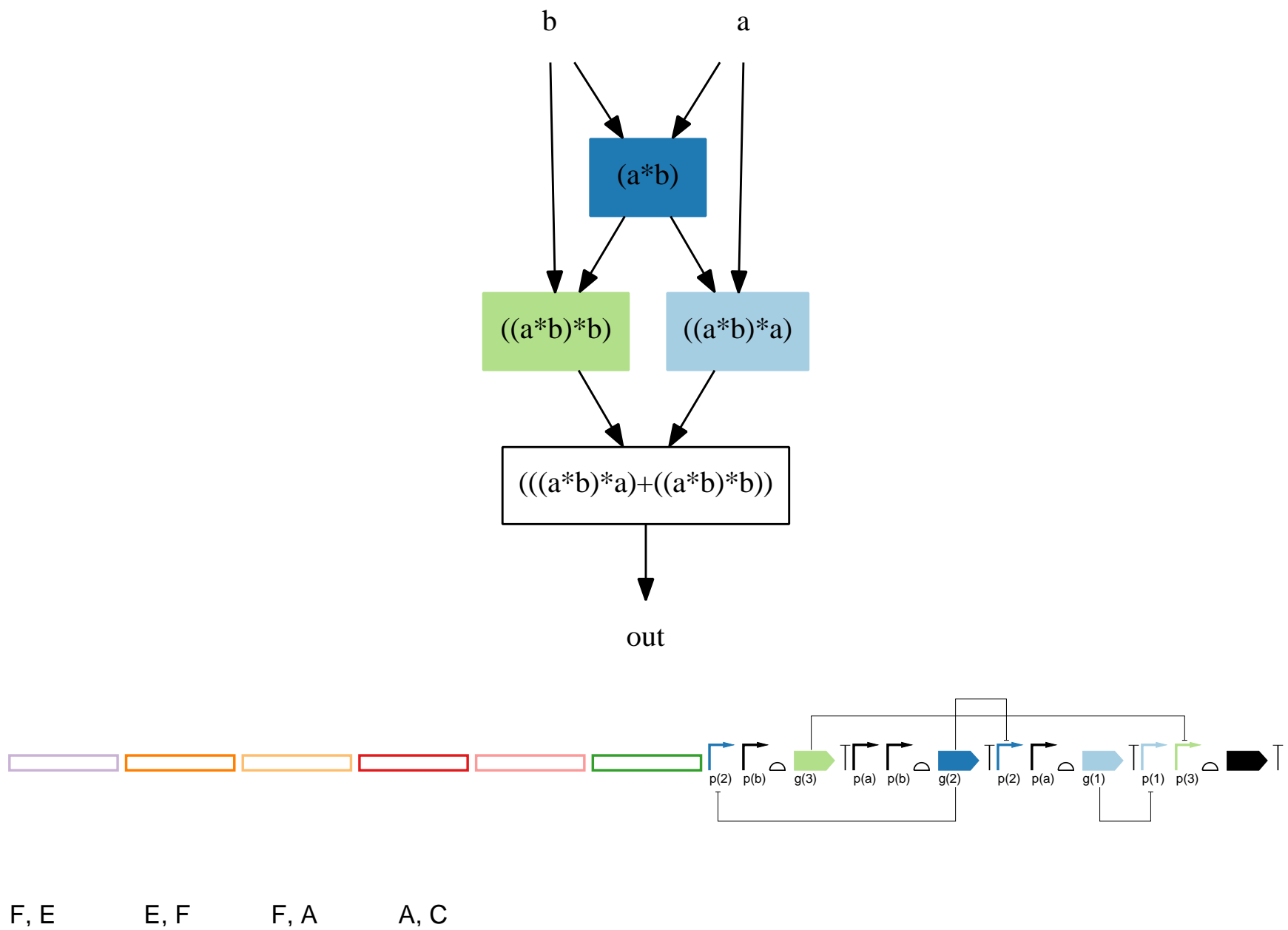


Figure 197: Circuit with truth table 0x3C.

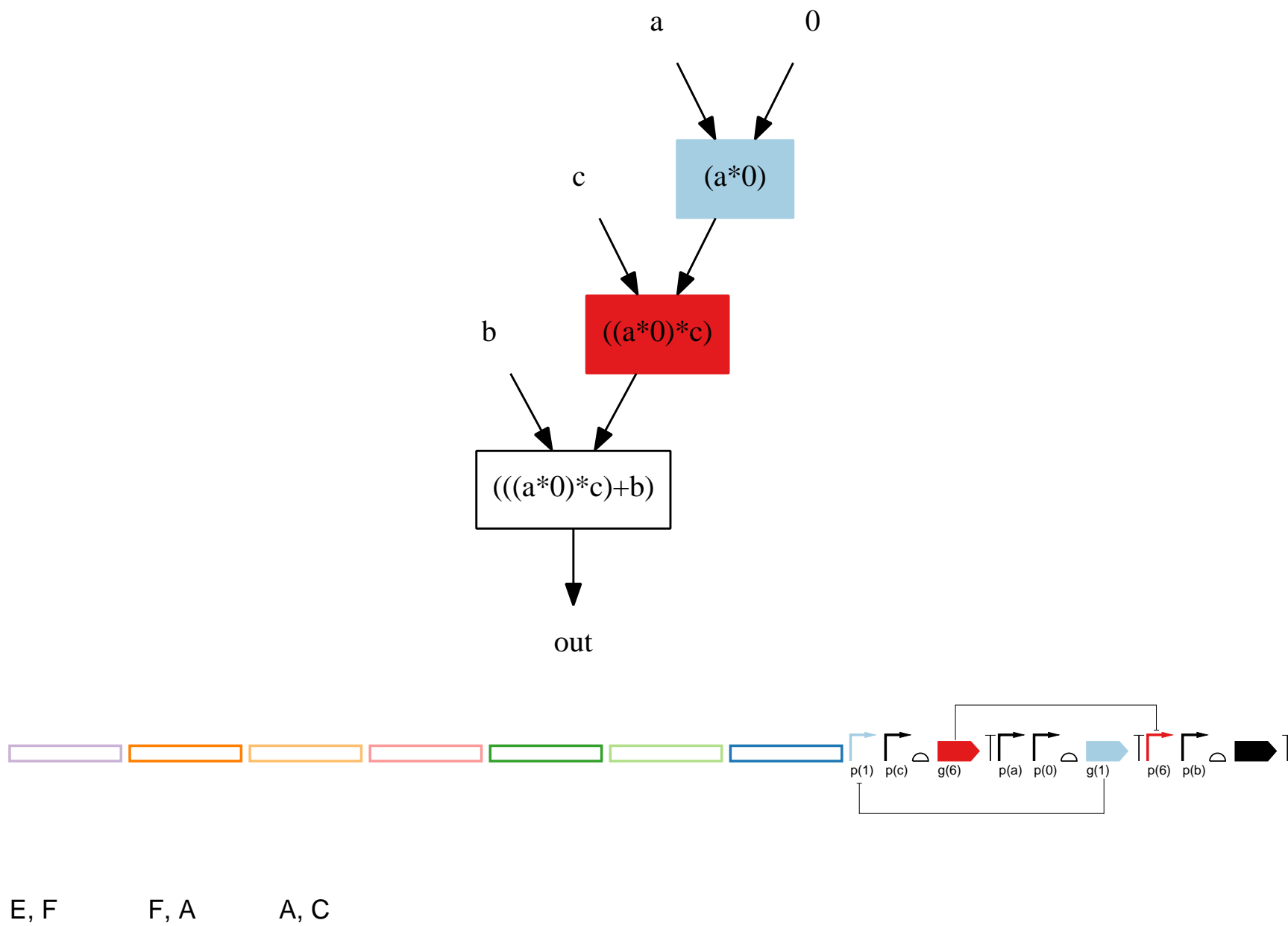


Figure 198: Circuit with truth table 0x3B.

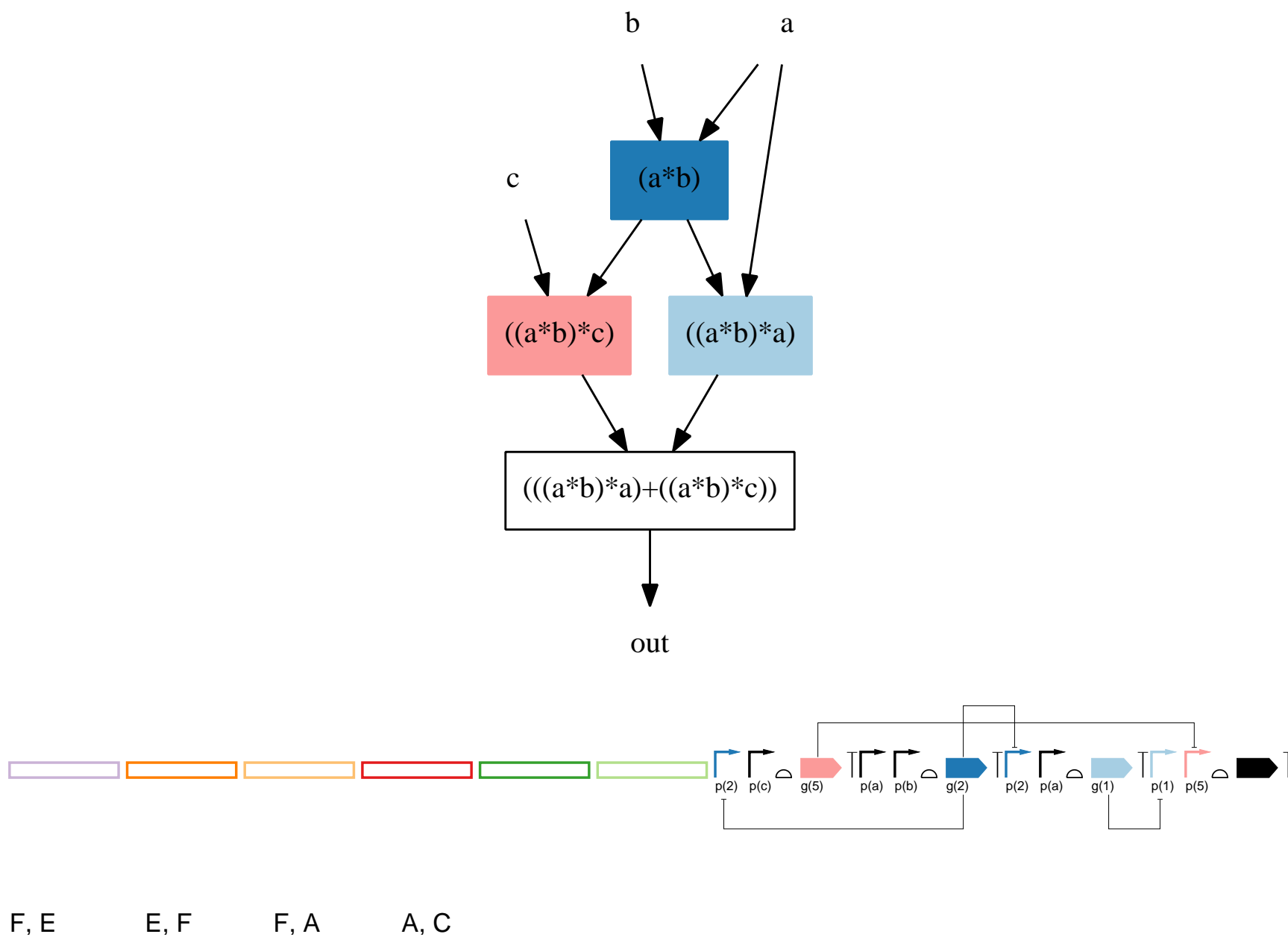


Figure 199: Circuit with truth table 0x3A.

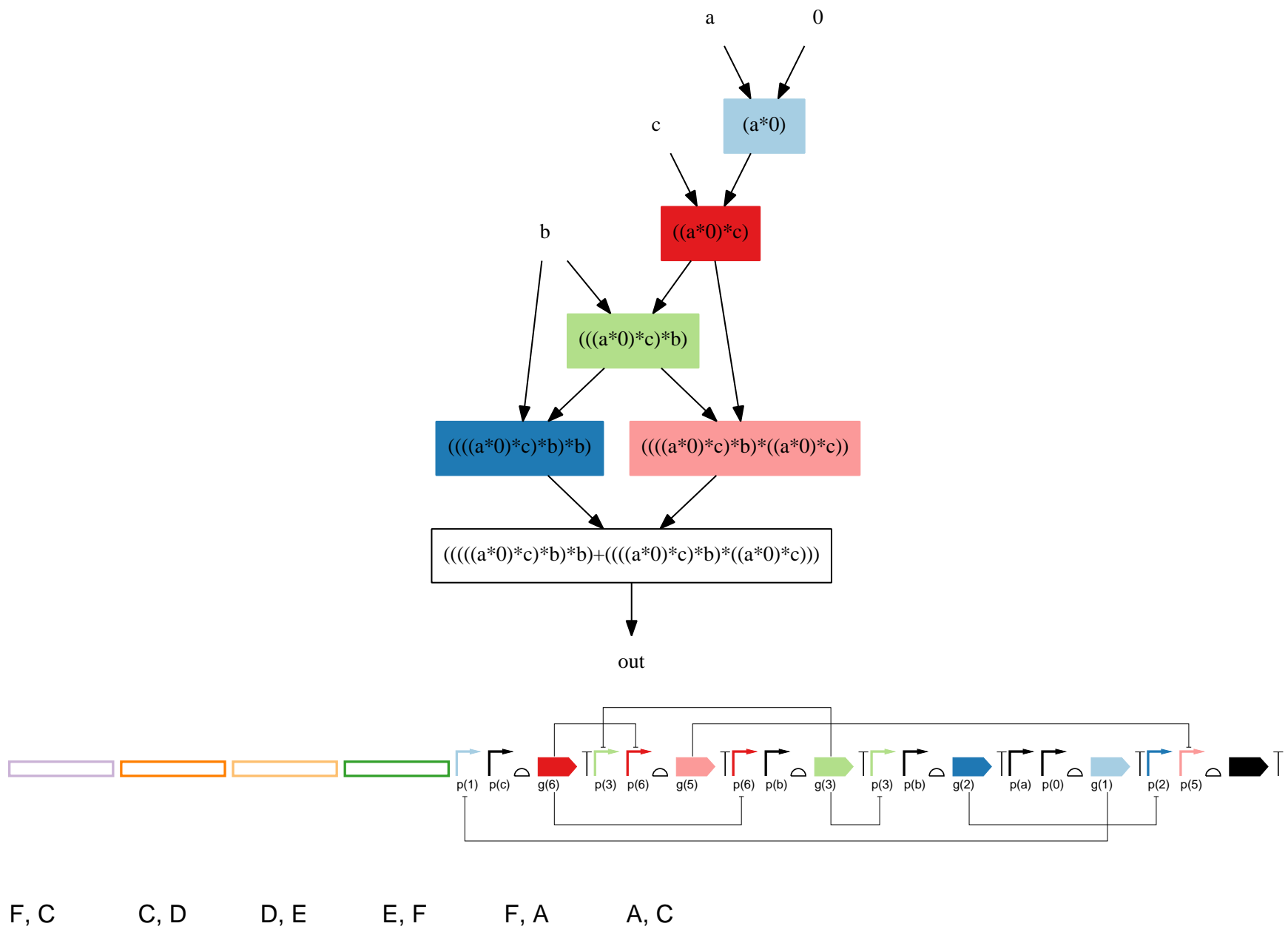


Figure 200: Circuit with truth table 0x39.

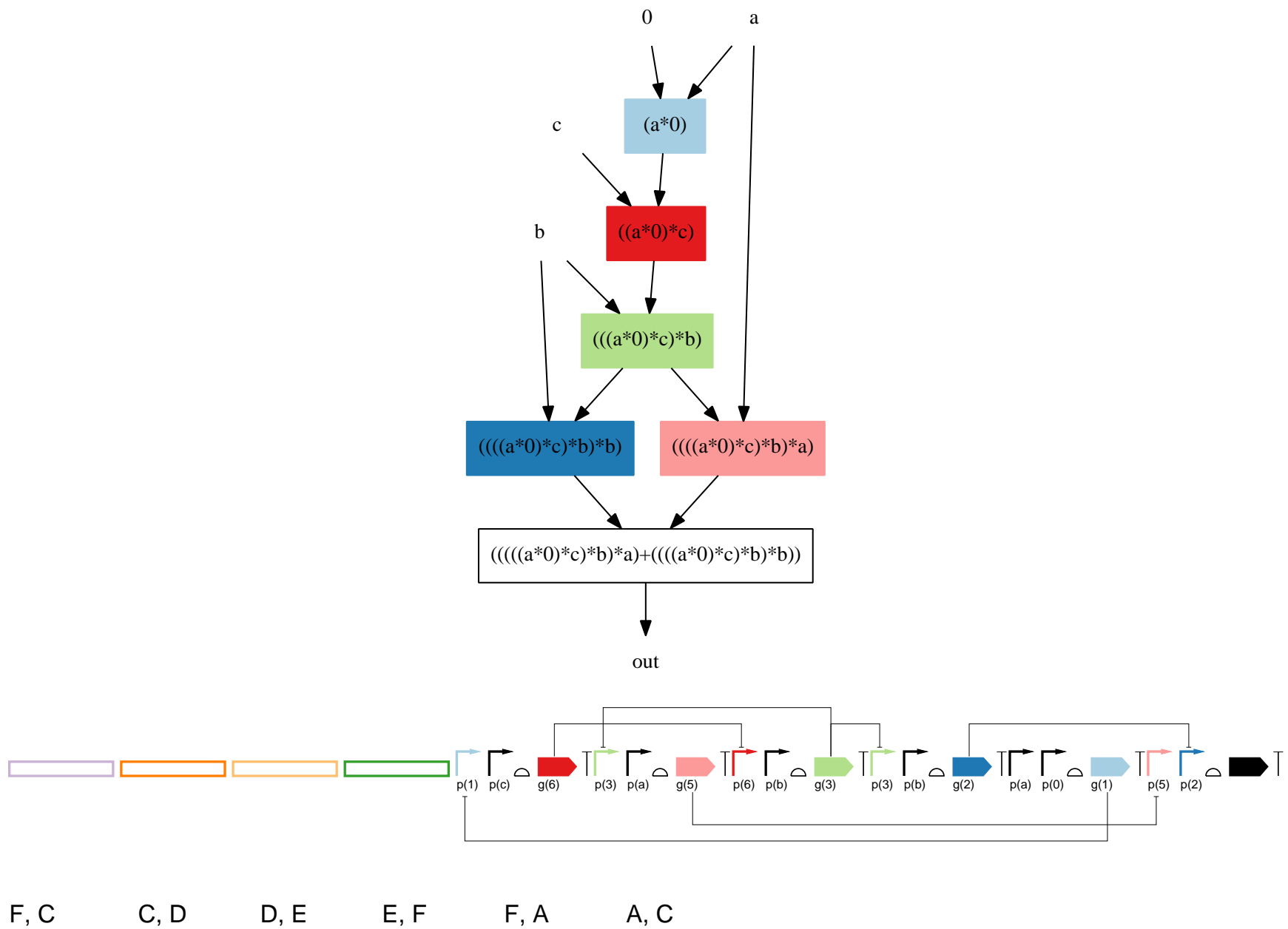


Figure 201: Circuit with truth table 0x38.

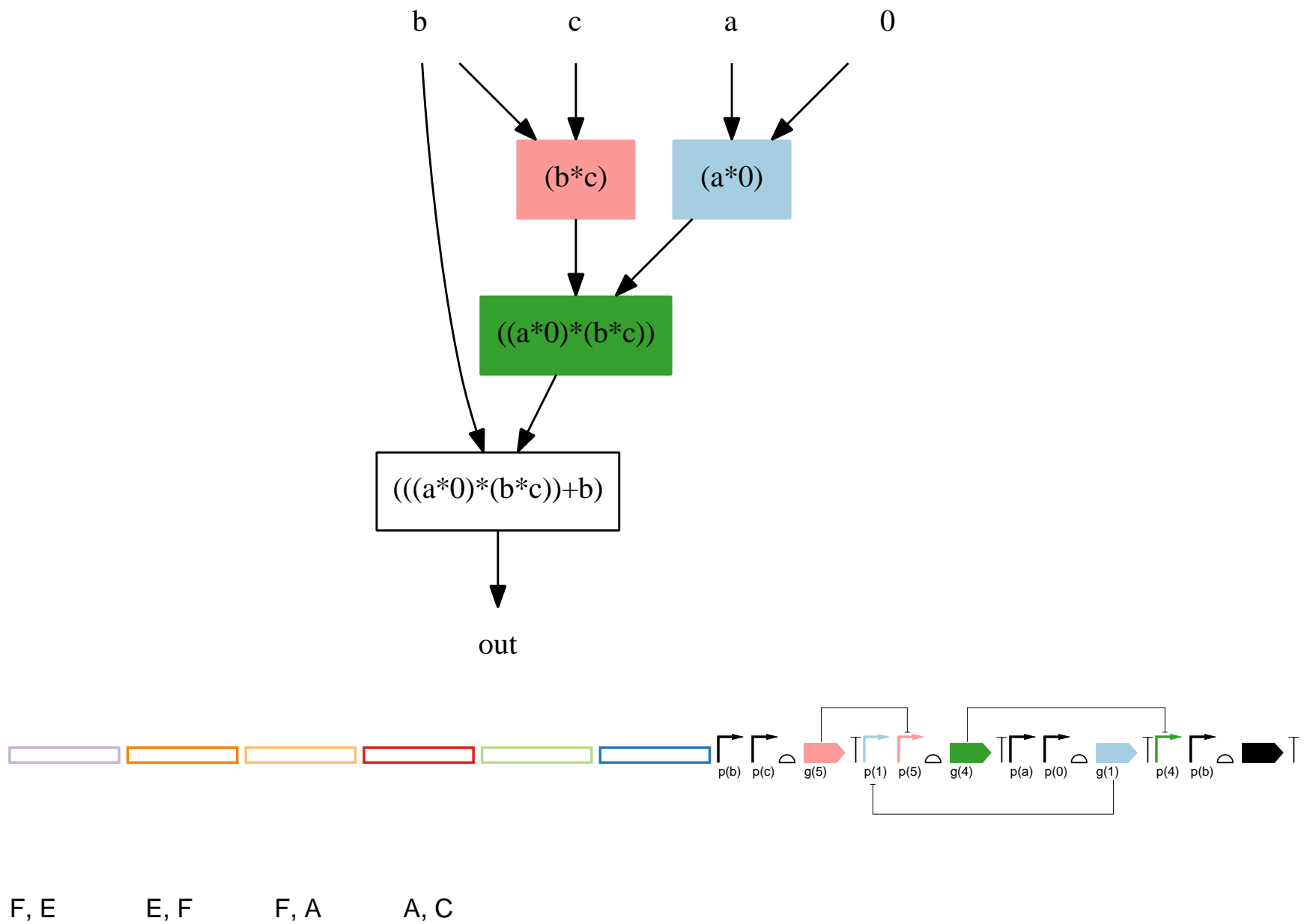


Figure 202: Circuit with truth table 0x37.

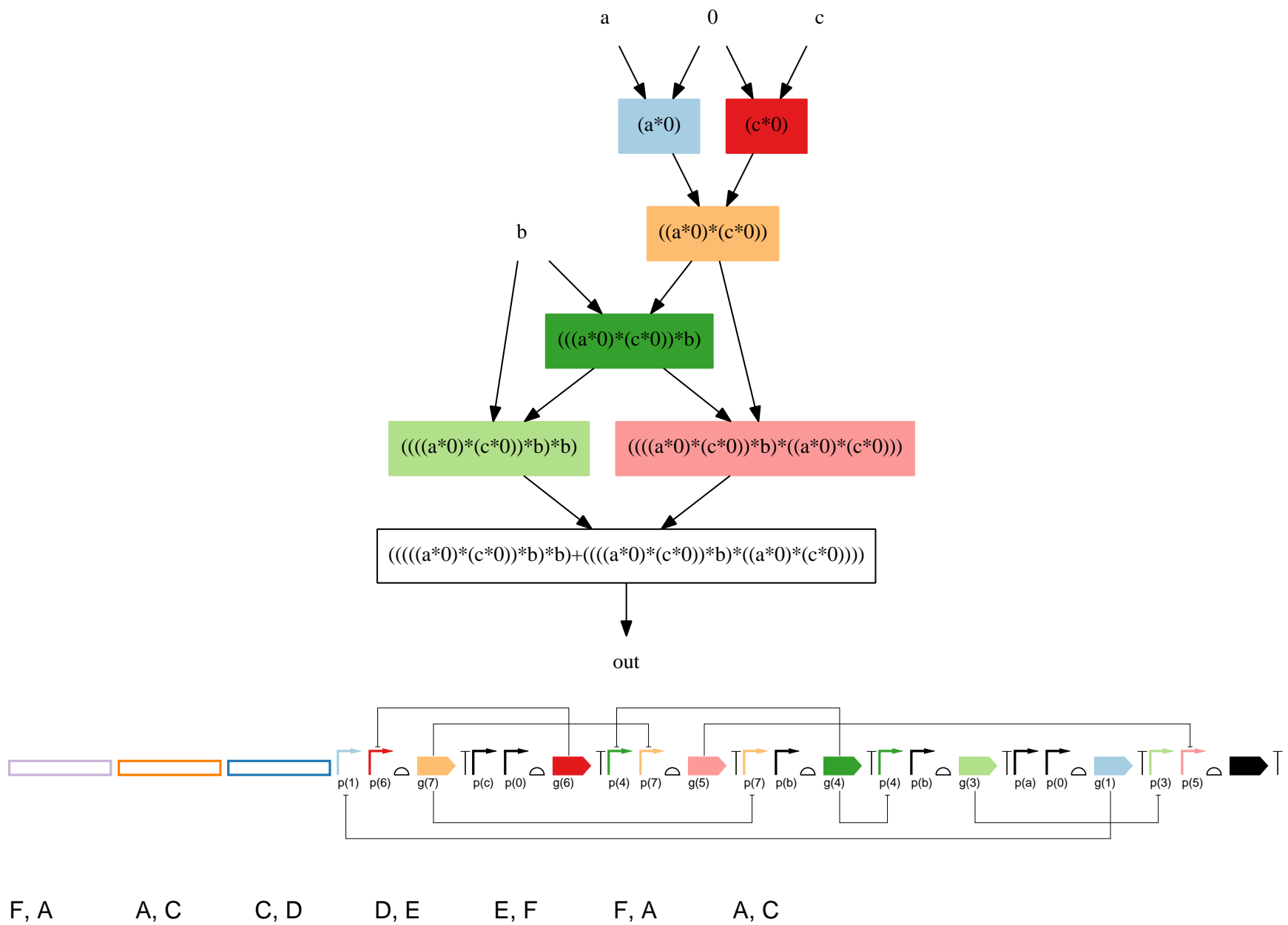


Figure 203: Circuit with truth table 0x36.

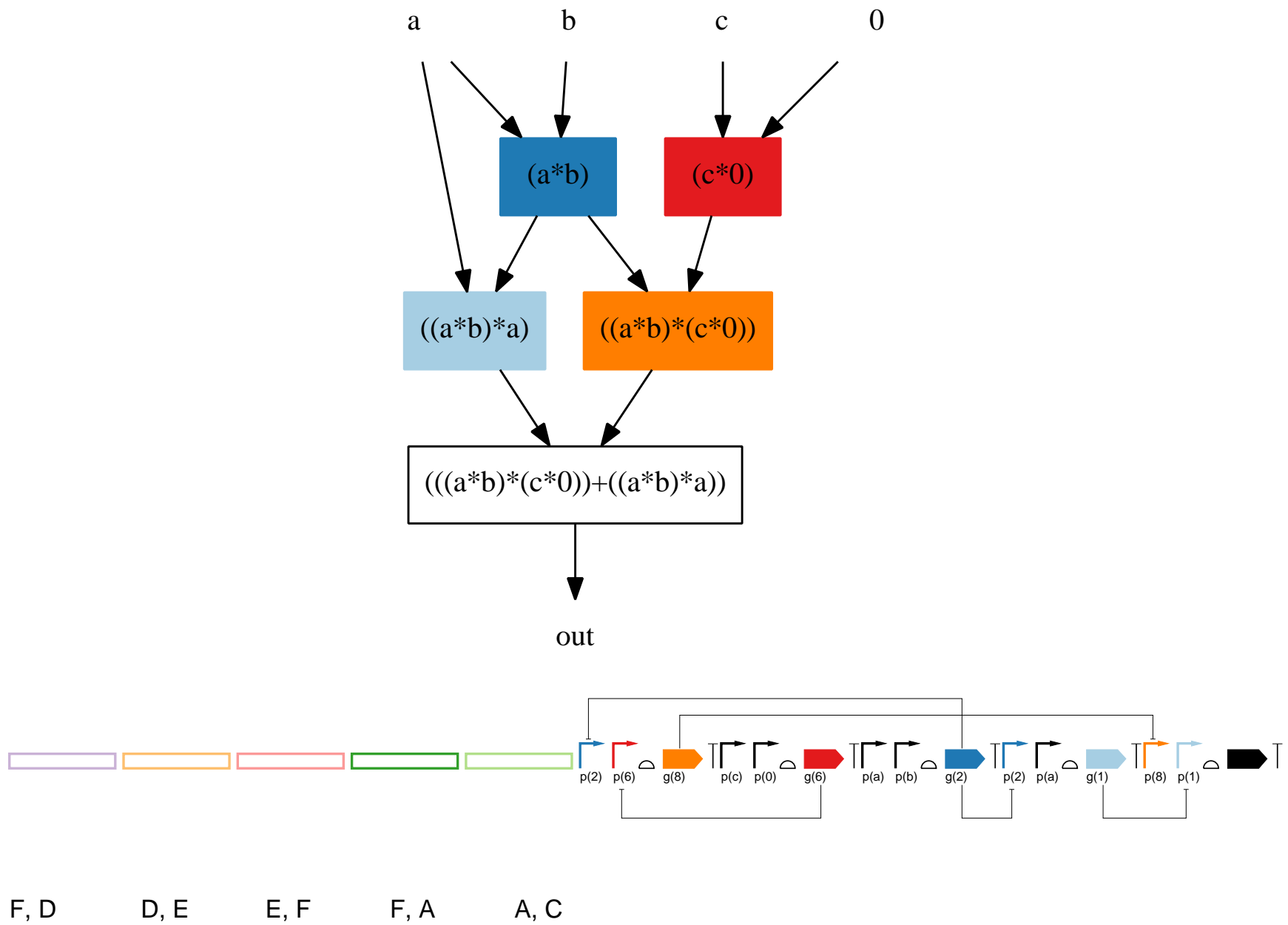


Figure 204: Circuit with truth table 0x35.

