TaskBuilder

Tutorial and Reference Manual

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www.taitcommunications.com

Contact Information

Tait Communications

Corporate Head Office

Tait International Limited
P.O. Box 1645
Christchurch
New Zealand

Imported into the EU by:	Imported into the UK by:
Tait Communications GmbH	Tait Europe Limited
Strozzigasse 10/14	Unit A, Buckingway Business Park
Vienna 1080	Anderson Road
Austria	Swavesey
	Cambridge, CB24 4UQ
	United Kingdom

For the address and telephone number of regional offices, refer to our website: www.taitcommunications.com

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Contents

Preface

Scope of Manual

TaskBuilder allows the system designer to create rules that respond to base station conditions and events, and control base station operation. Examples of use include: select a channel based upon digital input states, drive a metallic hardware output on a defined alarm condition, and lock out the transmitter after a defined transmission time.

This manual introduces TaskBuilder through examples with explanations and provides a complete language reference.

It is intended to assist those who are responsible for designing, commissioning and maintaining systems. See Associated Documentation below below for more specific information on base station configuration.

New in this Release

Variables for control over generating a coverage test signal. Note that these new variables are only supported by Series 2 reciters.

Other improvements, such as a counter, and a Clear button for the trace viewer.

See Change History on page 87 for a complete description of all changes to TaskBuilder.

Alerts

This alert is used to highlight significant information that may be required to ensure that you perform procedures correctly, or to draw your attention to ways of doing things that can improve your efficiency or effectiveness.

Associated Documentation

The following associated documentation for this product is available on the Tait Partner Portal website (https://partnerinfo.taitcommunications.com).

- TB9400 Installation and Operation Manual (MBC-00001-xx)
- TB9400 Specifications Manual (MBC-00002-xx)
- TB9300 Installation and Operation Manual (MBC-00008-xx)
- TB9300 Specifications Manual (MBC-00009-xx)
- TB7300 Installation and Operation Manual (MBD-00001-xx)

- TB7300 Specifications Manual (MBD-00002-xx)
- DMR Channel Group System Manual (MNB-00010-xx)
- P25 and AS-IP Channel Group System Manual (MND-00002-xx)

The characters xx represent the latest issue number of the documentation.

Publication Record

Issue	Publication Date	Description
7	August 2024	Series 2 reciter standard variables added: • `counter` • `function-code-receive` • `function-code-send` • `rx-subaudible-detector` • `carrier-tx-generator` • `fm-tx-generator` • `p25-phase1-tx-generator` Clear button added to Monitor > TaskBuilder.
6	June 2024	Add `tx-operation`, `rx-operation`, `rx-gate-state`, `tx-key-operation`, `tx-key-state`, `tone-remote-key-operation`, `tone-remote-key-state` and `rx-squelch-mode` standard variables.
5	December 2023	Add `tone-remote` and `call-profile` standard variables
4	August 2022	Corporate website domain update
3	October 2021	Updated with v3.25 content
2	April 2021	Updated with v3.20 content
1	March 2021	First release. V3.15

Tutorial Section

This section of the manual contains the following:

1 Getting Started

This chapter introduces TaskBuilder and provides a basic explanation of how to work with TaskBuilder programs.

1.1 Introducing TaskBuilder

TaskBuilder provides a way to control base station operation.

TaskBuilder allows the base station to:

- respond to alarms
- raise and clear custom alarms
- respond to digital inputs
- sense base station Tx
- activate digital outputs
- change the base station channel

TaskBuilder programs specify actions to take when given conditions are true and when specified events occur. Here is an example that sets the channel when the base station goes online:

```
// TaskBuilder Example 1

when: operation.running then: channel => 2
```

Double slash (//) denotes a comment. Comments can appear on a line following TaskBuilder statements, or on a line by themselves. The TaskBuilder compiler ignores comments, so you can use them freely to remind yourself what the program is supposed to do.

1.2 TaskBuilder Feature License

To use TaskBuilder you must have a TBAS073 TaskBuilder License. Contact Tait for more information.

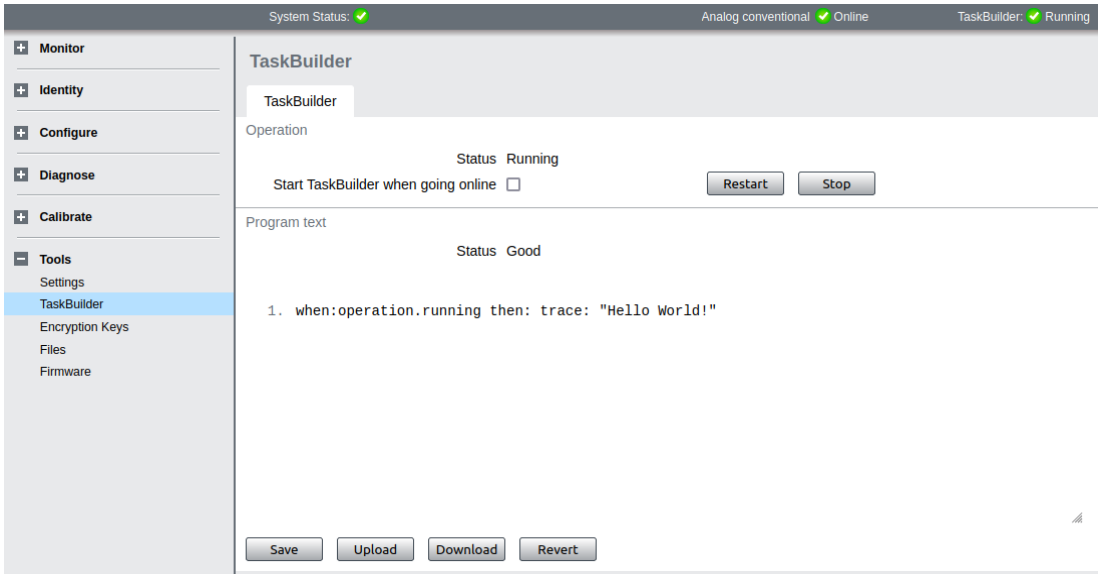
1.3 Running a TaskBuilder Program

The base station WebUI has two pages that allow you to control the operation of TaskBuilder and monitor its execution. See Monitoring TaskBuilder Execution on page 12 for information about monitoring.

The Tools > TaskBuilder page allows you to manage TaskBuilder programs, including the following:

- display TaskBuilder status
- start and stop TaskBuilder execution

- choose whether TaskBuilder should run when the base station goes online
- display the current TaskBuilder program text
- edit the TaskBuilder program
- display program errors, if any are present
- read a TaskBuilder program from your computer
- write a TaskBuilder program to your computer
- revert to the last working TaskBuilder program if the current TaskBuilder program text contains errors



1.3.1 Running Your First TaskBuilder Program

In this exercise, you will run the following basic example on the Base Station and observe the result.

```
// TaskBuilder Example 1

when: operation.running then: channel => 2
```

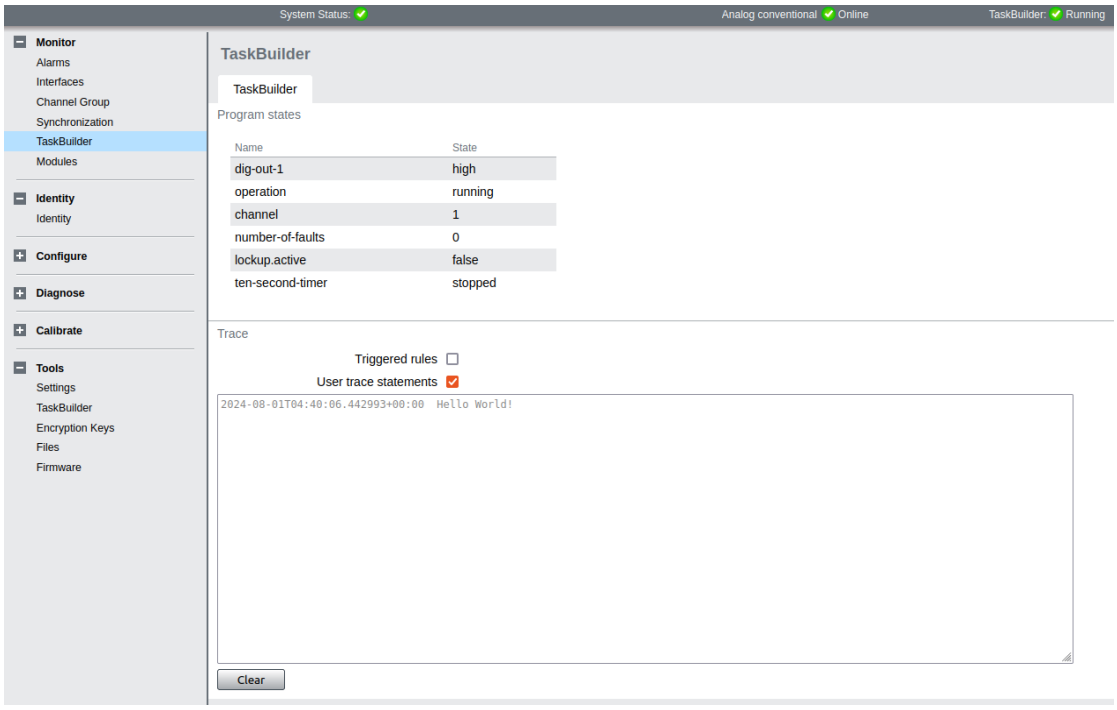
1. Set up channel 2 on the base station, or modify the program text above to reference a channel that is defined on the base station.
2. Ensure that your base station has a TaskBuilder feature license TBAS073.
3. Set the base station offline.
4. Go to the Tools > TaskBuilder page on the WebUI.
5. Type the program as shown above into the Program text area, and press Save.
6. Does the base station report it as good? If not, seeTroubleshooting on page 14.
7. Set the base station online. If "Start TaskBuilder when going online" is checked, the WebUI should show that TaskBuilder is running . If not, see Troubleshooting.

8. Check one of the RF monitoring screens. It should show that the base station channel is 2, and that the reason is TaskBuilder.
9. Look in the TaskBuilder trace log (Monitor > TaskBuilder > Trace). You should see the execution of the rule in the log along with a timestamp.

1.4 Monitoring TaskBuilder Execution

The TaskBuilder monitoring page on the base station Web UI (Monitor > TaskBuilder) allows you to verify that the TaskBuilder program is operating as expected:

- the Program states pane shows the states of your TaskBuilder program variables
- the Trace pane shows log output in real time
- you can choose what goes into the log. You can enable or disable log entries for triggered rules and trace actions.
- the Clear button can be used to clear the on-screen messages, this will not clear the log file



The Trace pane displays an execution history with two types of record:

1. Triggered rules, including the trigger (`when:` condition), and actions (`then:` condition). Triggered rules are useful as a record for what your TaskBuilder program did, and to confirm whether it is doing what you expect. The log of triggered rules can serve as a good test record.
2. User trace statements (when executed as part of an action). User trace statements give more targeted visibility into specific scenarios and conditions. If your program is not

doing what you expect, you can apply trace statements as a 'trail of breadcrumbs' to locate the point where your program operation diverged

Executing the example program above produces a log message similar to the following :

```
2020-11-27T03:16:56.077170 rule: when: operation.running then:
channel => 2
```

1.5 Trace Actions

One TaskBuilder action allows you to trace the execution of your program with a message that you specify. The trace message is written to the output log, and can report the current values of TaskBuilder variables.

Here is the set channel program from the example above with a trace message added:

```
// TaskBuilder Example 2: include a trace message
when: operation.running then:
{
channel => 2,
trace: "channel is ${channel}"
}
```

Running this program (with just user trace statements enabled) results in a log output similar to the following:

```
2021-08-29T23:49:34.170658 channel is 2
```

Tips:

It can be useful to enable logging of rules when first verifying the operation of a new TaskBuilder program. The logs will show when:

- the expected events occurred, the corresponding rules triggered
- the rule actions were taken

Once you are confident in program operation, disable the rules in the logs to keep the logs quiet and to minimize CPU overhead.

