

# GR(1) Template Catalog for LTL Specification Patterns

<http://smlab.cs.tau.ac.il/syntech/patterns/>

Shahar Maoz and Jan Oliver Ringert

# Introduction

The following pages contain for each LTL specification pattern from the catalog published by Dwyer et al. [2] the pattern's number, kind, scope, and LTL semantics (following [1]). For each pattern we present a GR(1) template and a GR(1) template for its negation, if these can be computed following our approach described in [3]. The content of all listings is available for download from [4].

## References

- [1] Property Pattern Mappings for LTL website. <http://patterns.projects.cis.ksu.edu/documentation/patterns/ltl.shtml>.
- [2] M. B. Dwyer, G. S. Avrunin, and J. C. Corbett. Patterns in Property Specifications for Finite-State Verification. In *ICSE' 99*, pages 411–420. ACM, 1999.
- [3] S. Maoz and J. O. Ringert. GR(1) Synthesis for LTL Specification Patterns, 2015. Accepted to FSE'15.
- [4] Supporting Materials Website. <http://smlab.cs.tau.ac.il/syntech/patterns/>.

## Overview by Scope and Kind

Absence: p is false

- Globally: Pattern01 on page 3
- Before r: Pattern02 on page 4
- After q: Pattern03 on page 5
- Between q and r: Pattern04 on page 6
- After q until r: Pattern05 on page 8

Existence: p becomes true

- Globally: Pattern06 on page 9
- Before r: Pattern07 on page 10
- After q: Pattern08 on page 11
- Between q and r: Pattern09 on page 12
- After q until r: Pattern10 on page 13

Bounded Existence: p-states occur at most 2 times

- Globally: Pattern11 on page 14
- Before r: Pattern12 on page 16
- After q: Pattern13 on page 18
- Between q and r: Pattern14 on page 20
- After q until r: Pattern15 on page 22

Universality: p is true

- Globally: Pattern16 on page 24
- Before r: Pattern17 on page 25
- After q: Pattern18 on page 26
- Between q and r: Pattern19 on page 27
- After q until r: Pattern20 on page 29

Precedence: s precedes p

- Globally: Pattern21 on page 30
- Before r: Pattern22 on page 31
- After q: Pattern23 on page 32
- Between q and r: Pattern24 on page 33
- After q until r: Pattern25 on page 35

Response: s responds to p

- Globally: Pattern26 on page 36
- Before r: Pattern27 on page 37
- After q: Pattern28 on page 39
- Between q and r: Pattern29 on page 40
- After q until r: Pattern30 on page 42

Precedence Chain: s, t precedes p

- Globally: Pattern31 on page 43
- Before r: Pattern32 on page 45
- After q: Pattern33 on page 47
- Between q and r: Pattern34 on page 49
- After q until r: Pattern35 on page 51

Precedence Chain: p precedes (s, t)

- Globally: Pattern36 on page 53
- Before r: Pattern37 on page 54
- After q: Pattern38 on page 56
- Between q and r: Pattern39 on page 58
- After q until r: Pattern40 on page 60

Response Chain: p responds to s,t

— Globally: Pattern41 on page 62

- Before r: Pattern42 on page 63
- After q: Pattern43 on page 65
- Between q and r: Pattern44 on page 66
- After q until r: Pattern45 on page 68

Response Chain: s,t responds to p

- Globally: Pattern46 on page 69
- Before r: Pattern47 on page 70
- After q: Pattern48 on page 72
- Between q and r: Pattern49 on page 73
- After q until r: Pattern50 on page 75

Constrained Chain: s,t without z responds to p

- Globally: Pattern51 on page 76
- Before r: Pattern52 on page 77
- After q: Pattern53 on page 79
- Between q and r: Pattern54 on page 80
- After q until r: Pattern55 on page 82

# Pattern01

**Kind:** Absence: p is false

**Scope:** Globally

**LTL:**

**G** !p

The GR(1) template for the LTL semantics of pattern 01 is shown in Listing 1.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!p) & next(state=S0)) |
9    (state=S0 & (p) & next(state=S1)) |
10   (state=S1 & TRUE & next(state=S1)));
11
12 LTLSPEC -- equivalence of satisfaction
13   (G F (state=S0));
```

Listing 1: GR(1) template for pattern 01

The GR(1) template for the negated LTL semantics of pattern 01 is shown in Listing 2.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!p) & next(state=S0)) |
9    (state=S0 & (p) & next(state=S1)) |
10   (state=S1 & TRUE & next(state=S1)));
11
12 LTLSPEC -- equivalence of satisfaction
13   (G F (state=S1));
```

Listing 2: GR(1) template for negated LTL semantics of pattern 01

## Pattern02

**Kind:** Absence: p is false

**Scope:** Before r

**LTL:**

`(!p U r) || !F r`

The GR(1) template for the LTL semantics of pattern 02 is shown in Listing 3.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!r & !p) & next(state=S0)) |
9    (state=S0 & (r) & next(state=S1)) |
10  (state=S0 & (!r & p) & next(state=S2)) |
11  (state=S1 & TRUE & next(state=S1)) |
12  (state=S2 & (!r) & next(state=S2)) |
13  (state=S2 & (r) & next(state=S3)) |
14  (state=S3 & TRUE & next(state=S3)));
15
16 LTLSPEC -- equivalence of satisfaction
17  (G F (state=S0 | state=S1 | state=S2));
```

Listing 3: GR(1) template for pattern 02

The GR(1) template for the negated LTL semantics of pattern 02 is shown in Listing 4.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!r & !p) & next(state=S0)) |
9    (state=S0 & (r) & next(state=S1)) |
10  (state=S0 & (!r & p) & next(state=S2)) |
11  (state=S1 & TRUE & next(state=S1)) |
12  (state=S2 & (!r) & next(state=S2)) |
13  (state=S2 & (r) & next(state=S3)) |
14  (state=S3 & TRUE & next(state=S3)));
15
16 LTLSPEC -- equivalence of satisfaction
17  (G F (state=S3));
```

Listing 4: GR(1) template for negated LTL semantics of pattern 02

## Pattern03

**Kind:** Absence: p is false

**Scope:** After q

**LTL:**

**G** (!q || **G** !p)

The GR(1) template for the LTL semantics of pattern 03 is shown in Listing 5.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!q) & next(state=S0)) |
9    (state=S0 & (q & !p) & next(state=S1)) |
10   (state=S0 & (q & p) & next(state=S2)) |
11   (state=S1 & (!p) & next(state=S1)) |
12   (state=S1 & (p) & next(state=S2)) |
13   (state=S2 & TRUE & next(state=S2)));
14
15 LTLSPEC -- equivalence of satisfaction
16   (G F (state=S0 | state=S1));
```

Listing 5: GR(1) template for pattern 03

The GR(1) template for the negated LTL semantics of pattern 03 is shown in Listing 6.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!q) & next(state=S0)) |
9    (state=S0 & (!p & q) & next(state=S1)) |
10   (state=S0 & (p & q) & next(state=S2)) |
11   (state=S1 & (!p) & next(state=S1)) |
12   (state=S1 & (p) & next(state=S2)) |
13   (state=S2 & TRUE & next(state=S2)));
14
15 LTLSPEC -- equivalence of satisfaction
16   (G F (state=S2));
```

Listing 6: GR(1) template for negated LTL semantics of pattern 03

## Pattern04

**Kind:** Absence: p is false

**Scope:** Between q and r

**LTL:**

```
G ((!p U r) || !(q && !r && F r))
```

The GR(1) template for the LTL semantics of pattern 04 is shown in Listing 7.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & ((!q) | (r & q)) & next(state=S0)) |
9   (state=S0 & (!r & !p & q) & next(state=S1)) |
10  (state=S0 & (!r & p & q) & next(state=S3)) |
11  (state=S1 & (r) & next(state=S0)) |
12  (state=S1 & (!r & !p) & next(state=S1)) |
13  (state=S1 & (!r & p) & next(state=S3)) |
14  (state=S2 & TRUE & next(state=S2)) |
15  (state=S3 & (r) & next(state=S2)) |
16  (state=S3 & (!r) & next(state=S3)));
17
18 LTLSPEC -- equivalence of satisfaction
19  (G F (state=S0 | state=S1 | state=S3));
```

Listing 7: GR(1) template for pattern 04

The GR(1) template for the negated LTL semantics of pattern 04 is shown in Listing 8.

```

1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & ((!q) | (r & q)) & next(state=S0)) |
9   (state=S0 & (!r & !p & q) & next(state=S1)) |
10  (state=S0 & (!r & p & q) & next(state=S2)) |
11  (state=S1 & (r) & next(state=S0)) |
12  (state=S1 & (!r & !p) & next(state=S1)) |
13  (state=S1 & (!r & p) & next(state=S2)) |
14  (state=S2 & (!r) & next(state=S2)) |
15  (state=S2 & (r) & next(state=S3)) |
16  (state=S3 & TRUE & next(state=S3)));
17
18 LTLSPEC -- equivalence of satisfaction
19  (G F (state=S3));

```

Listing 8: GR(1) template for negated LTL semantics of pattern 04

## Pattern05

**Kind:** Absence: p is false

**Scope:** After q until r

**LTL:**

```
G (!(q && !r) || (r V (!p || r)))
```

The GR(1) template for the LTL semantics of pattern 05 is shown in Listing 9.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!(q & !r) | (r)) & next(state=S0)) |
9   (state=S0 & (q & !p & !r) & next(state=S1)) |
10  (state=S0 & (q & p & !r) & next(state=S2)) |
11  (state=S1 & (r) & next(state=S0)) |
12  (state=S1 & (!p & !r) & next(state=S1)) |
13  (state=S1 & (p & !r) & next(state=S2)) |
14  (state=S2 & TRUE & next(state=S2)));
15
16 LTLSPEC -- equivalence of satisfaction
17  (G F (state=S0 | state=S1));
```

Listing 9: GR(1) template for pattern 05

The GR(1) template for the negated LTL semantics of pattern 05 is shown in Listing 10.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!(q) | (r & q)) & next(state=S0)) |
9   (state=S0 & (!r & !p & q) & next(state=S1)) |
10  (state=S0 & (!r & p & q) & next(state=S2)) |
11  (state=S1 & (r) & next(state=S0)) |
12  (state=S1 & (!r & !p) & next(state=S1)) |
13  (state=S1 & (!r & p) & next(state=S2)) |
14  (state=S2 & TRUE & next(state=S2)));
15
16 LTLSPEC -- equivalence of satisfaction
17  (G F (state=S2));
```

Listing 10: GR(1) template for negated LTL semantics of pattern 05

## Pattern06

**Kind:** Existence: p becomes true

**Scope:** Globally

**LTL:**

**F** p

The GR(1) template for the LTL semantics of pattern 06 is shown in Listing 11.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!p) & next(state=S0)) |
9    (state=S0 & (p) & next(state=S1)) |
10   (state=S1 & TRUE & next(state=S1)));
11
12 LTLSPEC -- equivalence of satisfaction
13   (G F (state=S1));
```

Listing 11: GR(1) template for pattern 06

The GR(1) template for the negated LTL semantics of pattern 06 is shown in Listing 12.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!p) & next(state=S0)) |
9    (state=S0 & (p) & next(state=S1)) |
10   (state=S1 & TRUE & next(state=S1)));
11
12 LTLSPEC -- equivalence of satisfaction
13   (G F (state=S0));
```

Listing 12: GR(1) template for negated LTL semantics of pattern 06

## Pattern07

**Kind:** Existence: p becomes true

**Scope:** Before r

**LTL:**

$(p \ \&\& \ !r) \ \mathbf{V} \ (!r \ || \ (p \ \&\& \ !r))$

The GR(1) template for the LTL semantics of pattern 07 is shown in Listing 13.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!r & !p) & next(state=S0)) |
9    (state=S0 & (r) & next(state=S1)) |
10  (state=S0 & (!r & p) & next(state=S2)) |
11  (state=S1 & TRUE & next(state=S1)) |
12  (state=S2 & TRUE & next(state=S2)));
13
14 LTLSPEC -- equivalence of satisfaction
15  (G F (state=S0 | state=S2));
```

Listing 13: GR(1) template for pattern 07

The GR(1) template for the negated LTL semantics of pattern 07 is shown in Listing 14.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!r & !p) & next(state=S0)) |
9    (state=S0 & (r) & next(state=S1)) |
10  (state=S0 & (!r & p) & next(state=S2)) |
11  (state=S1 & TRUE & next(state=S1)) |
12  (state=S2 & TRUE & next(state=S2)));
13
14 LTLSPEC -- equivalence of satisfaction
15  (G F (state=S1));
```

Listing 14: GR(1) template for negated LTL semantics of pattern 07

## Pattern08

**Kind:** Existence: p becomes true

**Scope:** After q

**LTL:**

**G** !q || **F** (q && **F** p)

The GR(1) template for the LTL semantics of pattern 08 is shown in Listing 15.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!q) & next (state=S0)) |
9    (state=S0 & (q & !p) & next (state=S1)) |
10   (state=S0 & (q & p) & next (state=S2)) |
11   (state=S1 & (!p) & next (state=S1)) |
12   (state=S1 & (p) & next (state=S2)) |
13   (state=S2 & TRUE & next (state=S2)));
14
15 LTLSPEC -- equivalence of satisfaction
16   (G F (state=S0 | state=S2));
```