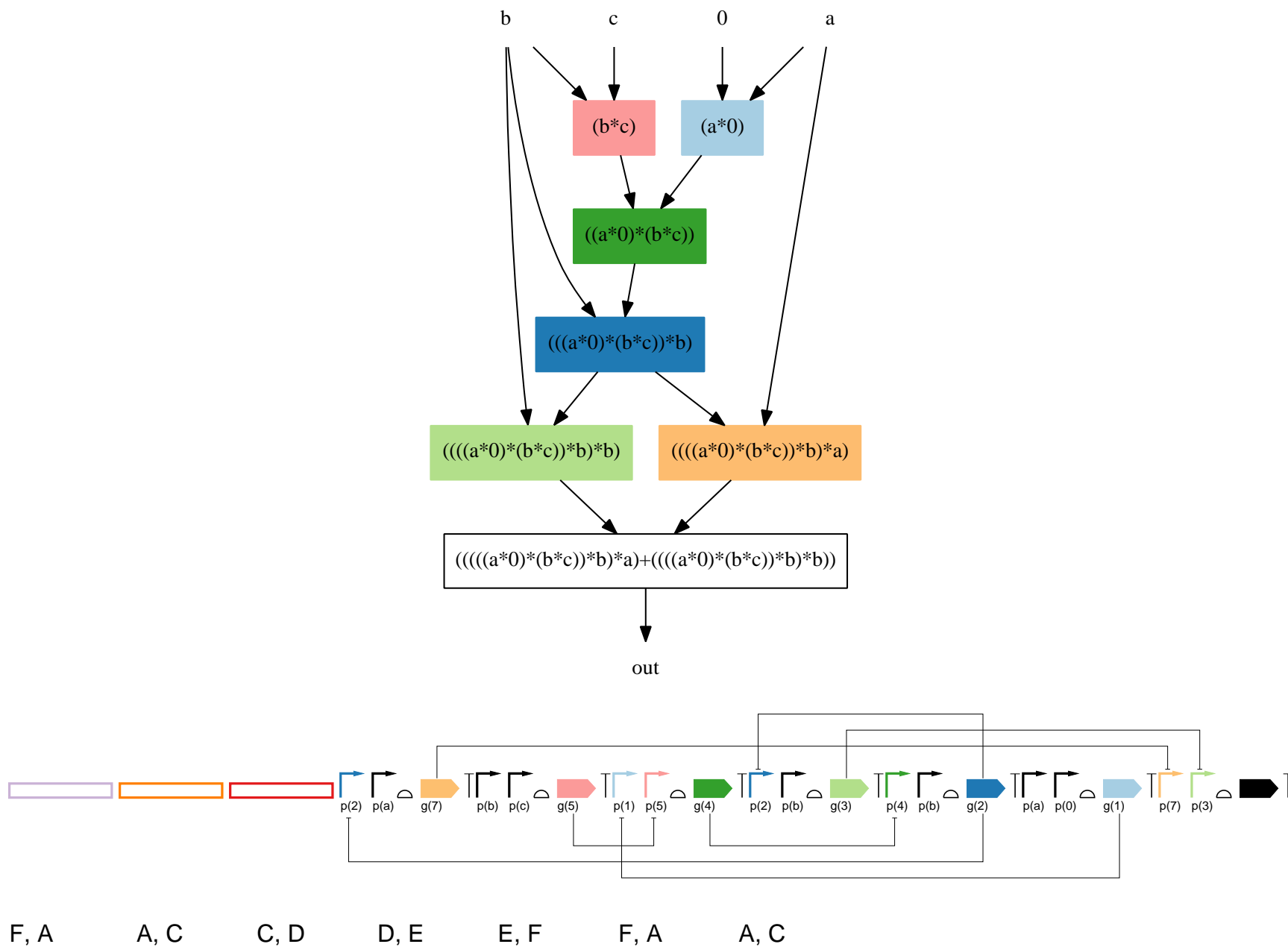


Figure 205: Circuit with truth table 0x34.

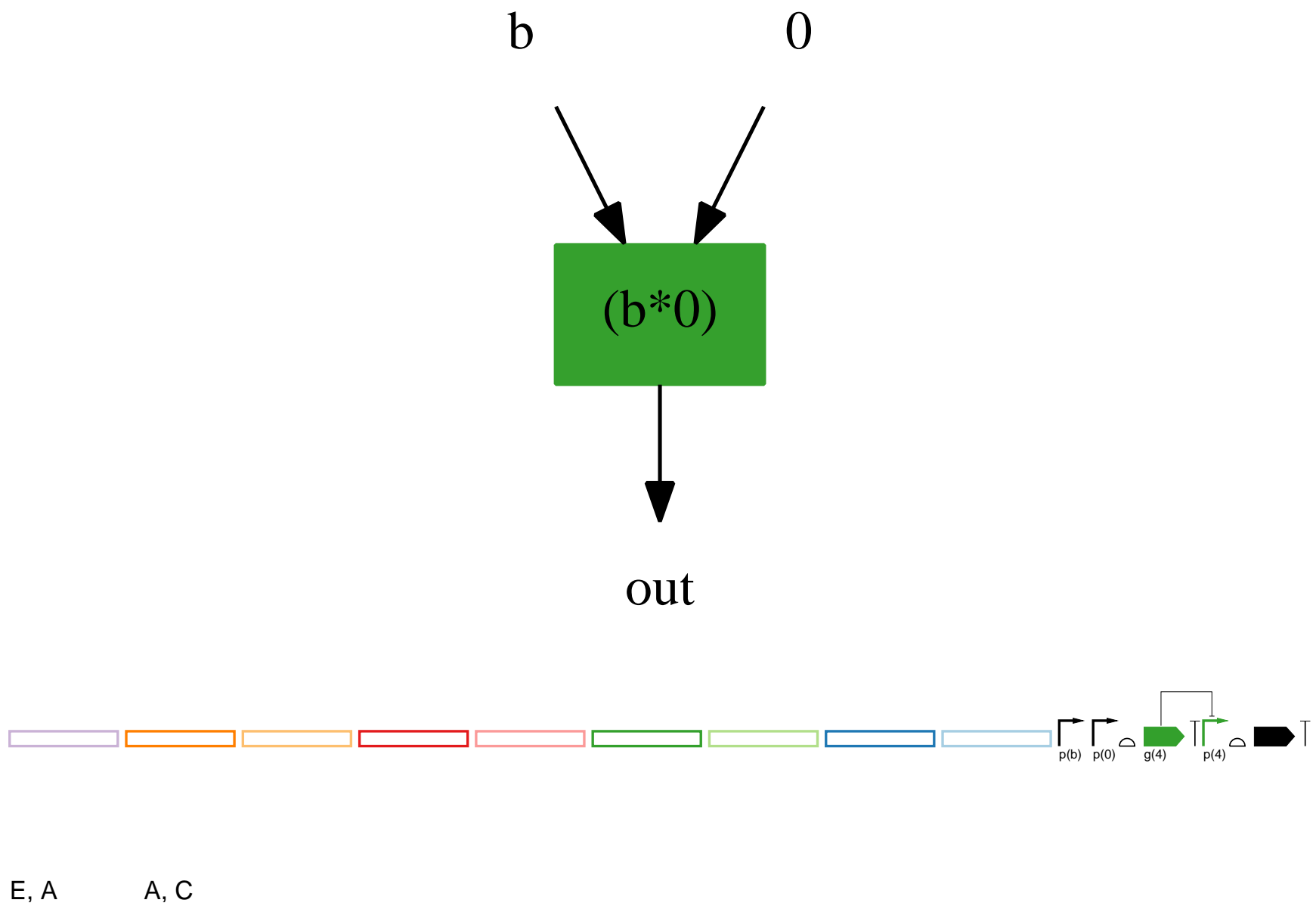


Figure 206: Circuit with truth table 0xCC.

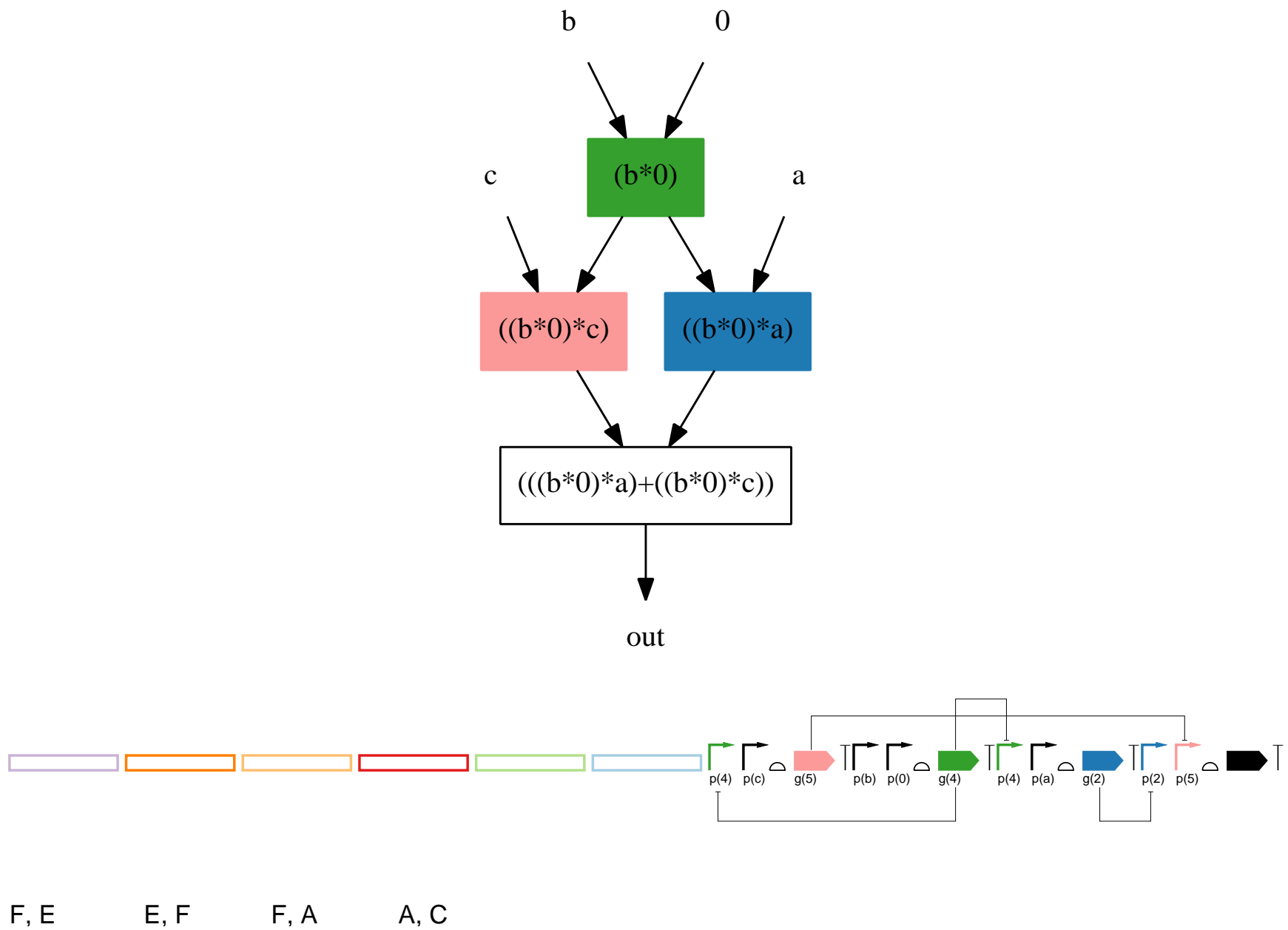


Figure 207: Circuit with truth table 0x32.

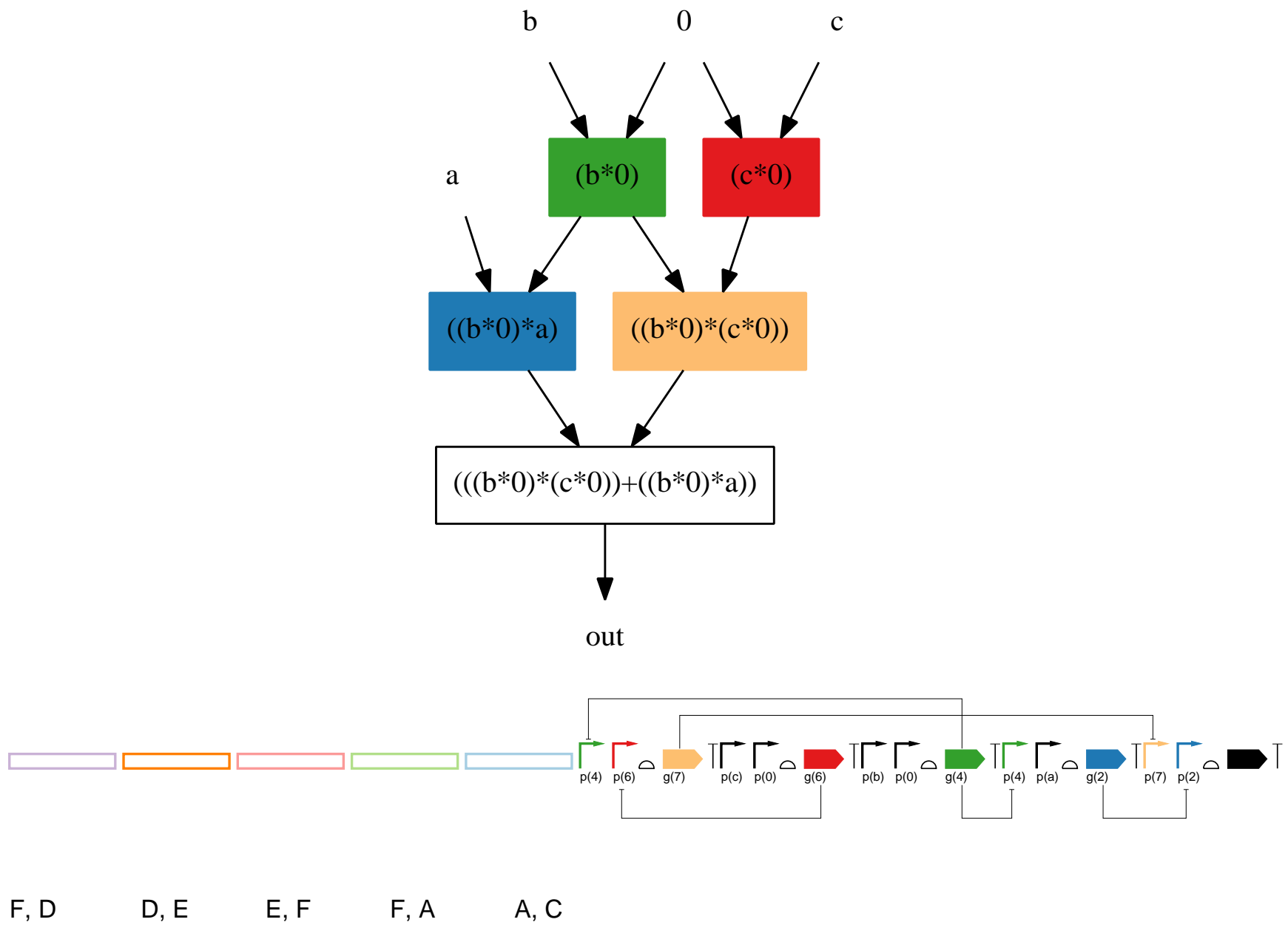


Figure 208: Circuit with truth table 0x31.

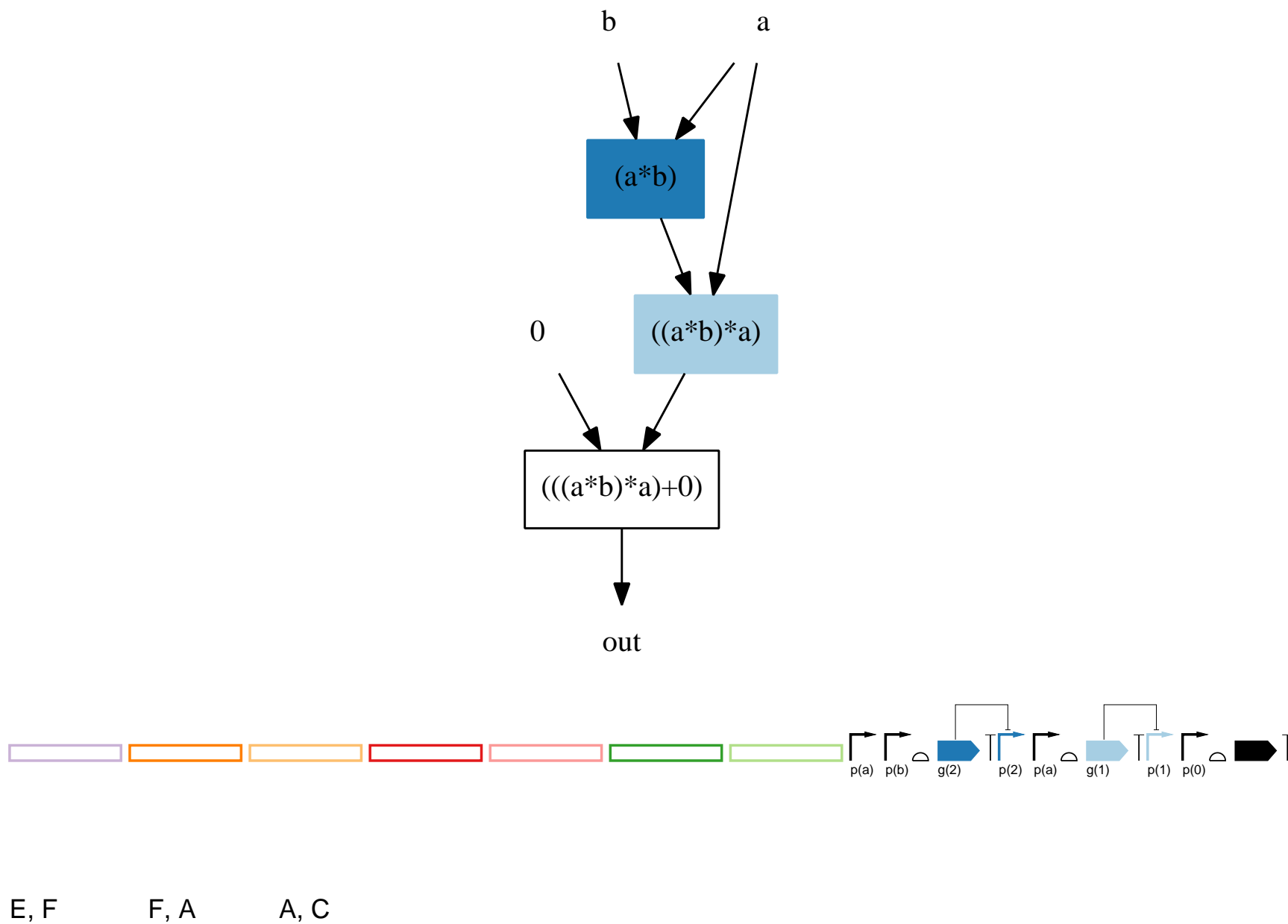


Figure 209: Circuit with truth table 0x30.

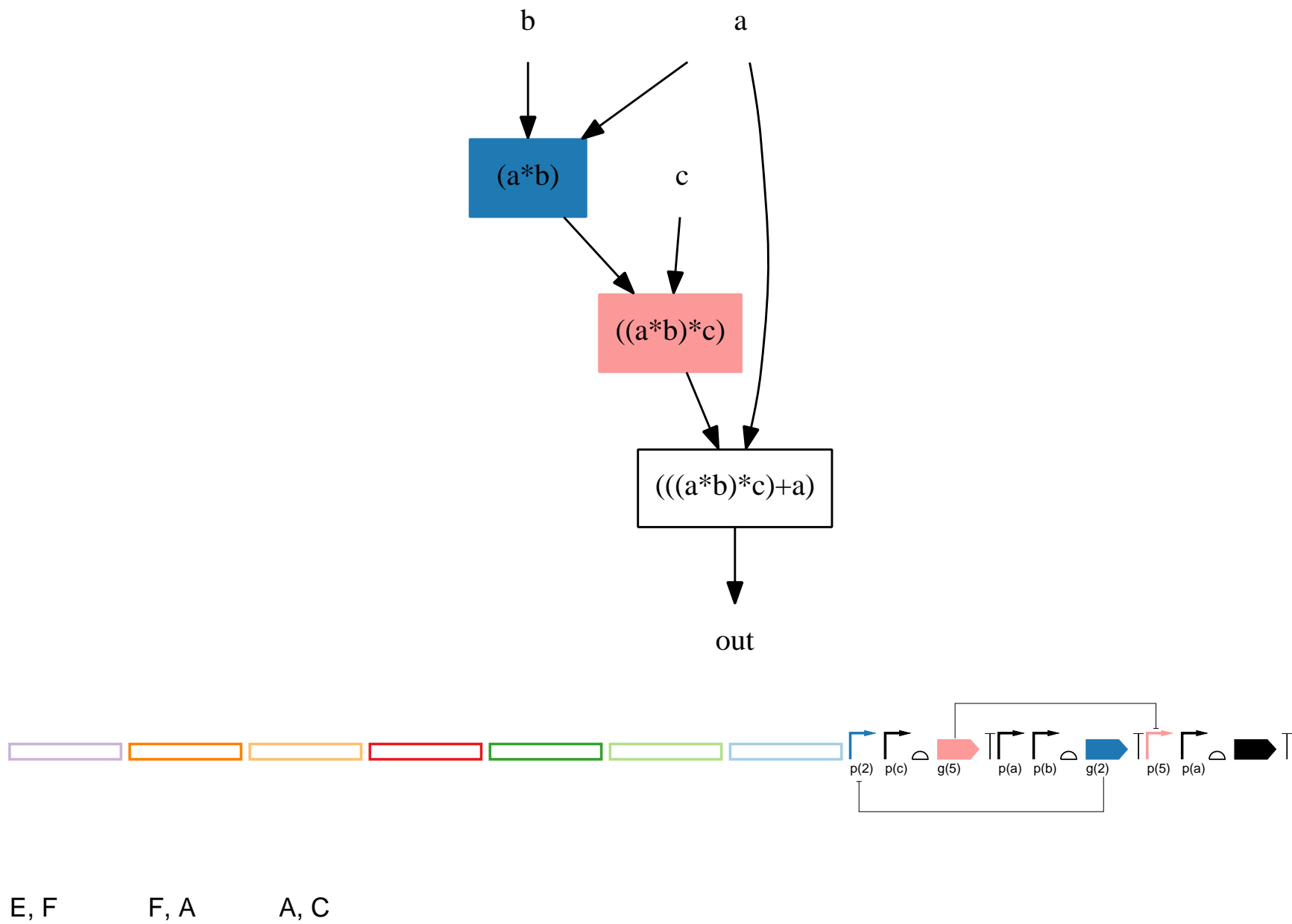


Figure 210: Circuit with truth table 0x2F.

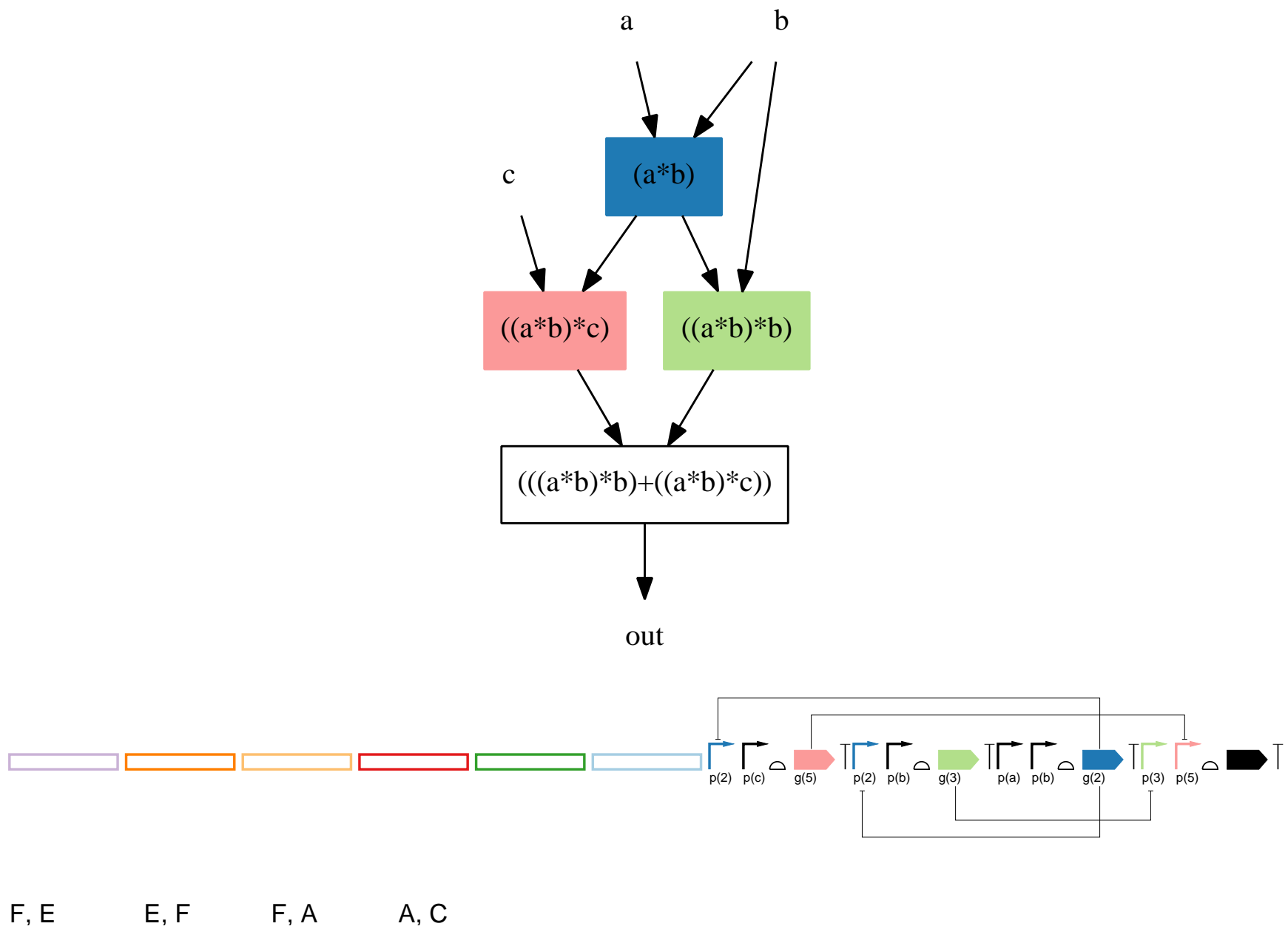


Figure 211: Circuit with truth table 0x2E.