Add trace statements to your program when:

- some aspect of your program is not doing what you expect and you want more visibility, or
- to provide a longer term record of important events and outcomes which is less verbose than dumping all triggered rules in the log

1.6 Troubleshooting

If	Then
Program error	Check that the base station has the TaskBuilder license. Check your variables are spelled correctly. TaskBuilder keywords usually end in a colon: Did you forget to define your variable?
No visible result	Check the base station is online Try restarting TaskBuilder (Tools > TaskBuilder) Check that it compiled successfully (Tools > TaskBuilder) Does your script need a start-up trigger (`operation.running`)? Try adding a timer and digital I/O toggle and monitor the output.
Base station is not doing what I expected	Did you read the correct program file onto the base station? Check the log file against the rules in your program.
Base station is unresponsive	Reset the base station, and take it offline on the WebUI. Unselect 'Start TaskBuilder when going online' (Tools > TaskBuilder). Review the trace information in Monitor > TaskBuilder.

2 Digital Inputs and Outputs

The first exercise in this chapter toggles a digital output at one second intervals. Then we extend the example so that the output only toggles if another input is low.

The exercises introduce the use of digital inputs and outputs, timers, user-defined variables and `given:when:then:` rules.

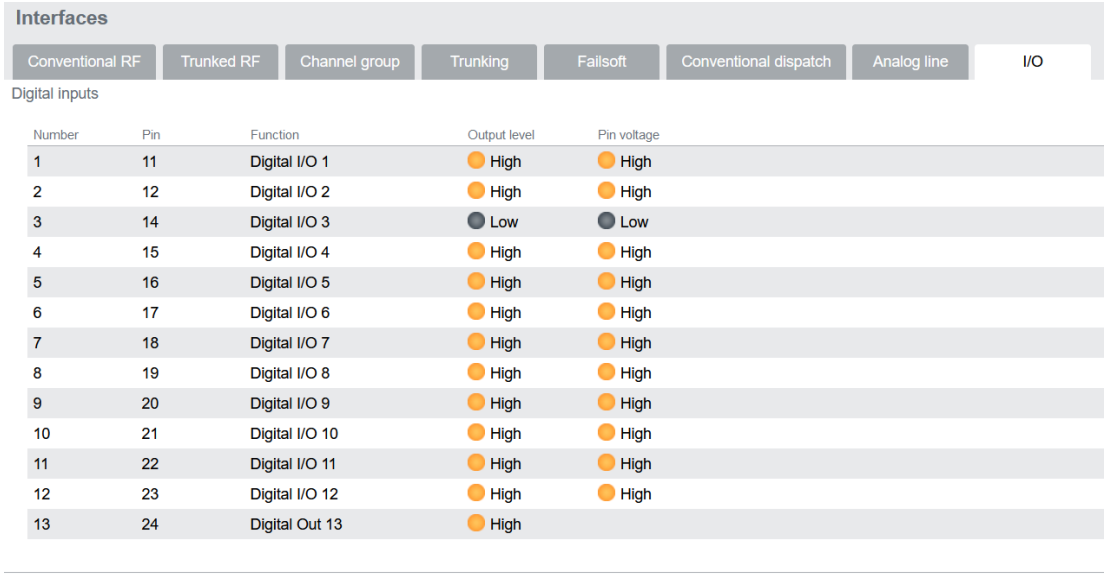
Toggling an output gives a visual indication that your TaskBuilder program is running, and could be a component of a high-availability (HA) set-up where one base station supervises another. The toggling output serves as a heart-beat.

The exercises in this chapter are set up so that you can enter the programs for yourself and see the results on the base station Web UI.

2.1 Digital I/O States

The base station has 12 digital I/O pins on the reciter DB-25 connector. (See the manuals for pinouts).

The Digital I/O monitoring page on the base station Web UI shows input and output states:

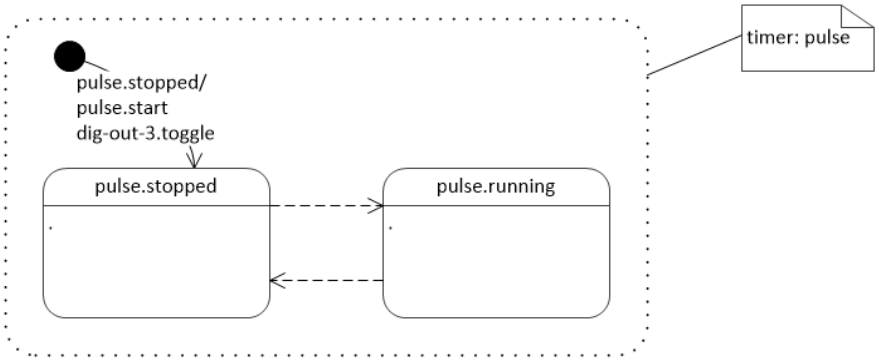


Number	Pin	Function	Output level	Pin voltage
1	11	Digital I/O 1	High	High
2	12	Digital I/O 2	High	High
3	14	Digital I/O 3	Low	Low
4	15	Digital I/O 4	High	High
5	16	Digital I/O 5	High	High
6	17	Digital I/O 6	High	High
7	18	Digital I/O 7	High	High
8	19	Digital I/O 8	High	High
9	20	Digital I/O 9	High	High
10	21	Digital I/O 10	High	High
11	22	Digital I/O 11	High	High
12	23	Digital I/O 12	High	High
13	24	Digital Out 13	High	

We distinguish inputs from outputs because each pin can function simultaneously as an input and output. Each pin has an output transistor which can pull the voltage level low, and a pullup resistor that allows the input to float high. If the base station output or an external input pulls the pin low, then the voltage on the pin will be low (the screenshot above shows the base station driving digital I/O 3 output low, with the input reading low as a result). No special initialization is required to use a digital I/O as an input. The digital output initialization values are high, which allows an external input to drive the pin into the desired logic state.

2.2 Using a Timer to Toggle the Output

First the state transition diagram and program text, then the explanation breaks down how it works:




```
// toggle digital output 3 at one second intervals
timer: pulse interval: 1 :s
when: pulse.stopped then: { pulse.start, dig-out-3.toggle }
```

The program defines a `timer` called `pulse` and a single rule which, when the timer is stopped, toggles the digital output and starts the timer.

TaskBuilder timers are standard variables that your program can create and initialize with a timer interval. You can have intervals as integer numbers of milliseconds, seconds, minutes and hours (denoted `:ms, :s, :min, :hour` respectively).

This example uses a 1 second timer. Timers have two states, `stopped` and `running`. The initial state of a timer is `stopped`. Timers respond to a `start` event which starts the timer running. After the timer interval, the timer generates an `expired` event, and becomes stopped. The example responds to `pulse.stopped` which the timer generates on entering the `stopped` state.

The `when:then:` rule has two actions, `{ dig-out-3.toggle, pulse.start }`. To perform multiple actions, separate them with commas and surround the actions with curly brackets. Note that white space is not significant, so the rule could also have been written like

```
when: pulse.stopped then:
{
pulse.start,
dig-out-3.toggle
}
```

Breaking statements on multiple lines like this can be useful if you want to include a comment with some of the actions.

`dig-out-3` is a TaskBuilder standard variable. As a variable it can be assigned high and low states (become `=>` operator), and it can respond to a `toggle` event.

2.2.1 Raising Events

`dig-out-3.toggle` and `pulse.start` are both events. You raise an event in a TaskBuilder action simply by writing the name of the event. Raising the event allows that event to trigger other rules in your program or base station actions. We have already seen that timers respond to a `start` event by going to their `running` state. Digital outputs respond to a `toggle` event by changing the output state from high to low or vice-versa.

TaskBuilder offers only two types of action. The become `=>` operator changes the state of a TaskBuilder variable. Raising an event can trigger other rules in your TaskBuilder program, or cause a pre-defined action in a standard variable (as is the case in this example).

2.2.2 Summary

What we learned in this exercise:

- digital I/Os are bidirectional - TaskBuilder can drive outputs and respond to inputs
- programs create instances of timer standard variables. Timers have intervals in the range of milliseconds to hours.
- the `then:` clause of a `when:then:` rule can have a list of actions. The actions are separated by commas, and the list of actions is surrounded by curly brackets `{ }`.
- you can freely use white-space in formatting TaskBuilder programs

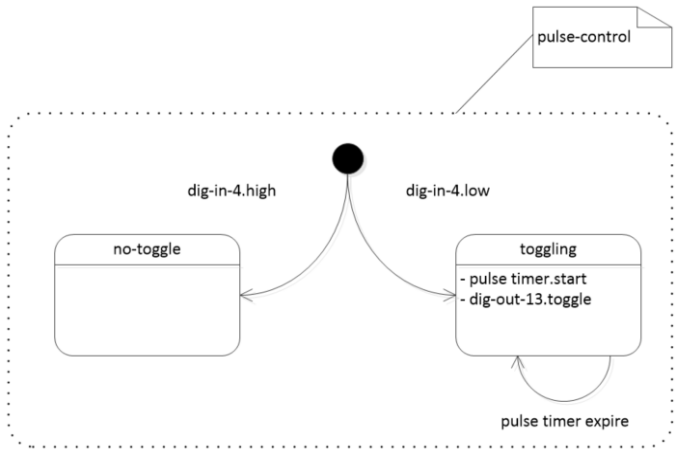
2.3 Toggle an Output Only When Digital Input 4 is Low

What if a digital output should only toggle when digital input 4 is low? This exercise introduces:

- stateful behaviors
- digital output 13 is an output-only pin, with current sinking capabilities suitable for driving a relay

> Digital output 13 is an output-only pin. TaskBuilder programs can change and respond to `dig-out-13`, but cannot reference the corresponding `dig-in-13`

The state transition diagram below shows what we want:



The program logic has two states. When digital input 4 is high, the no-toggle state does nothing interesting. When digital input 4 is low, a toggling state uses a timer to toggle digital output thirteen.

The equivalent TaskBuilder program matches the diagram:

```
// Toggle digital output 13 at one second intervals
// but only when digital input 4 is low

timer: pulse interval: 1 :s
// pulse control defines whether to toggle the output pin.
active: pulse-control has-states: { no-toggle, toggling }
when: dig-in-4.high then: pulse-control => no-toggle
when: dig-in-4.low then: pulse-control => toggling

// toggling
when: pulse-control.toggling then: { pulse.start, dig-out-13.toggle }

given: pulse-control.toggling
when: pulse.expire then: pulse-control => toggling
```

The free use of white-space visually aligns the different parts of each rule and quickly pick out what is relevant when reading the program.

Breaking the program down:

```
// pulse control defines whether to toggle the output pin.
active: pulse-control has-states: { no-toggle, toggling }
```

This line creates an active variable called `pulse-control` which can have two states: `no-toggle` and `toggling`. Making the states explicit lets us divide the problem in two parts:

1. What is the logic for deciding the state of `pulse-control`, and
2. What are the behaviors wanted for each distinct state.

The rules for defining which state is active are straight-forward to express:

```
when: dig-in-4.high then: pulse-control => no-toggle
when: dig-in-4.low then: pulse-control => toggling
```

`pulse-control` becomes `no-toggle` or `toggling` when a change in `dig-in-4` is detected.

The `no-toggle` state has no interesting behaviors, so it has no rules.

The `toggling` state should start the timer and toggle the digital output, as in the previous example:

```
when: pulse-control.toggling then: { pulse.start, dig-out-13.toggle }
```

Lastly, we need a rule for the expiry of the pulse timer. We already have a rule for `pulse-control.toggling` to perform those actions - so all that is necessary is to re-initialize `pulse-control`:

```
given: pulse-control.toggling when: pulse.expire then: pulse-control => toggling
```

This TaskBuilder statement adds a `given:` condition to the `when:then:` rule. The rule is only triggered if `pulse-control` is in the `toggling` state (because we only want to toggle the output in that state).