Listing 15: GR(1) template for pattern 08

The GR(1) template for the negated LTL semantics of pattern 08 is shown in Listing 16.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!q) & next (state=S0)) |
9    (state=S0 & (q & !p) & next (state=S1)) |
10   (state=S0 & (q & p) & next (state=S2)) |
11   (state=S1 & (!p) & next (state=S1)) |
12   (state=S1 & (p) & next (state=S2)) |
13   (state=S2 & TRUE & next (state=S2)));
14
15 LTLSPEC -- equivalence of satisfaction
16   (G F (state=S1));
```

Listing 16: GR(1) template for negated LTL semantics of pattern 08

## Pattern09

**Kind:** Existence: p becomes true

**Scope:** Between q and r

**LTL:**

```
G (!(q && !r) || ((p && !r) V (!r || (p && !r))))
```

The GR(1) template for the LTL semantics of pattern 09 is shown in Listing 17.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!(q & !p) | (q & r) | (!r & p) | (!q & r & p)) & next(state=S0)) |
9   (state=S0 & (q & !r & !p) & next(state=S1)) |
10  (state=S1 & (!r & p) & next(state=S0)) |
11  (state=S1 & (!r & !p) & next(state=S1)) |
12  (state=S1 & (r) & next(state=S2)) |
13  (state=S2 & TRUE & next(state=S2));
14
15 LTLSPEC -- equivalence of satisfaction
16  (G F (state=S0 | state=S1));
```

Listing 17: GR(1) template for pattern 09

The GR(1) template for the negated LTL semantics of pattern 09 is shown in Listing 18.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!(q) | (r & q) | (!r & p & q)) & next(state=S0)) |
9   (state=S0 & (!r & !p & q) & next(state=S1)) |
10  (state=S1 & (!r & p) & next(state=S0)) |
11  (state=S1 & (!r & !p) & next(state=S1)) |
12  (state=S1 & (r) & next(state=S2)) |
13  (state=S2 & TRUE & next(state=S2));
14
15 LTLSPEC -- equivalence of satisfaction
16  (G F (state=S2));
```

Listing 18: GR(1) template for negated LTL semantics of pattern 09

## Pattern10

**Kind:** Existence: p becomes true

**Scope:** After q until r

**LTL:**

```
G (!(q && !r) || (!r U (p && !r)))
```

The GR(1) template for the LTL semantics of pattern 10 is shown in Listing 19.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & ((!q & !p) | (q & r) | (!r & p) | (!q & r & p)) & next(state=S0)) |
9   (state=S0 & (q & !r & !p) & next(state=S2)) |
10  (state=S1 & TRUE & next(state=S1)) |
11  (state=S2 & (!r & p) & next(state=S0)) |
12  (state=S2 & (r) & next(state=S1)) |
13  (state=S2 & (!r & !p) & next(state=S2));
14
15 LTLSPEC -- equivalence of satisfaction
16  (G F (state=S0));
```

Listing 19: GR(1) template for pattern 10

No GR(1) template for negated LTL semantics of pattern 10.

## Pattern11

**Kind:** Bounded Existence: p-states occur at most 2 times

**Scope:** Globally

**LTL:**

```
((G !p V (p || G !p)) V (!p || (G !p V (p || G !p)))) V (p || ((G !p V (p || G !p))
V (!p || (G !p V (p || G !p)))) V (!p || ((G !p V (p || G !p)) V (!p || (G !
p V (p || G !p)))) V (p || ((G !p V (p || G !p)) V (!p || (G !p V (p || G !p))))
)))
```

The GR(1) template for the LTL semantics of pattern 11 is shown in Listing 20.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4, S5};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!p) & next(state=S0)) |
9    (state=S0 & (p) & next(state=S1)) |
10  (state=S1 & (p) & next(state=S1)) |
11  (state=S1 & (!p) & next(state=S2)) |
12  (state=S2 & (!p) & next(state=S2)) |
13  (state=S2 & (p) & next(state=S3)) |
14  (state=S3 & (p) & next(state=S3)) |
15  (state=S3 & (!p) & next(state=S4)) |
16  (state=S4 & (!p) & next(state=S4)) |
17  (state=S4 & (p) & next(state=S5)) |
18  (state=S5 & TRUE & next(state=S5)));
19
20 LTLSPEC -- equivalence of satisfaction
21 (G F (state=S0 | state=S1 | state=S2 | state=S3 | state=S4));
```

Listing 20: GR(1) template for pattern 11

The GR(1) template for the negated LTL semantics of pattern 11 is shown in Listing 21.

```

1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4, S5};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!p) & next(state=S0)) |
9    (state=S0 & (p) & next(state=S1)) |
10  (state=S1 & (p) & next(state=S1)) |
11  (state=S1 & (!p) & next(state=S2)) |
12  (state=S2 & (!p) & next(state=S2)) |
13  (state=S2 & (p) & next(state=S3)) |
14  (state=S3 & (p) & next(state=S3)) |
15  (state=S3 & (!p) & next(state=S4)) |
16  (state=S4 & (!p) & next(state=S4)) |
17  (state=S4 & (p) & next(state=S5)) |
18  (state=S5 & TRUE & next(state=S5)));
19
20 LTLSPEC -- equivalence of satisfaction
21  (G F (state=S5));

```

Listing 21: GR(1) template for negated LTL semantics of pattern 11

## Pattern12

**Kind:** Bounded Existence: p-states occur at most 2 times

**Scope:** Before r

**LTL:**

```
((!p && !r) U (r || ((p && !r) U (r || ((!p && !r) U (r || ((p && !r) U (r || (!p U
r)))))))) || !F r
```

The GR(1) template for the LTL semantics of pattern 12 is shown in Listing 22.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4, S5, S6, S7};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!r & !p) & next(state=S0)) |
9    (state=S0 & (r) & next(state=S1)) |
10  (state=S0 & (!r & p) & next(state=S2)) |
11  (state=S1 & TRUE & next(state=S1)) |
12  (state=S2 & (r) & next(state=S1)) |
13  (state=S2 & (!r & p) & next(state=S2)) |
14  (state=S2 & (!r & !p) & next(state=S3)) |
15  (state=S3 & (r) & next(state=S1)) |
16  (state=S3 & (!r & !p) & next(state=S3)) |
17  (state=S3 & (!r & p) & next(state=S4)) |
18  (state=S4 & (r) & next(state=S1)) |
19  (state=S4 & (!r & p) & next(state=S4)) |
20  (state=S4 & (!r & !p) & next(state=S5)) |
21  (state=S5 & (r) & next(state=S1)) |
22  (state=S5 & (!r & !p) & next(state=S5)) |
23  (state=S5 & (!r & p) & next(state=S6)) |
24  (state=S6 & (!r) & next(state=S6)) |
25  (state=S6 & (r) & next(state=S7)) |
26  (state=S7 & TRUE & next(state=S7)));
27
28 LTLSPEC -- equivalence of satisfaction
29   (G F (state=S0 | state=S1 | state=S2 | state=S3 | state=S4 | state=S5 | state=S6))
   ;
```

Listing 22: GR(1) template for pattern 12

The GR(1) template for the negated LTL semantics of pattern 12 is shown in Listing 23.

```

1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4, S5, S6, S7};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!r & !p) & next(state=S0)) |
9    (state=S0 & (r) & next(state=S1)) |
10  (state=S0 & (!r & p) & next(state=S2)) |
11  (state=S1 & TRUE & next(state=S1)) |
12  (state=S2 & (r) & next(state=S1)) |
13  (state=S2 & (!r & p) & next(state=S2)) |
14  (state=S2 & (!r & !p) & next(state=S3)) |
15  (state=S3 & (r) & next(state=S1)) |
16  (state=S3 & (!r & !p) & next(state=S3)) |
17  (state=S3 & (!r & p) & next(state=S4)) |
18  (state=S4 & (r) & next(state=S1)) |
19  (state=S4 & (!r & p) & next(state=S4)) |
20  (state=S4 & (!r & !p) & next(state=S5)) |
21  (state=S5 & (r) & next(state=S1)) |
22  (state=S5 & (!r & !p) & next(state=S5)) |
23  (state=S5 & (!r & p) & next(state=S6)) |
24  (state=S6 & (!r) & next(state=S6)) |
25  (state=S6 & (r) & next(state=S7)) |
26  (state=S7 & TRUE & next(state=S7)));
27
28 LTLSPEC -- equivalence of satisfaction
29   (G F (state=S7));

```

Listing 23: GR(1) template for negated LTL semantics of pattern 12

## Pattern13

**Kind:** Bounded Existence: p-states occur at most 2 times

**Scope:** After q

**LTL:**

```
(!q U (q && (((G !p V (p || G !p)) V (!p || (G !p V (p || G !p)))) V (p || ((G !p V (p || G !p)) V (!p || (G !p V (p || G !p)))))) V (!p || (((G !p V (p || G !p)) V (!p || (G !p V (p || G !p)))) V (p || ((G !p V (p || G !p)) V (!p || (G !p V (p || G !p)))))) || !F q
```

The GR(1) template for the LTL semantics of pattern 13 is shown in Listing 24.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4, S5, S6};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!q) & next (state=S0)) |
9    (state=S0 & (q & !p) & next (state=S1)) |
10   (state=S0 & (q & p) & next (state=S2)) |
11   (state=S1 & (!p) & next (state=S1)) |
12   (state=S1 & (p) & next (state=S2)) |
13   (state=S2 & (p) & next (state=S2)) |
14   (state=S2 & (!p) & next (state=S3)) |
15   (state=S3 & (!p) & next (state=S3)) |
16   (state=S3 & (p) & next (state=S4)) |
17   (state=S4 & (p) & next (state=S4)) |
18   (state=S4 & (!p) & next (state=S5)) |
19   (state=S5 & (!p) & next (state=S5)) |
20   (state=S5 & (p) & next (state=S6)) |
21   (state=S6 & TRUE & next (state=S6)));
22
23 LTLSPEC -- equivalence of satisfaction
24   (G F (state=S0 | state=S1 | state=S2 | state=S3 | state=S4 | state=S5));
```

Listing 24: GR(1) template for pattern 13

The GR(1) template for the negated LTL semantics of pattern 13 is shown in Listing 25.

```

1 VAR -- auxiliary variables States of DEW
2   state : { S0, S1, S2, S3, S4, S5, S6};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!q) & next(state=S0)) |
9    (state=S0 & (q & !p) & next(state=S1)) |
10  (state=S0 & (q & p) & next(state=S2)) |
11  (state=S1 & (!p) & next(state=S1)) |
12  (state=S1 & (p) & next(state=S2)) |
13  (state=S2 & (p) & next(state=S2)) |
14  (state=S2 & (!p) & next(state=S3)) |
15  (state=S3 & (!p) & next(state=S3)) |
16  (state=S3 & (p) & next(state=S4)) |
17  (state=S4 & (p) & next(state=S4)) |
18  (state=S4 & (!p) & next(state=S5)) |
19  (state=S5 & (!p) & next(state=S5)) |
20  (state=S5 & (p) & next(state=S6)) |
21  (state=S6 & TRUE & next(state=S6)));
22
23 LTLSPEC -- equivalence of satisfaction
24   (G F (state=S6));

```

Listing 25: GR(1) template for negated LTL semantics of pattern 13

## Pattern14

**Kind:** Bounded Existence: p-states occur at most 2 times

**Scope:** Between q and r

**LTL:**

```
G (((!p && !r) U (r || ((p && !r) U (r || ((!p && !r) U (r || ((p && !r) U (r || (!p  
U r)))))))) || !(q && F r))
```

The GR(1) template for the LTL semantics of pattern 14 is shown in Listing 26.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4, S5, S6, S7};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & ((!q) | (r & q)) & next(state=S0)) |
9   (state=S0 & (!r & !p & q) & next(state=S5)) |
10  (state=S0 & (!r & p & q) & next(state=S7)) |
11  (state=S1 & (r) & next(state=S0)) |
12  (state=S1 & (!r & !p) & next(state=S1)) |
13  (state=S1 & (!r & p) & next(state=S4)) |
14  (state=S2 & TRUE & next(state=S2)) |
15  (state=S3 & (r) & next(state=S0)) |
16  (state=S3 & (!r & !p) & next(state=S3)) |
17  (state=S3 & (!r & p) & next(state=S6)) |
18  (state=S4 & (r) & next(state=S2)) |
19  (state=S4 & (!r) & next(state=S4)) |
20  (state=S5 & (r) & next(state=S0)) |
21  (state=S5 & (!r & !p) & next(state=S5)) |
22  (state=S5 & (!r & p) & next(state=S7)) |
23  (state=S6 & (r) & next(state=S0)) |
24  (state=S6 & (!r & !p) & next(state=S1)) |
25  (state=S6 & (!r & p) & next(state=S6)) |
26  (state=S7 & (r) & next(state=S0)) |
27  (state=S7 & (!r & !p) & next(state=S3)) |
28  (state=S7 & (!r & p) & next(state=S7));
29
30 LTLSPEC -- equivalence of satisfaction
31  (G F (state=S0 | state=S1 | state=S3 | state=S4 | state=S5 | state=S6 | state=S7))
   ;
```