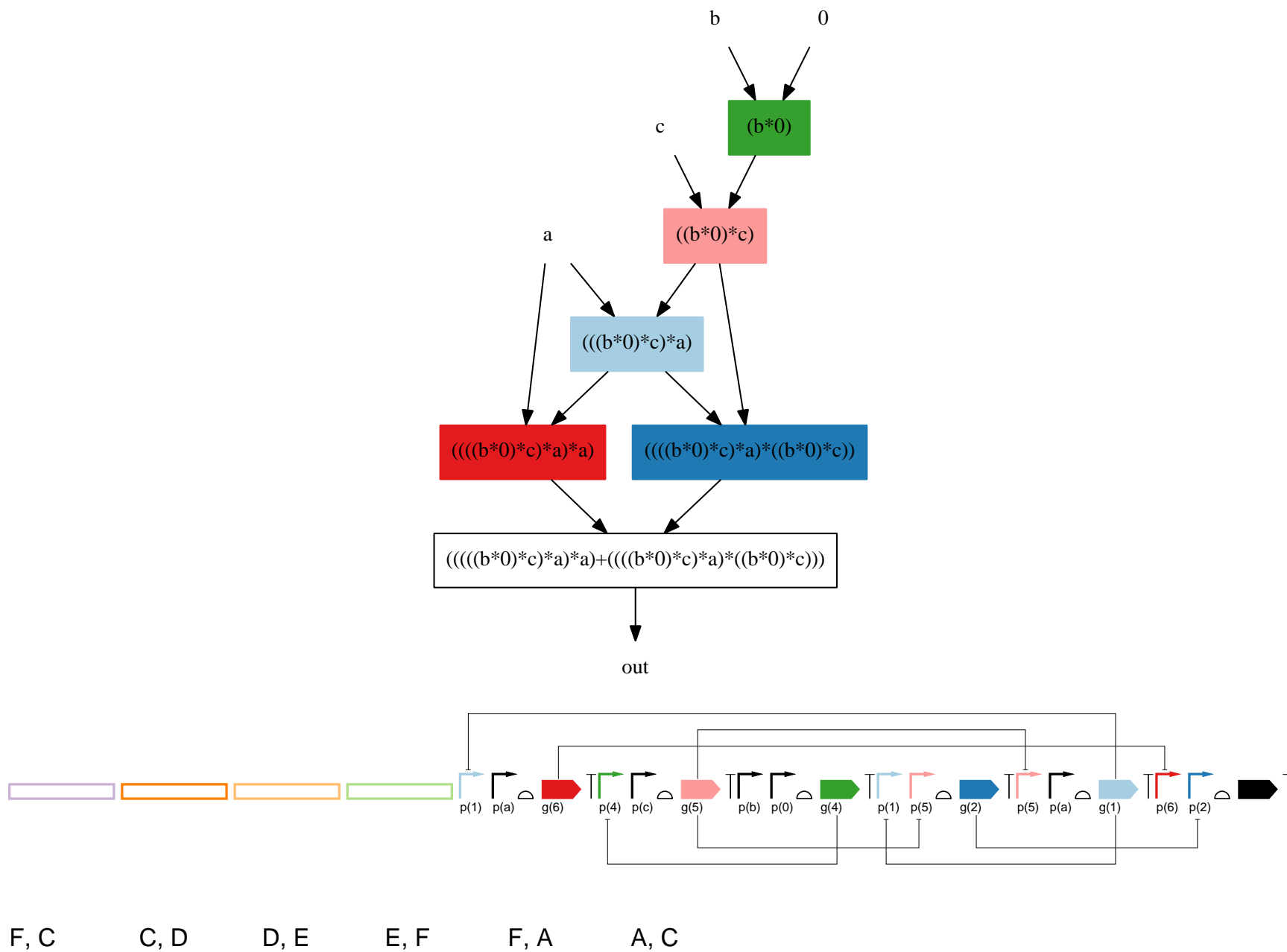


Figure 212: Circuit with truth table 0x2D.

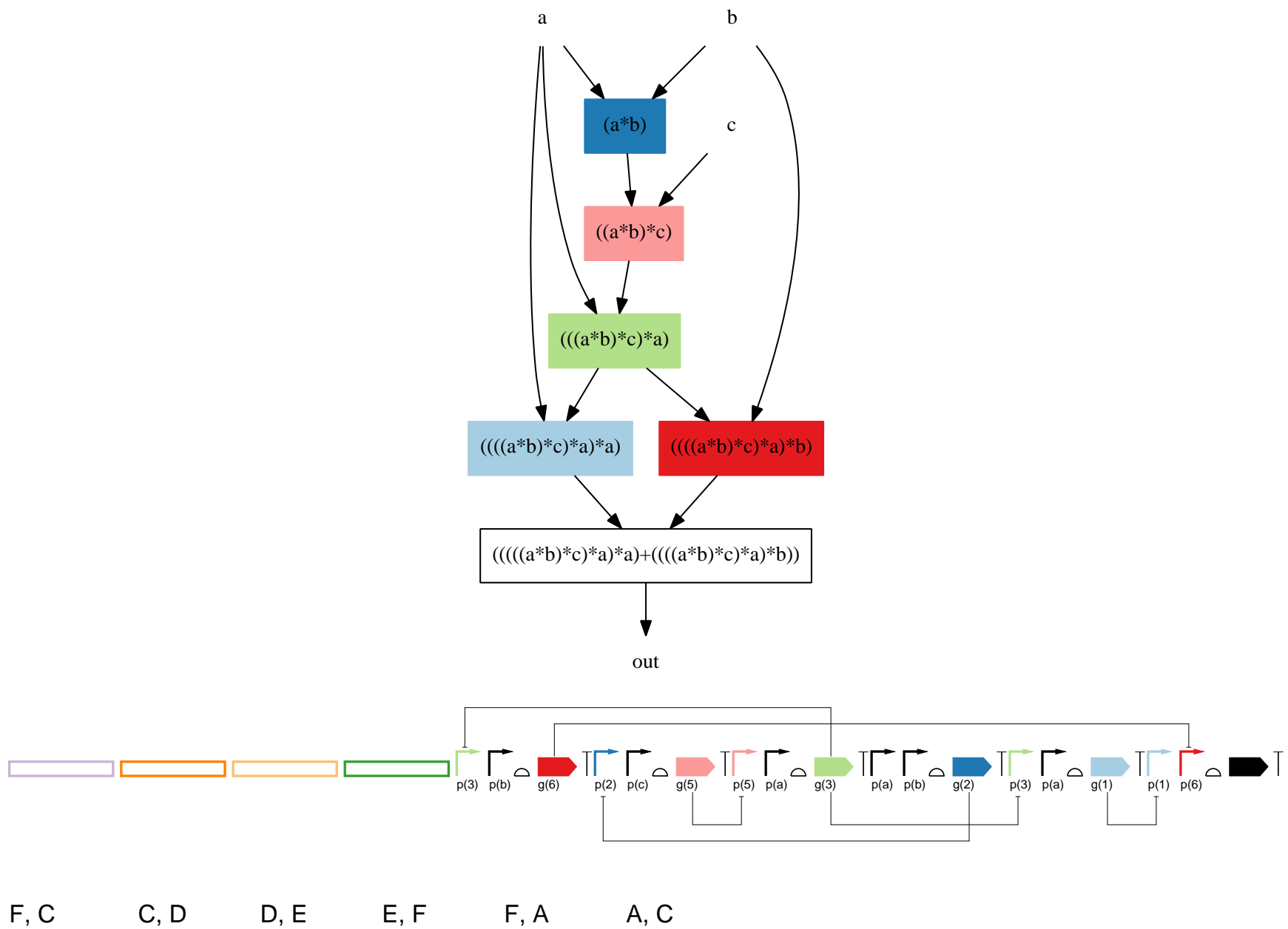


Figure 213: Circuit with truth table 0x2C.

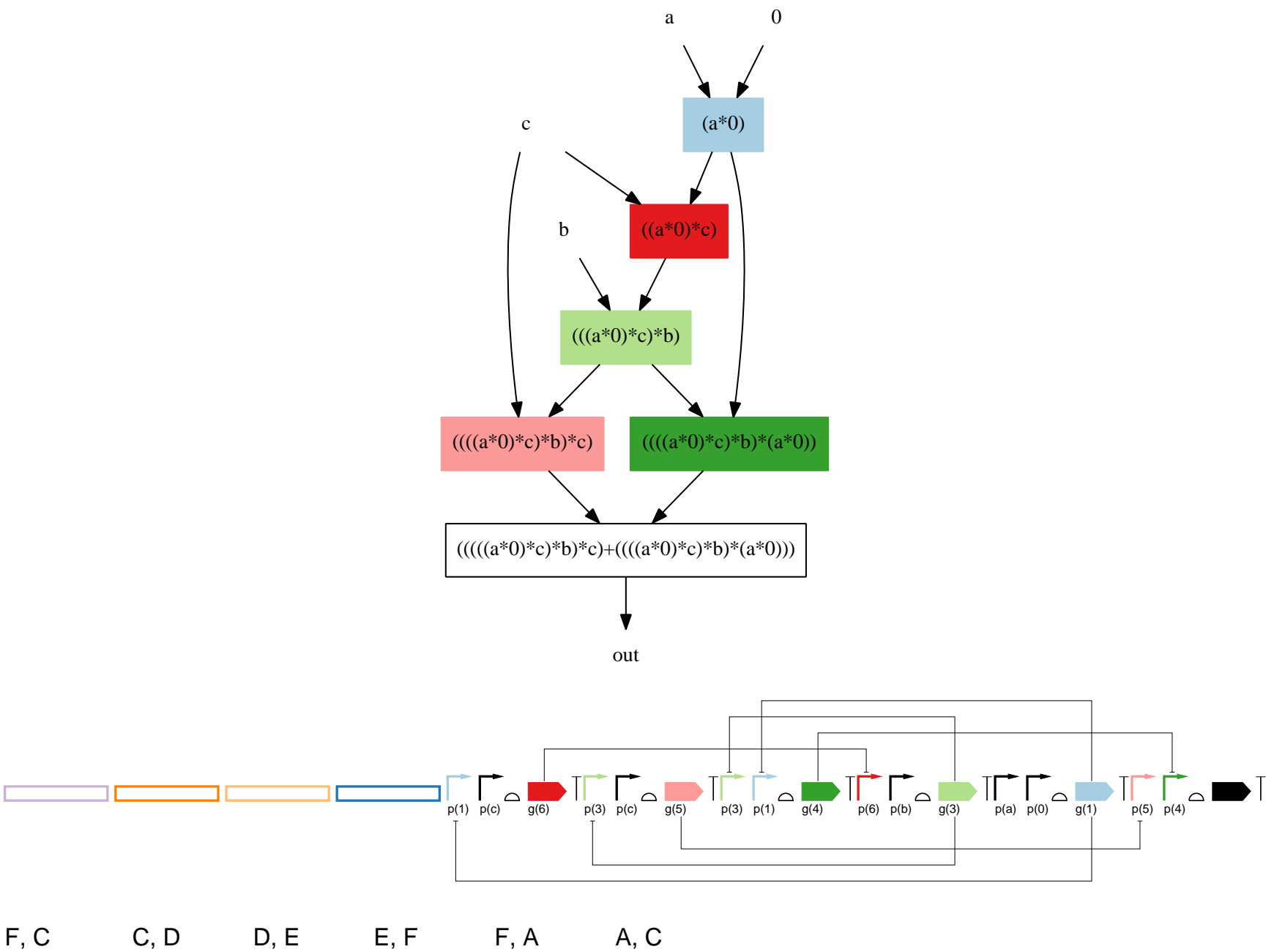


Figure 214: Circuit with truth table 0x2B.

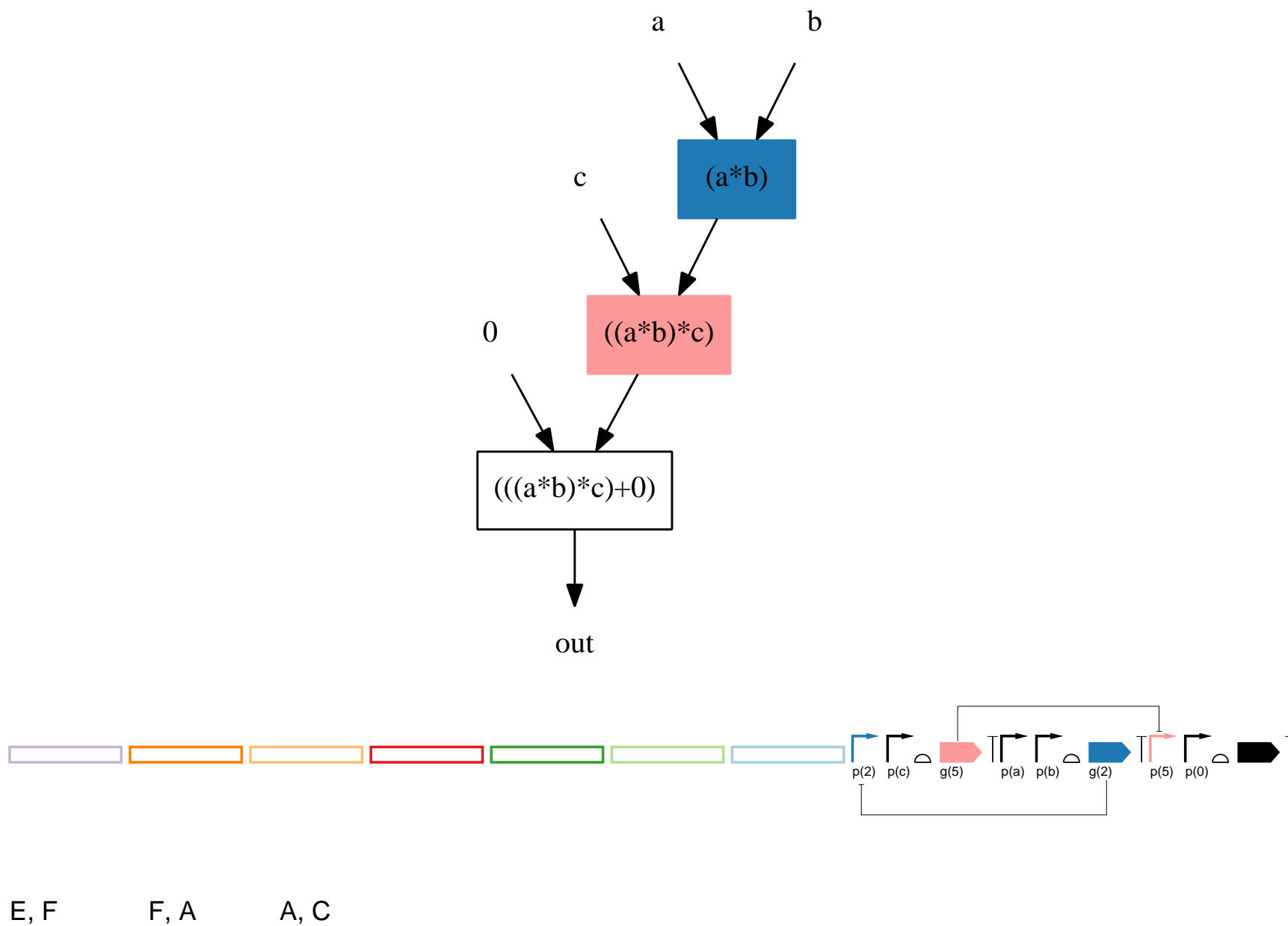


Figure 215: Circuit with truth table 0x2A.

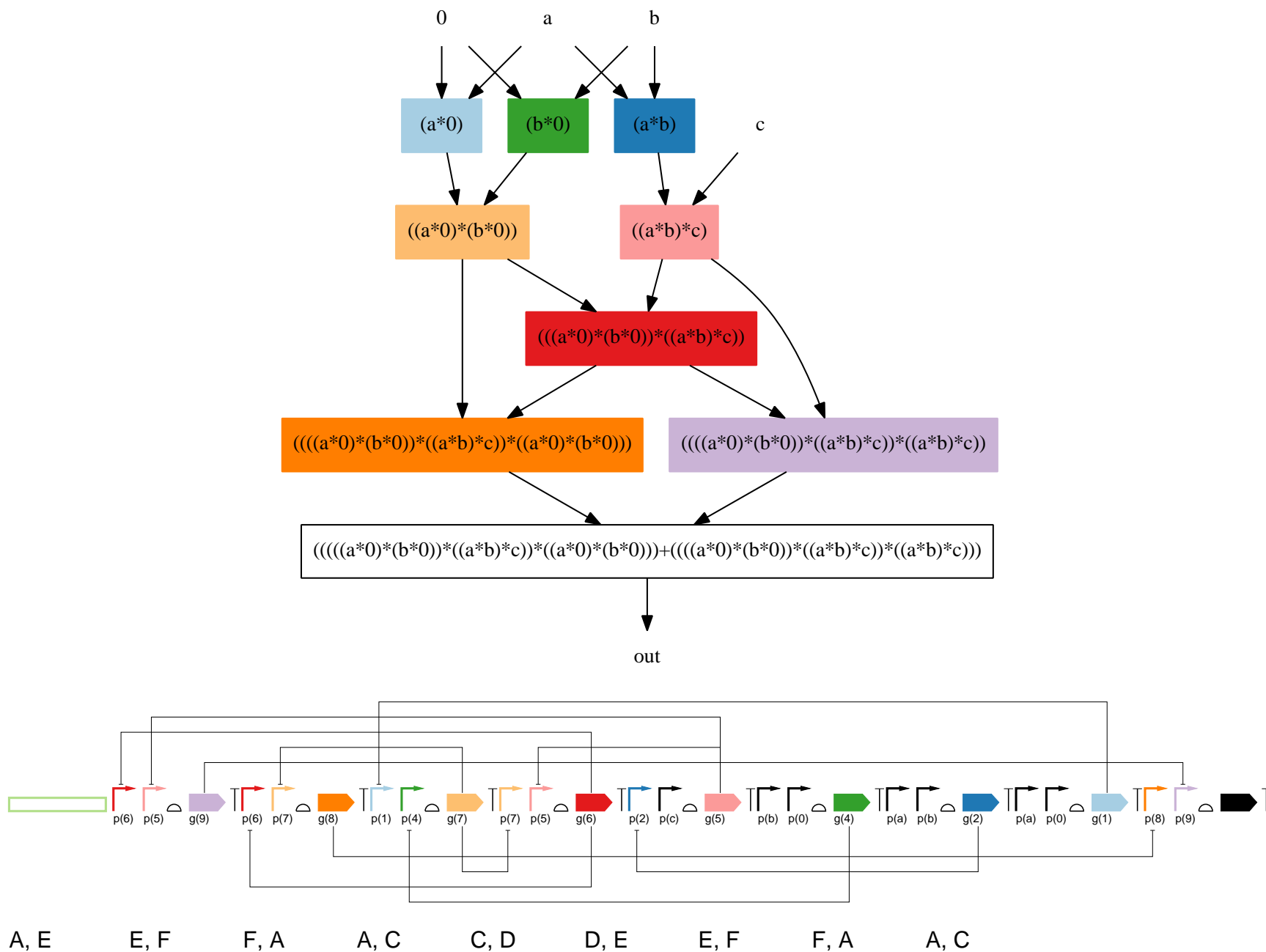


Figure 216: Circuit with truth table 0x29.

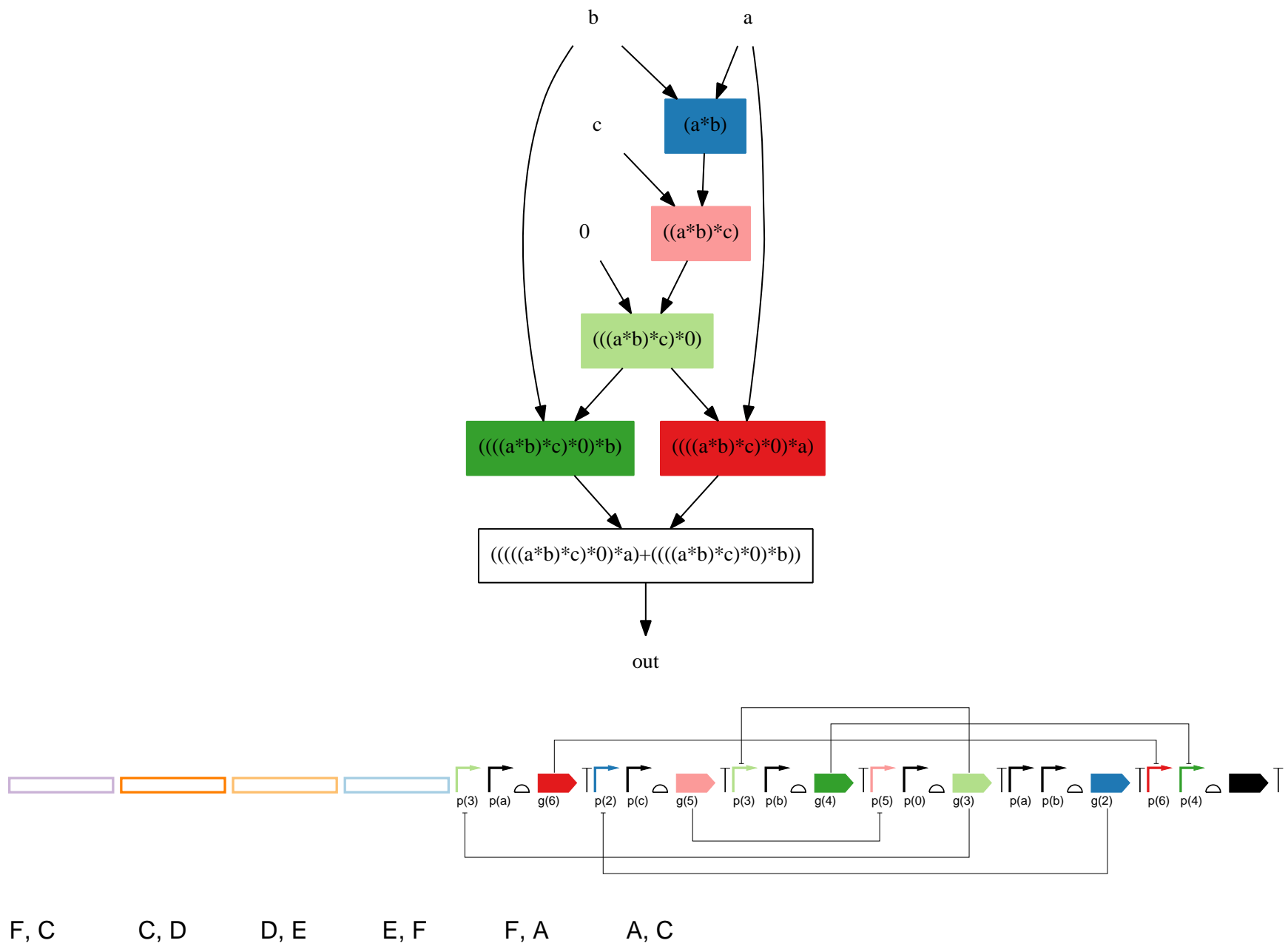


Figure 217: Circuit with truth table 0x28.

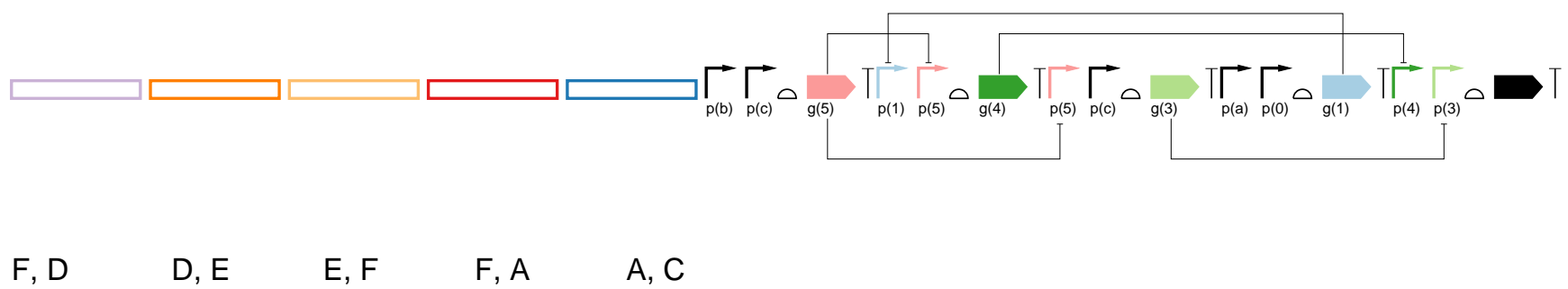
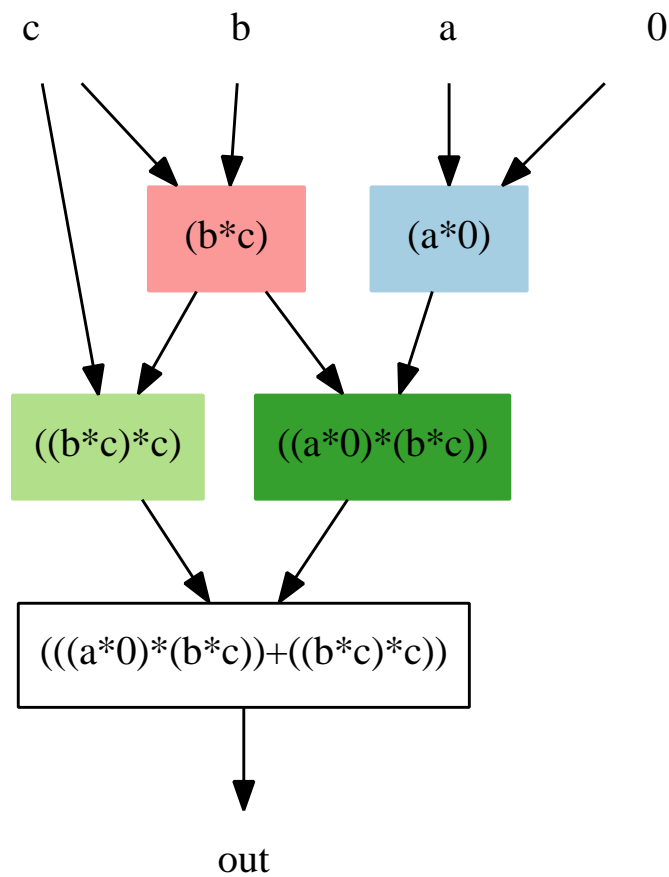


Figure 218: Circuit with truth table 0x27.

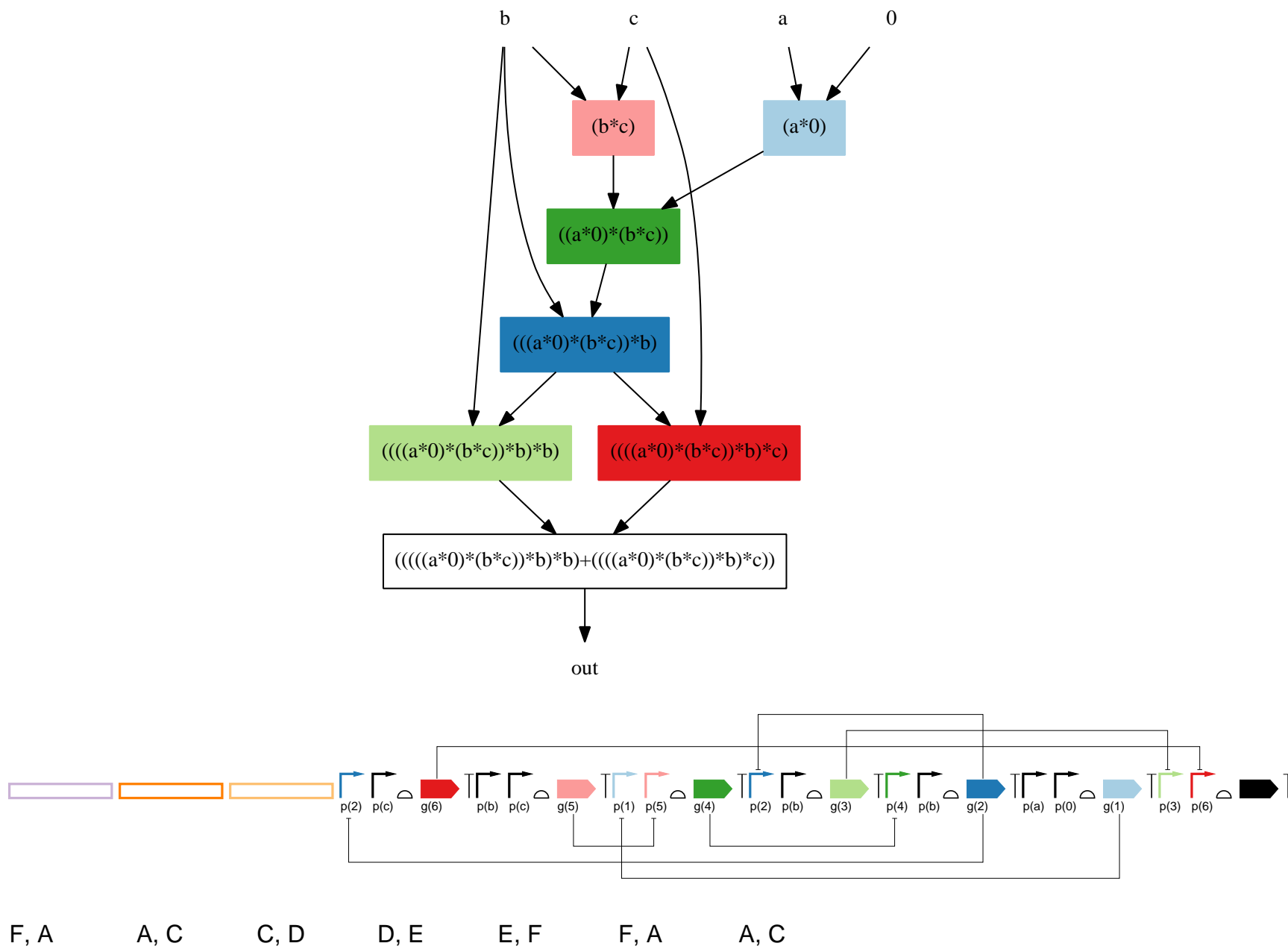


Figure 219: Circuit with truth table 0x26.