Because the `pulse-control.toggling` state already has a definition for the actions to perform on entering that state:

```
when: pulse-control.toggling then: { pulse.start, dig-out-13.toggle }
```

it is sufficient to simply re-enter the state when the timer expires (`pulse-control => toggling` above).

2.3.1 Active States and the `given:when:then` Rule

The `given:` clause of a `given:when:then:` rule must always be the fully qualified name of a state. A fully qualified state name is written in the form `variable-name.state-name` (such as `pulse-control.toggling`).

State names can be user defined active variables (as in this example), standard variable states (such as `dig-in-4.low`) or composite variable states (which are introduced in later examples).

The `given:when:then:` rule performs the specified actions `when:` the specified event occurs but only if the `given:` nominated state is active.

3 Set Channel on Start-Up

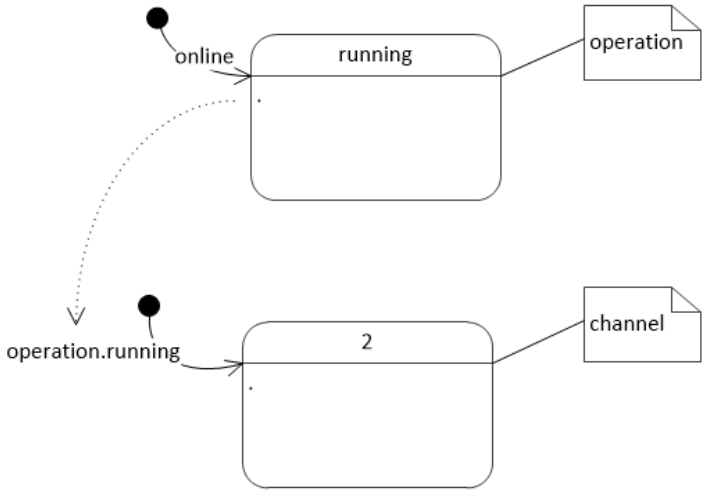
This chapter revisits the set channel examples and goes a bit more deeply into how to read it and recognize the different elements.

3.1 Example

Here it is again:

```
// TaskBuilder Example 1
when: operation.running then: channel => 2
```

The diagram provides a visualization of what happens:



The one-line TaskBuilder program relies on two variables:

- `operation` is a standard TaskBuilder variable. It has a single state called `running`, which becomes active at the time when TaskBuilder starts - when the base station is taken online via the base station WebUI.
- the other TaskBuilder variable is called `channel` which is described below

The text '`when: operation.running then: channel => 2`' is called a `when:then:` rule. `when:then:` rules have the form:

`when:` event `then:` do action(s)

In this rule, the triggering event is `operation.running` which as described above, occurs when the base station goes online and TaskBuilder starts running. That is the primary purpose of the `operation.running` variable is to provide an initialization event when TaskBuilder starts.

When a rule is triggered by an event, TaskBuilder carries out the action(s) in the `then:` clause. The rule in this example has one action: `channel => 2`. This action requests the base station to change channel:

- `channel` is a standard variable which represents the base station channel. TaskBuilder rules can react to the base station channel, and can change the base station channel.
- `=>` is the 'become' operator. The become operator changes the state of a TaskBuilder variable.

This TaskBuilder program also includes a comment. Comments are good places to remind the reader what the program is for and provide contextual information.

```
// This is a comment
```

Double forward slashes can follow TaskBuilder statements on the same line:

```
when: operation.running then: channel => 2 // base station goes
// online.
```

3.1.1 State Entry Events

The example uses two standard TaskBuilder variables: `operation` and `channel`. It relies on some specific properties that all variables share:

1. In the example, the rule is triggered by the '`when: operation.running`' part. `operation.running` is an event corresponding to `operation` becoming `running`. This is a property of all TaskBuilder variables: When a variable enters a state, TaskBuilder generates an event with the name of that state.
2. There are three actions that can cause a variable to enter a state:
    - base station operation - we saw that `2`is one possible `channel`. Whenever the base station changes channel the `channel` standard variable changes as well (and generates a state entry event).
    - start up - all TaskBuilder variables have an initial state when TaskBuilder begins running. The initial state of TaskBuilder output variables, those writable by TaskBuilder (see TaskBuilder Inputs and Actions) is the first listed state in that document.
    - a become action (eg: `channel => 2`) - even if the target state is active already, the become operator causes that variable to (re) enter that state.

3.1.2 Revert Channel on Exit

TaskBuilder can respond to exit events as well as start up events. Suppose you want the base station to be on channel 2 when TaskBuilder is running, but should be on channel 3 otherwise. You can do this using the `operation.stopping` event:

```
// Base station is on channel 2 when TaskBuilder is running and on
// channel 3 otherwise


when: operation.running then: channel => 2

when: operation.stopping then: channel => 3
```

On TaskBuilder exit (base station goes offline or user stops TaskBuilder from the Web UI), TaskBuilder will execute the actions for rules that include a `when: operation.stopping` clause. Those actions are the last to execute. So in the example above, the base station will be on channel 3 after the base station stops. If the actions for that rule trigger further rules (such as `when: channel.3`), those further rules are not triggered.

3.1.3 Summary

What we learned

- TaskBuilder variables have well defined states
- TaskBuilder generates state entry events when variables (re)enter a state. The name of the event is the name of the state (e.g. `operation.running`).
- `operation.running` is a start up event, which occurs when the variable `operation` enters its initial `running` state. It is a useful trigger for initialization actions.
- the when:then: rule specifies actions which should occur when triggered by the event specified in the `when:` condition
- `channel` is a standard variable which can be changed using the become => operator. The base station changes its channel in response to a `channel =>` become action.
- TaskBuilder recognizes everything following a double slash (`// This is a comment`) as commentary, and not part of the TaskBuilder program
- `operation.stopping` is the last event to be processed when TaskBuilder stops. You can use it to set the base station to a well defined operating state.

4 Select a Channel Using Digital Inputs

The exercises in this chapter show two approaches for selecting a channel based upon states of the base station digital inputs. It also introduces composite states which allow you to express combinations of states.

4.1 Using Two Inputs to Select Two Channels

Exercise: Write a program to select channel 20 on digital input 3 low and channel 21 on digital input 4 low.

The program is quite simple using what we have already learned:

```
// Select channel 20 on dig-input 3 low, and channel 21 on dig-input
// 4 low

when: dig-in-3.low then: channel => 20

when: dig-in-4.low then: channel => 21
```

You can generalize this simple example to more channels by adding more inputs and more rules.

Some questions to think about are:

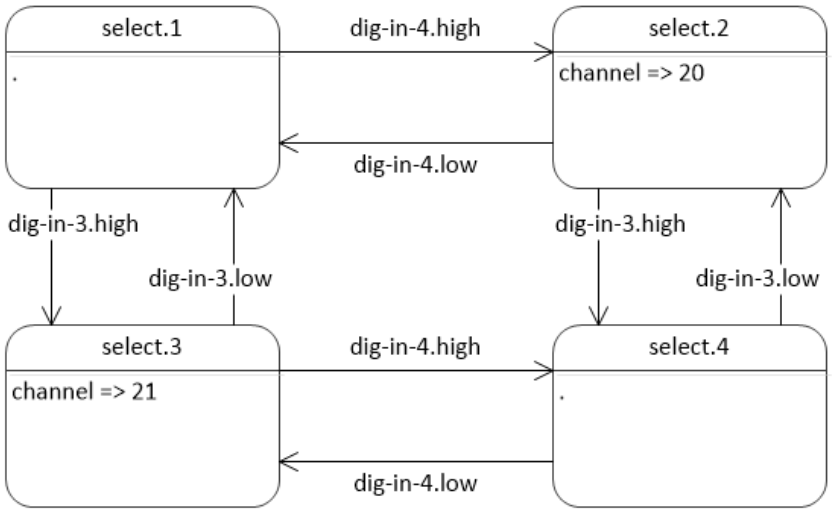
- what channel will the base station be on if both inputs are low?
- is it possible for digital inputs 3 and 4 to be high and low respectively, yet the base station is on channel 20?

If you are using a rotary switch to select the base station channel, this approach is probably fine. Rotary switches typically have a 'break before make' characteristic, so should not suffer from multiple inputs being low at the same time.

If you are using a switch or switches that could create intermediate states, you probably want to use logic such as the following:

- select channel 20 when digital input 4 is high AND digital input 3 is low
- select channel 21 when digital input 4 is low AND digital input 3 is high

How to create combinations of states? You could create a state variable and cover all of the possible states and transitions of digital inputs 3 & 4:



This is complex, easy to get wrong, and does not scale.

4.2 Composite States

Composite states allow you to define states as combinations of other states. Here is a program that selects channel 20 or 21 depending which of digital inputs 3 and 4 are low:

```
// Select channel 20 on digital input 3 low, and 21 on digital input
// 4 low.

composite-state: select.0 = dig-in-4.high AND dig-in-3.low

composite-state: select.1 = dig-in-4.low AND dig-in-3.high


when: select.0 then: channel => 20

when: select.1 then: channel => 21
```

With this program it is still possible for the base station to be on either channel 20 or 21 when both inputs are high or low (as in the previous example), but unlike the last example, if digital inputs 3 & 4 are high and low respectively, the base station will always go to channel 21.

4.3 Using Two Inputs to Select Four Channels

Composite states make it easy to use combinations of input conditions to select channels. With two inputs it is possible to select between four channels:

```
// Select channels 20 to 23 based on combinations of digital inputs 3
// & 4.

composite-state: select.0 = dig-in-4.low AND dig-in-3.low

composite-state: select.1 = dig-in-4.low AND dig-in-3.high

composite-state: select.2 = dig-in-4.high AND dig-in-3.low

composite-state: select.3 = dig-in-4.high AND dig-in-3.high
```

```
when: select.0 then: channel => 20
when: select.1 then: channel => 21
when: select.2 then: channel => 22
when: select.3 then: channel => 23
```

4.4 Debouncing the Switch Input

The final example uses a timer to add debounce to the inputs. Switch contacts can bounce, creating intermediate transient states which TaskBuilder can react to, resulting in multiple channel change requests in a short time. The base station internals are robust, but it is good practice to select a channel only when the switch contacts have settled. The program starts a debounce timer when any input changes, and only selects the target channel once the timer expires.

```
// Select channels 20 to 23 based on combinations of digital inputs 3
// & 4.
// Change channel only when the debounce timer expires.

timer: debounce interval: 50 :ms
when: dig-in-3.change then: debounce.start
when: dig-in-4.change then: debounce.start

composite-state: select.0 = dig-in-4.low AND dig-in-3.low
composite-state: select.1 = dig-in-4.low AND dig-in-3.high
composite-state: select.2 = dig-in-4.high AND dig-in-3.low
composite-state: select.3 = dig-in-4.high AND dig-in-3.high

given: select.0 when: debounce.expire then: channel => 20
given: select.1 when: debounce.expire then: channel => 21
given: select.2 when: debounce.expire then: channel => 22
given: select.3 when: debounce.expire then: channel => 23
```

`change` is an event generated by digital inputs when the input state changes. If the inputs have contact bounce, the debounce timer may be (re)started multiple times, but it will only expire 50 ms after the last restart of the timer. The program uses `given:when:then:` rules to select the correct channel when the debounce timer expires.

4.5 More on Composite States

Composite states can be defined in terms of any other states, including the states of standard variables, active variables or other composite states.

Composite state definitions can use boolean operators OR, AND, NOT and parentheses (). You can freely mix them in an expression as you would for an arithmetic expression. Like arithmetic expressions, the boolean operators have a precedence order: `() > NOT > AND > OR`.