Listing 26: GR(1) template for pattern 14

The GR(1) template for the negated LTL semantics of pattern 14 is shown in Listing 27.

```

1  VAR -- auxiliary variables States of DBW
2     state : { S0, S1, S2, S3, S4, S5, S6, S7};
3
4  INIT -- initial assignments: initial state
5     state=S0;
6
7  TRANS -- safety this and next state
8     ((state=S0 & ((!q) | (r & q)) & next(state=S0)) |
9     (state=S0 & (!r & !p & q) & next(state=S1)) |
10    (state=S0 & (!r & p & q) & next(state=S2)) |
11    (state=S1 & (r) & next(state=S0)) |
12    (state=S1 & (!r & !p) & next(state=S1)) |
13    (state=S1 & (!r & p) & next(state=S2)) |
14    (state=S2 & (r) & next(state=S0)) |
15    (state=S2 & (!r & p) & next(state=S2)) |
16    (state=S2 & (!r & !p) & next(state=S3)) |
17    (state=S3 & (r) & next(state=S0)) |
18    (state=S3 & (!r & !p) & next(state=S3)) |
19    (state=S3 & (!r & p) & next(state=S4)) |
20    (state=S4 & (r) & next(state=S0)) |
21    (state=S4 & (!r & p) & next(state=S4)) |
22    (state=S4 & (!r & !p) & next(state=S5)) |
23    (state=S5 & (r) & next(state=S0)) |
24    (state=S5 & (!r & !p) & next(state=S5)) |
25    (state=S5 & (!r & p) & next(state=S6)) |
26    (state=S6 & (!r) & next(state=S6)) |
27    (state=S6 & (r) & next(state=S7)) |
28    (state=S7 & TRUE & next(state=S7)));
29
30 LTLSPEC -- equivalence of satisfaction
31    (G F (state=S7));

```

Listing 27: GR(1) template for negated LTL semantics of pattern 14

## Pattern15

**Kind:** Bounded Existence: p-states occur at most 2 times

**Scope:** After q until r

**LTL:**

```
G (!q || ((!p && !r) U (r || ((p && !r) U (r || ((!p && !r) U (r || ((p && !r) U (r || G p || (r V (!p || r))))))))))
```

The GR(1) template for the LTL semantics of pattern 15 is shown in Listing 28.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4, S5, S6};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & ((!q & !r) | (r)) & next(state=S0)) |
9   (state=S0 & (q & !p & !r) & next(state=S1)) |
10  (state=S0 & (q & p & !r) & next(state=S4)) |
11  (state=S1 & (r) & next(state=S0)) |
12  (state=S1 & (!p & !r) & next(state=S1)) |
13  (state=S1 & (p & !r) & next(state=S4)) |
14  (state=S2 & TRUE & next(state=S2)) |
15  (state=S3 & (r) & next(state=S0)) |
16  (state=S3 & (p & !r) & next(state=S2)) |
17  (state=S3 & (!p & !r) & next(state=S3)) |
18  (state=S4 & (r) & next(state=S0)) |
19  (state=S4 & (p & !r) & next(state=S4)) |
20  (state=S4 & (!p & !r) & next(state=S5)) |
21  (state=S5 & (r) & next(state=S0)) |
22  (state=S5 & (!p & !r) & next(state=S5)) |
23  (state=S5 & (p & !r) & next(state=S6)) |
24  (state=S6 & (r) & next(state=S0)) |
25  (state=S6 & (!p & !r) & next(state=S3)) |
26  (state=S6 & (p & !r) & next(state=S6));
27
28 LTLSPEC -- equivalence of satisfaction
29   (G F (state=S0 | state=S1 | state=S3 | state=S4 | state=S5 | state=S6));
```

Listing 28: GR(1) template for pattern 15

The GR(1) template for the negated LTL semantics of pattern 15 is shown in Listing 29.

```

1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4, S5, S6};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & ((!q & !r) | (r)) & next(state=S0)) |
9   (state=S0 & (q & !p & !r) & next(state=S1)) |
10  (state=S0 & (q & p & !r) & next(state=S4)) |
11  (state=S1 & (r) & next(state=S0)) |
12  (state=S1 & (!p & !r) & next(state=S1)) |
13  (state=S1 & (p & !r) & next(state=S4)) |
14  (state=S2 & (r) & next(state=S0)) |
15  (state=S2 & (p & !r) & next(state=S2)) |
16  (state=S2 & (!p & !r) & next(state=S6)) |
17  (state=S3 & (r) & next(state=S0)) |
18  (state=S3 & (p & !r) & next(state=S2)) |
19  (state=S3 & (!p & !r) & next(state=S3)) |
20  (state=S4 & (r) & next(state=S0)) |
21  (state=S4 & (!p & !r) & next(state=S3)) |
22  (state=S4 & (p & !r) & next(state=S4)) |
23  (state=S5 & TRUE & next(state=S5)) |
24  (state=S6 & (r) & next(state=S0)) |
25  (state=S6 & (p & !r) & next(state=S5)) |
26  (state=S6 & (!p & !r) & next(state=S6));
27
28 LTLSPEC -- equivalence of satisfaction
29   (G F (state=S5));

```

Listing 29: GR(1) template for negated LTL semantics of pattern 15

## Pattern16

**Kind:** Universality: p is true

**Scope:** Globally

**LTL:**

**G** p

The GR(1) template for the LTL semantics of pattern 16 is shown in Listing 30.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (p) & next (state=S0)) |
9    (state=S0 & (!p) & next (state=S1)) |
10   (state=S1 & TRUE & next (state=S1)));
11
12 LTLSPEC -- equivalence of satisfaction
13   (G F (state=S0));
```

Listing 30: GR(1) template for pattern 16

The GR(1) template for the negated LTL semantics of pattern 16 is shown in Listing 31.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (p) & next (state=S0)) |
9    (state=S0 & (!p) & next (state=S1)) |
10   (state=S1 & TRUE & next (state=S1)));
11
12 LTLSPEC -- equivalence of satisfaction
13   (G F (state=S1));
```

Listing 31: GR(1) template for negated LTL semantics of pattern 16

## Pattern17

**Kind:** Universality: p is true

**Scope:** Before r

**LTL:**

(p U r) || !F r

The GR(1) template for the LTL semantics of pattern 17 is shown in Listing 32.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!r & p) & next(state=S0)) |
9    (state=S0 & (!r & !p) & next(state=S1)) |
10   (state=S0 & (r) & next(state=S2)) |
11   (state=S1 & (!r) & next(state=S1)) |
12   (state=S1 & (r) & next(state=S3)) |
13   (state=S2 & TRUE & next(state=S2)) |
14   (state=S3 & TRUE & next(state=S3)));
15
16 LTLSPEC -- equivalence of satisfaction
17   (G F (state=S0 | state=S1 | state=S2));
```

Listing 32: GR(1) template for pattern 17

The GR(1) template for the negated LTL semantics of pattern 17 is shown in Listing 33.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!r & p) & next(state=S0)) |
9    (state=S0 & (!r & !p) & next(state=S1)) |
10   (state=S0 & (r) & next(state=S2)) |
11   (state=S1 & (!r) & next(state=S1)) |
12   (state=S1 & (r) & next(state=S3)) |
13   (state=S2 & TRUE & next(state=S2)) |
14   (state=S3 & TRUE & next(state=S3)));
15
16 LTLSPEC -- equivalence of satisfaction
17   (G F (state=S3));
```

Listing 33: GR(1) template for negated LTL semantics of pattern 17

## Pattern18

**Kind:** Universality: p is true

**Scope:** After q

**LTL:**

**G** (!q || **G** p)

The GR(1) template for the LTL semantics of pattern 18 is shown in Listing 34.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!q) & next(state=S0)) |
9    (state=S0 & (q & !p) & next(state=S1)) |
10   (state=S0 & (q & p) & next(state=S2)) |
11   (state=S1 & TRUE & next(state=S1)) |
12   (state=S2 & (!p) & next(state=S1)) |
13   (state=S2 & (p) & next(state=S2)));
14
15 LTLSPEC -- equivalence of satisfaction
16   (G F (state=S0 | state=S2));
```

Listing 34: GR(1) template for pattern 18

The GR(1) template for the negated LTL semantics of pattern 18 is shown in Listing 35.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!q) & next(state=S0)) |
9    (state=S0 & (!p & q) & next(state=S1)) |
10   (state=S0 & (p & q) & next(state=S2)) |
11   (state=S1 & TRUE & next(state=S1)) |
12   (state=S2 & (!p) & next(state=S1)) |
13   (state=S2 & (p) & next(state=S2)));
14
15 LTLSPEC -- equivalence of satisfaction
16   (G F (state=S1));
```

Listing 35: GR(1) template for negated LTL semantics of pattern 18

## Pattern19

**Kind:** Universality: p is true

**Scope:** Between q and r

**LTL:**

```
G ((p U r) || !(q && !r && F r))
```

The GR(1) template for the LTL semantics of pattern 19 is shown in Listing 36.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & ((!q) | (r & q)) & next(state=S0)) |
9   (state=S0 & (!r & p & q) & next(state=S1)) |
10  (state=S0 & (!r & !p & q) & next(state=S3)) |
11  (state=S1 & (r) & next(state=S0)) |
12  (state=S1 & (!r & p) & next(state=S1)) |
13  (state=S1 & (!r & !p) & next(state=S3)) |
14  (state=S2 & TRUE & next(state=S2)) |
15  (state=S3 & (r) & next(state=S2)) |
16  (state=S3 & (!r) & next(state=S3)));
17
18 LTLSPEC -- equivalence of satisfaction
19  (G F (state=S0 | state=S1 | state=S3));
```

Listing 36: GR(1) template for pattern 19

The GR(1) template for the negated LTL semantics of pattern 19 is shown in Listing 37.

```

1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & ((!q) | (r & q)) & next(state=S0)) |
9   (state=S0 & (!r & !p & q) & next(state=S1)) |
10  (state=S0 & (!r & p & q) & next(state=S2)) |
11  (state=S1 & (!r) & next(state=S1)) |
12  (state=S1 & (r) & next(state=S3)) |
13  (state=S2 & (r) & next(state=S0)) |
14  (state=S2 & (!r & !p) & next(state=S1)) |
15  (state=S2 & (!r & p) & next(state=S2)) |
16  (state=S3 & TRUE & next(state=S3)));
17
18 LTLSPEC -- equivalence of satisfaction
19  (G F (state=S3));

```

Listing 37: GR(1) template for negated LTL semantics of pattern 19

## Pattern20

**Kind:** Universality: p is true

**Scope:** After q until r

**LTL:**

```
G (!(q && !r) || (r V (p || r)))
```

The GR(1) template for the LTL semantics of pattern 20 is shown in Listing 38.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!(q & !r) | (r)) & next(state=S0)) |
9   (state=S0 & (q & !p & !r) & next(state=S1)) |
10  (state=S0 & (q & p & !r) & next(state=S2)) |
11  (state=S1 & TRUE & next(state=S1)) |
12  (state=S2 & (r) & next(state=S0)) |
13  (state=S2 & (!p & !r) & next(state=S1)) |
14  (state=S2 & (p & !r) & next(state=S2)));
15
16 LTLSPEC -- equivalence of satisfaction
17  (G F (state=S0 | state=S2));
```

Listing 38: GR(1) template for pattern 20

The GR(1) template for the negated LTL semantics of pattern 20 is shown in Listing 39.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!(q) | (r & q)) & next(state=S0)) |
9   (state=S0 & (!p & !r & q) & next(state=S1)) |
10  (state=S0 & (p & !r & q) & next(state=S2)) |
11  (state=S1 & TRUE & next(state=S1)) |
12  (state=S2 & (r) & next(state=S0)) |
13  (state=S2 & (!p & !r) & next(state=S1)) |
14  (state=S2 & (p & !r) & next(state=S2)));
15
16 LTLSPEC -- equivalence of satisfaction
17  (G F (state=S1));
```

Listing 39: GR(1) template for negated LTL semantics of pattern 20

## Pattern21

**Kind:** Precedence: s precedes p

**Scope:** Globally

**LTL:**

s **V** (!p || s)

The GR(1) template for the LTL semantics of pattern 21 is shown in Listing 40.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!p & !s) & next(state=S0)) |
9    (state=S0 & (p & !s) & next(state=S1)) |
10   (state=S0 & (s) & next(state=S2)) |
11   (state=S1 & TRUE & next(state=S1)) |
12   (state=S2 & TRUE & next(state=S2)));
13
14 LTLSPEC -- equivalence of satisfaction
15   (G F (state=S0 | state=S2));
```

Listing 40: GR(1) template for pattern 21

The GR(1) template for the negated LTL semantics of pattern 21 is shown in Listing 41.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!s & !p) & next(state=S0)) |
9    (state=S0 & (s) & next(state=S1)) |
10   (state=S0 & (!s & p) & next(state=S2)) |
11   (state=S1 & TRUE & next(state=S1)) |
12   (state=S2 & TRUE & next(state=S2)));
13
14 LTLSPEC -- equivalence of satisfaction
15   (G F (state=S2));
```

Listing 41: GR(1) template for negated LTL semantics of pattern 21

## Pattern22

**Kind:** Precedence: s precedes p

**Scope:** Before r

**LTL:**

$(!p \text{ U } (r \parallel s)) \parallel !F r$

The GR(1) template for the LTL semantics of pattern 22 is shown in Listing 42.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!r & !s & !p) & next(state=S0)) |
9    (state=S0 & ((r) | (!r & s)) & next(state=S1)) |
10   (state=S0 & (!r & !s & p) & next(state=S2)) |
11   (state=S1 & TRUE & next(state=S1)) |
12   (state=S2 & (!r) & next(state=S2)) |
13   (state=S2 & (r) & next(state=S3)) |
14   (state=S3 & TRUE & next(state=S3)));
15
16 LTLSPEC -- equivalence of satisfaction
17   (G F (state=S0 | state=S1 | state=S2));
```

Listing 42: GR(1) template for pattern 22

The GR(1) template for the negated LTL semantics of pattern 22 is shown in Listing 43.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!r & !s & !p) & next(state=S0)) |
9    (state=S0 & ((r) | (!r & s)) & next(state=S1)) |
10   (state=S0 & (!r & !s & p) & next(state=S2)) |
11   (state=S1 & TRUE & next(state=S1)) |
12   (state=S2 & (!r) & next(state=S2)) |
13   (state=S2 & (r) & next(state=S3)) |
14   (state=S3 & TRUE & next(state=S3)));
15
16 LTLSPEC -- equivalence of satisfaction
17   (G F (state=S3));
```