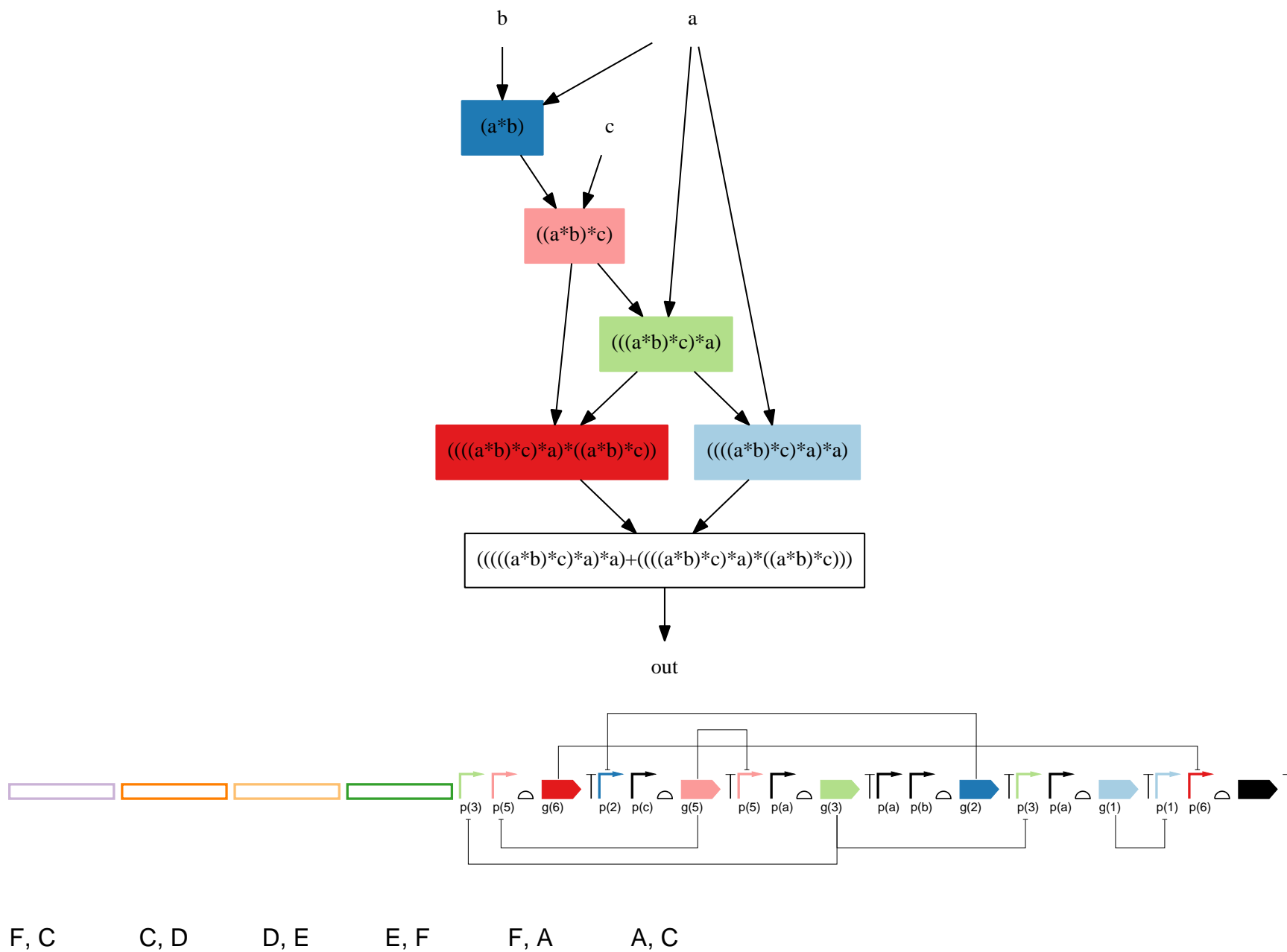


Figure 220: Circuit with truth table 0x25.

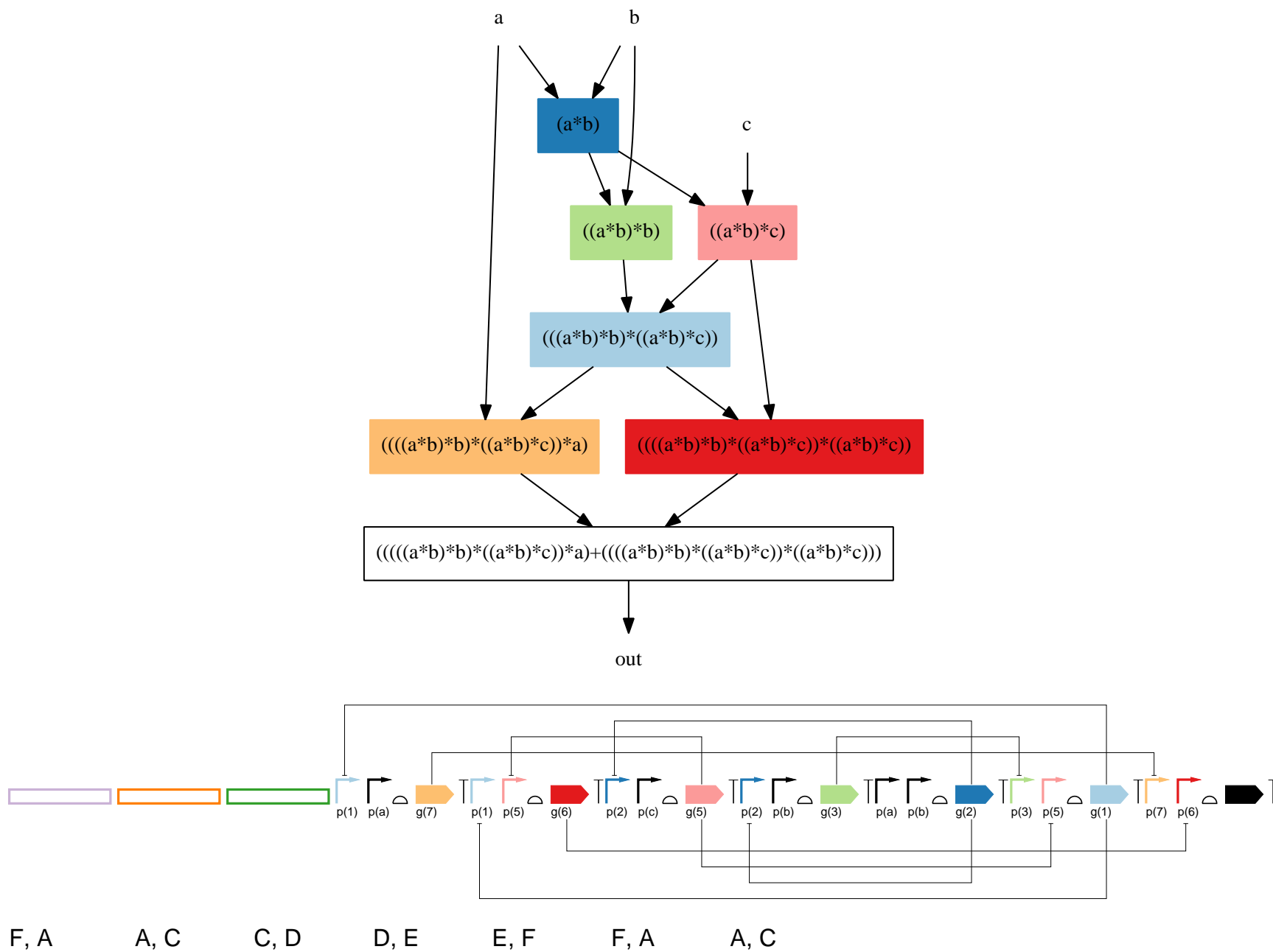


Figure 221: Circuit with truth table 0x24.

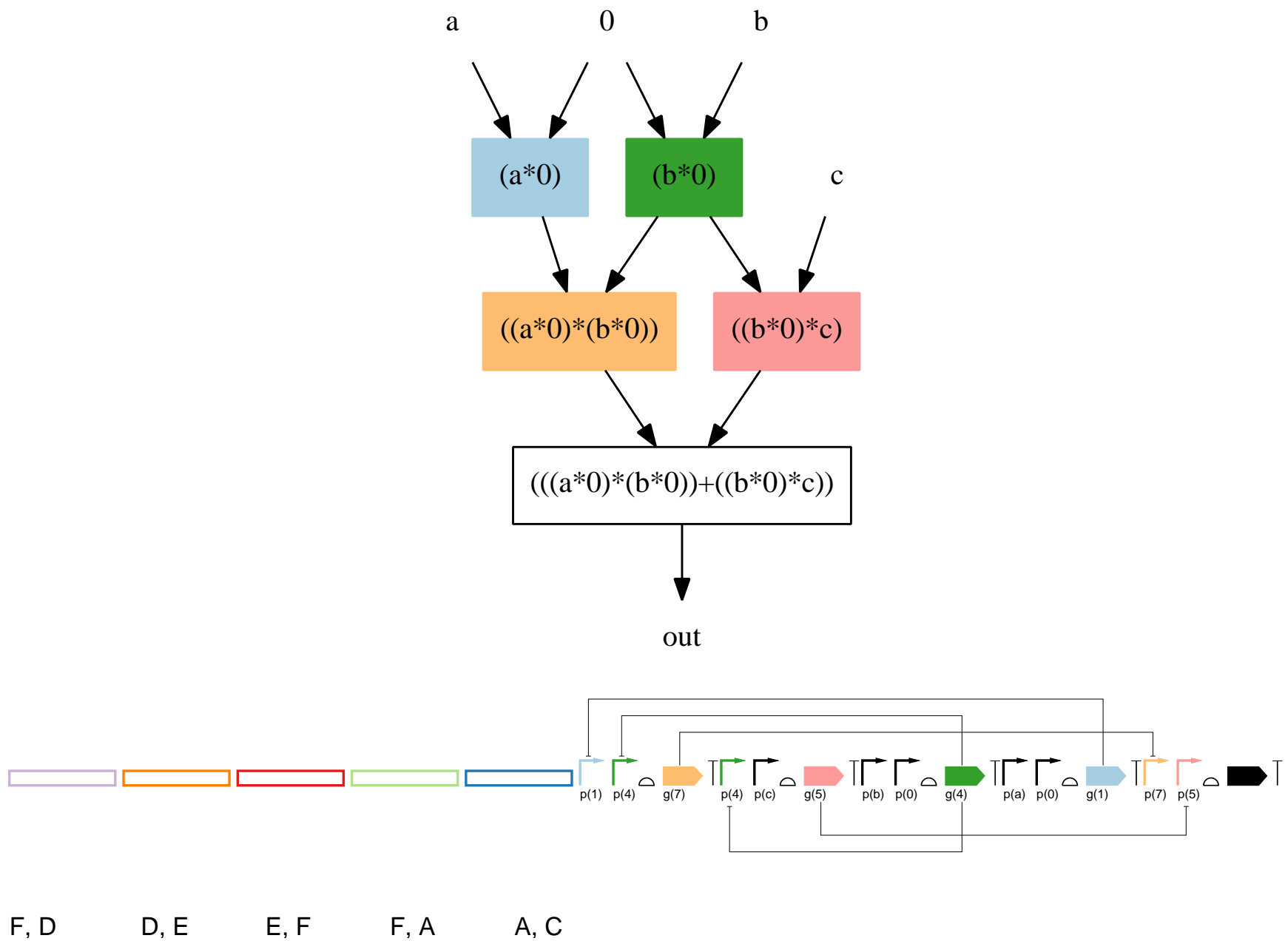


Figure 222: Circuit with truth table 0x23.

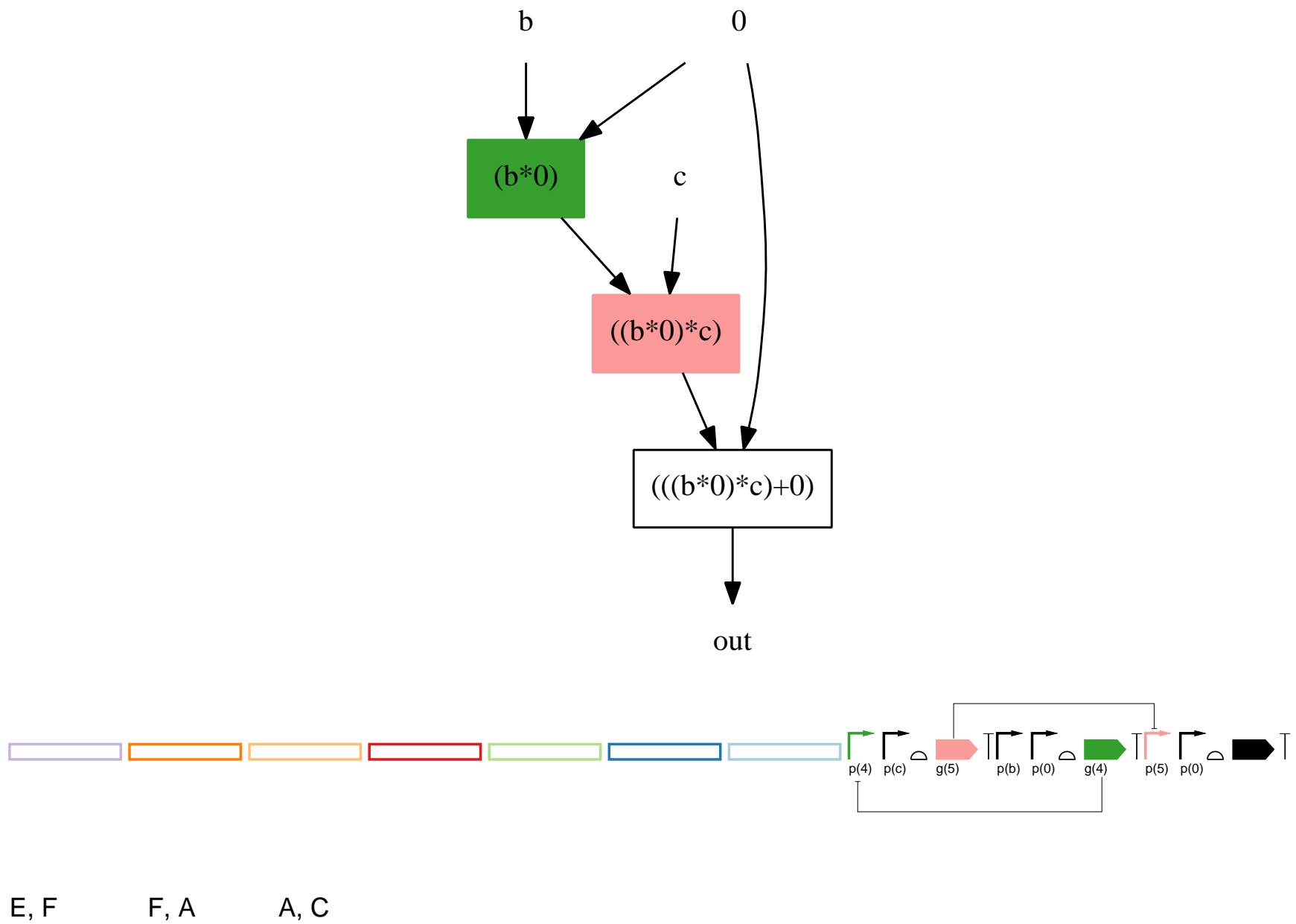


Figure 223: Circuit with truth table 0x22.

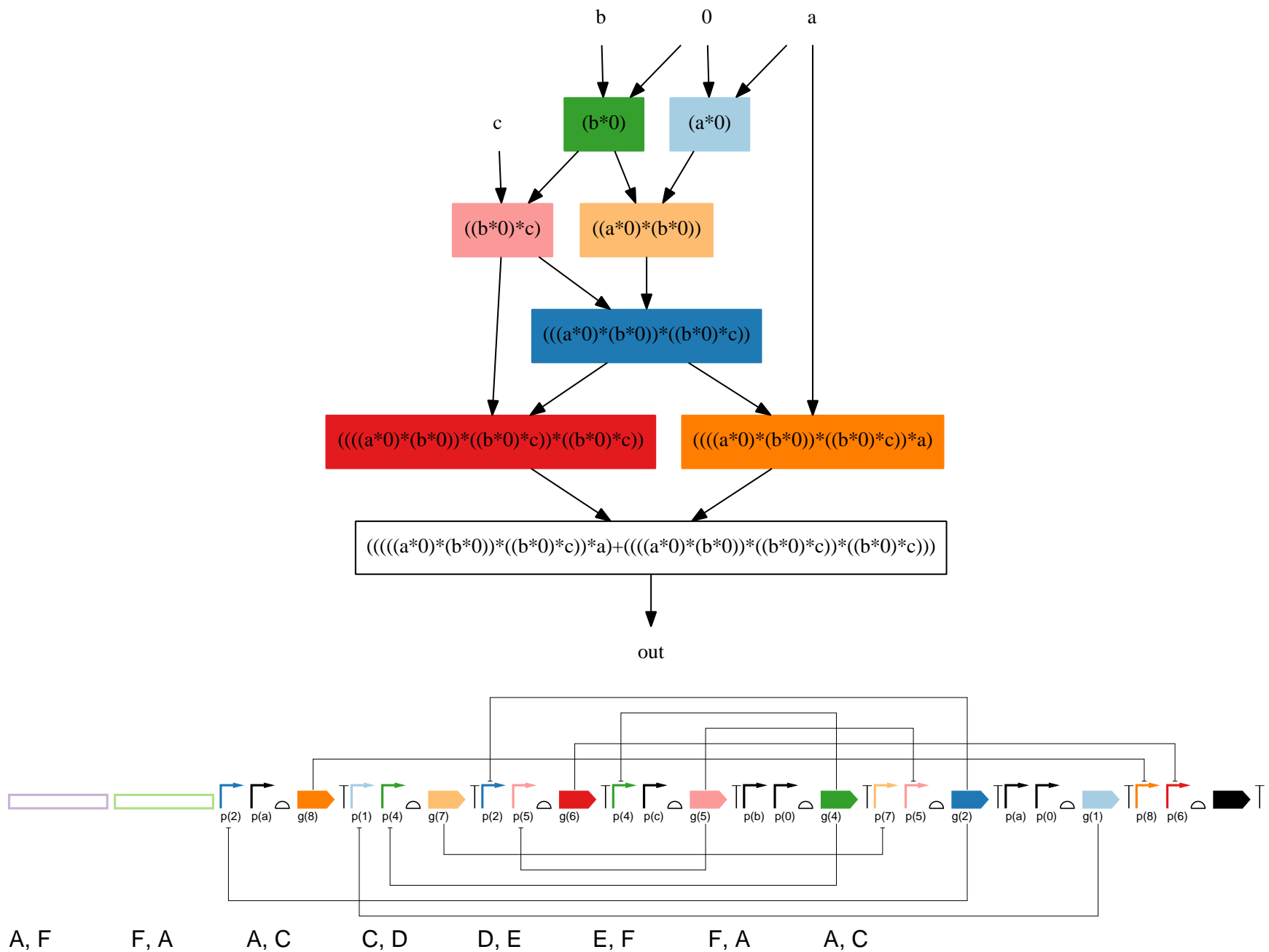


Figure 224: Circuit with truth table 0x21.

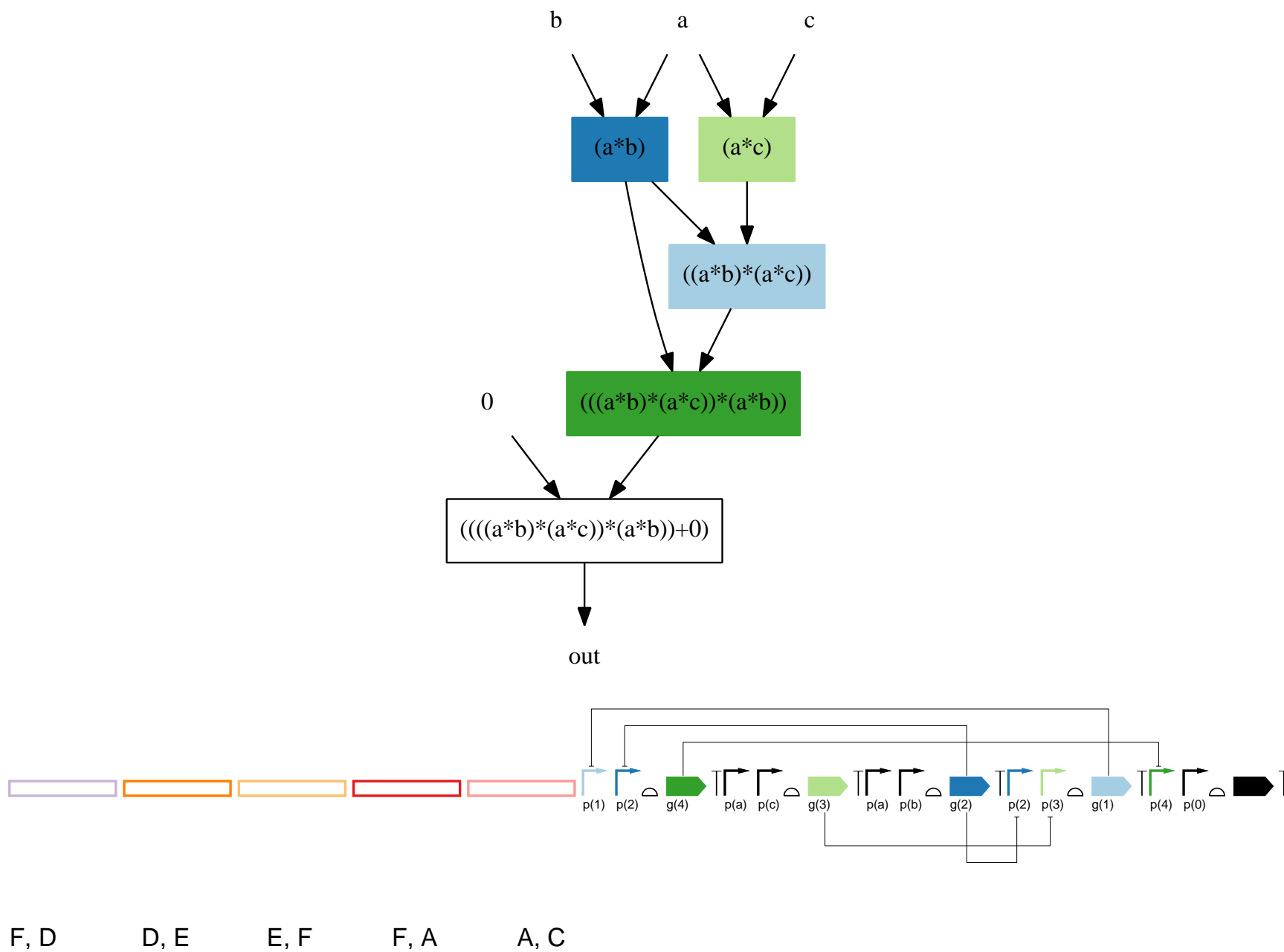


Figure 225: Circuit with truth table 0x20.

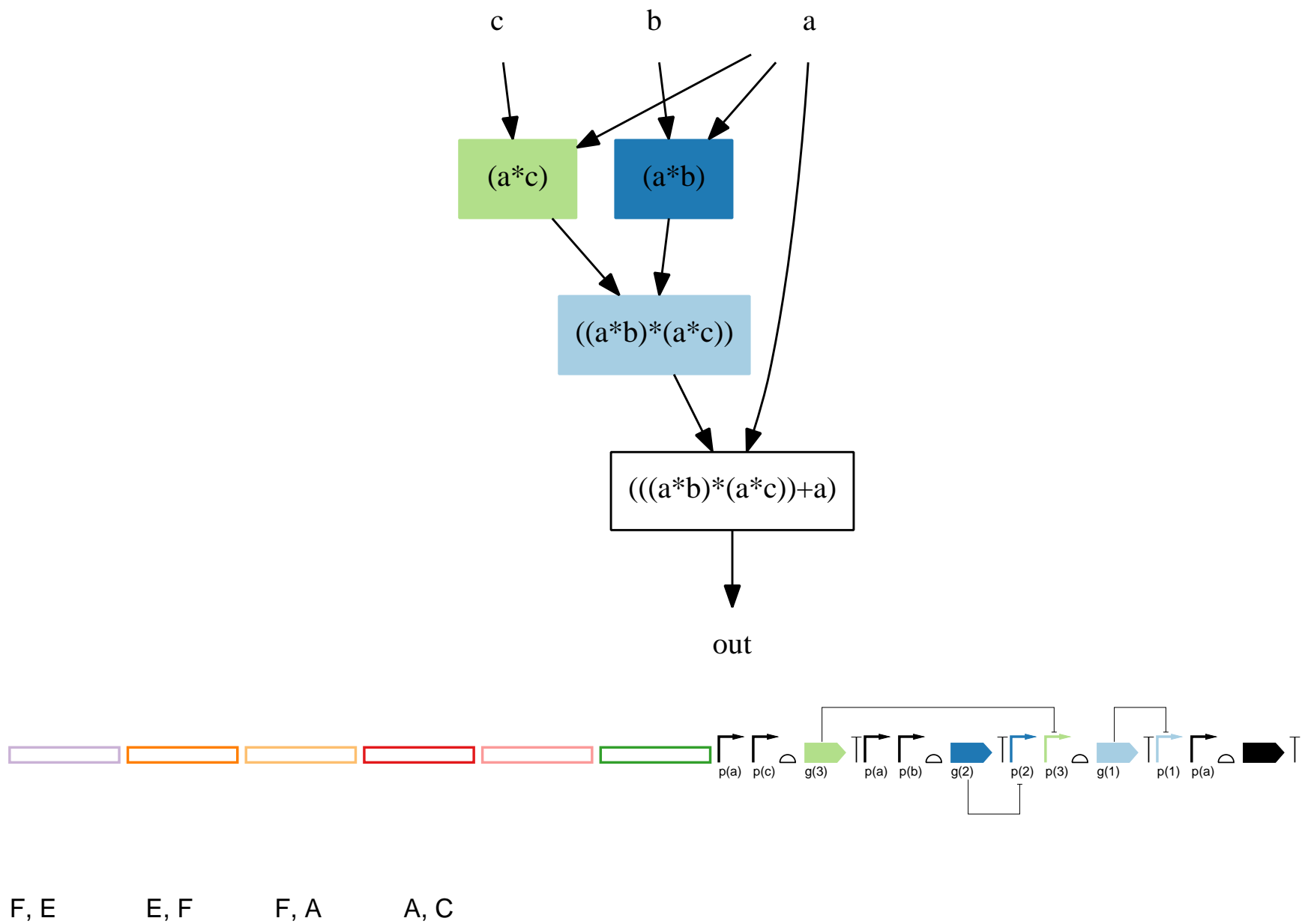


Figure 226: Circuit with truth table 0x1F.