So, for example if `var-1.true` is a state that is currently active and `var-2.false` is not currently active, then `NOT (var-1.true OR var-2.false)` gives a different result to `(NOT var-1.true OR var-2.false)`

4.5.1 Comparisons Between Active Variables and Composite States

Both active variables and composite states give you a way to define the conditions for responding to an event (when used in a `given:` clause) and as a trigger (the `when:` clause). There are some differences as well:

- active variables define a set of states, of which exactly one is true at any time
- composite states do not have any specific relationship to each other. Given a set of composite states with the same variable name (eg `select` in the example above), none may be active at any given time, or multiple may be active. (For example, write down a truth table to convince yourself that `var.a OR var.b` is active whenever `NOT(NOT var.a AND NOT var.b)` is.
- variable names: although composite states can share a variable name, it is for notational convenience only. Although the `select` states in the example have an obvious real-world relationship, TaskBuilder treats them as independently defined states.
- the become => operator applies to active variables but not composite states. The value of a composite state depends only on the states from which it is derived. Applying the become operator to a composite state is a program error.
- composite states are good for capturing combinations of input conditions. Active variable states are useful to represent distinct sets of behaviors.

4.6 State Diagrams

The examples in this chapter mostly do not have state diagrams. Given that TaskBuilder treats composite states independently, while it is possible to draw state diagrams including composite states (see the example above), there is not the same direct relationship between diagram elements and program elements as there is with state diagrams based on active variables. Again, this goes to the different uses for active variables versus composite states: If the problem domain and solution are naturally expressed using a state transition diagram, then there is likely a straightforward solution using active variables. If the problem space suffers from a potential explosion of states, then composite states may reduce that problem space complexity.

5 Drive a Digital Output Given an Alarm Condition

A common requirement is to drive a contact closure if an alarm is present. The contact could be connected to a warning light at a local or remote location.

The examples in this chapter include:

- light a lamp when the base station front panel is absent
- indicate a major alarm

The base station has many alarms, all of which can be used as TaskBuilder inputs. Alarms are listed in TaskBuilder Alarm Names. TaskBuilder treats alarms as individual state variables, each of which can have the values of `active`, `inactive` or `disabled`.

5.1 Light a Lamp When the Base Station Front Panel is Absent

The front panel includes the fans that cool the base station and allow it to operate under the widest range of temperatures. The front panel may be removed to replace modules, but forgetting to replace the front panel could require a costly return to site. This example uses TaskBuilder to drive digital output 10 low, to close a contact and light a lamp when a base station has the front panel removed.

The specifications manuals listed in Associated Documentation on page 7 define the operating current and voltage conditions for the digital inputs and outputs. Using a digital output to drive a relay may require an electrical interface circuit.

```
// Drive digital output 10 low when the front panel alarm is active
when: alarm-front-panel-not-detected.active then: dig-out-10 => low
```

This is not quite the end of the story, because you probably also want the light to turn off when the alarm is no longer active. You can do that in different ways - use multiple rules:

```
// Drive digital output 10 low when the front panel alarm is active -
// variation 1
when: alarm-front-panel-not-detected.active then: dig-out-10 => low
when: alarm-front-panel-not-detected.disabled then: dig-out-10 =>
high
when: alarm-front-panel-not-detected.inactive then: dig-out-10 =>
high
```

Or, you could use a composite state:

```
// Drive digital output 10 low when the front panel alarm is active -
// variation 2

composite-state: fp-alarm.not-active = NOT alarm-front-panel-not-
detected.active


when: alarm-front-panel-not-detected.active then: dig-out-10 => low

when: fp-alarm.not-active then: dig-out-10 => high
```

The first variation is simpler, and more flexible, but you may forget to account for the disabled state; using composite states is also the natural way to combine alarm inputs. See the next example.

5.2 P25 Major Alarm

DMR base station firmware assigns to alarms a status: Under a major alarm condition the channel is unusable. With a minor alarm the channel may be degraded but still provide service. The result of the major alarm could be a remote status indication, or take the channel out of service, or even switch another channel into service as a replacement.

This example provides the equivalent of the DMR major alarm with P25 firmware on a TB7300. The specific conditions that contribute to a major alarm are of course system specific. For simplicity, this example uses the same values as the DMR fixed and default configurable values.

The DMR major alarms (using default values where configurable) on TB7300 are:

PA calibration invalid, PA shutdown, 1PPS pulse absent, Channel invalid, Simulcast unsynchronized, Receiver calibration invalid, Hardware configuration invalid, 25 MHz synthesizer out of lock, 61.44 MHz synthesizer out of lock, TxF synthesizer out of lock, Rx synthesizer out of lock

The standard TaskBuilder alarms are listed in TaskBuilder Alarm Names

It is straightforward to define a major alarm as a TaskBuilder composite state:

```
// Major alarms result in the base station being out of service

composite-state: major-alarm.active =

alarm-pa-calibration-invalid.active OR

alarm-pa-shutdown.active OR

alarm-1pps-pulse-absent.active OR

alarm-simulcast-unsynchronized.active OR

alarm-receiver-calibration-invalid.active OR

alarm-hardware-configuration-invalid.active OR

alarm-25-mhz-synthesizer-out-of-lock.active OR

alarm-61-44-mhz-synthesizer-out-of-lock.active OR
```

```
alarm-txf-synthesizer-out-of-lock.active OR
alarm-rx-synthesizer-out-of-lock.active
```

To drive a pin, we want the inactive alarm state as well:

```
composite-state: major-alarm.inactive = NOT major-alarm.active
when: major-alarm.active then: dig-out-10 => low
when: major-alarm.inactive then: dig-out-10 => high
```

5.3 Raising a Custom Alarm

Extending the example above, it is possible to assert a custom alarm for a given TaskBuilder condition (see TaskBuilder Inputs and Actions). To associate Custom alarm 1 with the major alarm from the example above , we would add rules such as:

```
when: major-alarm.active then:
{ dig-out-10 => low, alarm-custom-alarm-1.raise }
when: major-alarm.inactive then:
{ dig-out-10 => high, alarm-custom-alarm-1.clear }
```

5.4 Summary

What we learned:

- when writing rules that react to the presence of an alarm (such as driving a contact output), ensure that you capture the conditions both for asserting the pin output and de-asserting. You can either provide rules for all the alarm states (including disabled) or use a composite state.
- composite states are a good way to represent combinations of alarms
- TaskBuilder can raise and clear custom alarms

6 Select Squelch Mode Using Digital Inputs

6.1 rx-squelch-mode

Represents the current level of squelch applied to the receiver.

Three states: `normal, subaudible-bypass, carrier-bypass`

- default state is normal

State	Decode subaudible config	Gating control config
normal	As configured	As configured
subaudible-bypass	Ignored	As configured
carrier bypass	Ignored	Ignored

Points to note

- `rx-squelch-mode` is not affected by the channel group control Monitor Squelch
- the state `carrier-bypass` is unsupported in P25 conventional and trunking and DMR conventional and trunking. Any rule which will set `rx-squelch-mode` to `carrier-bypass` will instead set it to normal
- the state `subaudible-bypass` also bypasses NAC in P25 and color code in DMR

The following are valid TaskBuilder statements:

```
when: dig-in-1.low then: rx-squelch-mode => normal
```

```
when: dig-in-2.low then: rx-squelch-mode => subaudible-bypass
```

```
when: dig-in-3.low then: rx-squelch-mode => carrier-bypass given: rx-squelch-mode.subaudible-bypass when: dig-in-4.low then: rx-squelch-mode => normal
```

6.2 rx-gate-state

Reports the receiver state in the context of TaskBuilder squelch control.

Four states: `closed, open, subaudible-bypassed, carrier-bypassed`

- default state: closed

`rx-gate-state` is tightly coupled with the receiver gate and another TaskBuilder variable; the `rx-squelch-mode`. `rx-gate-state` is derived based on the following logic:

Rx gate	rx-squelch-mode	rx-gate-state
closed	can be any state	closed
open	normal	open
open	subaudible-bypass	subaudible-bypass
open	carrier-bypass	carrier-bypass

Points to note

- `rx-gate-state` is not directly affected by the following user configuration
- Configure > RF Interfaces > Channel profile > Analog > Gating condition
- Configure > RF Interfaces > Signalling profile > Analog > Subaudible squelch decode
- `rx-gate-state` is not affected by the monitor mode requested by a console
- `rx-gate-state` does not have carrier-bypass state in P25 or DMR system types

The following are valid TaskBuilder statements:

```
when: rx-gate-state.open then: dig-out-10 => low
when: rx-gate-state.closed then: dig-out-9 => low
when: rx-gate-state.carrier-bypassed then: dig-out-8 => low
when: rx-gate-state.subaudible-bypassed then: dig-out-7 => low
given: rx-gate-state.subaudible-bypassed when: dig-in-4.low then:
channel.up
```

7 Select Tx Key Using Digital Inputs

7.1 tx-key-operation

Controls whether the E&M is disabled or works normally (according to the configuration)

Two states: `normal, disabled`

- default state is normal

State	E&M configuration
normal	As configured
disabled	Disabled

Points to note

- `tx-key-operation` is not supported in DMR
- `tx-key-operation` stays disabled in the system type (P25 trunking) where analog lines are not used

The following are valid TaskBuilder statements:

```
when: dig-in-1.low then: tx-key-operation => normal
```

```
when: dig-in-2.low then: tx-key-operation => disabled
```

```
given: tx-key-operation.disabled when: dig-in-4.low then: rx-squelch-mode => normal
```

7.2 tx-key-state

Reflects the state of Tx-Key.

Two states: `inactive, active`:

- inactive: E&M is either disabled or not active (stream is not accepted from the audio line)
- active : E&M is not disabled and is active (stream can be accepted from the audio line)

The following are valid TaskBuilder statements:

```
when: tx-key-state.inactive then: rx-squelch-mode => normal
```

```
when: tx-key-state.active then: dig-out-4 => low
```

```
given: tx-key-state.active when: dig-in-4.low then: rx-squelch-mode => normal
```

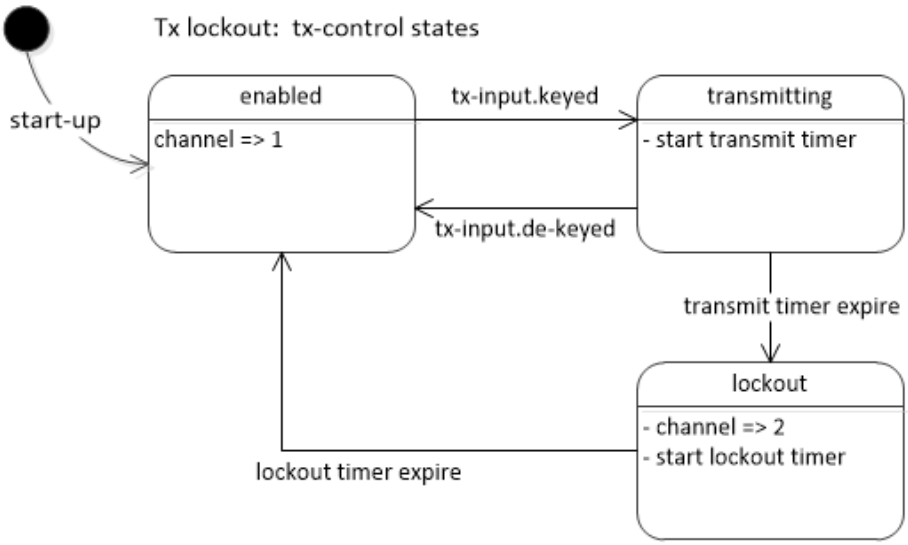
8 Transmit Lockout

This chapter shows a transmit lockout use case with graphical and TaskBuilder solutions and offers some advice for good program style.

Problem

Solar and battery powered sites may provide a transmit lockout function to preserve battery storage. After transmitting for a maximum time, stop transmitting and wait until the transmitter is no longer keyed before resetting the lockout condition. Re-enable the transmitter once it is no longer keyed.