Listing 43: GR(1) template for negated LTL semantics of pattern 22

## Pattern23

**Kind:** Precedence: s precedes p

**Scope:** After q

**LTL:**

```
G !q || F (q && (s V (!p || s)))
```

**No GR(1) template.**

The GR(1) template for the negated LTL semantics of pattern 23 is shown in Listing 44.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!q) & next(state=S0)) |
9    (state=S0 & (q & !s & !p) & next(state=S1)) |
10   (state=S0 & (q & s) & next(state=S2)) |
11   (state=S0 & (q & !s & p) & next(state=S3)) |
12   (state=S1 & (!s & !p) & next(state=S1)) |
13   (state=S1 & (s) & next(state=S2)) |
14   (state=S1 & (!s & p) & next(state=S3)) |
15   (state=S2 & TRUE & next(state=S2)) |
16   (state=S3 & (q & !s & !p) & next(state=S1)) |
17   (state=S3 & (q & s) & next(state=S2)) |
18   (state=S3 & ((!q & !p) | (!s & p) | (!q & s & p)) & next(state=S3)));
19
20 LTLSPEC -- equivalence of satisfaction
21 (G F (state=S3));
```

Listing 44: GR(1) template for negated LTL semantics of pattern 23

## Pattern24

**Kind:** Precedence: s precedes p

**Scope:** Between q and r

**LTL:**

```
G ((!p U (r || s)) || !(q && !r && F r))
```

The GR(1) template for the LTL semantics of pattern 24 is shown in Listing 45.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & ((!q) | (r & q) | (!r & s & q)) & next(state=S0)) |
9   (state=S0 & (!r & !s & !p & q) & next(state=S1)) |
10  (state=S0 & (!r & !s & p & q) & next(state=S3)) |
11  (state=S1 & ((r) | (!r & s)) & next(state=S0)) |
12  (state=S1 & (!r & !s & !p) & next(state=S1)) |
13  (state=S1 & (!r & !s & p) & next(state=S3)) |
14  (state=S2 & TRUE & next(state=S2)) |
15  (state=S3 & (r) & next(state=S2)) |
16  (state=S3 & (!r) & next(state=S3));
17
18 LTLSPEC -- equivalence of satisfaction
19  (G F (state=S0 | state=S1 | state=S3));
```

Listing 45: GR(1) template for pattern 24

The GR(1) template for the negated LTL semantics of pattern 24 is shown in Listing 46.

```

1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & ((!q) | (r & q) | (!r & s & q)) & next(state=S0)) |
9   (state=S0 & (!r & !s & !p & q) & next(state=S1)) |
10  (state=S0 & (!r & !s & p & q) & next(state=S2)) |
11  (state=S1 & ((r) | (!r & s)) & next(state=S0)) |
12  (state=S1 & (!r & !s & !p) & next(state=S1)) |
13  (state=S1 & (!r & !s & p) & next(state=S2)) |
14  (state=S2 & (!r) & next(state=S2)) |
15  (state=S2 & (r) & next(state=S3)) |
16  (state=S3 & TRUE & next(state=S3)));
17
18 LTLSPEC -- equivalence of satisfaction
19  (G F (state=S3));

```

Listing 46: GR(1) template for negated LTL semantics of pattern 24

## Pattern25

**Kind:** Precedence: s precedes p

**Scope:** After q until r

**LTL:**

```
G (!(q && !r) || ((r || s) V (!p || r || s)))
```

The GR(1) template for the LTL semantics of pattern 25 is shown in Listing 47.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & ((!q & !r & !s) | (r) | (!r & s)) & next(state=S0)) |
9   (state=S0 & (q & !p & !r & !s) & next(state=S1)) |
10  (state=S0 & (q & p & !r & !s) & next(state=S2)) |
11  (state=S1 & ((r) | (!r & s)) & next(state=S0)) |
12  (state=S1 & (!p & !r & !s) & next(state=S1)) |
13  (state=S1 & (p & !r & !s) & next(state=S2)) |
14  (state=S2 & TRUE & next(state=S2)));
15
16 LTLSPEC -- equivalence of satisfaction
17  (G F (state=S0 | state=S1));
```

Listing 47: GR(1) template for pattern 25

The GR(1) template for the negated LTL semantics of pattern 25 is shown in Listing 48.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & ((!q) | (r & q) | (!r & s & q)) & next(state=S0)) |
9   (state=S0 & (!r & !s & !p & q) & next(state=S1)) |
10  (state=S0 & (!r & !s & p & q) & next(state=S2)) |
11  (state=S1 & ((r) | (!r & s)) & next(state=S0)) |
12  (state=S1 & (!r & !s & !p) & next(state=S1)) |
13  (state=S1 & (!r & !s & p) & next(state=S2)) |
14  (state=S2 & TRUE & next(state=S2)));
15
16 LTLSPEC -- equivalence of satisfaction
17  (G F (state=S2));
```

Listing 48: GR(1) template for negated LTL semantics of pattern 25

## Pattern26

**Kind:** Response: s responds to p

**Scope:** Globally

**LTL:**

**G** (!p || **F** s)

The GR(1) template for the LTL semantics of pattern 26 is shown in Listing 49.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & ((!p) | (p & s)) & next(state=S0)) |
9   (state=S0 & (p & !s) & next(state=S1)) |
10  (state=S1 & (s) & next(state=S0)) |
11  (state=S1 & (!s) & next(state=S1)));
12
13 LTLSPEC -- equivalence of satisfaction
14  (G F (state=S0));
```

Listing 49: GR(1) template for pattern 26

**No GR(1) template for negated LTL semantics of pattern 26.**

## Pattern27

**Kind:** Response: s responds to p

**Scope:** Before r

**LTL:**

```
((!p || (!r U (!r && s))) U r) || !F r
```

The GR(1) template for the LTL semantics of pattern 27 is shown in Listing 50.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & ((!r & !p) | (!r & p & s)) & next(state=S0)) |
9    (state=S0 & (r) & next(state=S1)) |
10   (state=S0 & (!r & p & !s) & next(state=S2)) |
11   (state=S1 & TRUE & next(state=S1)) |
12   (state=S2 & (!r & s) & next(state=S0)) |
13   (state=S2 & (!r & !s) & next(state=S2)) |
14   (state=S2 & (r) & next(state=S3)) |
15   (state=S3 & TRUE & next(state=S3)));
16
17 LTLSPEC -- equivalence of satisfaction
18   (G F (state=S0 | state=S1 | state=S2));
```

Listing 50: GR(1) template for pattern 27

The GR(1) template for the negated LTL semantics of pattern 27 is shown in Listing 51.

```

1  VAR -- auxiliary variables States of DBW
2     state : { S0, S1, S2, S3};
3
4  INIT -- initial assignments: initial state
5     state=S0;
6
7  TRANS -- safety this and next state
8     ((state=S0 & ((!r & !p) | (!r & s & p)) & next(state=S0)) |
9     (state=S0 & (r) & next(state=S1)) |
10    (state=S0 & (!r & !s & p) & next(state=S2)) |
11    (state=S1 & TRUE & next(state=S1)) |
12    (state=S2 & (!r & s) & next(state=S0)) |
13    (state=S2 & (!r & !s) & next(state=S2)) |
14    (state=S2 & (r) & next(state=S3)) |
15    (state=S3 & TRUE & next(state=S3)));
16
17 LTLSPEC -- equivalence of satisfaction
18    (G F (state=S3));

```

Listing 51: GR(1) template for negated LTL semantics of pattern 27

## Pattern28

**Kind:** Response: s responds to p

**Scope:** After q

**LTL:**

**G** (!q || **G** (!p || **F** s))

The GR(1) template for the LTL semantics of pattern 28 is shown in Listing 52.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!q) & next(state=S0)) |
9    (state=S0 & ((q & !p) | (q & p & s)) & next(state=S1)) |
10  (state=S0 & (q & p & !s) & next(state=S2)) |
11  (state=S1 & ((!p) | (p & s)) & next(state=S1)) |
12  (state=S1 & (p & !s) & next(state=S2)) |
13  (state=S2 & (s) & next(state=S1)) |
14  (state=S2 & (!s) & next(state=S2)));
15
16 LTLSPEC -- equivalence of satisfaction
17  (G F (state=S0 | state=S1));
```

Listing 52: GR(1) template for pattern 28

**No GR(1) template for negated LTL semantics of pattern 28.**

## Pattern29

**Kind:** Response: s responds to p

**Scope:** Between q and r

**LTL:**

```
G ((!p || (!r U (!r && s))) U r) || !(q && !r && F r))
```

The GR(1) template for the LTL semantics of pattern 29 is shown in Listing 53.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & ((!q) | (r & q)) & next(state=S0)) |
9   (state=S0 & ((!r & !p & q) | (!r & p & s & q)) & next(state=S2)) |
10  (state=S0 & (!r & p & !s & q) & next(state=S3)) |
11  (state=S1 & TRUE & next(state=S1)) |
12  (state=S2 & (r) & next(state=S0)) |
13  (state=S2 & ((!r & !p) | (!r & p & s)) & next(state=S2)) |
14  (state=S2 & (!r & p & !s) & next(state=S3)) |
15  (state=S3 & (r) & next(state=S1)) |
16  (state=S3 & (!r & s) & next(state=S2)) |
17  (state=S3 & (!r & !s) & next(state=S3)));
18
19 LTLSPEC -- equivalence of satisfaction
20   (G F (state=S0 | state=S2 | state=S3));
```

Listing 53: GR(1) template for pattern 29

The GR(1) template for the negated LTL semantics of pattern 29 is shown in Listing 54.

```

1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & ((!q) | (r & q)) & next(state=S0)) |
9   (state=S0 & ((!r & !p & q) | (!r & s & p & q)) & next(state=S1)) |
10  (state=S0 & (!r & !s & p & q) & next(state=S2)) |
11  (state=S1 & (r) & next(state=S0)) |
12  (state=S1 & ((!r & !p) | (!r & s & p)) & next(state=S1)) |
13  (state=S1 & (!r & !s & p) & next(state=S2)) |
14  (state=S2 & (!r & s) & next(state=S1)) |
15  (state=S2 & (!r & !s) & next(state=S2)) |
16  (state=S2 & (r) & next(state=S3)) |
17  (state=S3 & TRUE & next(state=S3));
18
19 LTLSPEC -- equivalence of satisfaction
20  (G F (state=S3));

```

Listing 54: GR(1) template for negated LTL semantics of pattern 29

## Pattern30

**Kind:** Response: s responds to p

**Scope:** After q until r

**LTL:**

```
G (!(q && !r) || (r V (!p || r || (!r U (!r && s)))))
```

The GR(1) template for the LTL semantics of pattern 30 is shown in Listing 55.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!(q & !r) | (r)) & next(state=S0)) |
9   (state=S0 & ((q & !p & !r) | (q & p & !r & s)) & next(state=S1)) |
10  (state=S0 & (q & p & !r & !s) & next(state=S2)) |
11  (state=S1 & (r) & next(state=S0)) |
12  (state=S1 & (!(p & !r) | (p & !r & s)) & next(state=S1)) |
13  (state=S1 & (p & !r & !s) & next(state=S2)) |
14  (state=S2 & (!r & s) & next(state=S1)) |
15  (state=S2 & (!r & !s) & next(state=S2)) |
16  (state=S2 & (r) & next(state=S3)) |
17  (state=S3 & TRUE & next(state=S3)));
18
19 LTLSPEC -- equivalence of satisfaction
20   (G F (state=S0 | state=S1));
```

Listing 55: GR(1) template for pattern 30

**No GR(1) template for negated LTL semantics of pattern 30.**

## Pattern31

**Kind:** Precedence Chain: s, t precedes p

**Scope:** Globally

**LTL:**

```
(!p U (!p && s && X(!p U t))) || !F p
```

The GR(1) template for the LTL semantics of pattern 31 is shown in Listing 56.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!p & !s) & next(state=S0)) |
9    (state=S0 & (p) & next(state=S1)) |
10   (state=S0 & (!p & s) & next(state=S2)) |
11   (state=S1 & TRUE & next(state=S1)) |
12   (state=S2 & (p & !t) & next(state=S1)) |
13   (state=S2 & (!p & !t) & next(state=S2)) |
14   (state=S2 & (t) & next(state=S3)) |
15   (state=S3 & TRUE & next(state=S3)));
16
17 LTLSPEC -- equivalence of satisfaction
18   (G F (state=S0 | state=S2 | state=S3));
```

Listing 56: GR(1) template for pattern 31

The GR(1) template for the negated LTL semantics of pattern 31 is shown in Listing 57.

```

1  VAR -- auxiliary variables States of DBW
2     state : { S0, S1, S2, S3};
3
4  INIT -- initial assignments: initial state
5     state=S0;
6
7  TRANS -- safety this and next state
8     ((state=S0 & (!p & !s) & next(state=S0)) |
9     (state=S0 & (p) & next(state=S1)) |
10    (state=S0 & (!p & s) & next(state=S2)) |
11    (state=S1 & TRUE & next(state=S1)) |
12    (state=S2 & (p & !t) & next(state=S1)) |
13    (state=S2 & (!p & !t) & next(state=S2)) |
14    (state=S2 & (t) & next(state=S3)) |
15    (state=S3 & TRUE & next(state=S3)));
16
17 LTLSPEC -- equivalence of satisfaction
18 (G F (state=S1));

```

Listing 57: GR(1) template for negated LTL semantics of pattern 31

## Pattern32

**Kind:** Precedence Chain: s, t precedes p

**Scope:** Before r

**LTL:**

```
(!p U (r || (!p && s && X(!p U t))) || !F r
```

The GR(1) template for the LTL semantics of pattern 32 is shown in Listing 58.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!r & !p & !s) & next(state=S0)) |
9    (state=S0 & (r) & next(state=S1)) |
10  (state=S0 & (!r & p) & next(state=S2)) |
11  (state=S0 & (!r & !p & s) & next(state=S3)) |
12  (state=S1 & TRUE & next(state=S1)) |
13  (state=S2 & (!r) & next(state=S2)) |
14  (state=S2 & (r) & next(state=S4)) |
15  (state=S3 & ((r & !t) | (t)) & next(state=S1)) |
16  (state=S3 & (!r & p & !t) & next(state=S2)) |
17  (state=S3 & (!r & !p & !t) & next(state=S3)) |
18  (state=S4 & TRUE & next(state=S4)));
19
20 LTLSPEC -- equivalence of satisfaction
21  (G F (state=S0 | state=S1 | state=S2 | state=S3));
```

Listing 58: GR(1) template for pattern 32

The GR(1) template for the negated LTL semantics of pattern 32 is shown in Listing 59.