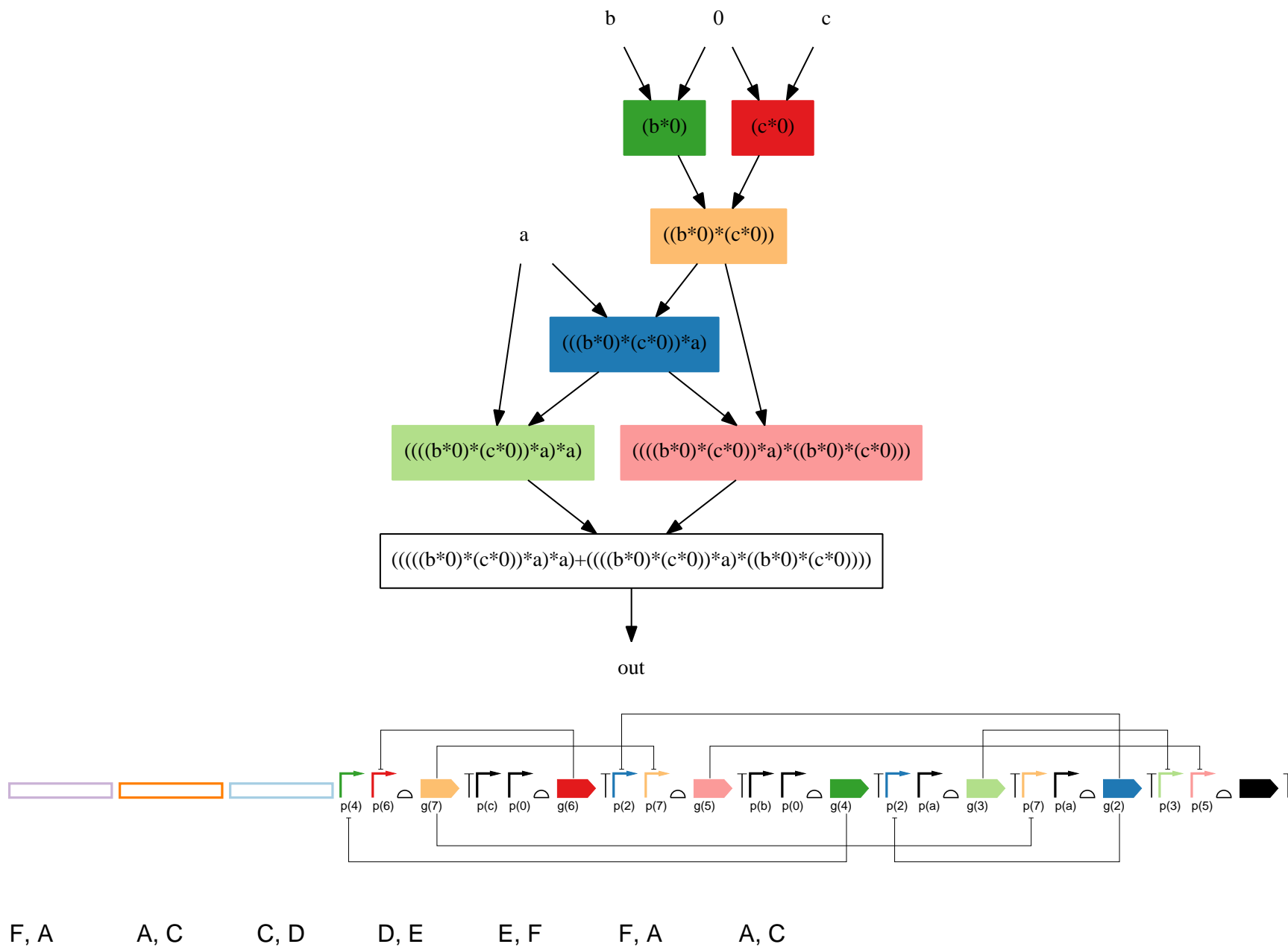
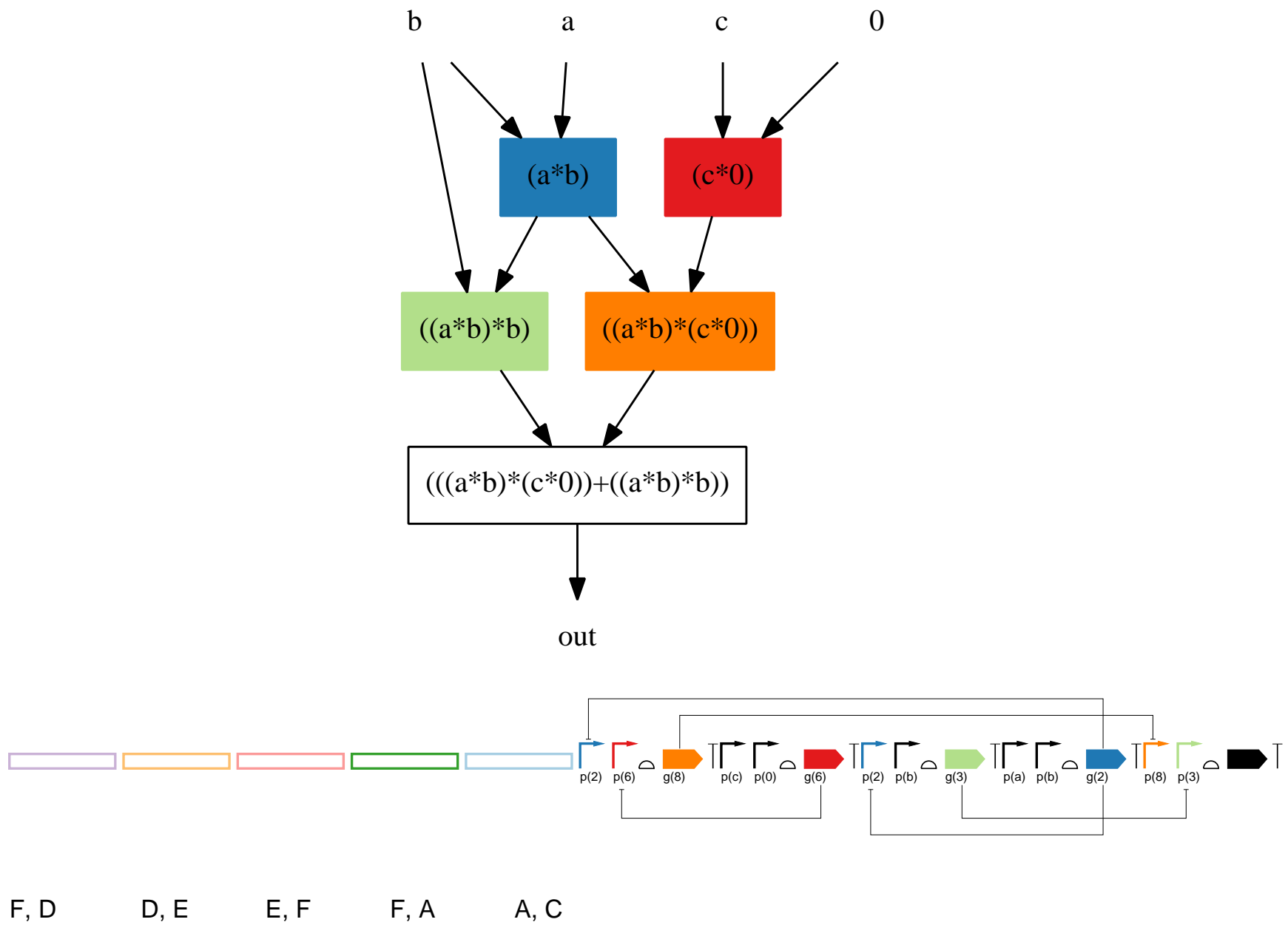


Figure 227: Circuit with truth table 0x1E.



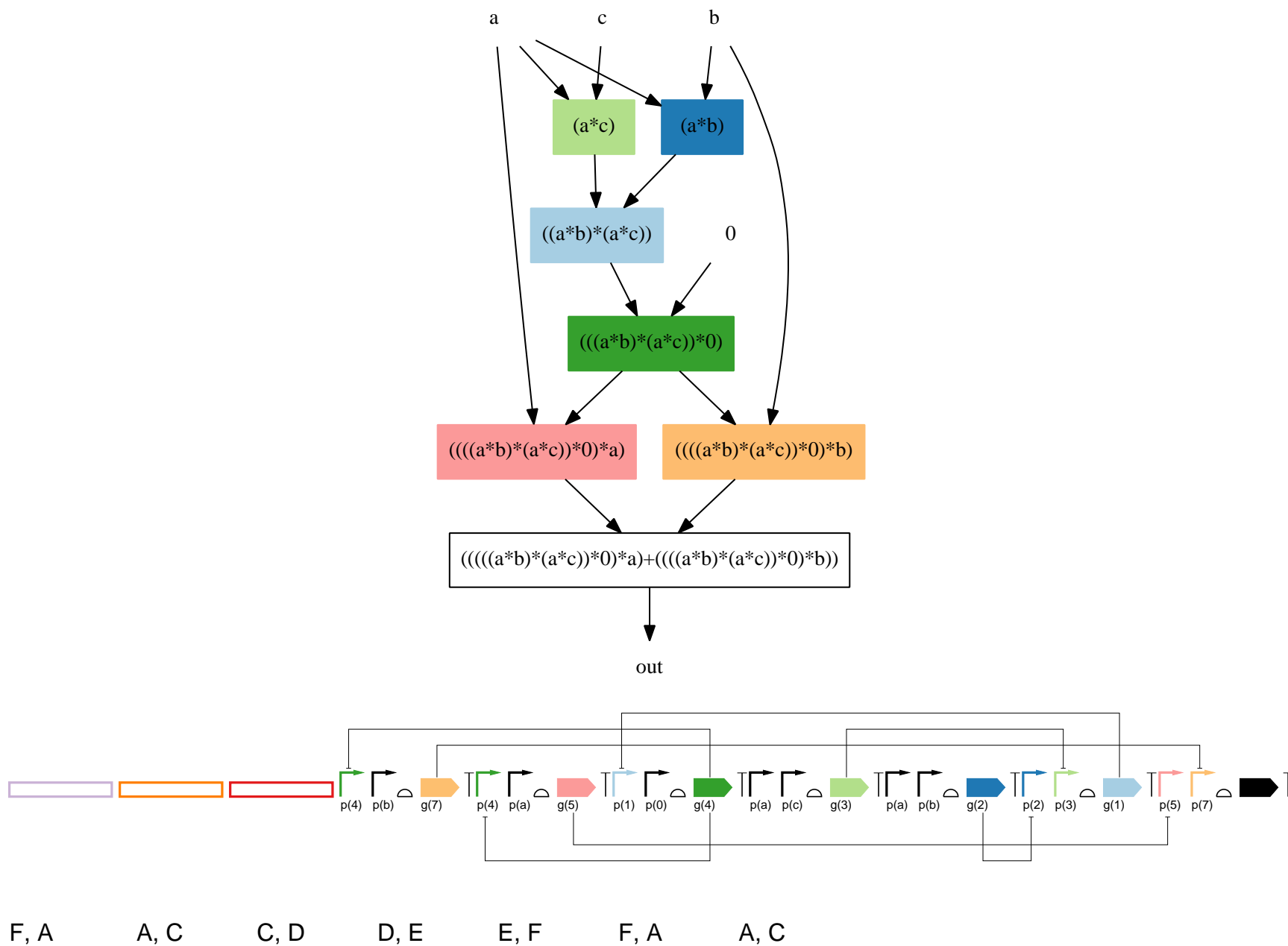


Figure 229: Circuit with truth table 0x1C.

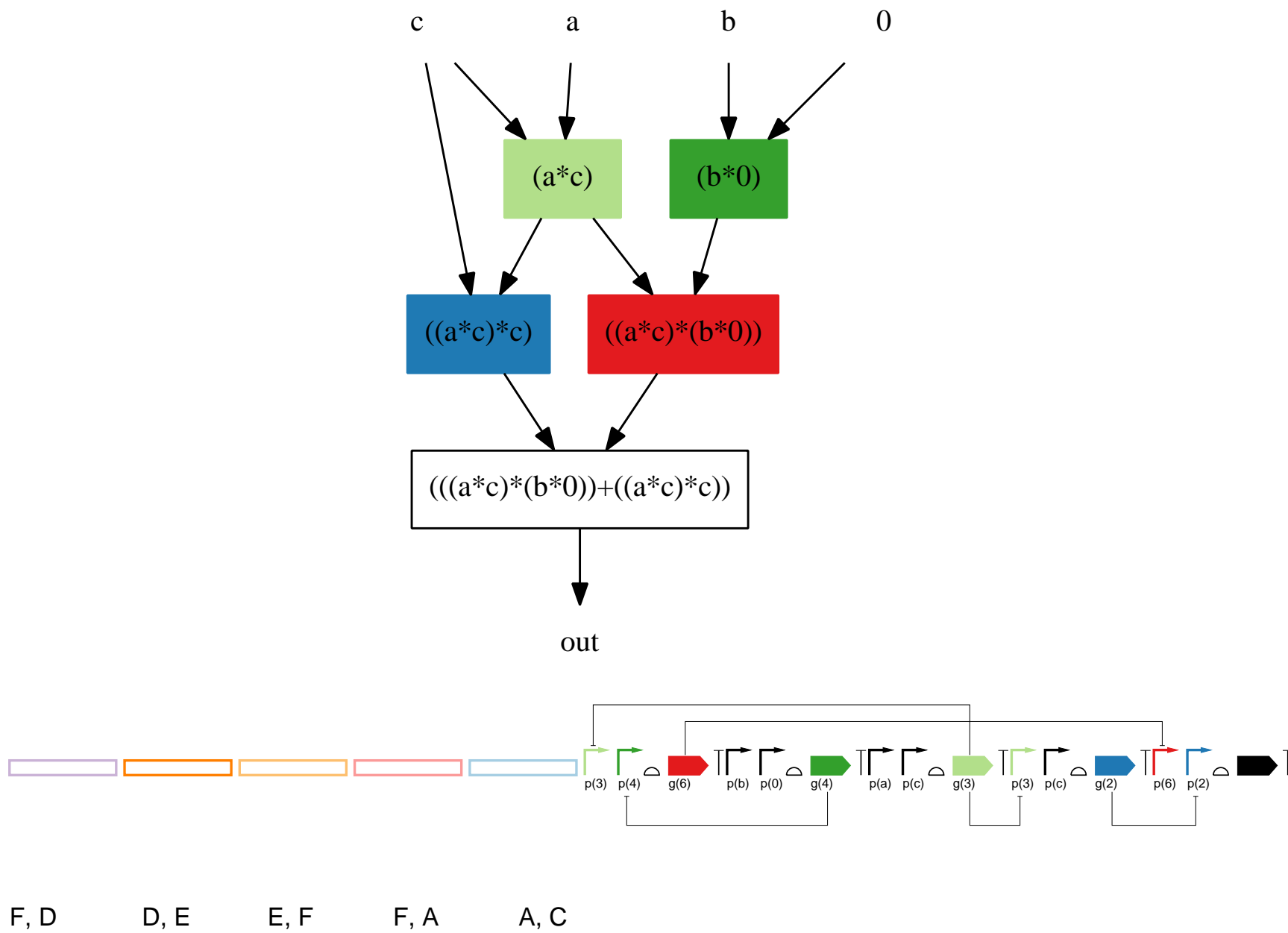


Figure 230: Circuit with truth table 0x1B.

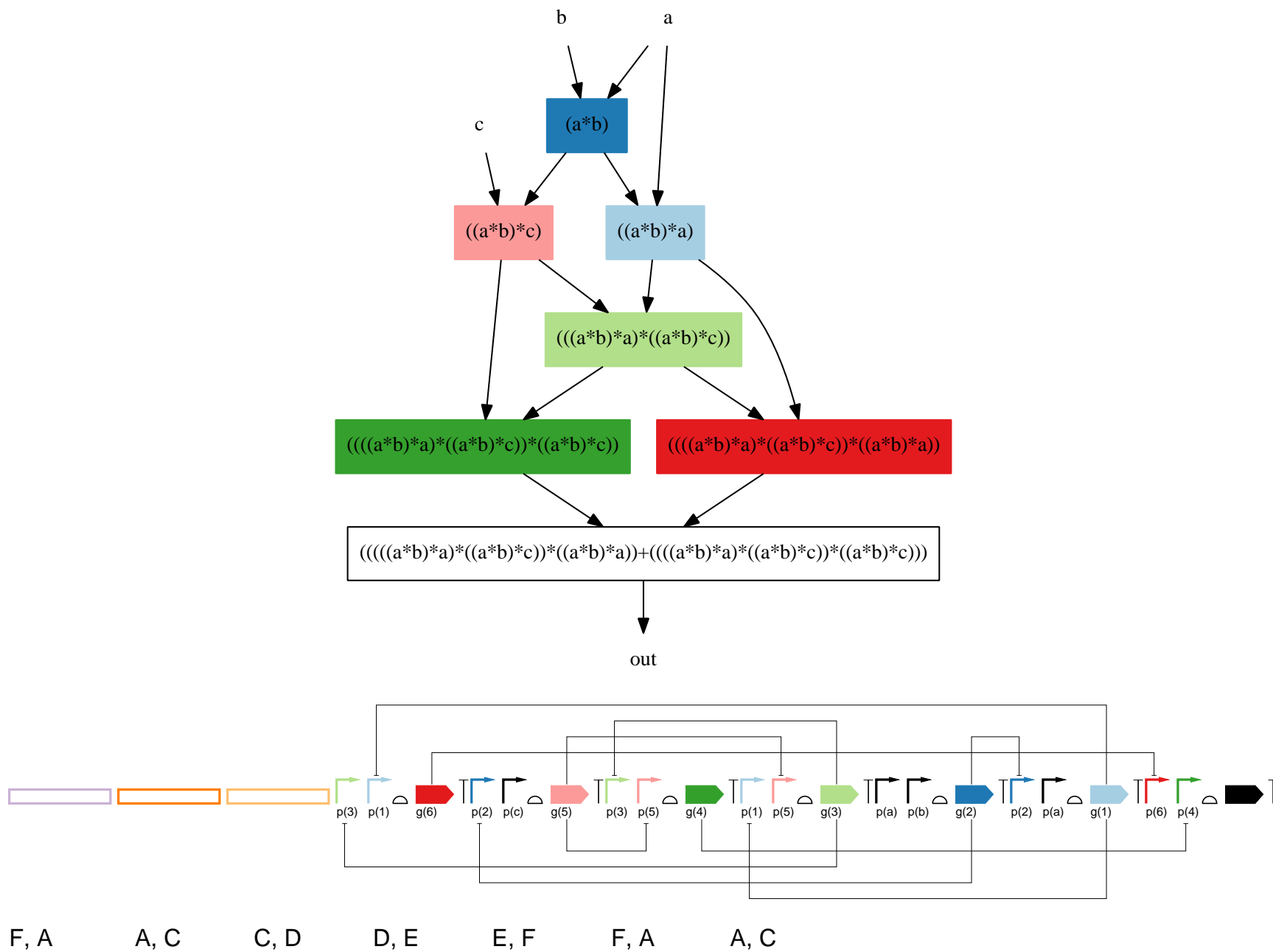


Figure 231: Circuit with truth table 0x1A.

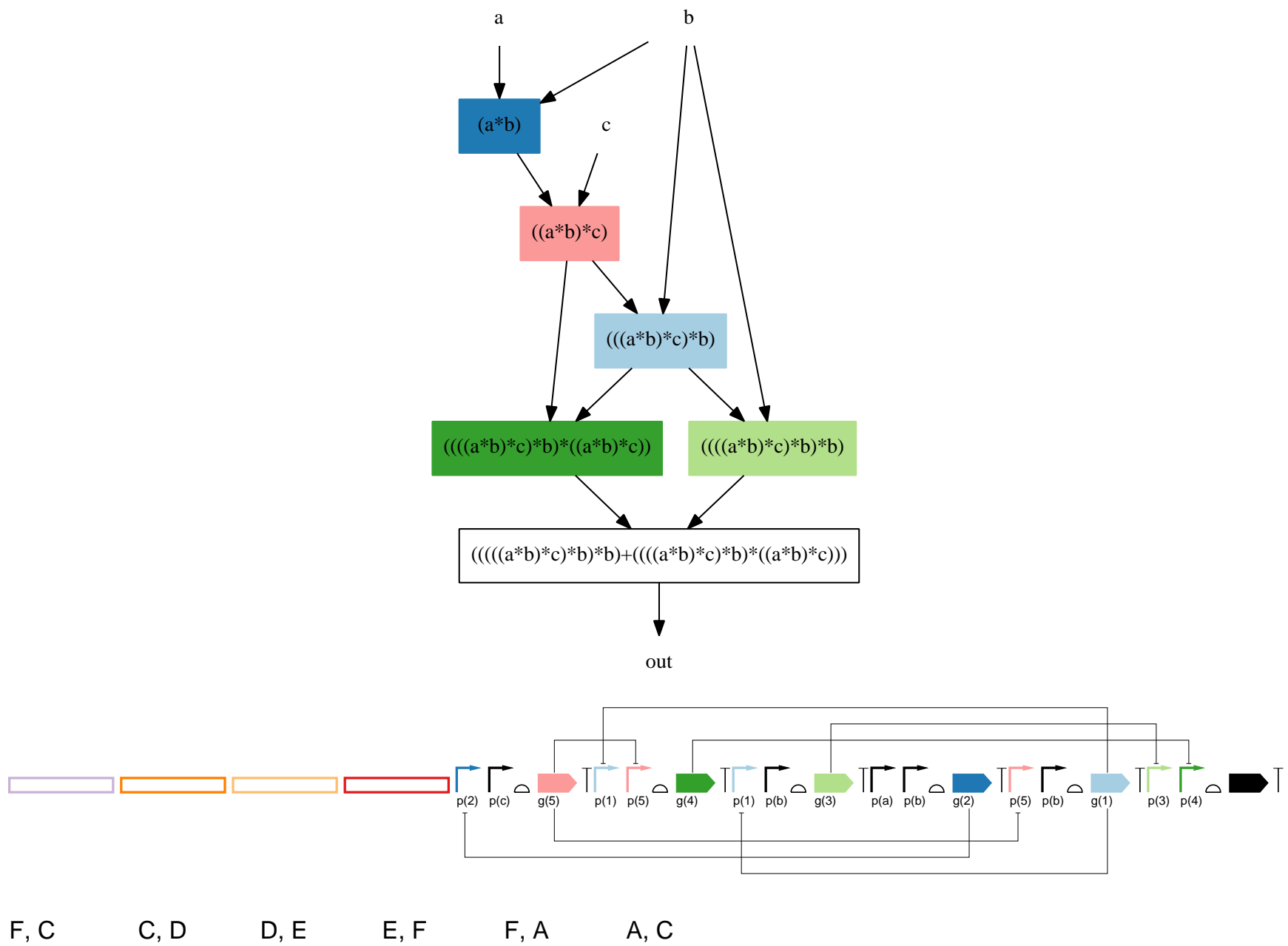


Figure 232: Circuit with truth table 0x19.

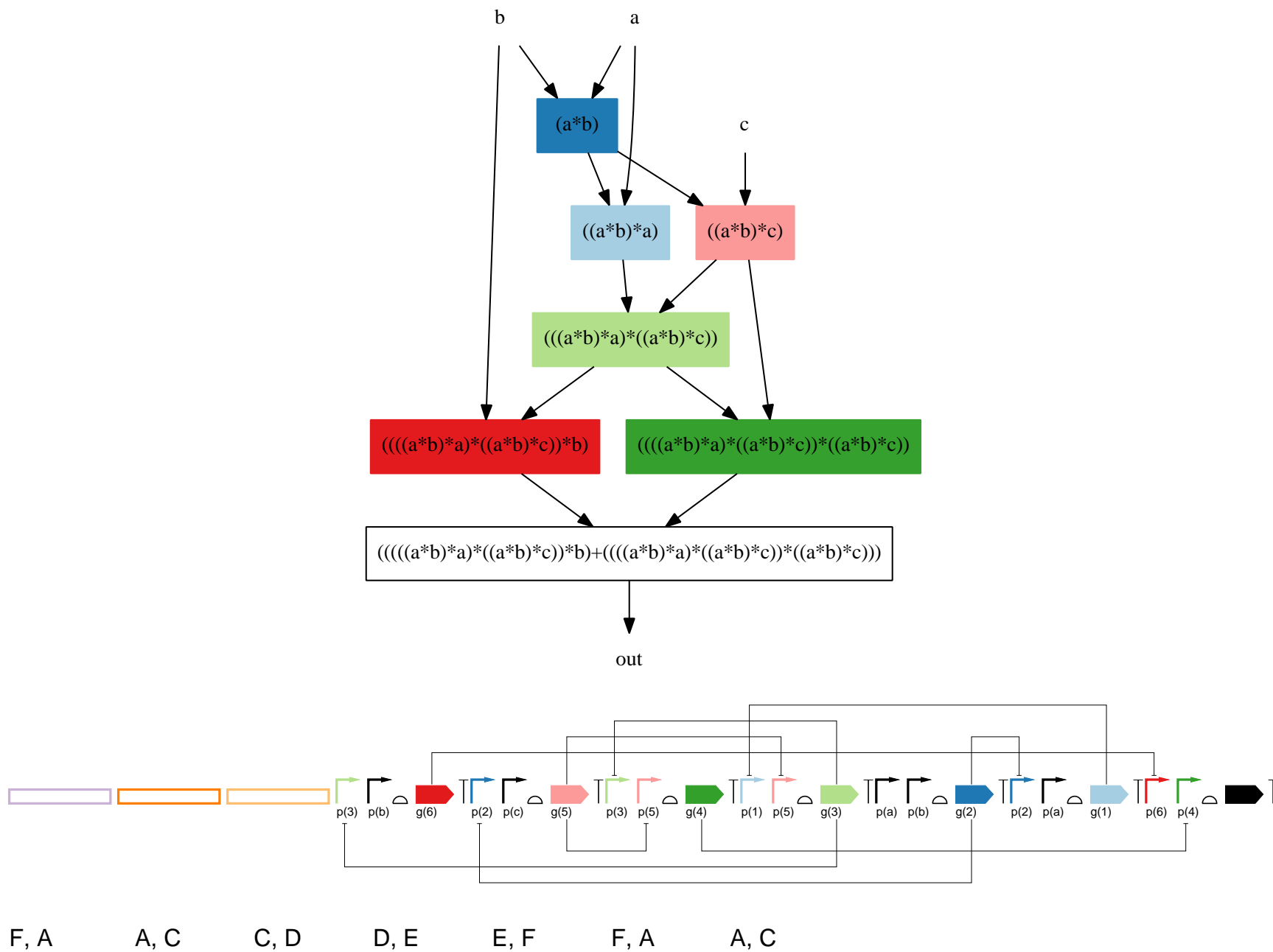


Figure 233: Circuit with truth table 0x18.

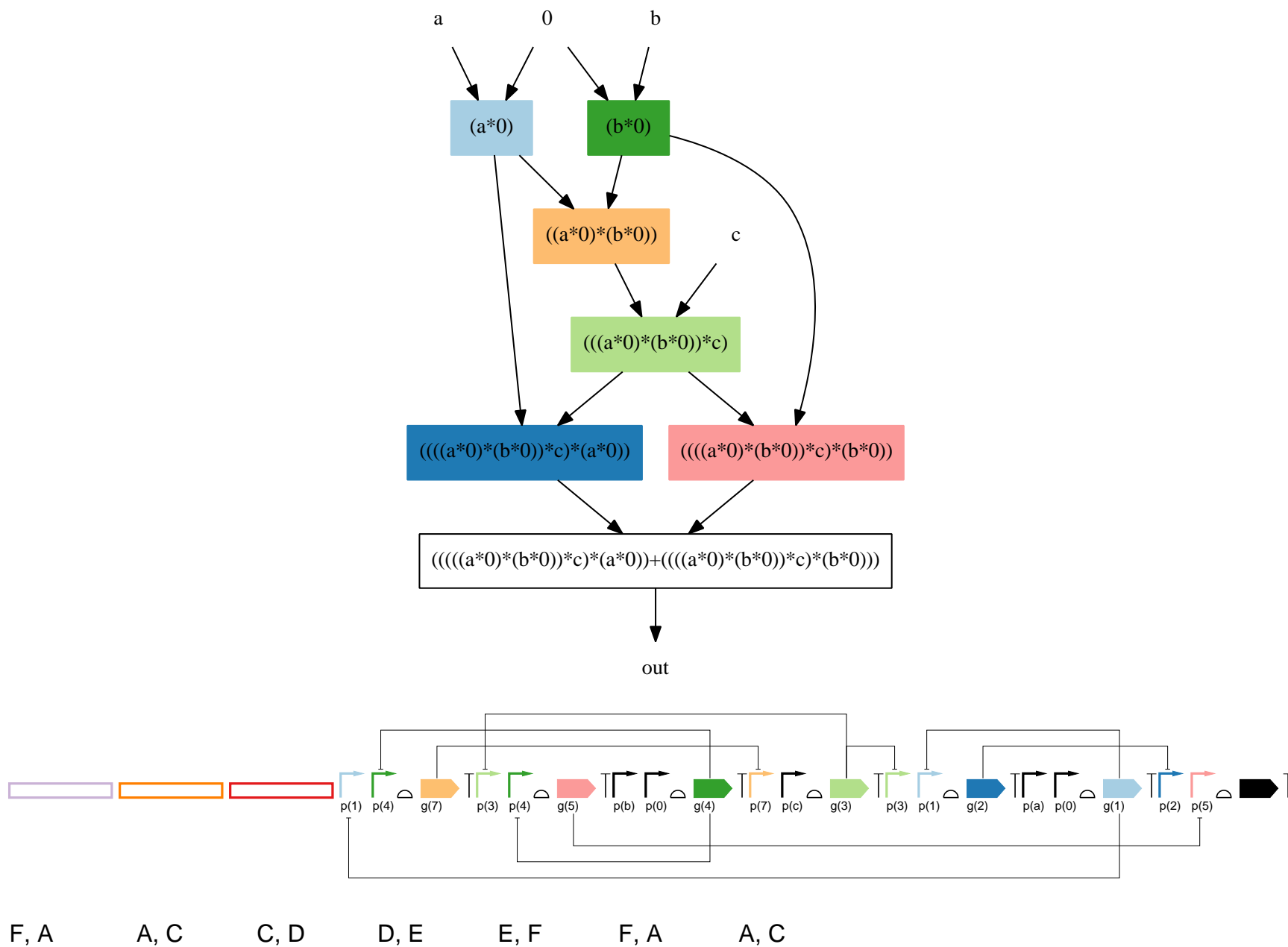


Figure 234: Circuit with truth table 0x17.

