**Frame Representation**

**Electronic Circuit Example**

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**Electrical Component**

**Subclass-Of:** Thing  
**Instance-Of:** Class  
*Component-Of:*  
  - **Maximum Slot-Cardinality:** 1  
  - **Value Type:** Electrical Component  
*Component:*  
  - **Value Type:** Electrical Component  
  - **Inverse:** Component ⊒

---

**Thing and Class**

**Thing**  
Documentation: “The class of all objects.”  
Instance-Of: Class  
Subclass-Of: Thing  
Slot-Cardinality: 1  
Value-Type: Class  
*Instance-Of:*  
  - **Minimum-Slot-Cardinality:** 1  
  - **Value-Type:** Class  
*Documentation:*  
  - **Value-Type:** String  
*Subclass-Of:*  
  - **Minimum-Slot-Cardinality:** 1  
  - **Value-Type:** Class

---

**Circuit**

**Instance-Of:** Class  
Subclass-Of: Electrical-Component  
*Input:*  
  - **Minimum Slot-Cardinality:** 1  
  - **Value Type:** Terminal  
  - **Subset Values:** Component  
*Output:*  
  - **Minimum Slot-Cardinality:** 1  
  - **Value Type:** Terminal  
  - **Subset Values:** Component  
*Gate:*  
  - **Value Type:** Gate  
  - **Subset Values:** Component
Terminal

Terminal
  Instance-Of: Class
  Subclass-Of: Electrical-Component
*Signal:
  Slot Cardinality: 1
  Value Type: (Set Of On Off)
*Connected-To:
  Value Type: Terminal
  Inverse: Connected To

(=> (Terminal ?t1)
(=> (Connected To ?t1 ?t2)
  (Signal ?t1 ?s)
  (Signal ?t2 ?s)))

---

Gate

Gate
  Instance-Of: Class
  Subclass-Of: Electrical-Component
*Type:
  Slot Cardinality: 1
  Value Type: (Set Of And Or Xor Not)
*Input:
  Minimum Slot Cardinality: 1
  Value Type: Terminal
  Subset Of Values: Component
*Output:
  Minimum Slot Cardinality: 1
  Value Type: Terminal
  Subset Of Values: Component

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Two-To-One Gate

Two-To-One-Gate
  Subclass-Of: Gate
*Input:
  Slot Cardinality: 2
*Output:
  Slot Cardinality: 1
*Input1:
  Slot Cardinality: 1
  Value Type: Terminal
  Subset Of Values: Input
*Input2:
  Slot Cardinality: 1
  Value Type: Terminal
  Subset Of Values: Input

---

And Gate

And-Gate
  Subclass-Of: Two-To-One-Gate
*Type: And

Or-Gate
  Subclass-Of: Two-To-One-Gate
*Type: Or

(=> (And-Gate ?g)
  (<> (Signal (Output ?g) On)
    (and (Signal (Input1 ?g) On) (Signal (Input2 ?g) On))))
(=> (Or-Gate ?g)
  (<> (Signal (Output ?g) On)
    (or (Signal (Input1 ?g) On) (Signal (Input2 ?g) On))))
### Xor Gate

**Xor-Gate**
- Subclass-Of: Two-To-One-Gate
- *Type: Xor

```
(=> (Xor-Gate ?g)
    (<=> (Signal (Output ?g) On)
        (or (and (Signal (Input1 ?g) On)
            (Signal (Input2 ?g) Off))
        (and (Signal (Input1 ?g) Off)
            (Signal (Input2 ?g) On))))
```

### Not Gate

**Not-Gate**
- Subclass-Of: Gate
- *Type: Not
- *Input:
  - Slot Cardinality: 1
- *Output:
  - Slot Cardinality: 1

```
(=> (Not-Gate ?g)
    (and (=> (Signal (Input ?g) Off)
        (Signal (Output ?g) On))
    (=> (Signal (Input ?g) On)
        (Signal (Output ?g) Off))))
```

### Digital Circuit C1

Russell and Norvig, Figure 8.1

### Frame Representation of C1

**C1**
- Instance Of: Circuit
- Input: C1 Addend1 C1 Addend2 C1 Carry In
- Output: C1 Sum C1 Carry Out
- Gate: X1 X2 A1 A2 O1