```

1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!r & !s & !p) & next(state=S0)) |
9    (state=S0 & (r) & next(state=S1)) |
10   (state=S0 & (!r & s & !p) & next(state=S2)) |
11   (state=S0 & (!r & p) & next(state=S3)) |
12   (state=S1 & TRUE & next(state=S1)) |
13   (state=S2 & ((r & !t) | (t)) & next(state=S1)) |
14   (state=S2 & (!r & !t & !p) & next(state=S2)) |
15   (state=S2 & (!r & !t & p) & next(state=S3)) |
16   (state=S3 & (!r) & next(state=S3)) |
17   (state=S3 & (r) & next(state=S4)) |
18   (state=S4 & TRUE & next(state=S4)));
19
20 LTLSPEC -- equivalence of satisfaction
21   (G F (state=S4));

```

Listing 59: GR(1) template for negated LTL semantics of pattern 32

## Pattern33

**Kind:** Precedence Chain: s, t precedes p

**Scope:** After q

**LTL:**

```
G !q || (!q U ((!p U (!p && s && X(!p U t))) || !(q && F p)))
```

The GR(1) template for the LTL semantics of pattern 33 is shown in Listing 60.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!q) & next(state=S1)) |
9    (state=S0 & (!p & !s & q) & next(state=S2)) |
10   (state=S0 & (p & q) & next(state=S3)) |
11   (state=S0 & (!p & s & q) & next(state=S4)) |
12   (state=S1 & TRUE & next(state=S1)) |
13   (state=S2 & (!p & !s) & next(state=S2)) |
14   (state=S2 & (p) & next(state=S3)) |
15   (state=S2 & (!p & s) & next(state=S4)) |
16   (state=S3 & TRUE & next(state=S3)) |
17   (state=S4 & (t) & next(state=S1)) |
18   (state=S4 & (p & !t) & next(state=S3)) |
19   (state=S4 & (!p & !t) & next(state=S4)));
20
21 LTLSPEC -- equivalence of satisfaction
22 (G F (state=S0 | state=S1 | state=S2 | state=S4));
```

Listing 60: GR(1) template for pattern 33

The GR(1) template for the negated LTL semantics of pattern 33 is shown in Listing 61.

```

1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!q) & next(state=S1)) |
9    (state=S0 & (!p & !s & q) & next(state=S2)) |
10   (state=S0 & (p & q) & next(state=S3)) |
11   (state=S0 & (!p & s & q) & next(state=S4)) |
12   (state=S1 & TRUE & next(state=S1)) |
13   (state=S2 & (!p & !s) & next(state=S2)) |
14   (state=S2 & (p) & next(state=S3)) |
15   (state=S2 & (!p & s) & next(state=S4)) |
16   (state=S3 & TRUE & next(state=S3)) |
17   (state=S4 & (t) & next(state=S1)) |
18   (state=S4 & (p & !t) & next(state=S3)) |
19   (state=S4 & (!p & !t) & next(state=S4)));
20
21 LTLSPEC -- equivalence of satisfaction
22   (G F (state=S0 | state=S3));

```

Listing 61: GR(1) template for negated LTL semantics of pattern 33

## Pattern34

**Kind:** Precedence Chain: s, t precedes p

**Scope:** Between q and r

**LTL:**

```
G ((!p U (r || (!p && s && X(!p U t)))) || !(q && F r))
```

The GR(1) template for the LTL semantics of pattern 34 is shown in Listing 62.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & ((!q) | (r & q)) & next(state=S0)) |
9   (state=S0 & (!r & !p & !s & q) & next(state=S1)) |
10  (state=S0 & (!r & p & q) & next(state=S3)) |
11  (state=S0 & (!r & !p & s & q) & next(state=S4)) |
12  (state=S1 & (r) & next(state=S0)) |
13  (state=S1 & (!r & !p & !s) & next(state=S1)) |
14  (state=S1 & (!r & p) & next(state=S3)) |
15  (state=S1 & (!r & !p & s) & next(state=S4)) |
16  (state=S2 & TRUE & next(state=S2)) |
17  (state=S3 & (r) & next(state=S2)) |
18  (state=S3 & (!r) & next(state=S3)) |
19  (state=S4 & ((r & !t) | (t & !q) | (r & t & q)) & next(state=S0)) |
20  (state=S4 & (!r & !p & !s & q) & next(state=S1)) |
21  (state=S4 & ((!r & p & !t) | (!r & p & t & q)) & next(state=S3)) |
22  (state=S4 & ((!r & !p & !t & !q) | (!r & !p & s & q)) & next(state=S4));
23
24 LTLSPEC -- equivalence of satisfaction
25   (G F (state=S0 | state=S1 | state=S3 | state=S4));
```

Listing 62: GR(1) template for pattern 34

The GR(1) template for the negated LTL semantics of pattern 34 is shown in Listing 63.

```

1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & ((!q) | (r & q)) & next(state=S0)) |
9   (state=S0 & (!r & !s & !p & q) & next(state=S2)) |
10  (state=S0 & (!r & p & q) & next(state=S3)) |
11  (state=S0 & (!r & s & !p & q) & next(state=S4)) |
12  (state=S1 & TRUE & next(state=S1)) |
13  (state=S2 & (r) & next(state=S0)) |
14  (state=S2 & (!r & !s & !p) & next(state=S2)) |
15  (state=S2 & (!r & p) & next(state=S3)) |
16  (state=S2 & (!r & s & !p) & next(state=S4)) |
17  (state=S3 & (r) & next(state=S1)) |
18  (state=S3 & (!r) & next(state=S3)) |
19  (state=S4 & ((r & !t & !q) | (t & !q) | (r & q)) & next(state=S0)) |
20  (state=S4 & (!r & !s & !p & q) & next(state=S2)) |
21  (state=S4 & ((!r & !t & p) | (!r & t & p & q)) & next(state=S3)) |
22  (state=S4 & ((!r & !t & !p & !q) | (!r & s & !p & q)) & next(state=S4));
23
24 LTLSPEC -- equivalence of satisfaction
25  (G F (state=S1));

```

Listing 63: GR(1) template for negated LTL semantics of pattern 34

## Pattern35

**Kind:** Precedence Chain: s, t precedes p

**Scope:** After q until r

**LTL:**

```
G (!q || (!p U (r || (!p && s && X(!p U t)))) || !F p)
```

The GR(1) template for the LTL semantics of pattern 35 is shown in Listing 64.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & ((!q) | (q & r)) & next(state=S0)) |
9   (state=S0 & (q & !r & !p & s) & next(state=S1)) |
10  (state=S0 & (q & !r & !p & !s) & next(state=S2)) |
11  (state=S0 & (q & !r & p) & next(state=S3)) |
12  (state=S1 & ((r & !t) | (!q & t) | (q & r & t)) & next(state=S0)) |
13  (state=S1 & ((!q & !r & !p & !t) | (q & !r & !p & s)) & next(state=S1)) |
14  (state=S1 & (q & !r & !p & !s) & next(state=S2)) |
15  (state=S1 & (!r & p & !t) | (q & !r & p & t)) & next(state=S3)) |
16  (state=S2 & (r) & next(state=S0)) |
17  (state=S2 & (!r & !p & s) & next(state=S1)) |
18  (state=S2 & (!r & !p & !s) & next(state=S2)) |
19  (state=S2 & (!r & p) & next(state=S3)) |
20  (state=S3 & TRUE & next(state=S3));
21
22 LTLSPEC -- equivalence of satisfaction
23  (G F (state=S0 | state=S1 | state=S2));
```

Listing 64: GR(1) template for pattern 35

The GR(1) template for the negated LTL semantics of pattern 35 is shown in Listing 65.

```

1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & ((!q) | (r & q)) & next(state=S0)) |
9   (state=S0 & (!p & !r & !s & q) & next(state=S1)) |
10  (state=S0 & (p & !r & q) & next(state=S2)) |
11  (state=S0 & (!p & !r & s & q) & next(state=S3)) |
12  (state=S1 & (r) & next(state=S0)) |
13  (state=S1 & (!p & !r & !s) & next(state=S1)) |
14  (state=S1 & (p & !r) & next(state=S2)) |
15  (state=S1 & (!p & !r & s) & next(state=S3)) |
16  (state=S2 & TRUE & next(state=S2)) |
17  (state=S3 & ((r & !t) | (t & !q) | (r & t & q)) & next(state=S0)) |
18  (state=S3 & (!p & !r & !s & q) & next(state=S1)) |
19  (state=S3 & ((p & !r & !t) | (p & !r & t & q)) & next(state=S2)) |
20  (state=S3 & ((!p & !r & !t & !q) | (!p & !r & s & q)) & next(state=S3));
21
22 LTLSPEC -- equivalence of satisfaction
23  (G F (state=S2));

```

Listing 65: GR(1) template for negated LTL semantics of pattern 35

## Pattern36

**Kind:** Precedence Chain: p precedes (s, t)

**Scope:** Globally

**LTL:**

```
(!s U p) || !F (s && XF t)
```

The GR(1) template for the LTL semantics of pattern 36 is shown in Listing 66.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!p & !s) & next(state=S0)) |
9    (state=S0 & (p) & next(state=S1)) |
10  (state=S0 & (!p & s) & next(state=S3)) |
11  (state=S1 & TRUE & next(state=S1)) |
12  (state=S2 & TRUE & next(state=S2)) |
13  (state=S3 & (t) & next(state=S2)) |
14  (state=S3 & (!t) & next(state=S3)));
15
16 LTLSPEC -- equivalence of satisfaction
17  (G F (state=S0 | state=S1 | state=S3));
```

Listing 66: GR(1) template for pattern 36

The GR(1) template for the negated LTL semantics of pattern 36 is shown in Listing 67.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!s & !p) & next(state=S0)) |
9    (state=S0 & (s & !p) & next(state=S1)) |
10  (state=S0 & (p) & next(state=S2)) |
11  (state=S1 & (!t) & next(state=S1)) |
12  (state=S1 & (t) & next(state=S3)) |
13  (state=S2 & TRUE & next(state=S2)) |
14  (state=S3 & TRUE & next(state=S3)));
15
16 LTLSPEC -- equivalence of satisfaction
17  (G F (state=S3));
```

Listing 67: GR(1) template for negated LTL semantics of pattern 36

## Pattern37

**Kind:** Precedence Chain: p precedes (s, t)

**Scope:** Before r

**LTL:**

```
(!(r && s && X(!r U (!r && t))) U (p || r)) || !F r
```

The GR(1) template for the LTL semantics of pattern 37 is shown in Listing 68.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!p & !r & !s) & next (state=S0)) |
9    (state=S0 & ((p) | (!p & r)) & next (state=S1)) |
10   (state=S0 & (!p & !r & s) & next (state=S2)) |
11   (state=S1 & TRUE & next (state=S1)) |
12   (state=S2 & (r) & next (state=S1)) |
13   (state=S2 & (!r & !t) & next (state=S2)) |
14   (state=S2 & (!r & t) & next (state=S3)) |
15   (state=S3 & (!r) & next (state=S3)) |
16   (state=S3 & (r) & next (state=S4)) |
17   (state=S4 & TRUE & next (state=S4)));
18
19 LTLSPEC -- equivalence of satisfaction
20   (G F (state=S0 | state=S1 | state=S2 | state=S3));
```

Listing 68: GR(1) template for pattern 37

The GR(1) template for the negated LTL semantics of pattern 37 is shown in Listing 69.