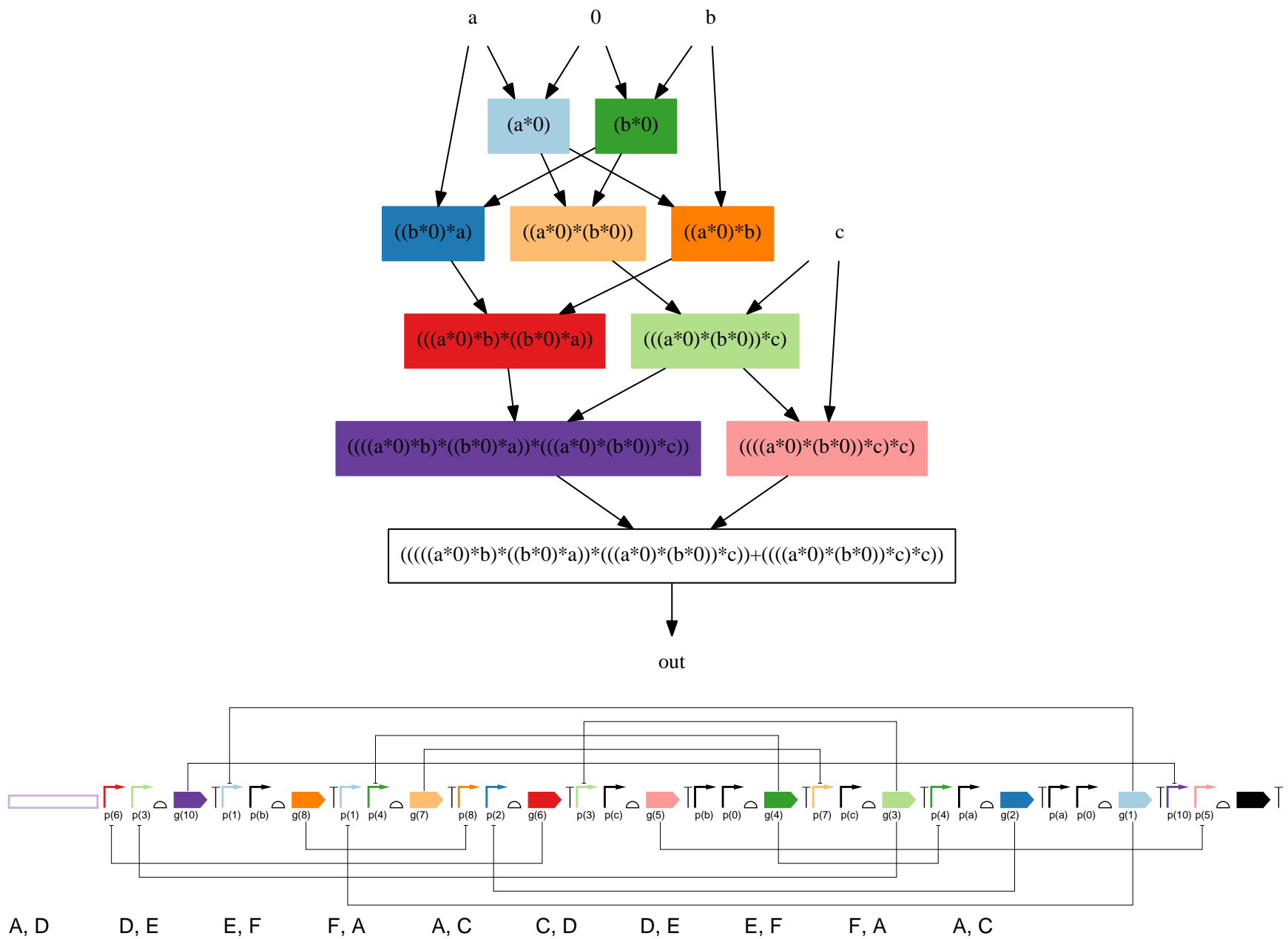


Figure 235: Circuit with truth table 0x16.

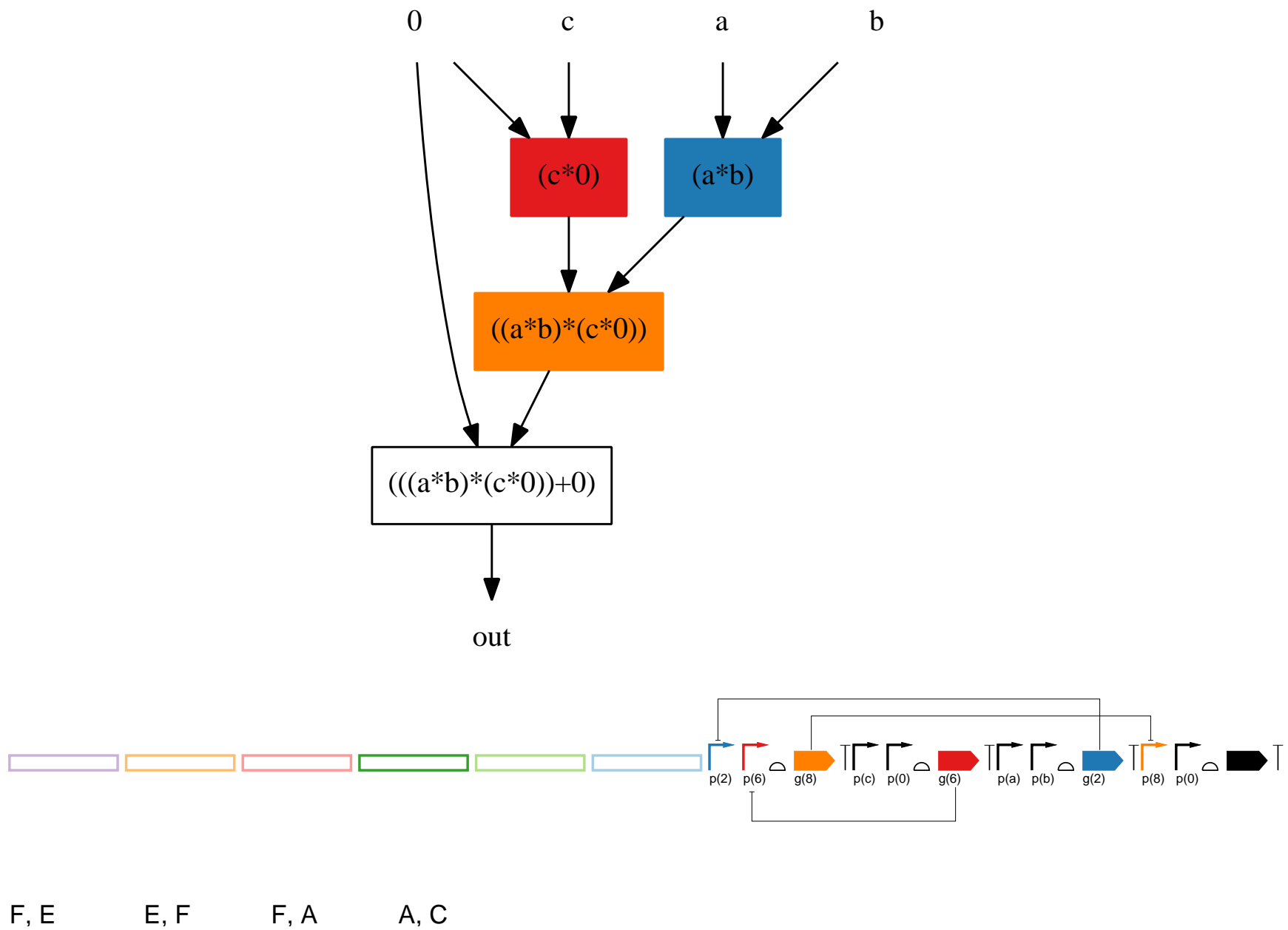


Figure 236: Circuit with truth table 0x15.

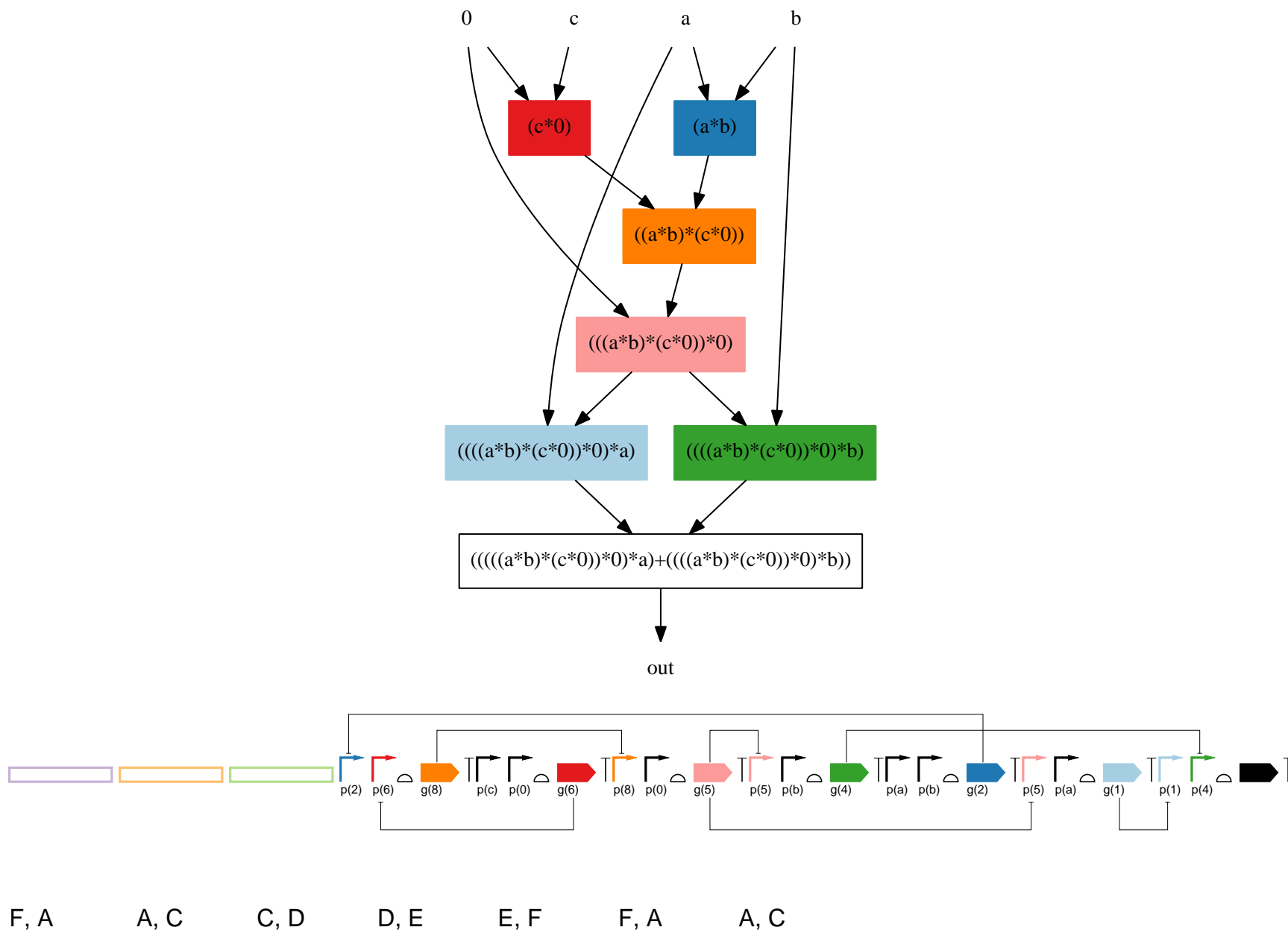


Figure 237: Circuit with truth table 0x14.

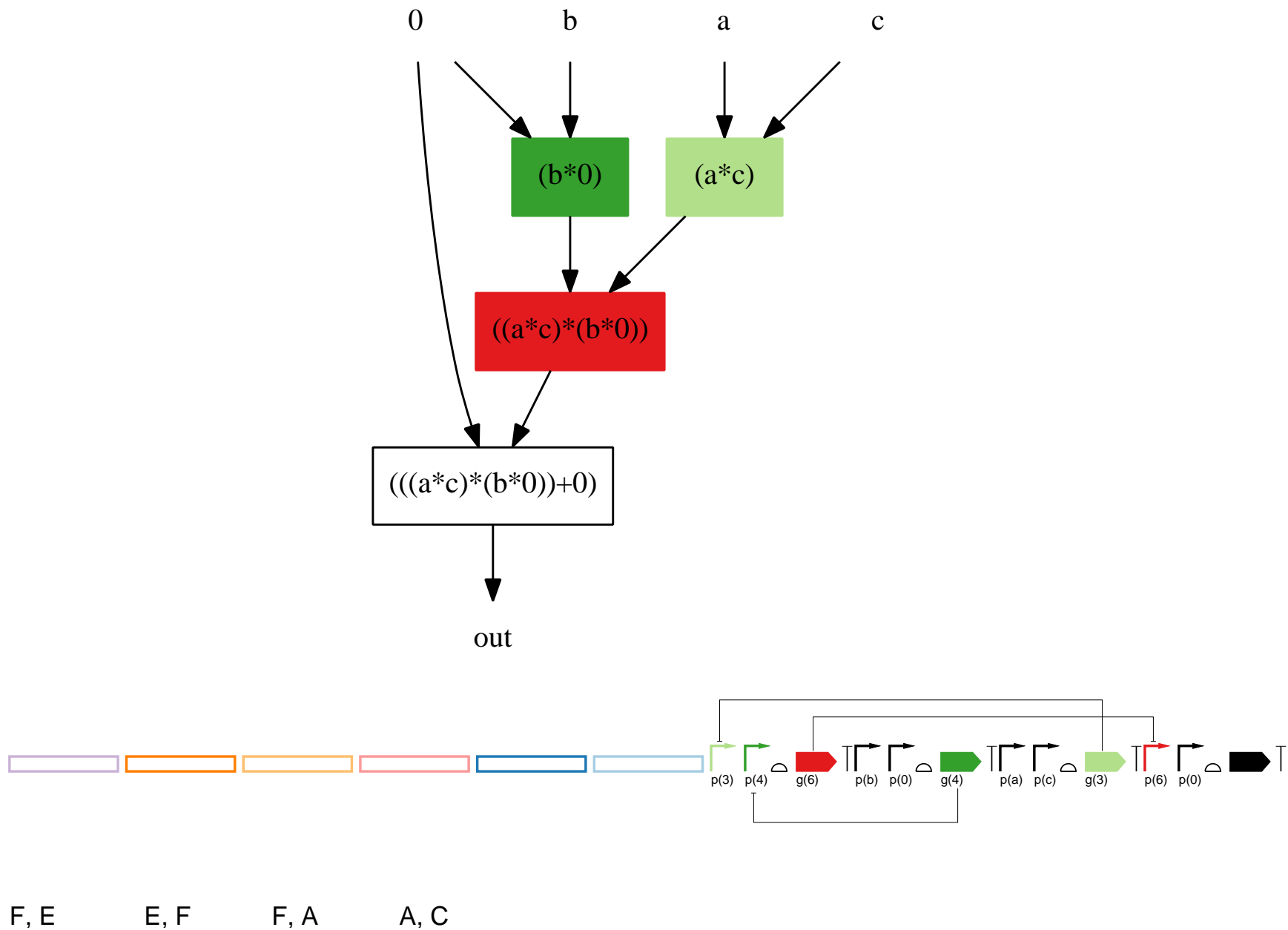


Figure 238: Circuit with truth table 0x13.

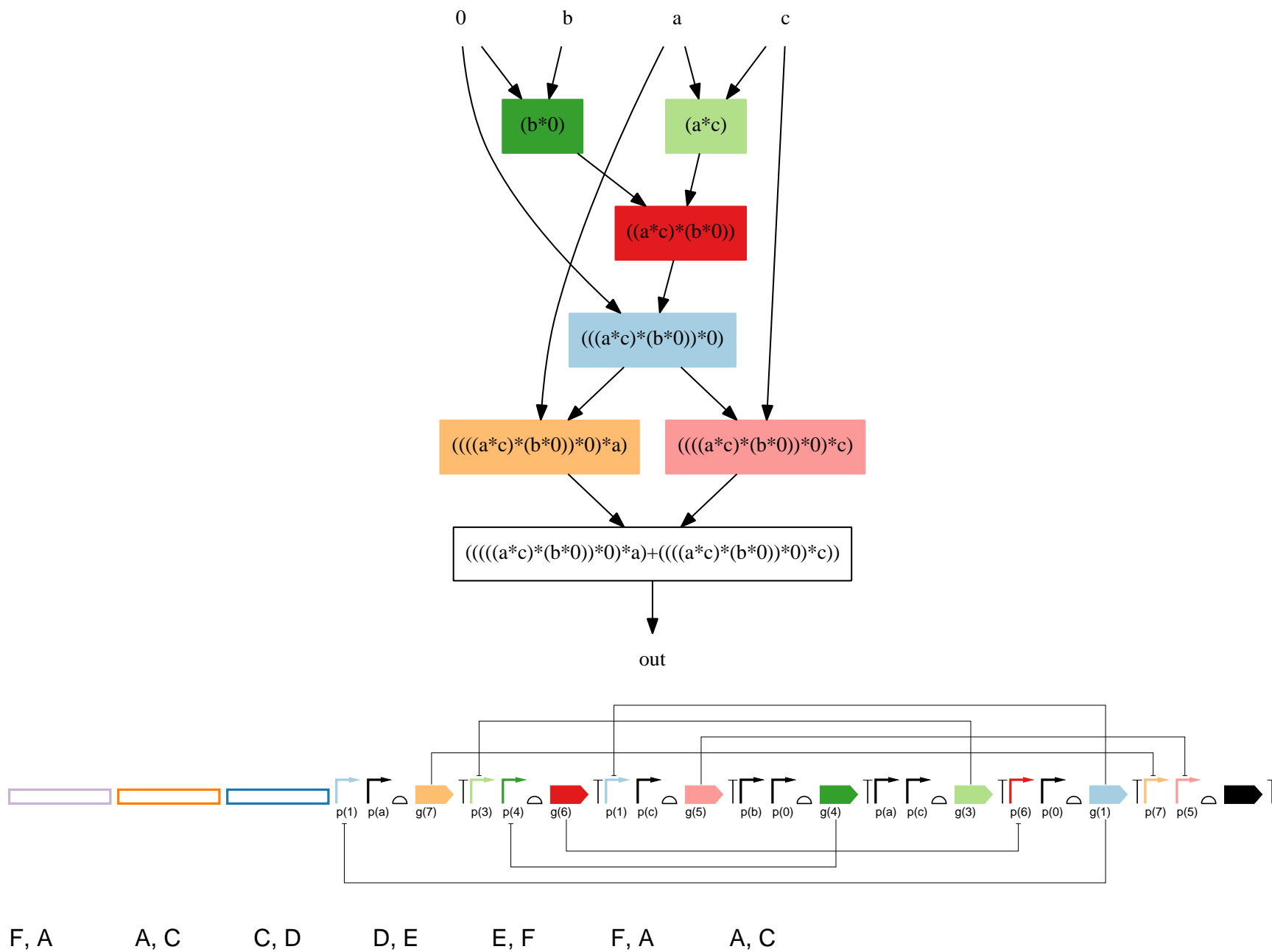


Figure 239: Circuit with truth table 0x12.

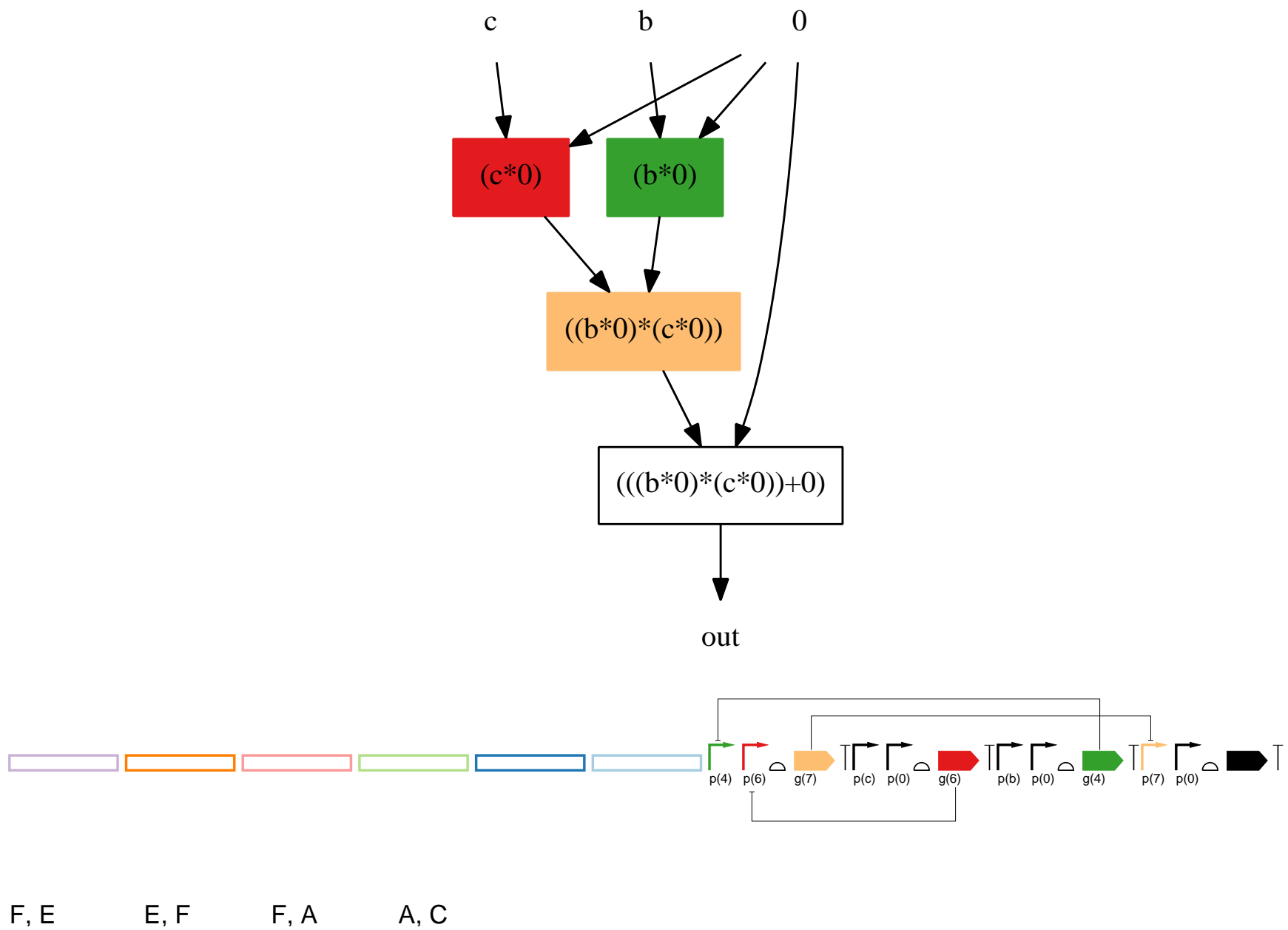


Figure 240: Circuit with truth table 0x11.

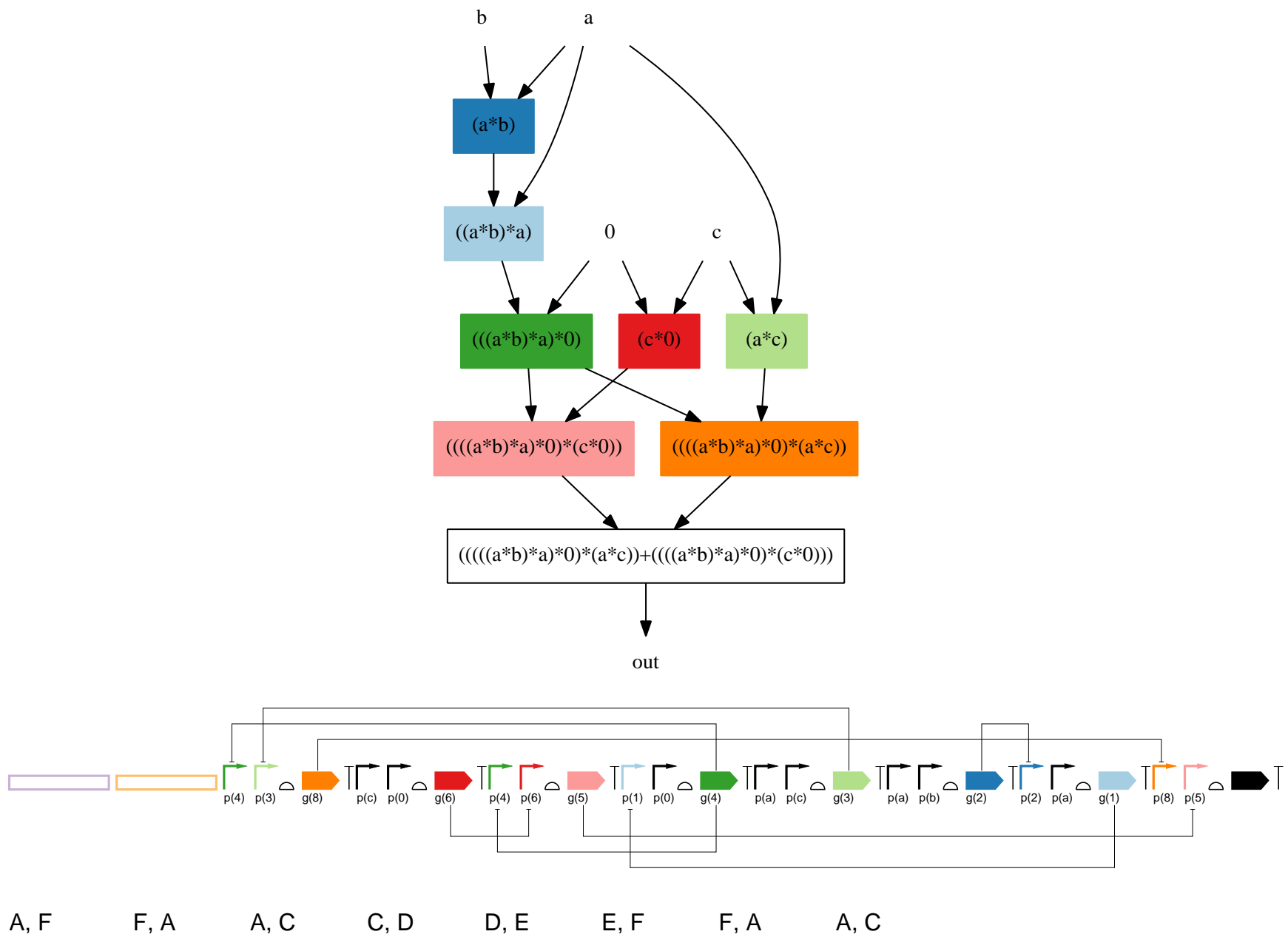


Figure 241: Circuit with truth table 0x10.