Here is a state transition diagram illustrating a tx-control function implementing lockout. Channel 1 is able to transmit. Channel 2 has transmit disabled.



In the enabled state the repeater will transmit if keyed.

In the transmitting state, the base station is keyed, and the transmit timer will end the transmission if it expires.

In the lockout state, the transmitter is disabled and a lockout timer is running.

Lockout ends only when both the lockout timer has stopped (expired) and the transmit input has finished.

Here is a TaskBuilder program that does the same thing. It is the same design, i.e. the TaskBuilder elements correspond to the diagram.

```
// Transmit lockout.
// After 30 seconds of transmission, lock out the transmitter:

// Useful for solar or battery operation.
// To re-enable the transmitter, the lockout timer must complete, and the
// transmit source must be removed.

// 2020-12-11 Tait Communications, Iain McInnes
```

```
// Tx control enables or disables transmission based on a timeout.


active: tx-control has-states:
 {
 enabled, // would transmit if keyed.
 transmitting, // is transmitting - waiting for lockout.
 lockout, // transmission was too long - wait for timer and end of
// transmission request
 }

timer: tx-timer interval: 30 :s
timer: lockout-timer interval: 10 :s


// Condition for ending lockout

composite-state: lockout.end = lockout-timer.stopped AND tx-input.de-keyed

// enabled state
when: tx-control.enabled then: channel => 1 // channel 1 allows tx
given: tx-control.enabled

when: tx-input.keyed then: tx-control => transmitting

// transmitting state
when: tx-control.transmitting then: tx-timer.start


given: tx-control.transmitting

when: tx-input.de-keyed then: tx-control => enabled


given: tx-control.transmitting

when: tx-timer.expire then: tx-control => lockout


// lockout state

// channel 2 has tx disabled

when: tx-control.lockout then: { channel => 2, lockout-timer.start }

given: tx-control.lockout

when: lockout.end then: tx-control => enabled
```

Implementation notes

`tx-input` is a standard variable that reports whether the base station would be transmitting if it was able (transmit signal is present). The most likely reason not to be able to transmit is the channel configuration has transmit operation disabled (Configure > RF Interfaces > Channel profiles > Transmitter enabled).

The composite state `lockout.end` is a good example of simplifying the solution when it depends on multiple inputs:

```
composite-state: lockout.end = lockout-timer.stopped AND tx-input.de-keyed
```

The rule uses the timer `stopped` state rather than the `expire` event because composite states are derived from states, not events.

You could achieve the same thing with two extra `tx-control` states (perhaps labeled `lockout-timeout` and `tx-dekeyed`) and a few additional rules. The composite state expresses the solution intention better.

9 Call Profiles and Tone Remote

9.1 Tone Remote Input

Base station P25/AS-IP firmware release 3.55 (December 2023) includes TaskBuilder support for call profiles and tone remote operation.

Tone remote is an analog single-tone signaling method used by analog consoles. There are 16 distinct tone signaling frequencies at 100 Hz intervals between 550 Hz and 2050 Hz. Combining two successive tones provides 256 distinct combinations. Tone remote signaling is commonly used for:

- selecting a channel
- unmuting the receiver
- enabling / disabling RF repeat
- keying the transmitter

The signal for keying the transmitter is different from function tones: A low level guard tone is superimposed on the console audio, and the transmitter is keyed while the tone is present. Transmitter keying is a function of the base station without requiring TaskBuilder programming.

TaskBuilder can change channel, and enable or disable RF repeat via a channel change. Unmuting the receiver (also known as monitor squelch) is also supported. Keying the transmitter does not require TaskBuilder support.

9.2 Call Profiles

Call profiles provide P25 call signaling information for downlink transmissions from an analog line connected console to radio subscriber units. In release 3.55, TaskBuilder can change and respond to changes in call profiles.

Example: using tone remote to change channel

```
// Tone remote 1150 Hz selects channel 1
// Tone remote 1250 Hz selects channel 2
// Tone remote 1350 Hz selects channel 3
//-------------------------------------------------------------
when: tone-remote.single-1150 then: channel => 1
when: tone-remote.single-1250 then: channel => 2
when: tone-remote.single-1350 then: channel => 3
```

Tone remote configuration on the base station WebUI (Configure > Analog line > Tone remote) has a selection for recognizing single or dual function tones. TaskBuilder follows that selection:

- with single function tone configuration, TaskBuilder recognizes all of the tones `tone-remote.single-550` through `tone-remote.single-2050`
- with dual function tone configuration, TaskBuilder recognizes all of the tones `tone-remote.dual-550-550` through `tone-remote.dual-2050-2050`
- with dual tone configuration, the above example could look like:

```
// Tone remote dual tone 550 / 1150 Hz selects channel 1
// Tone remote dual tone 550 / 1250 Hz selects channel 2
// Tone remote dual tone 550 / 1350 Hz selects channel 3
//-------------------------------------------------------------
when: tone-remote.dual-550-1150 then: channel => 1
when: tone-remote.dual-550-1250 then: channel => 2
when: tone-remote.dual-550-1350 then: channel => 3
```

Example: using tone remote to unmute the receiver

```
// Temporarily enable monitor squelch upon receiving a function tone
timer: squelch-timeout interval:5:s
when: tone-remote.single-1150 then:
{
squelch-timeout.start,
rx-squelch-mode => subaudible-bypass
}
when: squelch-timeout.expire then: rx-squelch-mode => normal
```

Example: using digital inputs to select call profile

A P25 channel has an analog console which provides signaling via wired digital outputs. The channel has two P25 talkgroups, and TaskBuilder selects a talkgroup based on the state of a digital input.

```
// dig-in-1 low selects call profile 1
// dig-in-1 high selects call profile 2
when: dig-in-1.low then: call-profile => 1
when: dig-in-1.high then: call-profile => 2
```

Usage notes

Call profiles apply to analog and P25 conventional operation when used with the analog line. As of version 3.55, DMR/MPT firmware does not support call profiles, tone remote operation or integration of those functions into TaskBuilder.

9.3 tone-remote-key-operation

Controls whether the tone-remote-key is disabled or works normally (according to the configuration)

Two states: `normal, disabled`.

- default state is normal

State	Tone remote configuration
normal	As configured
disabled	Disabled

Points to note

- `tone-remote-key-operation` is not supported in DMR
- `tone-remote-key-operation` stays `disabled` in the system type (P25 trunking) where analog lines are not used

The following are valid TaskBuilder statements:

```
when: dig-in-1.low then: tone-remote-key-operation => normal
```

```
when: dig-in-2.low then: tone-remote-key-operation => disabled
```

```
when: dig-in-3.low then: rx-squelch-mode => carrier-bypass
```

```
given: tone-remote-key-operation.disabled when: dig-in-4.low then:
channel => 7
```

9.4 tone-remote-key-state

Reflects the state of tone remote.

Two states: `inactive, active`

- inactive: tone remote is either disabled or not detected (stream is not accepted from the audio line)
- active : tone remote is not disabled and is active (stream can be accepted from the audio line)

The following are valid TaskBuilder statements:

```
when: tone-remote-key-state.inactive then: rx-squelch-mode => normal
```

```
when: tone-remote-key-state.active then: dig-out-4 => low
```

```
given: tone-remote-key-state.active when: dig-in-4.low then: rx-
squelch-mode => normal
```

10 Signal Path States

10.1 tx-operation

The `tx-operation` variable allows a TaskBuilder program to disable the transmitter.

Two states: `normal, disabled`

- normal: normal transmitter operation
- disabled: TaskBuilder has disabled the transmit signal path

At TaskBuilder start-up the initial state is `normal`.\

The following are valid TaskBuilder statements:

```
when: operation.running then: tx-operation => disabled
when: tx-operation.normal then: dig-out-10 => low
when: tx-operation.disabled then: dig-out-9 => low
given: tx-operation.disabled when: dig-in-10.low then: channel.up
```

10.2 rx-operation

The `rx-operation` variable allows a TaskBuilder program to disable the receiver.

Two states: `normal, disabled`

- normal: normal receiver operation
- disabled: TaskBuilder has disabled the receive signal path.

At TaskBuilder start-up the initial state is `normal`

> `rx-operation.disabled` is not supported in DMR conventional, DMR trunking & P25 trunking.

The following are valid TaskBuilder statements:

```
when: operation.running then: rx-operation => disabled
when: rx-operation.normal then: dig-out-10 => low
when: rx-operation.disabled then: dig-out-9 => low
given: rx-operation.disabled when: dig-in-10.low then: channel.up
```

11 High Availability Repeater

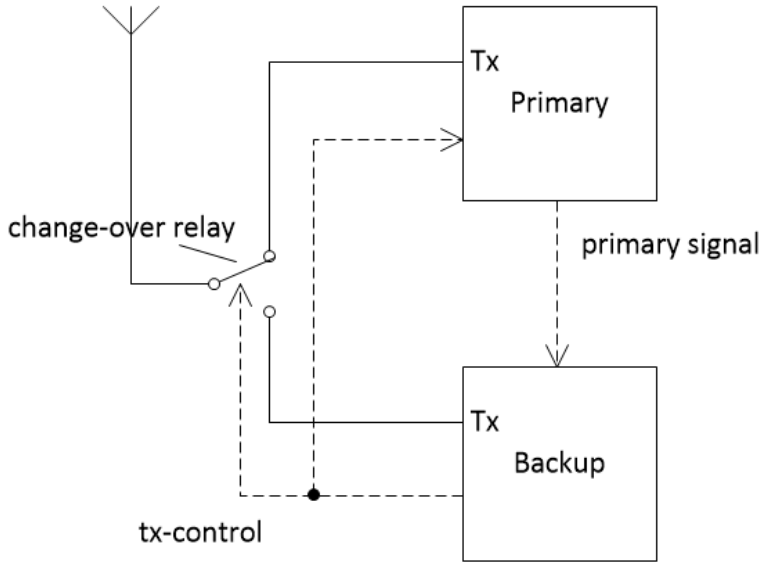
11.1 Requirements

If a channel has stringent down time requirements, the channel can be made resilient to the failure of a repeater by deploying primary and backup repeaters:

- if the primary repeater is not able to provide service, the backup repeater takes over
- a major alarm or power fail results in a 'no service' condition. The repeater can not provide service.
- the solution uses a change-over relay to switch the transmit antenna to the primary or secondary repeater. The solution needs to produce a signal that drives the relay, and must avoid operating the relay when either base station is transmitting.

11.2 Problem Logic

The diagram shows a possible solution:



The backup supervises the primary by means of a digital signal from the primary, which indicates whether the primary is up (nominal) or down (failed).

The backup has the decision logic for which repeater is in service. It outputs a tx-control signal which drives a change-over relay and informs the primary which repeater is in service.

Primary operation has the following states:

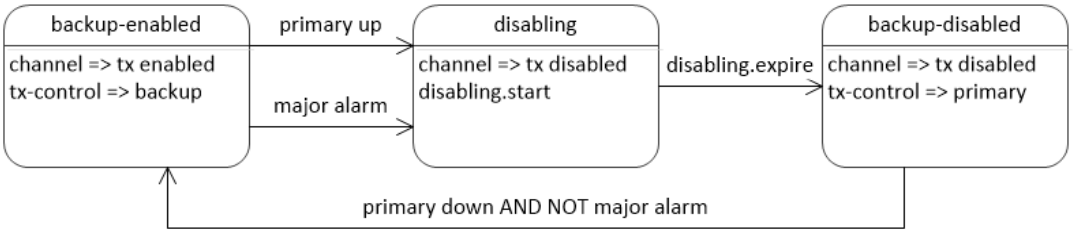
State	Composite inputs	Outputs	Commentary
nominal	NOT major alarm AND tx-control is primary	primary signal => up. transmit => enabled.	Normal operating condition. Primary does not have a major alarm, primary is reporting an 'up' signal to backup, and backup has responded by switching the change-over relay to the primary.
down	major alarm	primary signal => down. transmit => disabled	Primary has a fault taking it out of service. It sets the primary output signal to 'down', and disables its transmitter. Backup is expected to operate the change-over relay.
recovering	NOT major alarm AND tx-control is backup	primary signal => up. transmit => disable	Primary has recovered from a fault. Primary is up, but primary can detect that the backup repeater still has the change-over relay in the backup position. Backup is expected to recognize that the primary is up and operate the change-over relay. Primary transmit is disabled.
offline	Caused by fault or user action	primary signal => down	Faults which cause the channel to be invalid also result in the base station being offline. TaskBuilder programs can respond to the operation.stopping event.