```

1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!r & !p & !s) & next(state=S0)) |
9    (state=S0 & ((r) | (!r & p)) & next(state=S1)) |
10  (state=S0 & (!r & !p & s) & next(state=S2)) |
11  (state=S1 & TRUE & next(state=S1)) |
12  (state=S2 & (r) & next(state=S1)) |
13  (state=S2 & (!r & !t) & next(state=S2)) |
14  (state=S2 & (!r & t) & next(state=S3)) |
15  (state=S3 & (!r) & next(state=S3)) |
16  (state=S3 & (r) & next(state=S4)) |
17  (state=S4 & TRUE & next(state=S4)));
18
19 LTLSPEC -- equivalence of satisfaction
20   (G F (state=S4));

```

Listing 69: GR(1) template for negated LTL semantics of pattern 37

## Pattern38

**Kind:** Precedence Chain: p precedes (s, t)

**Scope:** After q

**LTL:**

```
G !q || (!q U (q && (!!s U p) || !F (s && XF t)))
```

The GR(1) template for the LTL semantics of pattern 38 is shown in Listing 70.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!q) & next(state=S0)) |
9    (state=S0 & (q & p) & next(state=S1)) |
10   (state=S0 & (q & !p & !s) & next(state=S2)) |
11   (state=S0 & (q & !p & s) & next(state=S4)) |
12   (state=S1 & TRUE & next(state=S1)) |
13   (state=S2 & (p) & next(state=S1)) |
14   (state=S2 & (!p & !s) & next(state=S2)) |
15   (state=S2 & (!p & s) & next(state=S4)) |
16   (state=S3 & TRUE & next(state=S3)) |
17   (state=S4 & (t) & next(state=S3)) |
18   (state=S4 & (!t) & next(state=S4)));
19
20 LTLSPEC -- equivalence of satisfaction
21 (G F (state=S0 | state=S1 | state=S2 | state=S4));
```

Listing 70: GR(1) template for pattern 38

The GR(1) template for the negated LTL semantics of pattern 38 is shown in Listing 71.

```

1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!q) & next(state=S0)) |
9    (state=S0 & (q & !s & !p) & next(state=S1)) |
10   (state=S0 & (q & p) & next(state=S3)) |
11   (state=S0 & (q & s & !p) & next(state=S4)) |
12   (state=S1 & (!s & !p) & next(state=S1)) |
13   (state=S1 & (p) & next(state=S3)) |
14   (state=S1 & (s & !p) & next(state=S4)) |
15   (state=S2 & TRUE & next(state=S2)) |
16   (state=S3 & TRUE & next(state=S3)) |
17   (state=S4 & (t) & next(state=S2)) |
18   (state=S4 & (!t) & next(state=S4)));
19
20 LTLSPEC -- equivalence of satisfaction
21   (G F (state=S2));

```

Listing 71: GR(1) template for negated LTL semantics of pattern 38

## Pattern39

**Kind:** Precedence Chain: p precedes (s, t)

**Scope:** Between q and r

**LTL:**

```
G ((!(r && s && X(!r U (!r && t))) U (p || r)) || !(q && F r)
```

The GR(1) template for the LTL semantics of pattern 39 is shown in Listing 72.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!(q) | (p & q) | (!p & r & q)) & next(state=S0)) |
9   (state=S0 & (!p & !r & !s & q) & next(state=S2)) |
10  (state=S0 & (!p & !r & s & q) & next(state=S3)) |
11  (state=S1 & TRUE & next(state=S1)) |
12  (state=S2 & ((p) | (!p & r)) & next(state=S0)) |
13  (state=S2 & (!p & !r & !s) & next(state=S2)) |
14  (state=S2 & (!p & !r & s) & next(state=S3)) |
15  (state=S3 & (r) & next(state=S0)) |
16  (state=S3 & (!r & !t) & next(state=S3)) |
17  (state=S3 & (!r & t) & next(state=S4)) |
18  (state=S4 & (r) & next(state=S1)) |
19  (state=S4 & (!r) & next(state=S4));
20
21 LTLSPEC -- equivalence of satisfaction
22 (G F (state=S0 | state=S2 | state=S3 | state=S4));
```

Listing 72: GR(1) template for pattern 39

The GR(1) template for the negated LTL semantics of pattern 39 is shown in Listing 73.

```

1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & ((!q) | (r & q) | (!r & p & q)) & next(state=S0)) |
9   (state=S0 & (!r & !p & !s & q) & next(state=S1)) |
10  (state=S0 & (!r & !p & s & q) & next(state=S3)) |
11  (state=S1 & ((r) | (!r & p)) & next(state=S0)) |
12  (state=S1 & (!r & !p & !s) & next(state=S1)) |
13  (state=S1 & (!r & !p & s) & next(state=S3)) |
14  (state=S2 & (!r) & next(state=S2)) |
15  (state=S2 & (r) & next(state=S4)) |
16  (state=S3 & (r) & next(state=S0)) |
17  (state=S3 & (!r & t) & next(state=S2)) |
18  (state=S3 & (!r & !t) & next(state=S3)) |
19  (state=S4 & TRUE & next(state=S4)));
20
21 LTLSPEC -- equivalence of satisfaction
22  (G F (state=S4));

```

Listing 73: GR(1) template for negated LTL semantics of pattern 39

## Pattern40

**Kind:** Precedence Chain: p precedes (s, t)

**Scope:** After q until r

**LTL:**

```
G (!q || (!(r && s && X(!r U (!r && t))) U (p || r)) || G !(s && XF t))
```

The GR(1) template for the LTL semantics of pattern 40 is shown in Listing 74.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & ((!q & !r) | (q & p) | (!p & r) | (!q & p & r)) & next(state=S0)) |
9   (state=S0 & (q & !p & !r & s) & next(state=S1)) |
10  (state=S0 & (q & !p & !r & !s) & next(state=S2)) |
11  (state=S1 & (r) & next(state=S0)) |
12  (state=S1 & (!r & !t) & next(state=S1)) |
13  (state=S1 & (!r & t) & next(state=S3)) |
14  (state=S2 & ((p) | (!p & r)) & next(state=S0)) |
15  (state=S2 & (!p & !r & s) & next(state=S1)) |
16  (state=S2 & (!p & !r & !s) & next(state=S2)) |
17  (state=S3 & TRUE & next(state=S3));
18
19 LTLSPEC -- equivalence of satisfaction
20  (G F (state=S0 | state=S1 | state=S2));
```

Listing 74: GR(1) template for pattern 40

The GR(1) template for the negated LTL semantics of pattern 40 is shown in Listing 75.

```

1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & ((!q) | (p & q) | (!p & r & q)) & next(state=S0)) |
9   (state=S0 & (s & !p & !r & q) & next(state=S1)) |
10  (state=S0 & (!s & !p & !r & q) & next(state=S3)) |
11  (state=S1 & (r) & next(state=S0)) |
12  (state=S1 & (!t & !r) & next(state=S1)) |
13  (state=S1 & (t & !r) & next(state=S2)) |
14  (state=S2 & TRUE & next(state=S2)) |
15  (state=S3 & ((p) | (!p & r)) & next(state=S0)) |
16  (state=S3 & (s & !p & !r) & next(state=S1)) |
17  (state=S3 & (!s & !p & !r) & next(state=S3)));
18
19 LTLSPEC -- equivalence of satisfaction
20   (G F (state=S2));

```

Listing 75: GR(1) template for negated LTL semantics of pattern 40

## Pattern41

**Kind:** Response Chain: p responds to s,t

**Scope:** Globally

**LTL:**

```
G (XF (t && F p) || !(s && XF t))
```

The GR(1) template for the LTL semantics of pattern 41 is shown in Listing 76.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!s) & next(state=S0)) |
9    (state=S0 & (s) & next(state=S2)) |
10  (state=S1 & (p & !s) & next(state=S0)) |
11  (state=S1 & (!p & !s) & next(state=S1)) |
12  (state=S1 & (p & s) & next(state=S2)) |
13  (state=S1 & (!p & s) & next(state=S3)) |
14  (state=S2 & (t & p & !s) & next(state=S0)) |
15  (state=S2 & (t & !p & !s) & next(state=S1)) |
16  (state=S2 & ((!t) | (t & p & s)) & next(state=S2)) |
17  (state=S2 & (t & !p & s) & next(state=S3)) |
18  (state=S3 & (t & p & !s) & next(state=S0)) |
19  (state=S3 & (t & !p & !s) & next(state=S1)) |
20  (state=S3 & ((!t & p) | (t & p & s)) & next(state=S2)) |
21  (state=S3 & ((!t & !p) | (t & !p & s)) & next(state=S3)));
22
23 LTLSPEC -- equivalence of satisfaction
24   (G F (state=S0 | state=S2));
```

Listing 76: GR(1) template for pattern 41

No GR(1) template for negated LTL semantics of pattern 41.

## Pattern42

**Kind:** Response Chain: p responds to s,t

**Scope:** Before r

**LTL:**

```
((X(!r U (t && F p)) || !(s && X(!r U t))) U r) || !F r
```

The GR(1) template for the LTL semantics of pattern 42 is shown in Listing 77.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4, S5};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!r & !s) & next(state=S0)) |
9    (state=S0 & (r) & next(state=S2)) |
10   (state=S0 & (!r & s) & next(state=S3)) |
11   (state=S1 & (!r & t & p & !s) & next(state=S0)) |
12   (state=S1 & ((!r & !t & !p) | (!r & t & !p & s)) & next(state=S1)) |
13   (state=S1 & (r & p) & next(state=S2)) |
14   (state=S1 & ((!r & !t & p) | (!r & t & p & s)) & next(state=S3)) |
15   (state=S1 & (!r & t & !p & !s) & next(state=S4)) |
16   (state=S1 & (r & !p) & next(state=S5)) |
17   (state=S2 & TRUE & next(state=S2)) |
18   (state=S3 & (!r & t & p & !s) & next(state=S0)) |
19   (state=S3 & (!r & t & !p & s) & next(state=S1)) |
20   (state=S3 & ((r & !t) | (r & t & p)) & next(state=S2)) |
21   (state=S3 & ((!r & !t) | (!r & t & p & s)) & next(state=S3)) |
22   (state=S3 & (!r & t & !p & !s) & next(state=S4)) |
23   (state=S3 & (r & t & !p) & next(state=S5)) |
24   (state=S4 & (!r & p & !s) & next(state=S0)) |
25   (state=S4 & (!r & !p & s) & next(state=S1)) |
26   (state=S4 & (r & p) & next(state=S2)) |
27   (state=S4 & (!r & p & s) & next(state=S3)) |
28   (state=S4 & (!r & !p & !s) & next(state=S4)) |
29   (state=S4 & (r & !p) & next(state=S5)) |
30   (state=S5 & (p) & next(state=S2)) |
31   (state=S5 & (!p) & next(state=S5)));
32
33 LTLSPEC -- equivalence of satisfaction
34   (G F (state=S0 | state=S1 | state=S2 | state=S3 | state=S4));
```

Listing 77: GR(1) template for pattern 42

The GR(1) template for the negated LTL semantics of pattern 42 is shown in Listing 78.

```

1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4, S5};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!r & !s) & next(state=S0)) |
9    (state=S0 & (r) & next(state=S2)) |
10   (state=S0 & (!r & s) & next(state=S5)) |
11   (state=S1 & (!p) & next(state=S1)) |
12   (state=S1 & (p) & next(state=S2)) |
13   (state=S2 & TRUE & next(state=S2)) |
14   (state=S3 & (!r & p & !s) & next(state=S0)) |
15   (state=S3 & (r & !p) & next(state=S1)) |
16   (state=S3 & (r & p) & next(state=S2)) |
17   (state=S3 & (!r & !p & !s) & next(state=S3)) |
18   (state=S3 & (!r & !p & s) & next(state=S4)) |
19   (state=S3 & (!r & p & s) & next(state=S5)) |
20   (state=S4 & (!r & t & p & !s) & next(state=S0)) |
21   (state=S4 & (r & !p) & next(state=S1)) |
22   (state=S4 & (r & p) & next(state=S2)) |
23   (state=S4 & (!r & t & !p & !s) & next(state=S3)) |
24   (state=S4 & ((!r & !t & !p) | (!r & t & !p & s)) & next(state=S4)) |
25   (state=S4 & ((!r & !t & p) | (!r & t & p & s)) & next(state=S5)) |
26   (state=S5 & (!r & t & p & !s) & next(state=S0)) |
27   (state=S5 & (r & t & !p) & next(state=S1)) |
28   (state=S5 & ((r & !t) | (r & t & p)) & next(state=S2)) |
29   (state=S5 & (!r & t & !p & !s) & next(state=S3)) |
30   (state=S5 & (!r & t & !p & s) & next(state=S4)) |
31   (state=S5 & ((!r & !t) | (!r & t & p & s)) & next(state=S5)));
32
33 LTLSPEC -- equivalence of satisfaction
34   (G F (state=S1));

```

Listing 78: GR(1) template for negated LTL semantics of pattern 42

## Pattern43

**Kind:** Response Chain: p responds to s,t

**Scope:** After q

**LTL:**

```
G (!q || G (X(!t U (t && F p)) || !(s && XF t)))
```

The GR(1) template for the LTL semantics of pattern 43 is shown in Listing 79.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!q) & next (state=S0)) |
9    (state=S0 & (q & !s) & next (state=S1)) |
10   (state=S0 & (q & s) & next (state=S3)) |
11   (state=S1 & (!s) & next (state=S1)) |
12   (state=S1 & (s) & next (state=S3)) |
13   (state=S2 & (p & !s) & next (state=S1)) |
14   (state=S2 & (!p & !s) & next (state=S2)) |
15   (state=S2 & (p & s) & next (state=S3)) |
16   (state=S2 & (!p & s) & next (state=S4)) |
17   (state=S3 & (t & p & !s) & next (state=S1)) |
18   (state=S3 & (t & !p & !s) & next (state=S2)) |
19   (state=S3 & ((!t) | (t & p & s)) & next (state=S3)) |
20   (state=S3 & (t & !p & s) & next (state=S4)) |
21   (state=S4 & (t & p & !s) & next (state=S1)) |
22   (state=S4 & (t & !p & !s) & next (state=S2)) |
23   (state=S4 & ((!t & p) | (t & p & s)) & next (state=S3)) |
24   (state=S4 & ((!t & !p) | (t & !p & s)) & next (state=S4)));
25
26 LTLSPEC -- equivalence of satisfaction
27   (G F (state=S0 | state=S1 | state=S3));
```

Listing 79: GR(1) template for pattern 43

No GR(1) template for negated LTL semantics of pattern 43.

## Pattern44

**Kind:** Response Chain: p responds to s,t

**Scope:** Between q and r

**LTL:**