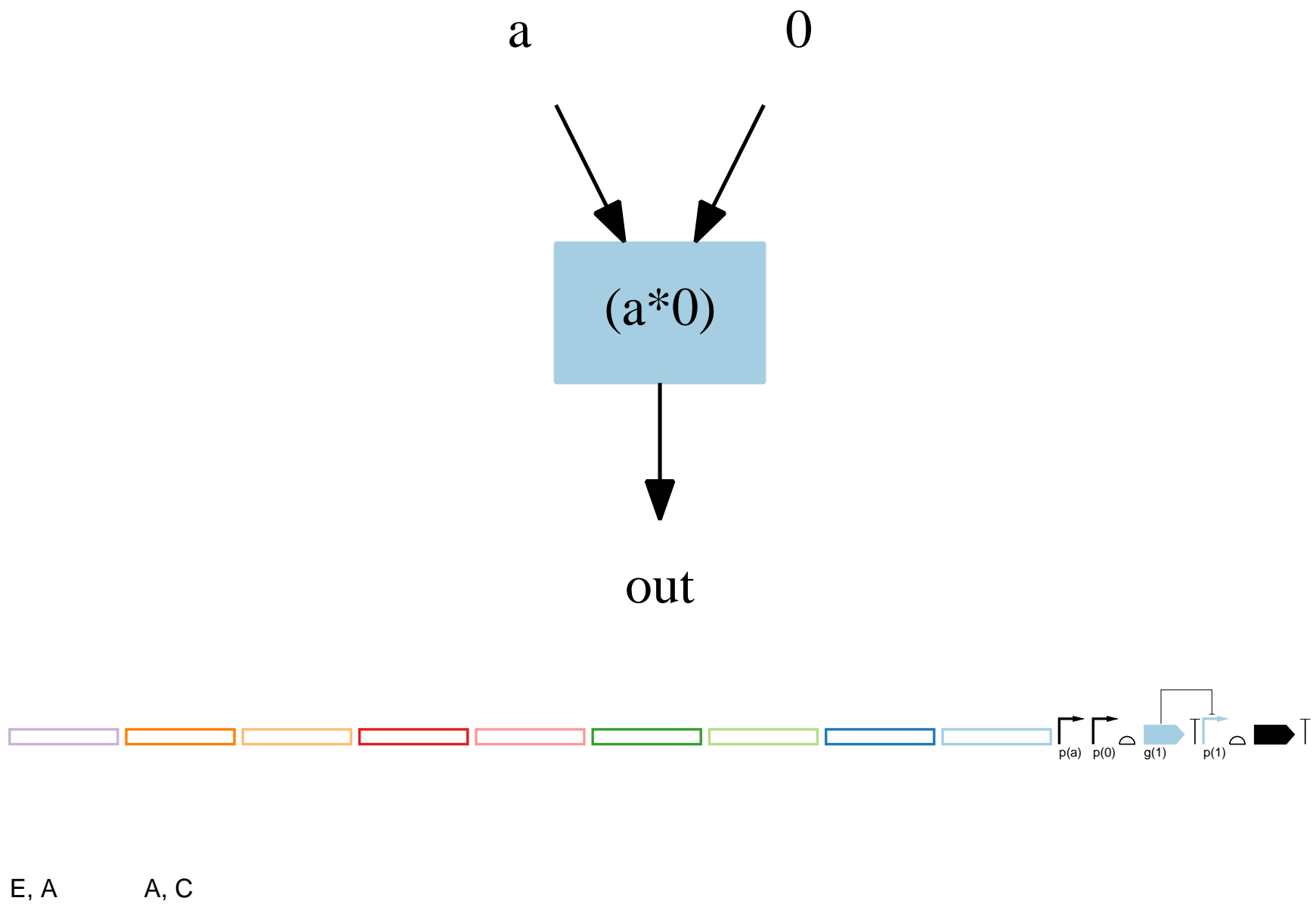


Figure 242: Circuit with truth table 0xF0.

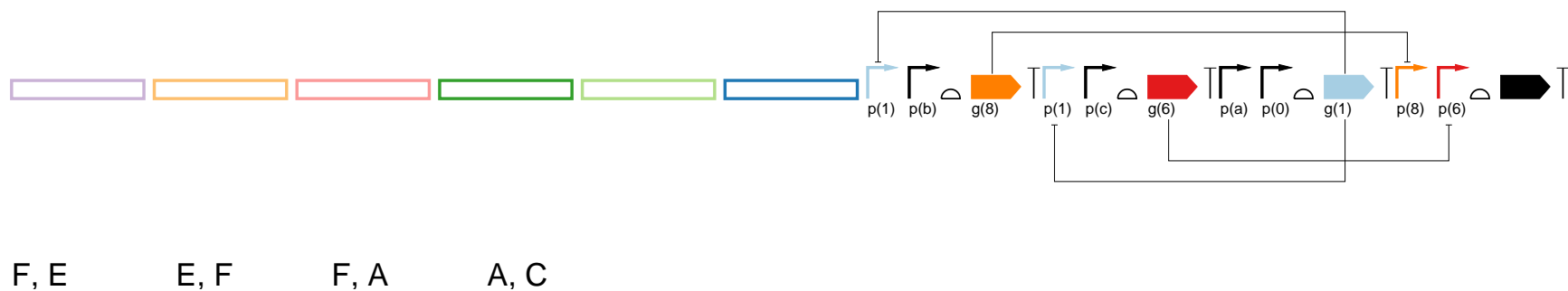
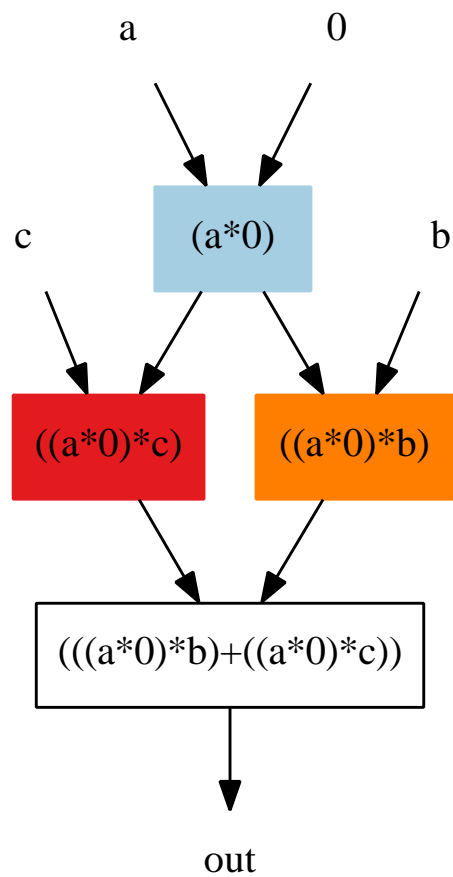


Figure 243: Circuit with truth table 0xE.

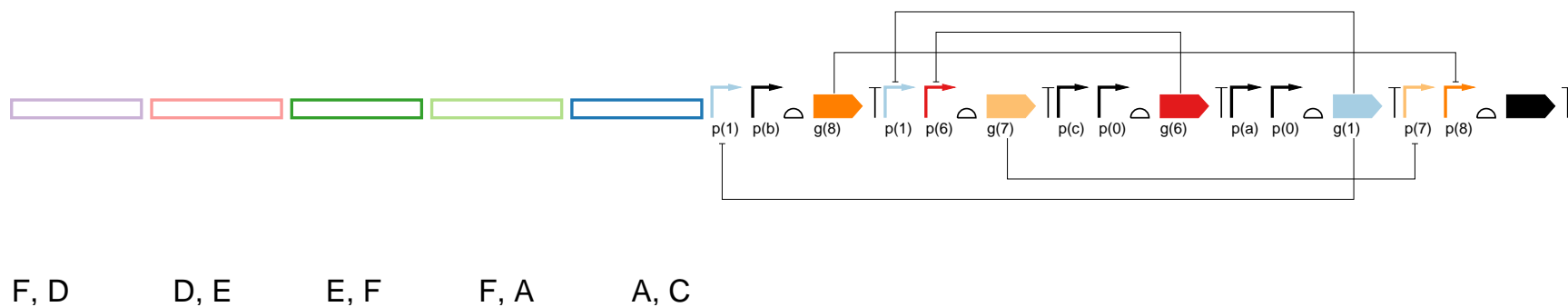
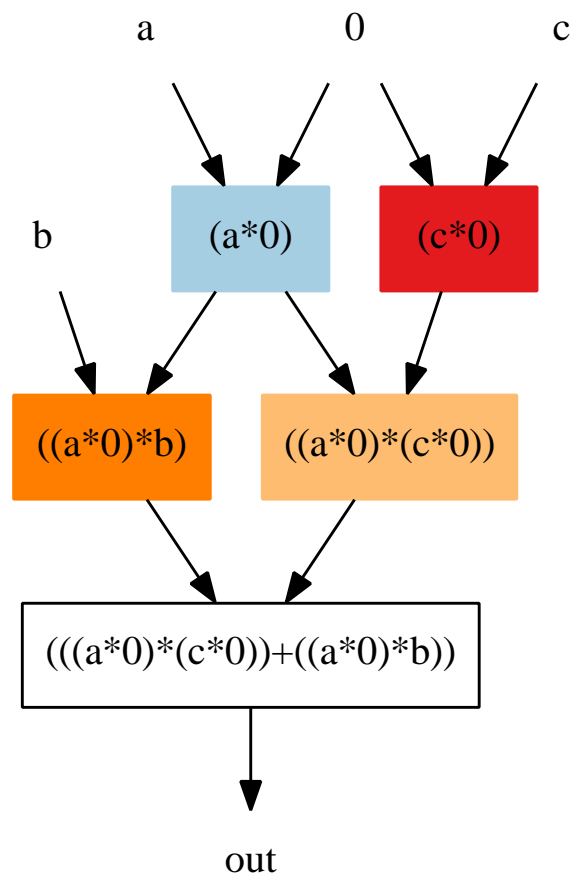


Figure 244: Circuit with truth table 0xD.

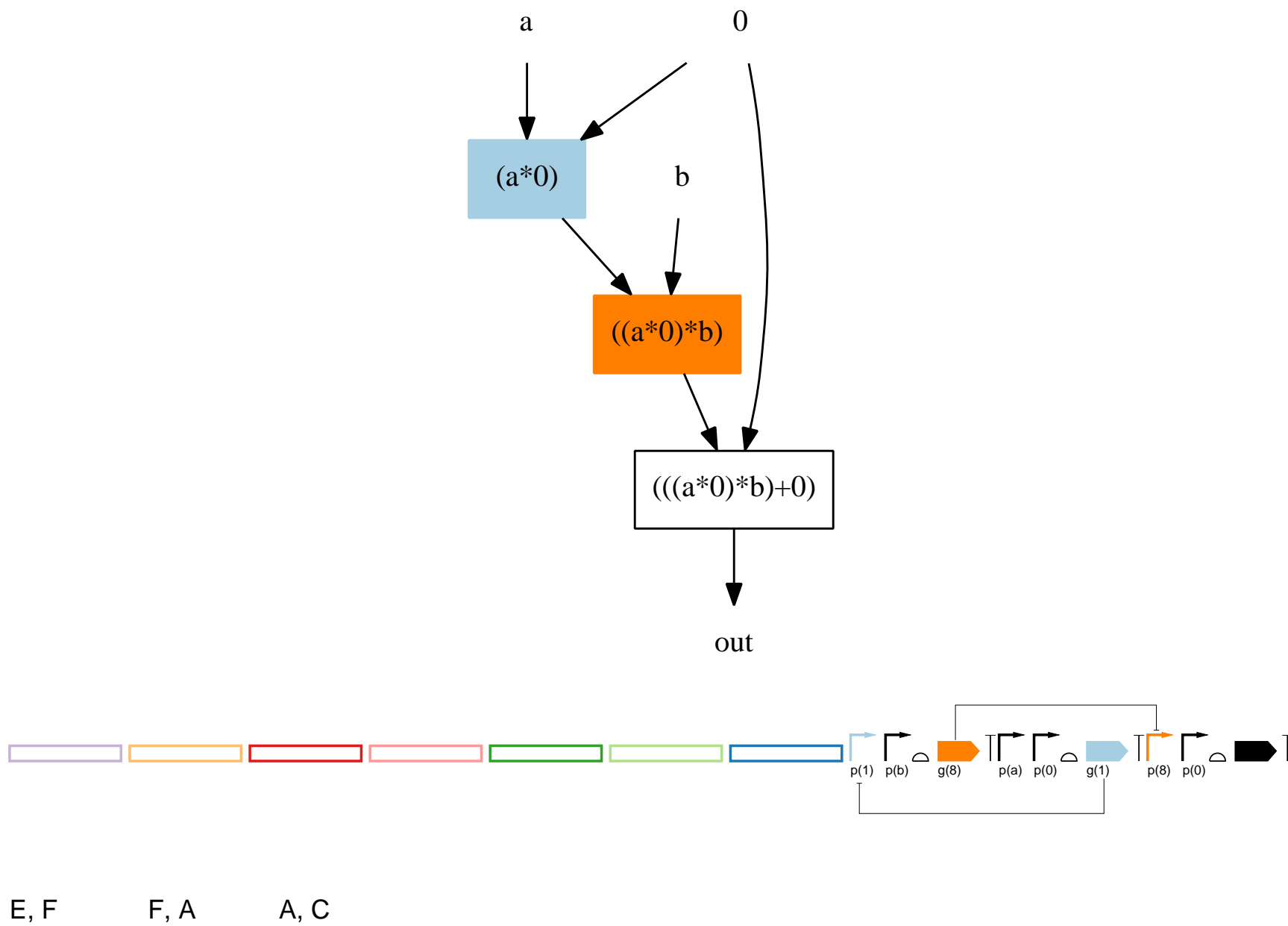


Figure 245: Circuit with truth table 0xC.

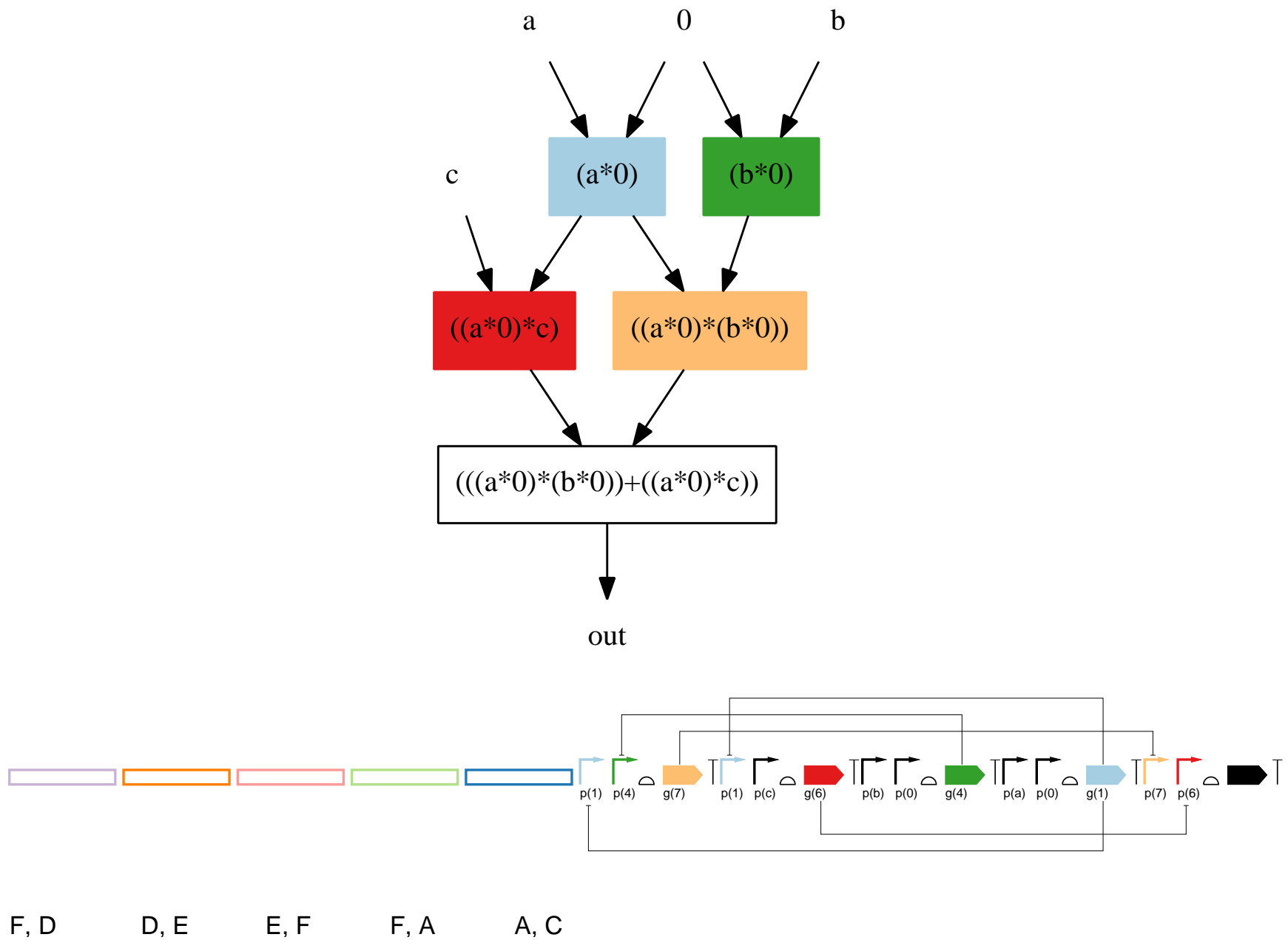


Figure 246: Circuit with truth table 0xB.

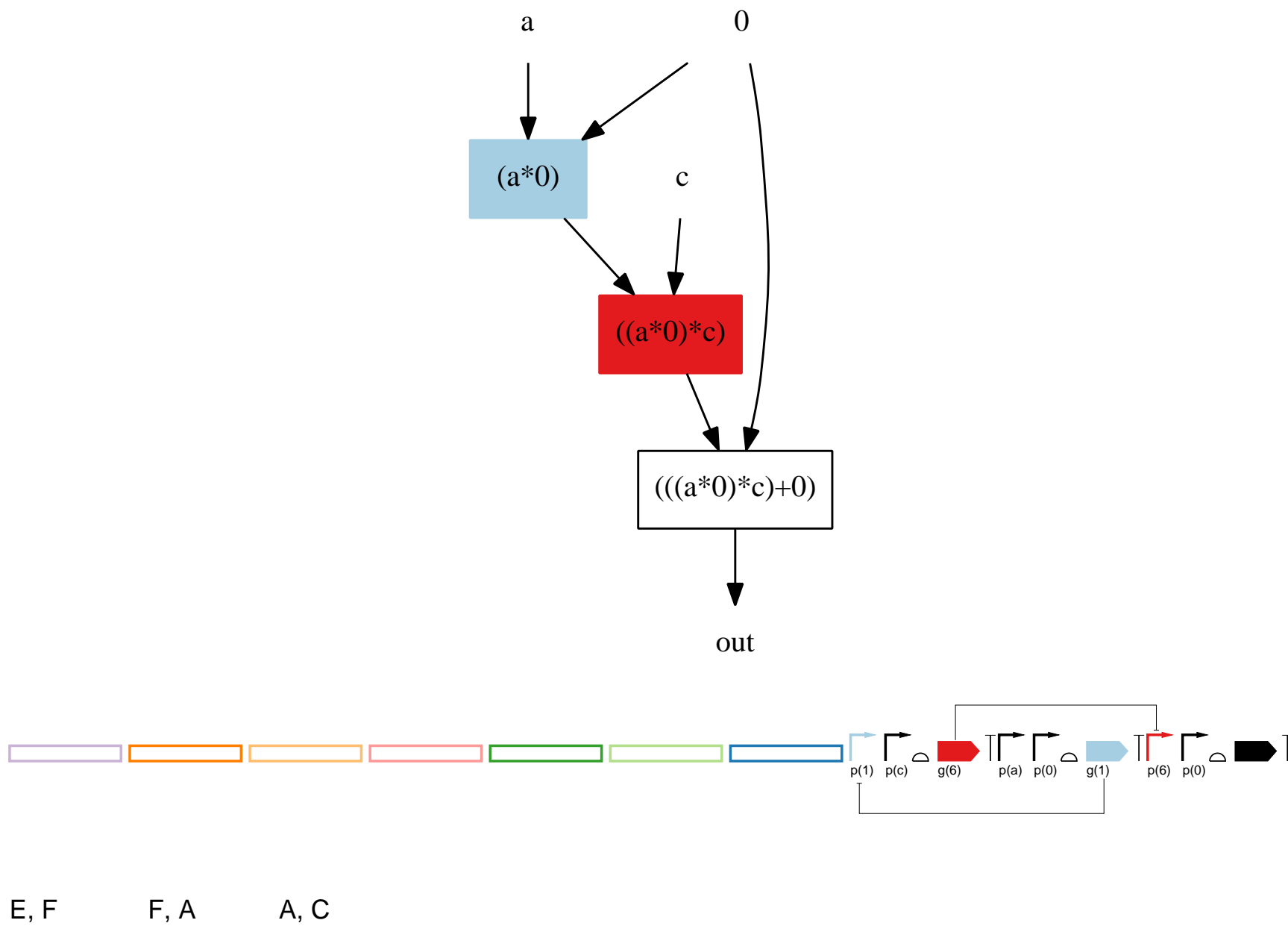


Figure 247: Circuit with truth table 0xA.

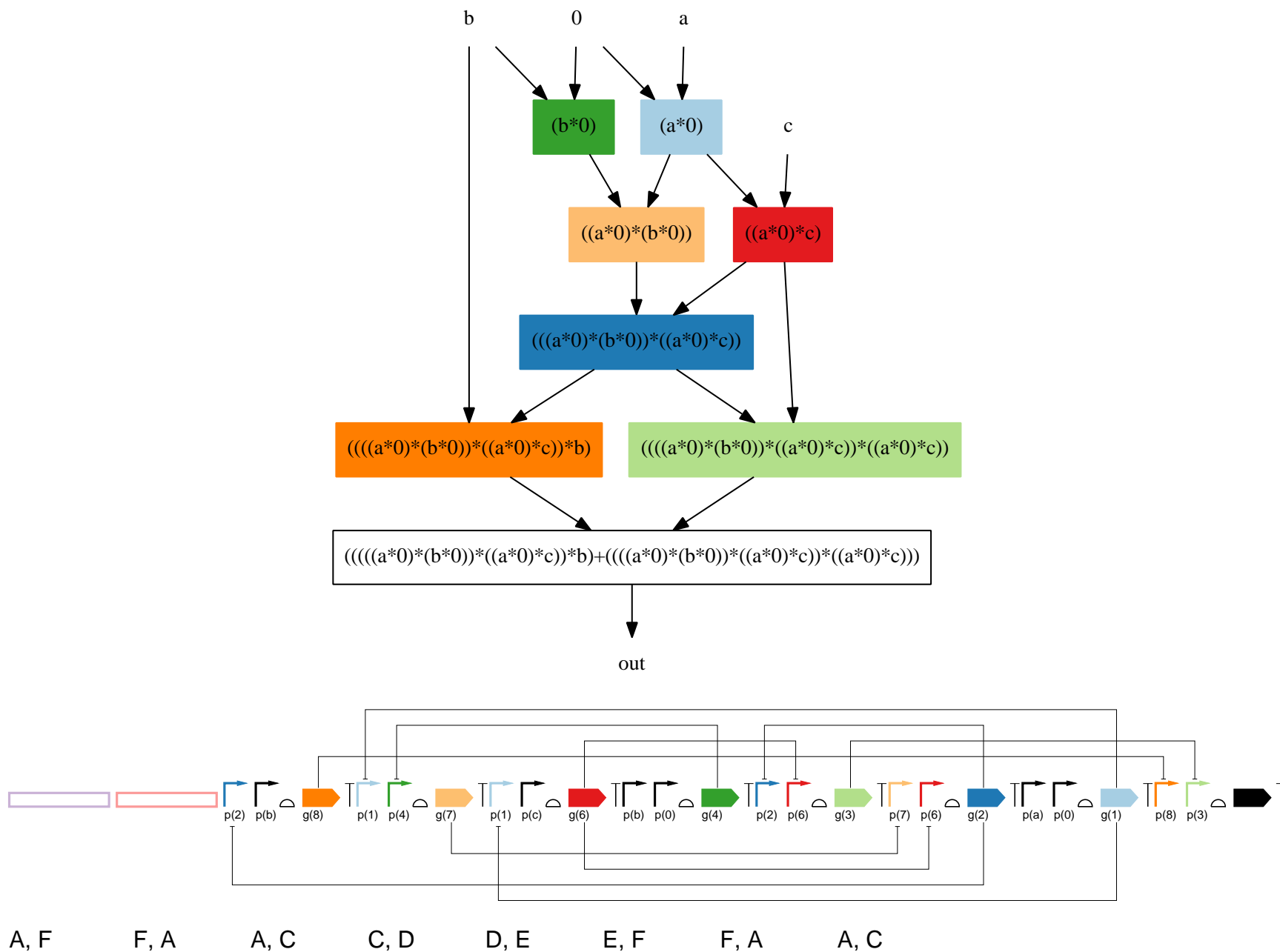


Figure 248: Circuit with truth table 0x9.

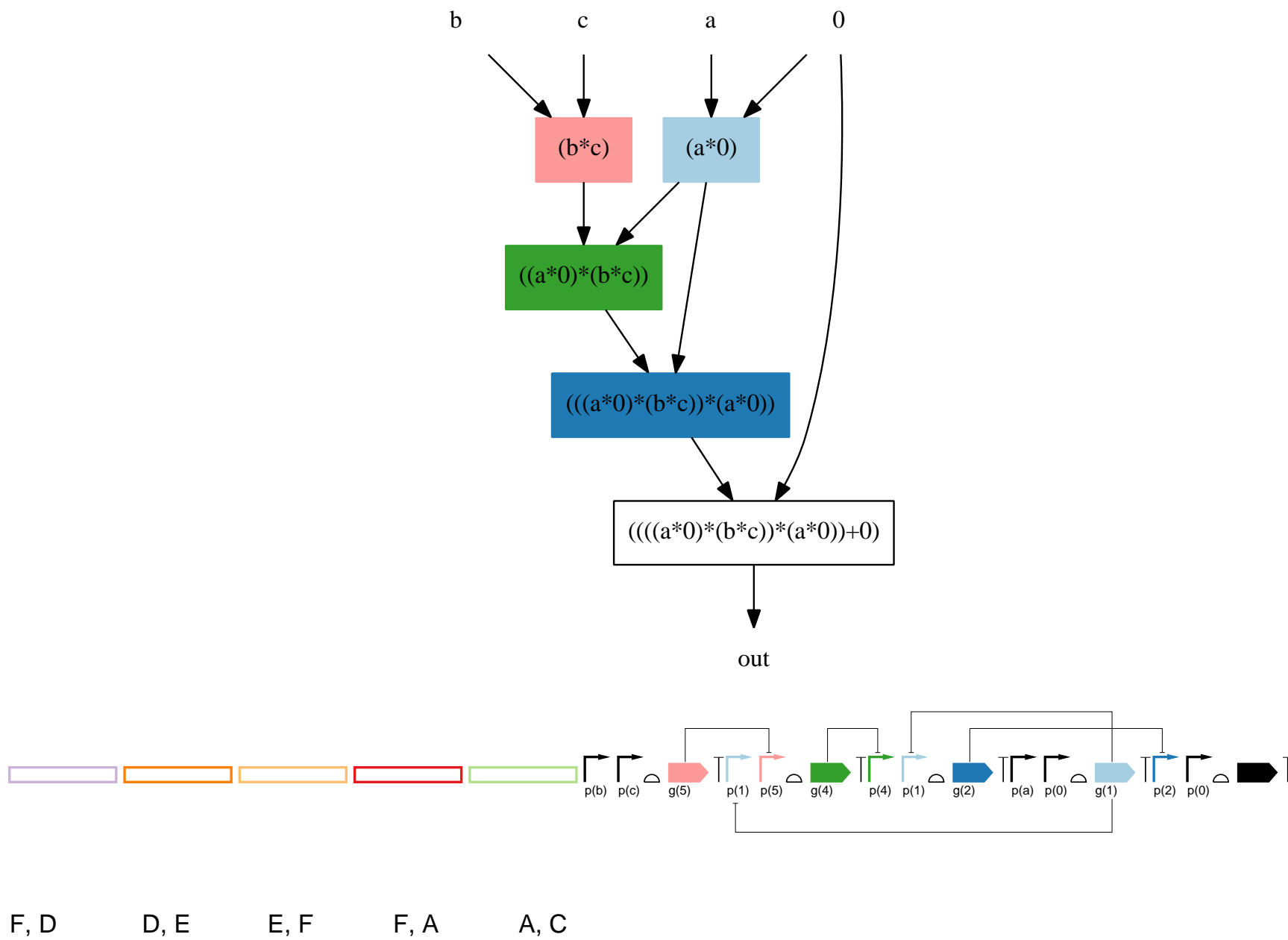


Figure 249: Circuit with truth table 0x8.