The primary states are composite (a combination of alarm status and tx-control input).

The primary should output a 'down' signal when it has a major alarm or when it goes offline. When the primary is outputting a down signal it must not transmit.

When the major alarm clears, it must output an 'up' signal, and wait until it sees that it has control (from the backup) before enabling transmit.

Backup operation has the following states:



State	Composite inputs	Outputs	Commentary
backup-enabled	primary-signal.down AND NOT (backup) major alarm	tx enabled tx-control switched to backup	The backup switches the change-over relay if the primary is down and the backup is up.
disabling	primary-signal.up OR major alarm	disable transmit start disable timer	Allow for channel change time before switching the relay.
primary-enabled	disable timer expired	tx-control switched to primary	Otherwise the backup switches the change-over relay to the primary.
offline	Caused by fault or user action	tx-control switched to primary	Faults which cause the channel to be invalid also result in the base station being offline. TaskBuilder programs can respond to the oper-ation.stopping event

Signal polarities

It is possible to choose signal polarities so as to make the system as robust as possible. If either the primary or backup is powered down or disconnected, the other should still operate.

- the primary signal indicates whether the primary is up or down. If it is unconnected or the primary is powered down, the input to the backup will float high. The backup should treat primary status as down when the signal input is high.
- the tx-control signal output from the backup drives the change-over relay and informs the primary. If the backup is disconnected or powered down, the input will float high at the primary. The primary should treat tx-control as primary when the input is high, and the relay should be in the primary position when it is de-energised.

Manual override

With the signal polarities as above, manually taking the primary or backup offline will result in the other one remaining in control.

Relay must not operate when either repeater is transmitting

The design assures this by means of the hardware handshake signals:

In the presence of a primary fault:

- the primary asserts the primary signal down and does not transmit
- the backup recognizes the primary is down, switches the change over relay to the secondary and can transmit.

When the primary fault clears:

- the primary asserts the primary signal up, but does not immediately transmit (recovering state)
- the backup recognizes the primary is up, stops any transmission itself, and switches tx-control to the primary
- the primary recognizes that it has tx-control, and enables transmit once again

11.3 Primary Repeater Definitions, States and Logic

For the primary repeater, all states are logical combinations of primary and backup operational status. The primary rules in the TaskBuilder solution just depend on the input conditions and their combinations.

`operation.stopping`

The program responds to alarms and base station offline in different ways:

```
when: primary-operation.down then: { signal => down, channel => 2 }
```

```
when: operation.stopping then: { dig-out-2 => high, channel => 2 }
```

Why isn't `operation.stopping` just a condition that contributes to `primary-operation.down` ?

`operation.stopping` is the last event to trigger any rule

A rule such as:

```
when: operation.stopping then: { signal => down, channel => 2 }
```

will not work as expected. It would depend upon the additional rule

```
when: signal.down then: dig-out-2 => high
```

before the output signal is actually asserted. But as discussed, since `operation.stopping` is the last event, `signal.down` is not able to trigger the rule that drives the output high.

The solution is to just drive the output high directly with the `operation.stopping` event.

Program text

```
// Simple high-availability solution utilizes two repeaters (primary
// and backup)
// The backup supervises the primary via a primary signal connection
// indicating the health of the primary (up or down)
// The backup operates a change-over relay (tx-control output)
// Primary or backup repeaters are down if they have a major alarm
// (see text below for definition of major alarm)
// Secondary must not operate relay while either repeater is
// transmitting.
// 2020-12-16 Tait Communications Iain McInnes
//---

//================================================
// Primary repeater definitions, states and logic.
//================================================
// Major alarms result in the base station being out of service
// Can customize for individual deployments.

composite-state: major-alarm.active =
alarm-pa-calibration-invalid.active OR
alarm-pa-shutdown.active OR
alarm-pa-forward-power-low.active OR
alarm-1pps-pulse-absent.active OR
alarm-channel-invalid.active OR
alarm-simulcast-unsynchronized.active OR
alarm-receiver-calibration-invalid.active OR
alarm-hardware-configuration-invalid.active OR
alarm-25-mhz-synthesizer-out-of-lock.active OR
alarm-61-44-mhz-synthesizer-out-of-lock.active OR
alarm-txf-synthesizer-out-of-lock.active OR
alarm-rx-synthesizer-out-of-lock.active

composite-state: major-alarm.inactive = NOT major-alarm.active

//------------------------------------------------
// Give the output health signal a readable name
```

```
active: signal has-states:
{
up, // operation is nominal
down // major alarm condition
}
when: signal.up then: dig-out-2 => low
when: signal.down then: dig-out-2 => high // will float high (down)
// if disconnect or powered down.

//-------------------------------------------------
// Give the tx relay control signal a readable name

active: tx-control has-states:
{
primary, // relay switched to primary; can transmit
backup // relay switched to backup; must not transmit
}

// default to primary if input disconnected.
when: dig-in-1.high then: tx-control => primary
when: dig-in-1.low then: tx-control => backup

//------------------
// Primary operation

// primary is in service.
composite-state: primary-operation.nominal =
NOT major-alarm.active AND tx-control.primary

// primary is out of service.
composite-state: primary-operation.down = major-alarm.active

// primary would be in service, but change-over relay is switched to
// backup.
composite-state: primary-operation.recovering =
NOT major-alarm.active AND tx-control.backup
```

```
// Channel 1 has transmit enabled.
when: primary-operation.nominal then: { signal => up , channel => 1 }

// Channel 2 has transmit disabled.
when: primary-operation.down then: { signal => down , channel => 2 }
when: primary-operation.recovering then: { signal => up , channel =>
2 }

// Signal down when go offline
when: operation.stopping then: { dig-out-2 => high, channel => 2 }

//------------------
// End of program
```

11.4 Backup Repeater Definitions, States and Logic

The secondary repeater TaskBuilder program needs a timeout state: Waiting for the channel change to end any transmission before signaling the primary. The active variable `backup` captures these states of the backup.

> The example below uses digital output 13 to control the relay and signal the primary base station.
> From firmware release 3.25, TaskBuilder can use the coax relay driver pin 24.
> To drive a relay such as TBCA03-10 or TBDA03-10 your TaskBuilder program should use digital output 13.

Program text

```
// Backup repeater definitions, states and logic
// Simple high-availability solution utilizes two repeaters (primary
// and backup)
// The backup supervises the primary via a primary signal connection
// indicating the health of the primary (up or down)
// The backup operates a change-over relay (tx-control output)
// Primary or backup repeaters are down if they have a major alarm
// (see text below for definition of major alarm)
// Secondary must not operate relay while either repeater is
// transmitting.
// 2021-04-15 Tait Communications Iain McInnes
//---
//================================================
// Backup repeater definitions, states and logic.
//================================================
// Major alarms result in the base station being out of service
// Can customize for individual deployments.
composite-state: major-alarm.active =
alarm-pa-calibration-invalid.active OR
alarm-pa-shutdown.active OR
alarm-pa-forward-power-low.active OR
alarm-1pps-pulse-absent.active OR
alarm-channel-invalid.active OR
alarm-simulcast-unsynchronized.active OR
alarm-receiver-calibration-invalid.active OR
alarm-hardware-configuration-invalid.active OR
alarm-25-mhz-synthesizer-out-of-lock.active OR
```

```
alarm-61-44-mhz-synthesizer-out-of-lock.active OR
alarm-txf-synthesizer-out-of-lock.active OR
alarm-rx-synthesizer-out-of-lock.active
composite-state: major-alarm.inactive = NOT major-alarm.active
//-------------------------------------------------------------
// Give the input health signal from the primary a readable name
active: primary has-states:
{
up , // operation is nominal
down // major alarm condition
}
when: dig-in-2.low then: primary => up
when: dig-in-2.high then: primary => down
//-------------------------------------------------------------
// States of the backup
active: backup has-states:
{
enabled , // backup has taken control
disabling, // changing channel to disabled TX
disabled // control given to primary
}
timer: disabling interval: 1000 :ms // wait for channel change to
// disable TX
//-------------------------------------------------------------
// Rules for backup
when: backup.enabled then:
{ dig-out-13 => low, channel => 1 } // enable TX when backup enabled
when: primary.up then: backup => disabling // hand control back to
// primary
when: major-alarm.active then: backup => disabling
when: backup.disabling then:
{ channel => 2, disabling.start } // disable TX and start the timer
when: disabling.expire then: backup => disabled // finished changing
// channel
when: backup.disabled then: dig-out-13 => high
//-------------------------------------------------------------
// tx-control drives the change-over relay
```

```
composite-state: tx-control.backup = primary.down AND NOT major-
alarm.active

when: tx-control.backup then: backup => enabled

when: operation.stopping then:

{ dig-out-13 => high, channel => 2 } // Relinquish control when go
// offline


// End of program
```

12 Function Code Variables

> The function code variables are supported by Series 2 reciters running P25/AS-IP firmware only.

Function codes are a series of values ranging from 0 to 255 that can be used to communicate between base stations in a channel group.

There are two variables: `function-code-send`, and `function-code-receive`.

When one base station sends a function code using the `function-code-send` variable, all base stations in the channel group can respond to the event generated by the corresponding `function-code-receive` variable.

Example usage

The following example uses function codes to communicate a channel change event between base stations in the channel group. Channel 13 or 14 is selected based on the state of digital input 10.

```
// Collective channel change using function codes based on the state
// of digital input.

when: dig-in-10.high then: function-code-send.240

when: dig-in-10.low then: function-code-send.241

when: function-code-receive.240 then: channel => 13

when: function-code-receive.241 then: channel => 14
```

The example above can create conflicting states between base stations. More likely, what is wanted is one base station responds to a digital input (as above), while the other base stations may just respond to the respective function codes:

```
// Change channel on receiving the respective function code.

when: function-code-receive.240 then: channel => 13

when: function-code-receive.241 then: channel => 14
```

Usage notes

TaskBuilder can react to its own `function-code-send` events.

13 Subaudible Signals

Supported by Series 2 reciters only.

`rx-subaudible-detector` is a stateless variable that allows a TaskBuilder script to respond to specific subaudible signals on the base station receiver.

Rx subaudible detector variables are defined with a name and subaudible code:

```
rx-subaudible-detector: name code: subaudible-code
```

The range of values that `subaudible-code` can take is the same as that of encode/decode CTCSS and DCS when configuring a signaling profile in the base station WebUI. Note that CTCSS values do not contain decimal places (e.g. `ctcss-1862` corresponds to the CTCSS 186.2 Hz tone).

When a signal is received which contains the subaudible code in the `rx-subaudible-detector` definition, the variable will produce a `detect` event.

Usage notes

Up to four `rx-subaudible-detector` variables are allowed in the same script.

The `detect` event will only be produced while the base station is in a system type that supports CTCSS and DCS. These are:

- analog conventional
- analog conventional with TSBK passthru
- DMR mixed mode
- P25 dual conventional

Received signals must match the RSSI & SINAD gating conditions in the current channel profile for TaskBuilder to detect the respective subaudible signaling and trigger an event.

When detecting multiple distinct CTCSS tones, avoid using frequencies within 30 Hz, as they can occasionally result in false detection. Lowering the subaudible deviation setting in the current signaling profile reduces the chance of a false detection occurring.