```
G ((X(!r U (t && F p)) || !(s && X(!r U t))) U r) || !(q && F r)
```

The GR(1) template for the LTL semantics of pattern 44 is shown in Listing 80.

**No GR(1) template for negated LTL semantics of pattern 44.**

```

1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4, S5, S6, S7};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!q) | (r & q)) & next(state=S0)) |
9   (state=S0 & (!r & !s & q) & next(state=S2)) |
10  (state=S0 & (!r & s & q) & next(state=S4)) |
11  (state=S1 & (r & p) & next(state=S0)) |
12  (state=S1 & ((!r & !t & !p) | (!r & t & !p & s)) & next(state=S1)) |
13  (state=S1 & (!r & t & p & !s) & next(state=S2)) |
14  (state=S1 & ((!r & !t & p) | (!r & t & p & s)) & next(state=S4)) |
15  (state=S1 & (!r & t & !p & !s) & next(state=S5)) |
16  (state=S1 & (r & !p) & next(state=S7)) |
17  (state=S2 & (r) & next(state=S0)) |
18  (state=S2 & (!r & !s) & next(state=S2)) |
19  (state=S2 & (!r & s) & next(state=S4)) |
20  (state=S3 & (r & p) & next(state=S0)) |
21  (state=S3 & (!r & t & p & !s) & next(state=S2)) |
22  (state=S3 & ((!r & !t & !p) | (!r & t & !p & s)) & next(state=S3)) |
23  (state=S3 & ((!r & !t & p) | (!r & t & p & s)) & next(state=S4)) |
24  (state=S3 & (!r & t & !p & !s) & next(state=S6)) |
25  (state=S3 & (r & !p) & next(state=S7)) |
26  (state=S4 & ((r & !t) | (r & t & p)) & next(state=S0)) |
27  (state=S4 & (!r & t & !p & s) & next(state=S1)) |
28  (state=S4 & (!r & t & p & !s) & next(state=S2)) |
29  (state=S4 & ((!r & !t) | (!r & t & p & s)) & next(state=S4)) |
30  (state=S4 & (!r & t & !p & !s) & next(state=S5)) |
31  (state=S4 & (r & t & !p) & next(state=S7)) |
32  (state=S5 & (r & p) & next(state=S0)) |
33  (state=S5 & (!r & !p & s) & next(state=S1)) |
34  (state=S5 & (!r & p & !s) & next(state=S2)) |
35  (state=S5 & (!r & p & s) & next(state=S4)) |
36  (state=S5 & (!r & !p & !s) & next(state=S5)) |
37  (state=S5 & (r & !p) & next(state=S7)) |
38  (state=S6 & (r & p) & next(state=S0)) |
39  (state=S6 & (!r & p & !s) & next(state=S2)) |
40  (state=S6 & (!r & !p & s) & next(state=S3)) |
41  (state=S6 & (!r & p & s) & next(state=S4)) |
42  (state=S6 & (!r & !p & !s) & next(state=S6)) |
43  (state=S6 & (r & !p) & next(state=S7)) |
44  (state=S7 & ((p & !q) | (r & p & q)) & next(state=S0)) |
45  (state=S7 & (!r & p & !s & q) & next(state=S2)) |
46  (state=S7 & (!r & !p & s & q) & next(state=S3)) |
47  (state=S7 & (!r & p & s & q) & next(state=S4)) |
48  (state=S7 & (!r & !p & !s & q) & next(state=S6)) |
49  (state=S7 & ((!p & !q) | (r & !p & q)) & next(state=S7));
50
51 LTLSPEC -- equivalence of satisfaction
52  (G F (state=S0 | state=S1 | state=S2 | state=S4 | state=S5));

```

Listing 80: GR(1) template for pattern 44

## Pattern45

**Kind:** Response Chain: p responds to s,t

**Scope:** After q until r

**LTL:**

```
G (!q || ((X(!r U (t && F p)) || !(s && X(!r U t))) U (r || G (X(!r U (t && F p)) || !(s && X(!r U t)))))
```

The GR(1) template for the LTL semantics of pattern 45 is shown in Listing 81.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4, S5};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & ((!q) | (q & r)) & next(state=S0)) |
9   (state=S0 & (q & !r & !s) & next(state=S1)) |
10  (state=S0 & (q & !r & s) & next(state=S3)) |
11  (state=S1 & (r) & next(state=S0)) |
12  (state=S1 & (!r & !s) & next(state=S1)) |
13  (state=S1 & (!r & s) & next(state=S3)) |
14  (state=S2 & (r & p) & next(state=S0)) |
15  (state=S2 & (!r & p & !s) & next(state=S1)) |
16  (state=S2 & (!r & !p & !s) & next(state=S2)) |
17  (state=S2 & (!r & p & s) & next(state=S3)) |
18  (state=S2 & (r & !p) & next(state=S4)) |
19  (state=S2 & (!r & !p & s) & next(state=S5)) |
20  (state=S3 & ((r & !t) | (r & t & p)) & next(state=S0)) |
21  (state=S3 & (!r & t & p & !s) & next(state=S1)) |
22  (state=S3 & (!r & t & !p & !s) & next(state=S2)) |
23  (state=S3 & ((!r & !t) | (!r & t & p & s)) & next(state=S3)) |
24  (state=S3 & (r & t & !p) & next(state=S4)) |
25  (state=S3 & (!r & t & !p & s) & next(state=S5)) |
26  (state=S4 & ((!q & p) | (q & r & p)) & next(state=S0)) |
27  (state=S4 & (q & !r & p & !s) & next(state=S1)) |
28  (state=S4 & (q & !r & !p & !s) & next(state=S2)) |
29  (state=S4 & (q & !r & p & s) & next(state=S3)) |
30  (state=S4 & ((!q & !p) | (q & r & !p)) & next(state=S4)) |
31  (state=S4 & (q & !r & !p & s) & next(state=S5)) |
32  (state=S5 & (r & p) & next(state=S0)) |
33  (state=S5 & (!r & t & p & !s) & next(state=S1)) |
34  (state=S5 & (!r & t & !p & !s) & next(state=S2)) |
35  (state=S5 & ((!r & !t & p) | (!r & t & p & s)) & next(state=S3)) |
36  (state=S5 & (r & !p) & next(state=S4)) |
37  (state=S5 & ((!r & !t & !p) | (!r & t & !p & s)) & next(state=S5));
38
39 LTLSPEC -- equivalence of satisfaction
40   (G F (state=S0 | state=S1 | state=S3));
```

Listing 81: GR(1) template for pattern 45

No GR(1) template for negated LTL semantics of pattern 45.

## Pattern46

**Kind:** Response Chain: s,t responds to p

**Scope:** Globally

**LTL:**

```
G (!p || F (s && XF t))
```

The GR(1) template for the LTL semantics of pattern 46 is shown in Listing 82.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!p) & next (state=S0)) |
9    (state=S0 & (p & !s) & next (state=S1)) |
10   (state=S0 & (p & s) & next (state=S4)) |
11   (state=S1 & (!s) & next (state=S1)) |
12   (state=S1 & (s) & next (state=S3)) |
13   (state=S2 & (!s & t) & next (state=S1)) |
14   (state=S2 & (!s & !t) & next (state=S2)) |
15   (state=S2 & (s & t) & next (state=S3)) |
16   (state=S2 & (s & !t) & next (state=S4)) |
17   (state=S3 & (!p & t) & next (state=S0)) |
18   (state=S3 & (p & !s & t) & next (state=S1)) |
19   (state=S3 & (p & !s & !t) & next (state=S2)) |
20   (state=S3 & (p & s & t) & next (state=S3)) |
21   (state=S3 & ((!p & !t) | (p & s & !t)) & next (state=S4)) |
22   (state=S4 & (!p & t) & next (state=S0)) |
23   (state=S4 & (p & !s & t) & next (state=S1)) |
24   (state=S4 & (p & !s & !t) & next (state=S2)) |
25   (state=S4 & (p & s & t) & next (state=S3)) |
26   (state=S4 & ((!p & !t) | (p & s & !t)) & next (state=S4)));
27
28 LTLSPEC -- equivalence of satisfaction
29   (G F (state=S0 | state=S3));
```

Listing 82: GR(1) template for pattern 46

**No GR(1) template for negated LTL semantics of pattern 46.**

## Pattern47

**Kind:** Response Chain: s,t responds to p

**Scope:** Before r

**LTL:**

```
((!p || (!r U (!r U (&& s && X(!r U t)))) U r) || !F r
```

The GR(1) template for the LTL semantics of pattern 47 is shown in Listing 83.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!r & !p) & next(state=S0)) |
9    (state=S0 & (r) & next(state=S1)) |
10  (state=S0 & (!r & p & !s) & next(state=S2)) |
11  (state=S0 & (!r & p & s) & next(state=S3)) |
12  (state=S1 & TRUE & next(state=S1)) |
13  (state=S2 & (!r & !s) & next(state=S2)) |
14  (state=S2 & (!r & s) & next(state=S3)) |
15  (state=S2 & (r) & next(state=S4)) |
16  (state=S3 & (!r & !p & t) & next(state=S0)) |
17  (state=S3 & (r & t) & next(state=S1)) |
18  (state=S3 & (!r & p & !s) & next(state=S2)) |
19  (state=S3 & ((!r & !p & !t) | (!r & p & s)) & next(state=S3)) |
20  (state=S3 & (r & !t) & next(state=S4)) |
21  (state=S4 & TRUE & next(state=S4));
22
23 LTLSPEC -- equivalence of satisfaction
24  (G F (state=S0 | state=S1 | state=S2 | state=S3));
```

Listing 83: GR(1) template for pattern 47

The GR(1) template for the negated LTL semantics of pattern 47 is shown in Listing 84.

```

1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!r & !p) & next(state=S0)) |
9    (state=S0 & (r) & next(state=S1)) |
10  (state=S0 & (!r & !s & p) & next(state=S2)) |
11  (state=S0 & (!r & s & p) & next(state=S3)) |
12  (state=S1 & TRUE & next(state=S1)) |
13  (state=S2 & (!r & !s) & next(state=S2)) |
14  (state=S2 & (!r & s) & next(state=S3)) |
15  (state=S2 & (r) & next(state=S4)) |
16  (state=S3 & (!r & t & !p) & next(state=S0)) |
17  (state=S3 & (r & t) & next(state=S1)) |
18  (state=S3 & (!r & !s & p) & next(state=S2)) |
19  (state=S3 & ((!r & !t & !p) | (!r & s & p)) & next(state=S3)) |
20  (state=S3 & (r & !t) & next(state=S4)) |
21  (state=S4 & TRUE & next(state=S4)));
22
23 LTLSPEC -- equivalence of satisfaction
24   (G F (state=S4));

```

Listing 84: GR(1) template for negated LTL semantics of pattern 47

## Pattern48

**Kind:** Response Chain: s,t responds to p

**Scope:** After q

**LTL:**

```
G (!q || G (!p || (s && XF t)))
```

The GR(1) template for the LTL semantics of pattern 48 is shown in Listing 85.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!q) & next(state=S0)) |
9    (state=S0 & (q & !p) & next(state=S1)) |
10   (state=S0 & (q & p & !s) & next(state=S2)) |
11   (state=S0 & (q & p & s) & next(state=S3)) |
12   (state=S1 & (!p) & next(state=S1)) |
13   (state=S1 & (p & !s) & next(state=S2)) |
14   (state=S1 & (p & s) & next(state=S4)) |
15   (state=S2 & TRUE & next(state=S2)) |
16   (state=S3 & (!p & t) & next(state=S1)) |
17   (state=S3 & (p & !s) & next(state=S2)) |
18   (state=S3 & ((!p & !t) | (p & s)) & next(state=S4)) |
19   (state=S4 & (!p & t) & next(state=S1)) |
20   (state=S4 & (p & !s) & next(state=S2)) |
21   (state=S4 & (p & s & t) & next(state=S3)) |
22   (state=S4 & ((!p & !t) | (p & s & !t)) & next(state=S4));
23
24 LTLSPEC -- equivalence of satisfaction
25   (G F (state=S0 | state=S1 | state=S3));
```

Listing 85: GR(1) template for pattern 48

No GR(1) template for negated LTL semantics of pattern 48.

## Pattern49

**Kind:** Response Chain: s,t responds to p

**Scope:** Between q and r

**LTL:**