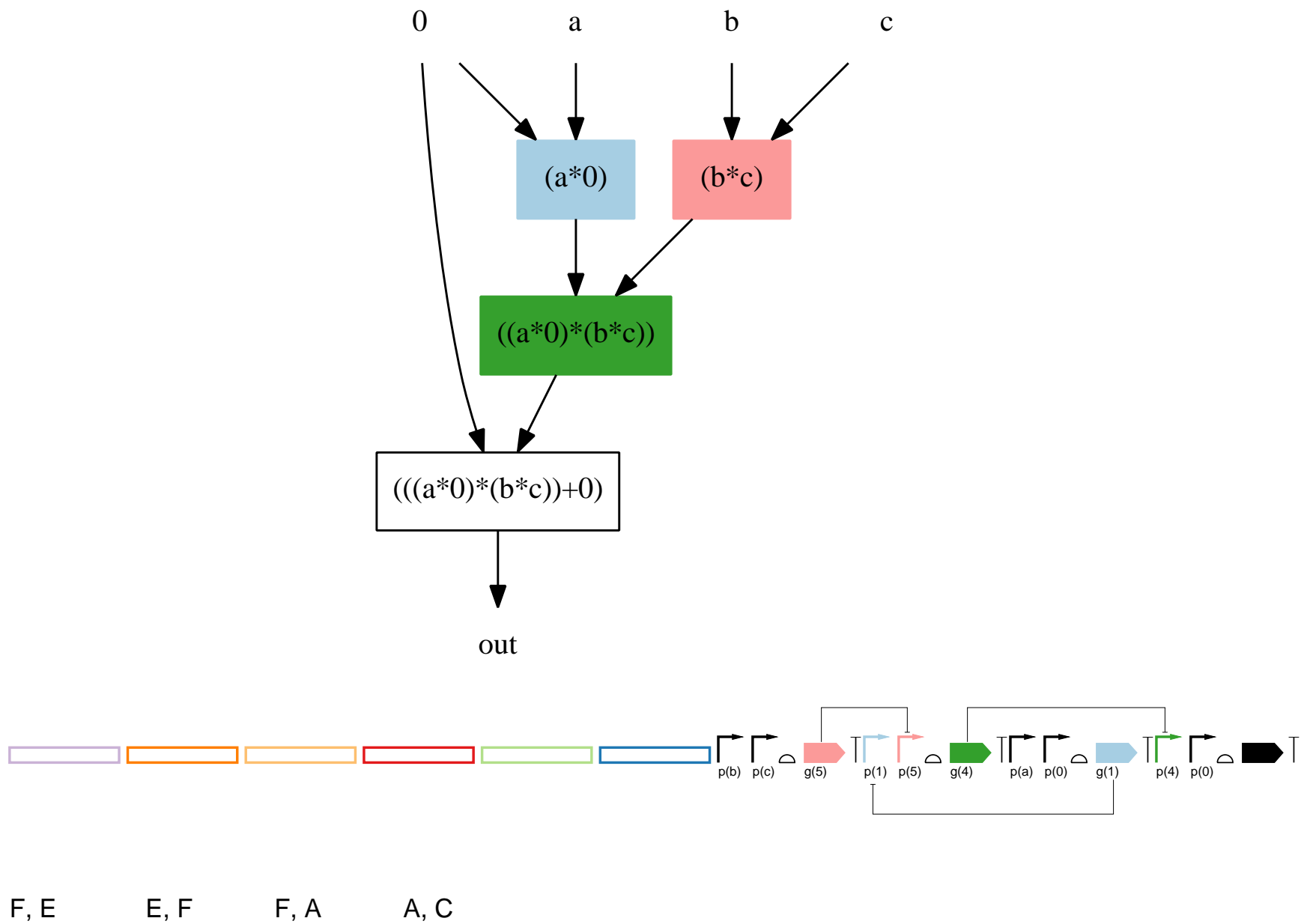


Figure 250: Circuit with truth table 0x7.

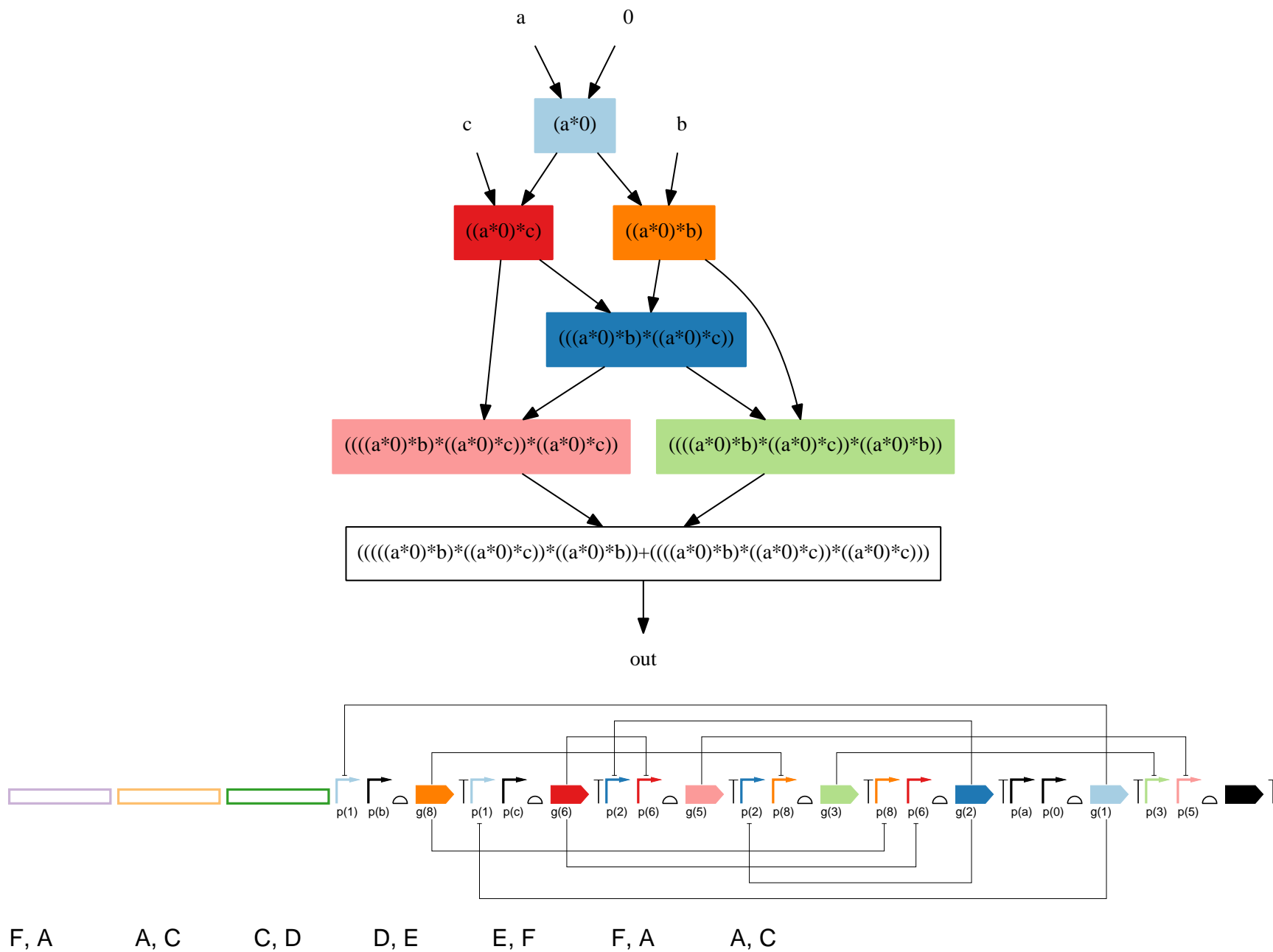


Figure 251: Circuit with truth table 0x6.

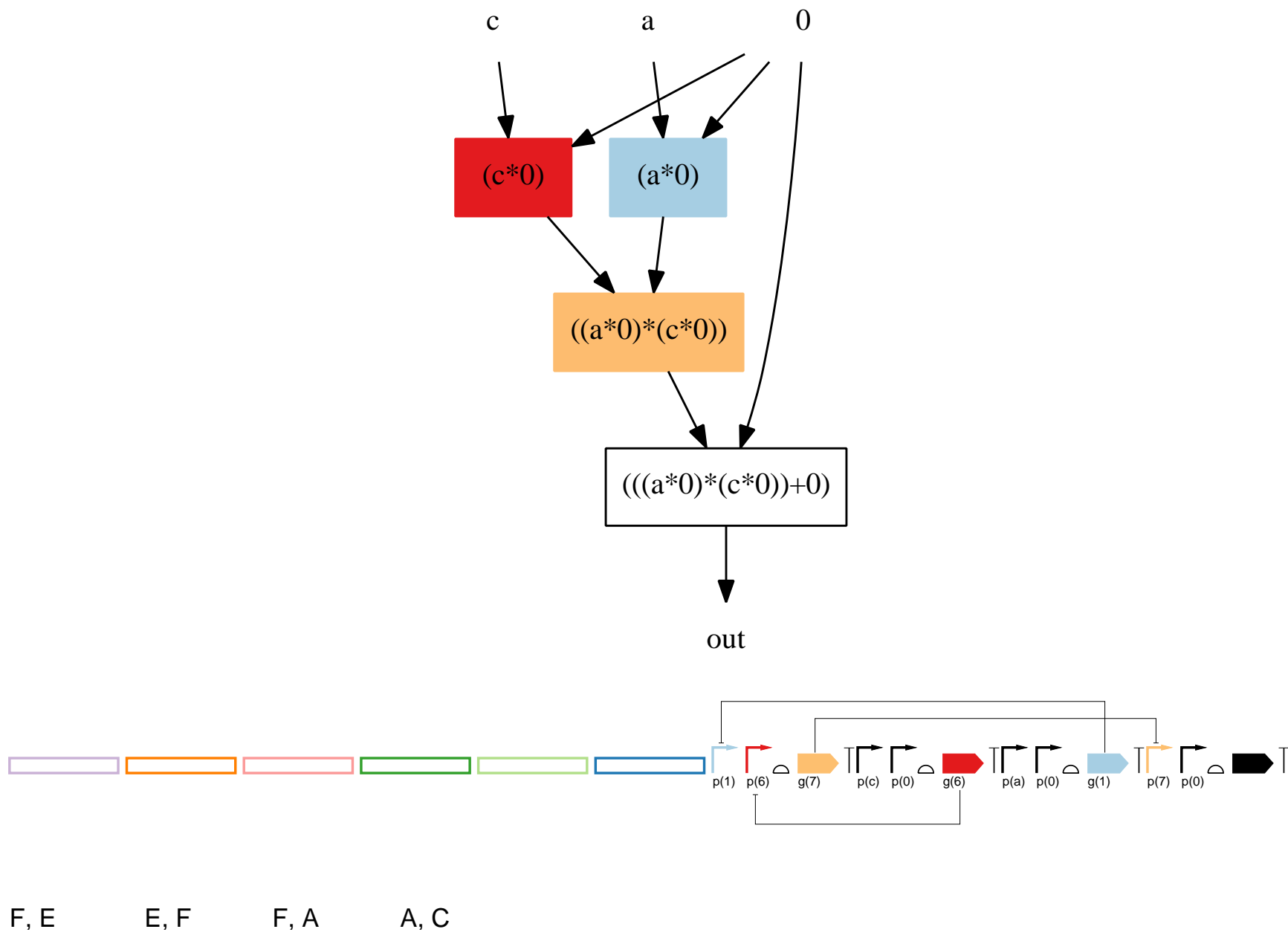


Figure 252: Circuit with truth table 0x5.

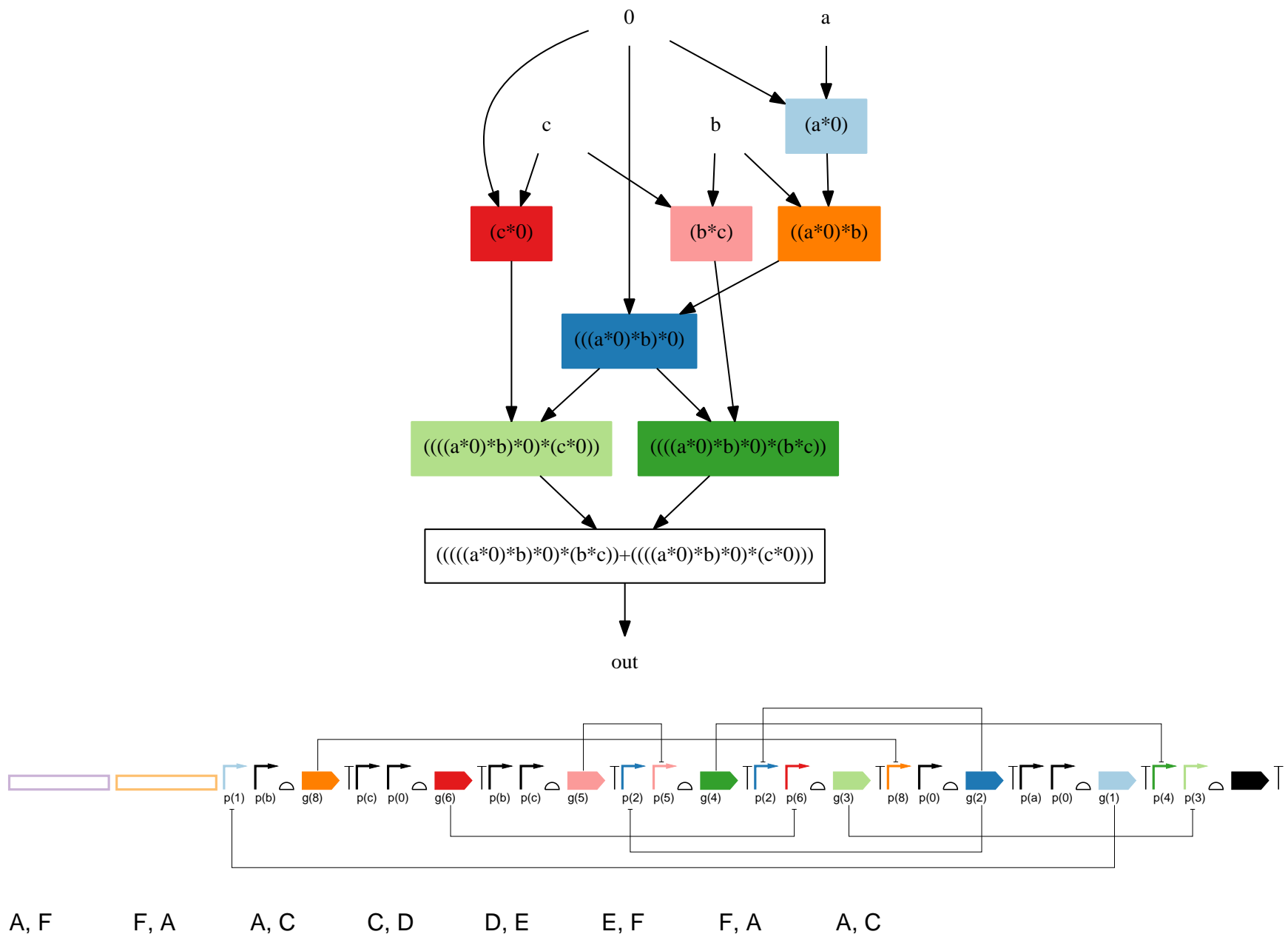


Figure 253: Circuit with truth table 0x4.

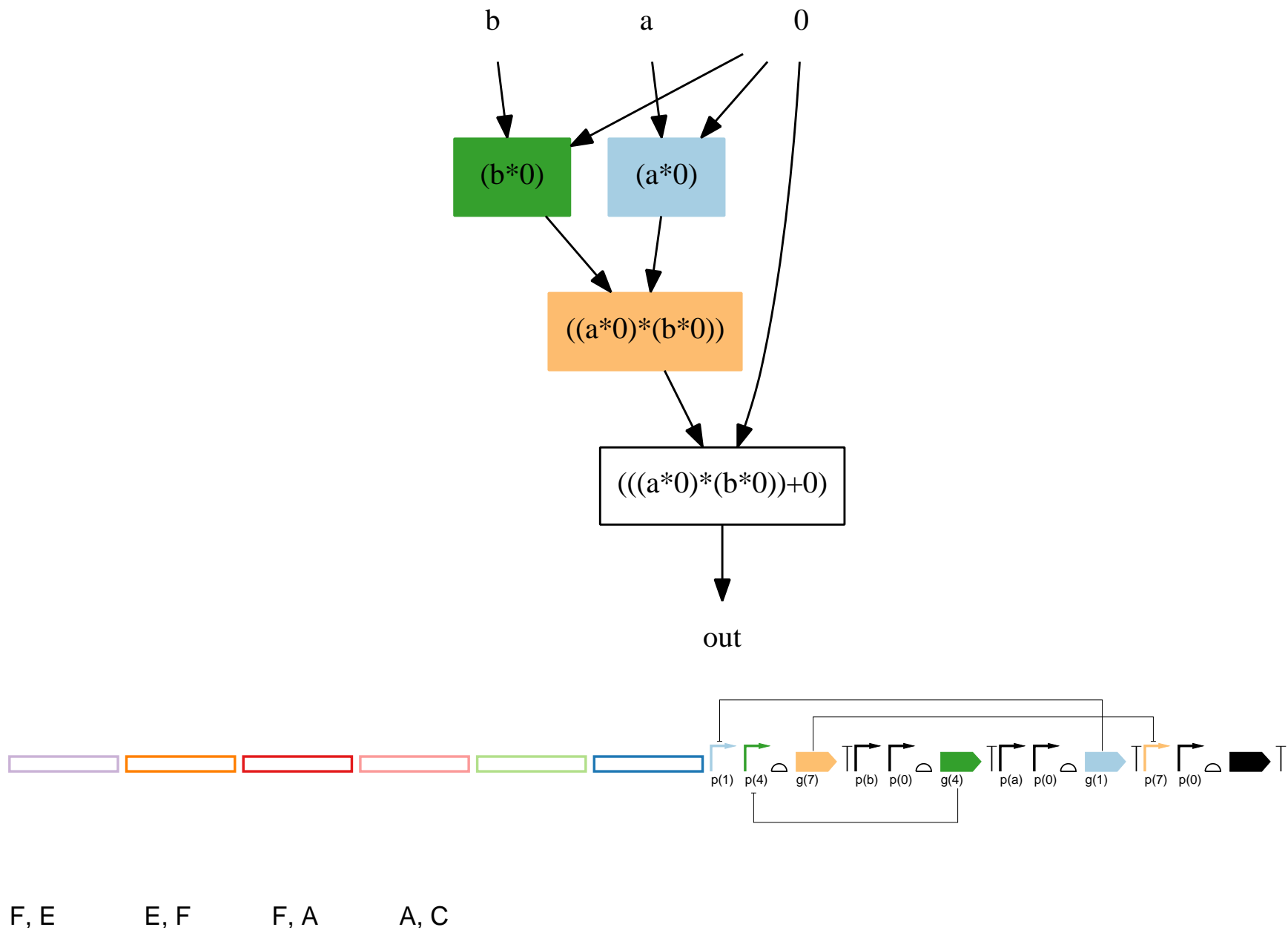


Figure 254: Circuit with truth table 0x3.

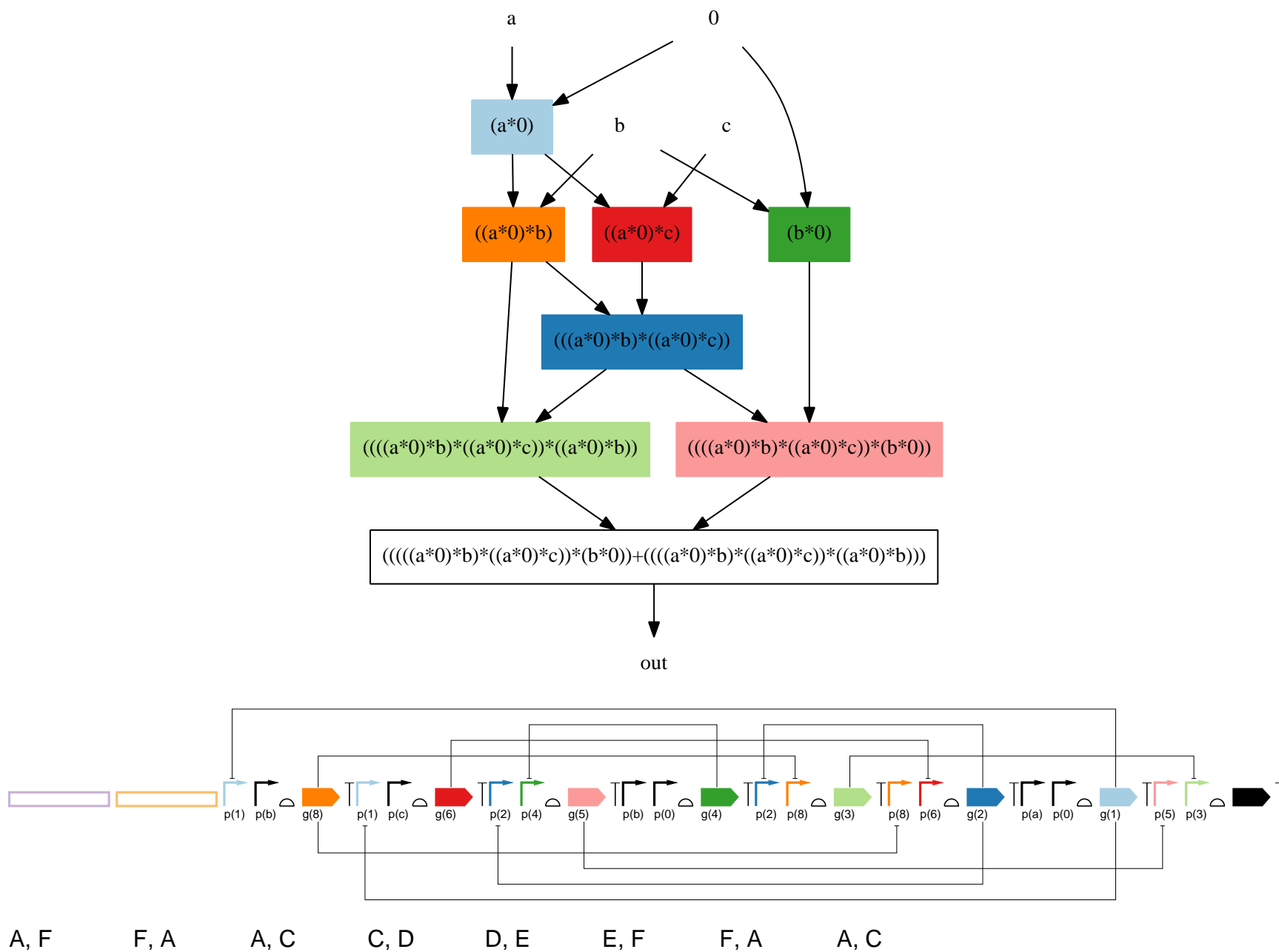


Figure 255: Circuit with truth table 0x2.

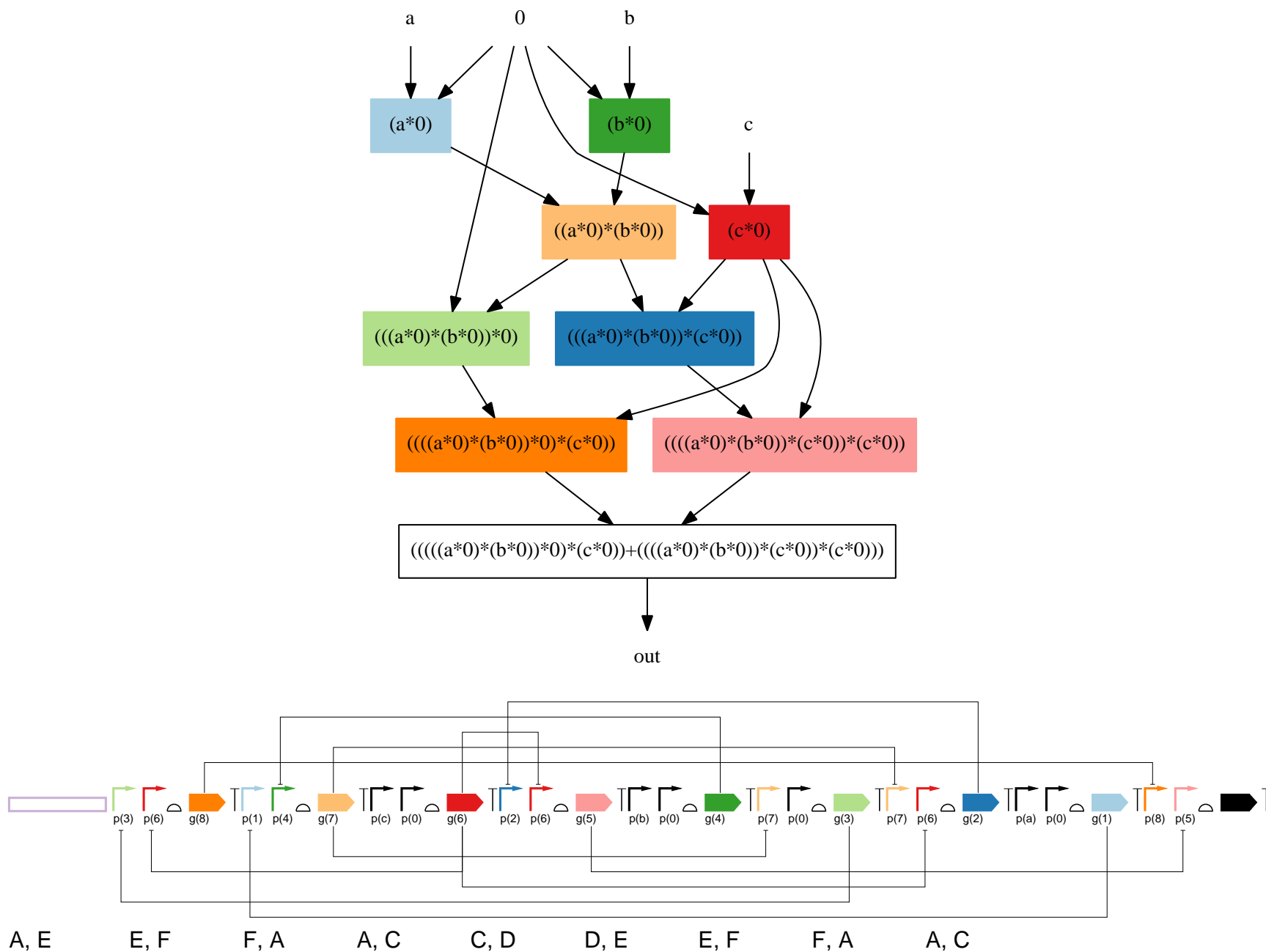


Figure 256: Circuit with truth table 0x1.

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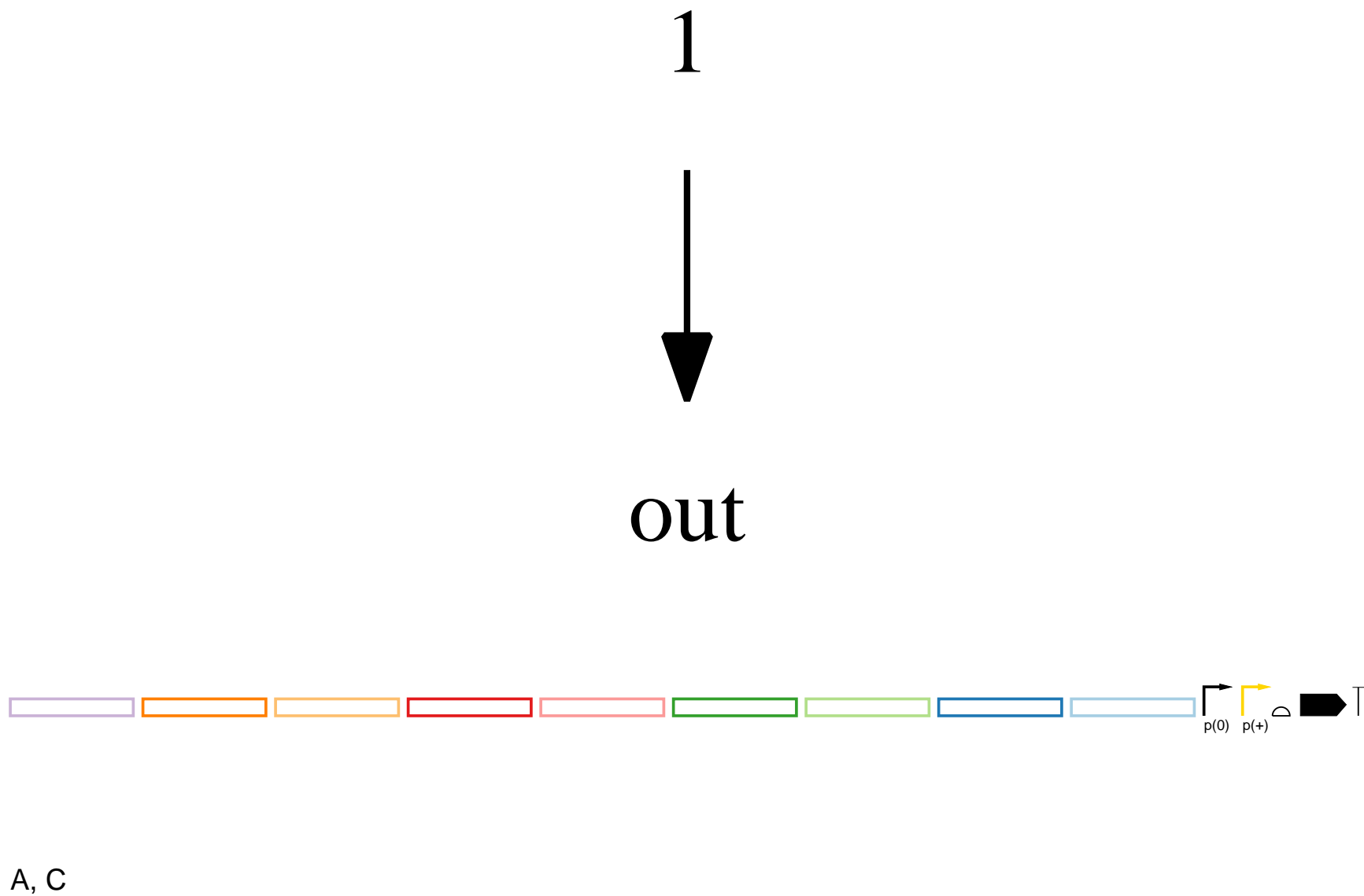


Figure 257: Circuit with truth table 0xFF.