Example usage

```
rx-subaudible-detector: r1 code: ctcss-670
rx-subaudible-detector: r2 code: ctcss-719
rx-subaudible-detector: r3 code: ctcss-770
rx-subaudible-detector: r4 code: dcs-017

when: r1.detect then: { trace: "CTCSS-670 detected"}
when: r2.detect then: { trace: "CTCSS-719 detected"}
when: r3.detect then: { trace: "CTCSS-770 detected"}
when: r4.detect then: { trace: "DCS-017 detected"}
```

14 Tx Generators

Supported by Series 2 reciters only.

Tx generator variables can generate a test signal while TaskBuilder is running

Similar to `timer` variables, Tx generator variables are defined using a statement that provides a user- defined name and duration:

- `carrier-tx-generator: tx-generator-name duration: expiration-time`
- `fm-tx-generator: tx-generator-name duration: expiration-time [subaudible: analog-subaudible]`
- `p25-phase1-tx-generator: tx-generator-name duration: expiration-time [tx-signal: signal-type]`

Tx generators have two states: `running, stopped`.

Tx generators begin running when they raise a `start` event, and can be stopped prematurely via a `stop` event.

Raising a `start` event to a running Tx generator will reset the remaining duration.

After the expiration time passes following the last `start` event, the Tx generator produces an `expire` event and becomes `stopped`.

You can set the duration to an integer number of milliseconds, seconds, minutes, or hours (denoted as `:ms`, `:s`, `:min`, and `:hour` respectively).

Optional parameters

An `fm-tx-generator` accepts a single optional parameter that can be supplied in addition to its definition: `subaudible`.

- `subaudible` - instructs the base station to apply an analog subaudible encoding to the test tone, such as CTCSS or DCS:
  - the range of values that `subaudible` can take is the same as that of encode/decode CTCSS and DCS when configuring a signaling profile in the base station WebUI. Note that CTCSS values do not contain decimal places (e.g. `ctcss-1862`).
  - alternatively, `subaudible` can be defined with the `none` token, which is its default value, and results in no subaudible encoding in the analog domain.

A `p25-phase1-tx-generator` accepts a single optional parameter that can be supplied in addition to its definition: `tx-signal`:

- the following `tx-signal` types are valid: `p25-standard`, `p25-tone`, `high-deviation`, `low-deviation`, `silence`, and `modulation-fidelity`
- by default, `p25-standard` is used

The `carrier-tx-generator`and `fm-tx-generator` variables can be used when the channel profile is configured for the following system types:

- DMR / MPT Applications:
  - analog conventional
  - DMR Mixed mode
  - MPT Trunking
- P25 / ASIP Applications:
  - analog conventional
  - analog conventional with TSBK passthru
  - P25 dual conventional

The `p25-phase1-tx-generator`Tx generator parameter is supported when the channel profile is configured for the following system types:

- P25 / ASIP Applications:
  - analog conventional with TSBK passthru
  - P25 conventional
  - P25 dual conventional
  - P25 trunking

Usage notes

A `tx-generator` will not transmit when the system is configured for simulcast.

The base station must be online for a `tx-generator` to operate.

A `tx-generator` will transmit at the configured transmit frequency for the current channel.

A `tx-generator` that is running will `expire` if the current channel changes.

When a `tx-generator` raises a `start` event and is not the currently running `tx-generator`, all other Tx generators will immediately `expire`:

- this is because the base station only has a single transmitter

An active stream from a `tx-generator` is given a lower priority than standard traffic. For example, a call from a radio-user will pre-empt (pause) the test stream. The test stream will resume and continue thereafter. During this period, the `duration` timer will continue to tick down.

Example usage

The following example uses received subaudible codes to start and stop a tx generator.

We apply a subaudible to the running tx generator so that users do not unmute for it.

```
// Begin or end an analog tx generator upon receiving specific
// subaudible codes.

fm-tx-generator: analog-test duration: 30 :min subaudible: dcs-464

rx-subaudible-detector: start-test-tone code: dcs-465

rx-subaudible-detector: stop-test-tone code: dcs-466

given: analog-test.stopped when: start-test-tone.detect then: analog-
test.start
```

```
given: analog-test.running when: stop-test-tone.detect then: analog-
test.stop

when: analog-test.running then: trace: "Analog test started"

when: analog-test.stopped then: trace: "Analog test stopped"
```

15 Good TaskBuilder Style

The examples in this document are written in a particular style. The style mimics a state transition diagram (which the examples also provide where useful).

The benefits of using a specific style are solutions that are more predictable, without losing any expressiveness. They will be easier to design, to read, to pick-up defects, and which communicate better their intention. All of these things result in solutions that are more likely to be correct and do what you want.

Style recommendations are as follow:

1. A few lines of comment at the beginning explain the purpose and provide a brief summary of the operation of the program. For a working program (as opposed to a toy exercise) it is useful for the comment block to identify the author and date.
2. Use active variable states to capture individual required system behaviors.
3. Use composite variables to capture combinations of input conditions
4. Give state variables a well defined purpose. Active variable declarations should have a single-line comment stating the purpose:
   `// Tx control enables/disables transmission based on a timeout.`
5. When defining states (active and composite), each state has a brief comment summarizing the system condition or behavior that the state represents.
6. Use good, descriptive state and variable names. You know you have succeeded when the program rules read naturally.
7. States will often have a timer that is associated with that state (waiting for timeout). The timer is started as a state entry action, and provides a default exit event for the state.
8. Rules are organized by variable states, with a single line comment grouping the rules associated with that state.
9. Where possible, have (changing channel, starting timers) actions occur on entry to the state that is associated with those actions:
   `when: tx-control.lockout then: { channel => 2, lockout-timer.start }`
10. The subsequent rules for each state have the state name as a given: condition. The action associated with the rule should be a simple state transition:
    `given: tx-control.transmitting when: tx-timer.expire then: tx-control => lockout`
11. Use vertical alignment to make it easy for the eye to distinguish distinct rule elements (`when:`, `then:` and actions)
12. Where useful, additional comments add context to rules. Use rule comments sparingly. If a rule needs a comment to explain it, then ask whether the states are well partitioned and the states and events are well named. See recommendation 5, above.

Reference Section

This section of the manual contains the following reference materials:

- TaskBuilder Language
- TaskBuilder Grammar
- TaskBuilder Inputs and Actions
- TaskBuilder Alarm Names
- Specifications and Limits
- TaskBuilder Comparison With Task Manager

16 TaskBuilder Language

This chapter defines how TaskBuilder programs are expressed and what they mean.

16.1 Syntax Highlighting

In this document, TaskBuilder statements are written in a `fixed-width-font`.

16.2 Names

TaskBuilder programs may assign names to active variables, states, events, and timers.

Names may include underscore_and-minus characters: `this_is-aValidIdentifier`.

Names are case-insensitive. In base station firmware release 3.20, names are converted internally to lower case, and displayed (WebUI, logs) in lower case. In future releases, names will still be case-insensitive, but the original case of the input text will be preserved.

16.3 Keywords

TaskBuilder reserves the following keywords:

```
active: has-states: composite-state: and or not timer:
interval: :ms :s :min :hour given: when: then: raise trace:
```

TaskBuilder keywords are case-insensitive. They are displayed in lower case independently of the case in the input text.

16.4 Comments

Comments in TaskBuilder help the reader understand the meaning of a program. They have no effect on execution.

Comments begin with a double slash, and comprise any printable text up to the end of the line:

```
// This is a comment
```

Comments can appear on the same line as TaskBuilder statements:

```
when: operation.running then: channel => 2 // base station
// online.
```

16.5 Active Variables

Active variables represent system state. Distinguishing states allows TaskBuilder to do different things in response to an input event, depending on the state.

An active variable is a set of mutually-exclusive states:

```
active: a-variable has-states: { state-1, state-2, state-3
}

active: beacon has-states: { on, off }
```

When an active variable has a value of a given state, we say that state is active. In a TaskBuilder program, an active state is written with a 'dot' notation - all of the following are true or false depending on whether the respective state is active:

```
a-variable.state-1

operation.running // base station online.

beacon.off
```

The initial value of an active variable when TaskBuilder starts is the first listed state.

16.6 Composite Variables

A composite state is defined as a logical combination of other states:

```
composite-state: alarm.major =

alarm-PA-forward-power-low.active OR

alarm-PA-reverse-power-high.active OR

alarm-PA-vswr-high.active OR

alarm-25-MHz-synthesizer-out-of-lock.active


composite-state: alarm.minor =

(

alarm-PA-driver-temperature-high.active OR

alarm-PMU-temperature-high.active OR

alarm-PMU-battery-voltage-low.active OR

alarm-PMU-mains-supply-failed.active

)

AND NOT alarm.major
```

As with active states, composite states notionally belong to a composite variable. The important differences between active and composite variables are:

1. The set of states belonging to a composite variable are not necessarily mutually exclusive, since they are defined by arbitrary logical functions. Therefore more than one state belonging to a given composite variable may be active at any time.
2. A TaskBuilder program may assign an active variable to become a given state, but may not assign a composite to become a given state, since the truthfulness of a composite state is given by the states from which it is derived.

Other than those differences, active and composite states behave the same way.

16.7 Timer Variables

A timer variable is defined using the statement:

```
timer: timer-variable-name interval: expiration-time
```

Timers have states: `{ stopped, running }`

Timers begin `running` when they are sent a `start` event.

Sending a `start` event to a running timer restarts the timer.

After the expiration time following the last `start` event, the timer produces an `expired` event and becomes `stopped`.

16.8 Counter Variables

Supported by Series 2 reciters only.

A counter is a kind of variable that can be used to 'count' a number of events and react to reaching a certain state, represented by a number between 0 and 65535.

They are defined using the following statement:

```
counter: counter-name
```

Counters can be incremented by an `up` event, decremented by the `down` event, or reset to 0 via the `reset` event.

They can also have their state explicitly assigned via the become (`=>`) operator.

Examples

Example 1 - defining a counter and changing its state:

```
// Create a counter, assign its state to "3", and react to
// that state.


counter: mycounter

when: operation.running then: mycounter => 3

when: mycounter.3 then: trace: "My counter is now 3"
```

This script is functionally identical to:

```
counter: mycounter

when: operation.running then: { mycounter.up, mycounter.up,
mycounter.up }

when: mycounter.3 then: trace: "My counter is now 3"
```

Example 2 - raise a custom alarm when more than 5 QOS jitter events are received, and move the base station out of a particular channel group:

```
// Define the counter, with an active to manage the maximum
// number of events

counter: qos-jitter-counter

active: qos-jitter-max has-states: { unreached, reached }


// Increment counter in response to qos-jitter alarm
// becoming active

given: qos-jitter-max.unreached when: alarm-qos-
jitter.active then: qos-jitter-counter.up


// Raise an alarm upon reaching a count of 5 events and
// change the channel.

given: qos-jitter-max.unreached when: qos-jitter-counter.5
then:

{

qos-jitter-max => reached,

channel => 5,

alarm-custom-alarm-1.raise

}


// Reset this demonstration script at running time.

when: operation.running then: alarm-custom-alarm-1.clear
```

Example 3 - a countdown implemented via use of a counter and an active managed by the "given" precondition (this is to avoid reacting to the counter's initial value of 0):

```
// A counter that decrements every second, managed via a
// controller to determine whether the countdown is active.

counter: countdown

active: countdown-active has-states: {false, true}

timer: countdown-timer interval: 1:s
```

```
// You may write the state of the counter to directly.
when: operation.running then: { countdown => 10, countdown-
timer.start }


// Handle the countdown via a Given statement
given: countdown-active.false when: countdown-timer.expire
then:
{
countdown-active => true,
countdown-timer.start,
}
given: countdown-active.true when: countdown-timer.expire
then:
{
countdown.down,
countdown-timer.start,
}


// If the countdown is active, when we reach zero, react.
given: countdown-active.true when: countdown.0 then:
{
trace: "Countdown finished.",
countdown-timer.stop,
countdown-active => false
}
```

A user of the above script could also write logic to react to any number between 1 and 10 (such as setting and unsetting thresholds), thereby providing utility that a timer cannot achieve with just a running state.