```
G (((!p || (!r U (!r && s && X(!r U t)))) U r) || !(q && F r))
```

The GR(1) template for the LTL semantics of pattern 49 is shown in Listing 86.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & ((!q) | (r & q)) & next(state=S0)) |
9   (state=S0 & (!r & p & s & q) & next(state=S1)) |
10  (state=S0 & (!r & p & !s & q) & next(state=S2)) |
11  (state=S0 & (!r & !p & q) & next(state=S4)) |
12  (state=S1 & (r & t) & next(state=S0)) |
13  (state=S1 & ((!r & !p & !t) | (!r & p & s)) & next(state=S1)) |
14  (state=S1 & (!r & p & !s) & next(state=S2)) |
15  (state=S1 & (r & !t) & next(state=S3)) |
16  (state=S1 & (!r & !p & t) & next(state=S4)) |
17  (state=S2 & (!r & s) & next(state=S1)) |
18  (state=S2 & (!r & !s) & next(state=S2)) |
19  (state=S2 & (r) & next(state=S3)) |
20  (state=S3 & TRUE & next(state=S3)) |
21  (state=S4 & (r) & next(state=S0)) |
22  (state=S4 & (!r & p & s) & next(state=S1)) |
23  (state=S4 & (!r & p & !s) & next(state=S2)) |
24  (state=S4 & (!r & !p) & next(state=S4)));
25
26 LTLSPEC -- equivalence of satisfaction
27  (G F (state=S0 | state=S1 | state=S2 | state=S4));
```

Listing 86: GR(1) template for pattern 49

The GR(1) template for the negated LTL semantics of pattern 49 is shown in Listing 87.

```

1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & ((!q) | (r & q)) & next(state=S0)) |
9   (state=S0 & (!r & !p & q) & next(state=S1)) |
10  (state=S0 & (!r & !s & p & q) & next(state=S2)) |
11  (state=S0 & (!r & s & p & q) & next(state=S3)) |
12  (state=S1 & (r) & next(state=S0)) |
13  (state=S1 & (!r & !p) & next(state=S1)) |
14  (state=S1 & (!r & !s & p) & next(state=S2)) |
15  (state=S1 & (!r & s & p) & next(state=S3)) |
16  (state=S2 & (!r & !s) & next(state=S2)) |
17  (state=S2 & (!r & s) & next(state=S3)) |
18  (state=S2 & (r) & next(state=S4)) |
19  (state=S3 & (r & t) & next(state=S0)) |
20  (state=S3 & (!r & t & !p) & next(state=S1)) |
21  (state=S3 & (!r & !s & p) & next(state=S2)) |
22  (state=S3 & ((!r & !t & !p) | (!r & s & p)) & next(state=S3)) |
23  (state=S3 & (r & !t) & next(state=S4)) |
24  (state=S4 & TRUE & next(state=S4));
25
26 LTLSPEC -- equivalence of satisfaction
27   (G F (state=S4));

```

Listing 87: GR(1) template for negated LTL semantics of pattern 49

## Pattern50

**Kind:** Response Chain: s,t responds to p

**Scope:** After q until r

**LTL:**

```
G (!q || ((!p || (!r U (!r && s && X(!r U t)))) U (r || G (!p || (s && XF t)))))
```

No GR(1) template.

No GR(1) template for negated LTL semantics of pattern 50.

## Pattern51

**Kind:** Constrained Chain: s,t without z responds to p

**Scope:** Globally

**LTL:**

```
G (!p || F (s && !z && X(!z U t)))
```

The GR(1) template for the LTL semantics of pattern 51 is shown in Listing 88.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4, S5};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!p) & next (state=S0)) |
9    (state=S0 & ((p & !s) | (p & s & z)) & next (state=S2)) |
10   (state=S0 & (p & s & !z) & next (state=S3)) |
11   (state=S1 & (!p & t) & next (state=S0)) |
12   (state=S1 & ((p & !s & t) | (p & s & z & t)) & next (state=S2)) |
13   (state=S1 & ((!p & !z & !t) | (p & s & !z)) & next (state=S3)) |
14   (state=S1 & ((p & !s & !t) | (!p & z & !t) | (p & s & z & !t)) & next (state=S4)) |
15   (state=S2 & (s & !z & t) & next (state=S1)) |
16   (state=S2 & (!s & !z & !t) & next (state=S2)) |
17   (state=S2 & (s & !z & !t) & next (state=S3)) |
18   (state=S2 & (z & !t) & next (state=S4)) |
19   (state=S2 & ((!s & t) | (s & z & t)) & next (state=S5)) |
20   (state=S3 & (!p & t) & next (state=S0)) |
21   (state=S3 & (p & s & !z & t) & next (state=S1)) |
22   (state=S3 & (p & !s & !z & !t) & next (state=S2)) |
23   (state=S3 & ((!p & !z & !t) | (p & s & !z & !t)) & next (state=S3)) |
24   (state=S3 & (z & !t) & next (state=S4)) |
25   (state=S3 & ((p & !s & t) | (p & s & z & t)) & next (state=S5)) |
26   (state=S4 & (s & !z) & next (state=S3)) |
27   (state=S4 & ((!s) | (s & z)) & next (state=S4)) |
28   (state=S5 & (s & !z) & next (state=S3)) |
29   (state=S5 & ((!s) | (s & z)) & next (state=S4)));
30
31 LTLSPEC -- equivalence of satisfaction
32 (G F (state=S0 | state=S1 | state=S5));
```

Listing 88: GR(1) template for pattern 51

**No GR(1) template for negated LTL semantics of pattern 51.**

## Pattern52

**Kind:** Constrained Chain: s,t without z responds to p

**Scope:** Before r

**LTL:**

```
((!p || (!r U (!r && s && !z && X(!r && !z) U t))) U r) || !F r
```

The GR(1) template for the LTL semantics of pattern 52 is shown in Listing 89.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!r & !p) & next(state=S0)) |
9    (state=S0 & (r) & next(state=S1)) |
10   (state=S0 & ((!r & p & !s) | (!r & p & s & z)) & next(state=S3)) |
11   (state=S0 & (!r & p & s & !z) & next(state=S4)) |
12   (state=S1 & TRUE & next(state=S1)) |
13   (state=S2 & TRUE & next(state=S2)) |
14   (state=S3 & (r) & next(state=S2)) |
15   (state=S3 & ((!r & !s) | (!r & s & z)) & next(state=S3)) |
16   (state=S3 & (!r & s & !z) & next(state=S4)) |
17   (state=S4 & (!r & !p & t) & next(state=S0)) |
18   (state=S4 & (r & t) & next(state=S1)) |
19   (state=S4 & (r & !t) & next(state=S2)) |
20   (state=S4 & ((!r & p & !s) | (!r & !p & z & !t) | (!r & p & s & z)) & next(state=
21     S3)) |
22   (state=S4 & ((!r & !p & !z & !t) | (!r & p & s & !z)) & next(state=S4));
23
24 LTLSPEC -- equivalence of satisfaction
25   (G F (state=S0 | state=S1 | state=S3 | state=S4));
```

Listing 89: GR(1) template for pattern 52

The GR(1) template for the negated LTL semantics of pattern 52 is shown in Listing 90.

```

1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!r & !p) & next(state=S0)) |
9   (state=S0 & (r) & next(state=S1)) |
10  (state=S0 & ((!r & !s & !z & p) | (!r & z & p)) & next(state=S2)) |
11  (state=S0 & (!r & s & !z & p) & next(state=S3)) |
12  (state=S1 & TRUE & next(state=S1)) |
13  (state=S2 & ((!r & !s & !z) | (!r & z)) & next(state=S2)) |
14  (state=S2 & (!r & s & !z) & next(state=S3)) |
15  (state=S2 & (r) & next(state=S4)) |
16  (state=S3 & (!r & t & !p) & next(state=S0)) |
17  (state=S3 & (r & t) & next(state=S1)) |
18  (state=S3 & ((!r & !t & z) | (!r & !s & !z & p) | (!r & t & z & p)) & next(state=
19  S2)) |
20  (state=S3 & ((!r & !t & !z & !p) | (!r & s & !z & p)) & next(state=S3)) |
21  (state=S3 & (r & !t) & next(state=S4)) |
22  (state=S4 & TRUE & next(state=S4)));
23
24 LTLSPEC -- equivalence of satisfaction
25   (G F (state=S4));

```

Listing 90: GR(1) template for negated LTL semantics of pattern 52

## Pattern53

**Kind:** Constrained Chain: s,t without z responds to p

**Scope:** After q

**LTL:**

```
G (!q || G (!p || (s && !z && X(!z U t))))
```

The GR(1) template for the LTL semantics of pattern 53 is shown in Listing 91.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & (!q) & next(state=S0)) |
9    (state=S0 & (q & !p) & next(state=S1)) |
10   (state=S0 & (q & p & s & !z) & next(state=S2)) |
11   (state=S0 & ((q & p & !s) | (q & p & s & z)) & next(state=S4)) |
12   (state=S1 & (!p) & next(state=S1)) |
13   (state=S1 & (p & s & !z) & next(state=S2)) |
14   (state=S1 & ((p & !s) | (p & s & z)) & next(state=S4)) |
15   (state=S2 & (!p & t) & next(state=S1)) |
16   (state=S2 & ((!p & !z & !t) | (p & s & !z & !t)) & next(state=S2)) |
17   (state=S2 & (p & s & !z & t) & next(state=S3)) |
18   (state=S2 & ((p & !s) | (!p & z & !t) | (p & s & z)) & next(state=S4)) |
19   (state=S3 & (!p & t) & next(state=S1)) |
20   (state=S3 & ((!p & !z & !t) | (p & s & !z)) & next(state=S2)) |
21   (state=S3 & ((p & !s) | (!p & z & !t) | (p & s & z)) & next(state=S4)) |
22   (state=S4 & TRUE & next(state=S4)));
23
24 LTLSPEC -- equivalence of satisfaction
25   (G F (state=S0 | state=S1 | state=S3));
```

Listing 91: GR(1) template for pattern 53

**No GR(1) template for negated LTL semantics of pattern 53.**

## Pattern54

**Kind:** Constrained Chain: s,t without z responds to p

**Scope:** Between q and r

**LTL:**

```
G (((!p || (!r U (!r && s && !z && X((!r && !z) U t)))) U r) || !(q && F r))
```

The GR(1) template for the LTL semantics of pattern 54 is shown in Listing 92.

```
1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & ((!q) | (r & q)) & next(state=S0)) |
9   (state=S0 & ((!r & p & !s & q) | (!r & p & s & z & q)) & next(state=S1)) |
10  (state=S0 & (!r & !p & q) & next(state=S3)) |
11  (state=S0 & (!r & p & s & !z & q) & next(state=S4)) |
12  (state=S1 & ((!r & !s) | (!r & s & z)) & next(state=S1)) |
13  (state=S1 & (r) & next(state=S2)) |
14  (state=S1 & (!r & s & !z) & next(state=S4)) |
15  (state=S2 & TRUE & next(state=S2)) |
16  (state=S3 & (r) & next(state=S0)) |
17  (state=S3 & ((!r & p & !s) | (!r & p & s & z)) & next(state=S1)) |
18  (state=S3 & (!r & !p) & next(state=S3)) |
19  (state=S3 & (!r & p & s & !z) & next(state=S4)) |
20  (state=S4 & (r & t) & next(state=S0)) |
21  (state=S4 & ((!r & p & !s) | (!r & !p & z & !t) | (!r & p & s & z)) & next(state=
22    S1)) |
23  (state=S4 & (r & !t) & next(state=S2)) |
24  (state=S4 & (!r & !p & t) & next(state=S3)) |
25  (state=S4 & ((!r & !p & !z & !t) | (!r & p & s & !z)) & next(state=S4));
26
27 LTLSPEC -- equivalence of satisfaction
28   (G F (state=S0 | state=S1 | state=S3 | state=S4));
```

Listing 92: GR(1) template for pattern 54

The GR(1) template for the negated LTL semantics of pattern 54 is shown in Listing 93.

```

1 VAR -- auxiliary variables States of DBW
2   state : { S0, S1, S2, S3, S4};
3
4 INIT -- initial assignments: initial state
5   state=S0;
6
7 TRANS -- safety this and next state
8   ((state=S0 & ((!q) | (r & q)) & next(state=S0)) |
9   (state=S0 & (!r & !p & q) & next(state=S1)) |
10  (state=S0 & ((!r & !s & !z & p & q) | (!r & z & p & q)) & next(state=S2)) |
11  (state=S0 & (!r & s & !z & p & q) & next(state=S3)) |
12  (state=S1 & (r) & next(state=S0)) |
13  (state=S1 & (!r & !p) & next(state=S1)) |
14  (state=S1 & ((!r & !s & !z & p) | (!r & z & p)) & next(state=S2)) |
15  (state=S1 & (!r & s & !z & p) & next(state=S3)) |
16  (state=S2 & ((!r & !s & !z) | (!r & z)) & next(state=S2)) |
17  (state=S2 & (!r & s & !z) & next(state=S3)) |
18  (state=S2 & (r) & next(state=S4)) |
19  (state=S3 & (r & t) & next(state=S0)) |
20  (state=S3 & (!r & t & !p) & next(state=S1)) |
21  (state=S3 & ((!r & !t & z) | (!r & !s & !z & p) | (!r & t & z & p)) & next(state=
22    S2)) |
23  (state=S3 & ((!r & !t & !z & !p) | (!r & s & !z & p)) & next(state=S3)) |
24  (state=S3 & (r & !t) & next(state=S4)) |
25  (state=S4 & TRUE & next(state=S4));
26
27 LTLSPEC -- equivalence of satisfaction
28   (G F (state=S4));

```

Listing 93: GR(1) template for negated LTL semantics of pattern 54

## Pattern55

**Kind:** Constrained Chain: s,t without z responds to p

**Scope:** After q until r

**LTL:**

```
G (!q || ((!p || (!r U (!r && s && !z && X((!r && !z) U t)))) U (r || G (!p || (s && !z && X(!z U t)))))
```

No GR(1) template.

No GR(1) template for negated LTL semantics of pattern 55.