**X1**
- Instance Of: Xor Gate
- Input1: X1 Input1
- Input2: X1 Input2
- Output: X1 Output

**X1-Input1**
- Instance Of: Terminal
- Connected To: C1 Addend1

...
### Frame Language Inferences

<table>
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<tr>
<th>Frame Language Inferences</th>
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<tbody>
<tr>
<td>C1</td>
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<tr>
<td>Instance-Of: Circuit</td>
</tr>
<tr>
<td>Input: C1-Addend1 C1-Addend2 C1-Carry-In</td>
</tr>
<tr>
<td>Output: C1-Sum C1-Carry-Out</td>
</tr>
<tr>
<td>Gate: X1 X2 A1 A2 O1</td>
</tr>
<tr>
<td>Component: C1-Addend1 C1-Addend2 C1-Carry-In C1-Sum C1-Carry-Out X1 X2 A1 A2 O1</td>
</tr>
</tbody>
</table>

| X1                        |
| Instance-Of: Xor-Gate    |
| Input1: X1-Input1        |
| Input2: X1-Input2        |
| Output: X1-Output        |
| Input: X1-Input1 X1-Input2 |
| Component: X1-Input1 X1-Input2 X1-Output |
| Component-Of: C1         |

| X1-Input1                 |
| Instance-Of: Terminal     |
| Connected-To: C1-Addend1   |

### One Bit Adder as a Class

<table>
<thead>
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<th>One Bit Adder as a Class</th>
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<tr>
<td>One Bit Adder</td>
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<tr>
<td>Subclass-Of: Circuit</td>
</tr>
<tr>
<td>*Addend1:</td>
</tr>
<tr>
<td>Slot-Cardinality: 1</td>
</tr>
<tr>
<td>Value-Type: One-Bit-Adder-Addend1</td>
</tr>
<tr>
<td>Subset-Of-Values: Input</td>
</tr>
<tr>
<td>*Input:</td>
</tr>
<tr>
<td>Slot-Cardinality: 3</td>
</tr>
<tr>
<td>*Sum:</td>
</tr>
<tr>
<td>Slot-Cardinality: 1</td>
</tr>
<tr>
<td>Value-Type: One-Bit-Adder-Sum</td>
</tr>
<tr>
<td>Subset-Of-Values: Output</td>
</tr>
<tr>
<td>*Output:</td>
</tr>
<tr>
<td>Slot-Cardinality: 2</td>
</tr>
<tr>
<td>*X1:</td>
</tr>
<tr>
<td>Slot-Cardinality: 1</td>
</tr>
<tr>
<td>Value-Type: One-Bit-Adder-X1</td>
</tr>
<tr>
<td>Subset-Of-Values: Gate</td>
</tr>
<tr>
<td>*Gate:</td>
</tr>
<tr>
<td>Slot-Cardinality: 5</td>
</tr>
</tbody>
</table>

### One-Bit-Adder Components

<table>
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<tbody>
<tr>
<td>One-Bit-Adder-Addend1</td>
</tr>
<tr>
<td>Subclass-Of: Terminal</td>
</tr>
<tr>
<td>*Connected-To:</td>
</tr>
<tr>
<td>Same-Values: (Component-Of X1 Input1)</td>
</tr>
</tbody>
</table>

| One-Bit-Adder-X1         |
| Subclass-Of: Xor-Gate    |
| *Input1:                 |
|   Value-Type: One-Bit-Adder-X1-Input1 |

| One-Bit-Adder-X1-Input1  |
| Subclass-Of: Terminal    |
| *Connected-To:           |
|   Same-Values: (Component-Of Component-Of Addend1) |

### C1 As An Instance Of One-Bit-Adder

| C1                        |
| Instance-Of: One-Bit-Adder|
| Addend1: C1-Addend1       |
| ...                       |
| Sum: C1-Sum               |
| ...                       |
| X1: C1-X1                 |
| ...                       |
| Component: C1-Addend1 ... C1-Sum ... C1-X1 ... |
| Input: C1-Addend1 C1-Addend2 C1-Carry-In |
| Output: C1-Sum C1-Carry-Out |
**Inferred C₁ Components**

C1-Addend1
- Instance: One Bit Adder Addend1
- Component: C1
- Connected to: C1 Input1

C1-X1
- Instance: One Bit Adder X1
- Component: C1
- Input1: C1 X Input1
  ...

C1-X1-Input1
- Instance: One Bit Adder X1 Input1
- Component: C1 X
- Connected to: C1 Addend1
  ...

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**The End**
Frame Representation
Electronic Circuit
Example