Usage notes

A counter has a maximum of 65535. When this maximum is exceeded, it will loop back to 0 and output a warning in the base station logs.

As with other named variables one cannot have duplicate names for a counter in the same script.

A counter will default to 0 when created.

16.9 Standard Variables

A timer is an example of a TaskBuilder standard variable. Standard variables have pre-defined names and behaviors. TaskBuilder Inputs and Actions on page 69 defines the variables making up the TaskBuilder standard library.

16.10 TaskBuilder Rules

The `when:then:` rule

The `when:then:` rule is written

```
when: variable.event then: action
```

or

```
when: variable.event then: { action-1, action-2, ... }
```

The rule defines the actions to occur in response the given event, for example:

```
when: debounce.expire then: channel => 1 // go to channel
// 1 after debounce time.
```

The => symbol is the 'become' operator, see Become a (new) state on page 64.

The `given:when:then:` rule

The `given:when:then:` rule is written

```
given: var-1.state when: var-2.event then: action
```

or

```
given: var-1.state when: var-2 then: { action-1, action-2,
... }
```

The `given:when:then:` rule adds an additional condition to the `when:then:` rule. TaskBuilder only performs the listed actions if the given state is active when the event occurs.

The state referenced by the `given:` clause of the `given:when:then` rule is always a fully qualified state name; that is, it follows the form `variable-name.state-name`.

Rule terminology

`when:then:` rules are always triggered when the event in the rule's `when:` clause occurs. `given:when:then:` rules are triggered when the rule state is

also active when the rule event occurs. Triggering a rule causes TaskBuilder to carry out the rule actions.

16.11 Events

Events are triggers that cause actions to occur. Events are generated by a `raise` action. Events carry no information other than their identity (and implicitly, their time sequence).

Events do not have to be explicitly defined; `when:` and `then:` clauses make it clear when a name should refer to an event.

16.12 State Entry Events

Good TaskBuilder practice is to identify and define states that represent characteristic behaviors, since that is how people think about states. To assist that idiom, TaskBuilder allows a `when:` clause to refer to a state name. The rule will be triggered when the variable enters that state:

```
when: var.state then: { actions-associated-with-a-state }
```

A `state-name` appearing in a `when:` clause refers to the event that is raised automatically on entering that state.

Events can be used without having to be declared. An example fragment is:

```
active: a-variable has-states: { state-1, state-2, state-3
}

when: some.condition then: raise a-variable.next

given: a-variable.state-1 when: a-variable.next then: a-
variable => state-2
```

Event lifetime

The lifetime of an event is the time between the event being raised, and the time when all rules referencing the event may be triggered (a rule may not be triggered if the `given:` clause is not satisfied at the time of the event). Events are atomic, and can be queued if events are occurring more quickly than the associated rules can be matched and executed. It is possible for multiple instances of the same event to be queued waiting to trigger their associated rules. In the most severe case, events may be discarded if it is not possible to queue the event.

16.13 Actions

TaskBuilder rules have either a single action:

```
when: variable.event then: action
```

or a list of actions:

```
when: variable.event then: { action-1, action-2, ... }
```

In the case of the list, the actions are carried out in order of the listed sequence.

Possible TaskBuilder actions are raise event(s) and change state(s):

Raise an Event

Use the keyword `raise`, or just write the event:

```
raise dig-out-1.toggle
debounce.start
```

Become a (new) state

The become operator `'=>'` causes a TaskBuilder variable to change its state, if it is one that can be changed from TaskBuilder:

Variables that can be changed by a TaskBuilder program are: user-defined active variables, timers, standard library output variables.

Examples:

```
when: debounce.expired then: channel => 1
when: alarm.minor then: dig-out-5 => low
```

Composite variables and standard library inputs may not be written to using the become operator.

If a variable already has the same state as the target of the become operation, the existing state is re-entered, and TaskBuilder automatically raises associated state entry event.

Standard library input objects that generate inputs into TaskBuilder do not generally re-enter existing states. For example the rule,

```
when: dig-in-1.low then: do-stuff
```

will only be triggered on actual transitions of the input.

Similarly, asking standard library variables to become the same state they are already in will not necessarily cause any change to the base station. The following program does not necessarily cause the base station channel to be continuously re-initialized:

```
timer: repeating interval: 1 :s
when: operation.running then: { channel => 1,
repeating.start }
when: repeating.expire then: { channel => 1,
repeating.start }
```

Trace actions

One TaskBuilder action allows you to trace the execution of your program with a message that you specify. The trace message is written to the output log, and can report the current values of TaskBuilder variables.

Here is the set channel program from the example above with a trace message added:

```
// TaskBuilder Example 2: include a trace message
```

```
when: operation.running then:
{
channel => 2,
trace: "channel is ${channel}"
}
```

16.14 Language Design Goals

The language here arose from the goals of:

1. Solve the same problems as Task manager

2. Orient the language around states and events: The 'active object' paradigm is robust, expressive, simple, well known, and fits base station internal execution.

3. Be expressive: The language should read naturally to people who are not expert TaskBuilder programmers without undue effort.

4. Be concise: Minimize the amount of stuff that is not directly involved in expressing the problem domain solution.

5. Minimize punctuation: because of (3) above.

6. Minimize declarations: because of (4) above. Events for example, are declared by using them.

7. Base stations mechanisms are expressed in the idioms of the language: Base station inputs and actions are defined in terms of TaskBuilder standard variables which interact with the running program in the ways described in this doc.

17 TaskBuilder Grammar

This chapter defines the rules for a well formed TaskBuilder program.

Notation here is Wirth syntax notation.

Key to grammar

```
{ }                     - repeat zero or more times
[ ]                     - option
( stuff )               - group stuff
!                       - anything but
|                       - separate alternatives
"stuff"                 - literal
<>                      - unprintable literal
```

Language clauses

```
TaskBuilder-script          = {statement} .
statement                   = active-declaration
                              | composite-declaration
                              | timer-declaration
                              | rule
                              | trace-statement .
active-declaration          = "active:" var-name "has-states:" qualifier-list .
qualifier-list              = "{" qualifier { "," qualifier } [,] "}" .
composite declaration       = "composite-state:" qualified-name "=" sum .
sum                         = product { "OR" product } .
product                     = term { "AND" term } .
term                        = ["NOT"] ( qualified-name | "(" sum ")" ) .
timer-declaration           = "timer:" var-name "interval:" timer-interval .
rule                        = [ "given:" qualified-name ]
                              "when:" qualified-name
                              "then:" (action | action-list) .
action-list                 = "{" action { "," action } [,] "}"
action                      = ["raise"] qualified-name
                              | [var-name] "=>" qualifier .
timer-interval              = digits (":ms" | ":s" | ":min" | ":hour") .
trace-statement             = "trace:" """ { char | interpolated-variable } """
                              .
interpolated-variable       = "${" var-name | qualified-name "}"
rx-subaudible-detector-
declaration                 = "rx-subaudible-detector:" var-name
                              "code:" subaudible-token
test-generator-declaration  = carrier-tx-generator | fm-tx-generator
```

```
                          | p25-phase1-tx-generator .
carrier-tx-generator      = "carrier-tx-generator:" name
                          "duration:" expiration-time .
fm-tx-generator           = "fm-tx-generator:" name
                          "duration:" expiration-time
                          [ "subaudible:" analog-subaudible ] .
p25-phase1-tx-generator   = "p25-phase1-tx-generator:" name
                          "duration:" expiration-time
                          "tx-signal:" [ "p25-standard" | "p25-tone"
                          | "high-deviation" | "low-deviation" | "silence"
                          | "modulation-fidelity" ] .
analog-subaudible         = "none" | "ctcss-670" | "ctcss-694" | "ctcss-719"
                          | "ctcss-744" | "ctcss-770" | "ctcss-797"
                          | "ctcss-825" | "ctcss-854" | "ctcss-885"
                          | "ctcss-915" | "ctcss-948" | "ctcss-974"
                          | "ctcss-1000" | "ctcss-1035" | "ctcss-1072"
                          | "ctcss-1109" | "ctcss-1148" | "ctcss-1188"
                          | "ctcss-1230" | "ctcss-1273" | "ctcss-1318"
                          | "ctcss-1365" | "ctcss-1413" | "ctcss-1462"
                          | "ctcss-1514" | "ctcss-1567" | "ctcss-1598"
                          | "ctcss-1622" | "ctcss-1655" | "ctcss-1679"
                          | "ctcss-1713" | "ctcss-1738" | "ctcss-1773"
                          | "ctcss-1799" | "ctcss-1835" | "ctcss-1862"
                          | "ctcss-1899" | "ctcss-1928" | "ctcss-1966"
                          | "ctcss-1995" | "ctcss-2035" | "ctcss-2065"
                          | "ctcss-2107" | "ctcss-2181" | "ctcss-2257"
                          | "ctcss-2291" | "ctcss-2336" | "ctcss-2418"
                          | "ctcss-2503" | "ctcss-2541" | "dcs-017"
                          | "dcs-023" | "dcs-025" | "dcs-026" | "dcs-031"
                          | "dcs-032" | "dcs-036" | "dcs-043" | "dcs-047"
                          | "dcs-050" | "dcs-051" | "dcs-053" | "dcs-054"
                          | "dcs-065" | "dcs-071" | "dcs-072" | "dcs-073"
                          | "dcs-074" | "dcs-114" | "dcs-115" | "dcs-116"
                          | "dcs-122" | "dcs-125" | "dcs-131" | "dcs-132"
                          | "dcs-134" | "dcs-143" | "dcs-145" | "dcs-152"
                          | "dcs-155" | "dcs-156" | "dcs-162" | "dcs-165"
                          | "dcs-172" | "dcs-174" | "dcs-205" | "dcs-212"
                          | "dcs-223" | "dcs-225" | "dcs-226" | "dcs-243"
                          | "dcs-244" | "dcs-245" | "dcs-246" | "dcs-251"
                          | "dcs-252" | "dcs-255" | "dcs-261" | "dcs-263"
                          | "dcs-265" | "dcs-266" | "dcs-271" | "dcs-274"
                          | "dcs-306" | "dcs-311" | "dcs-315" | "dcs-325"
                          | "dcs-331" | "dcs-332" | "dcs-343" | "dcs-346"
                          | "dcs-351" | "dcs-356" | "dcs-364" | "dcs-365"
                          | "dcs-371" | "dcs-411" | "dcs-412" | "dcs-413"
                          | "dcs-423" | "dcs-431" | "dcs-432" | "dcs-445"
                          | "dcs-446" | "dcs-452" | "dcs-454" | "dcs-455"
                          | "dcs-462" | "dcs-464" | "dcs-465" | "dcs-466"
                          | "dcs-503" | "dcs-506" | "dcs-516" | "dcs-523"
```

```
                        | "dcs-526" | "dcs-532" | "dcs-546" | "dcs-565"
                        | "dcs-606" | "dcs-612" | "dcs-624" | "dcs-627"
                        | "dcs-631" | "dcs-632" .
```

Language tokens

```
qualified-name          = var-name "." qualifier .
qualifier               = name | digits .
var-name                = name .
name                    = letter { name-char } .
name-char               = digit | letter | "-" | "_" .
digits                  = digit {digit} .
comment                 = "//" { !<newline> } .
name                    = letter { name-char } .
char                    = <any printable character> .
```

18 TaskBuilder Inputs and Actions

What is it possible to do using TaskBuilder?

18.1 TaskBuilder Standard Variables

TaskBuilder inputs and actions are presented as a set of active variables each having distinct states and events. Whether a variable is primarily intended for input or output is a function of the events and states of that variable. The base station current channel for example is both an input and an output.

Notes:

1. All variables generate a state-change event when the respective state becomes active.
2. Variables with writable states (such as channel) can be changed from within TaskBuilder. They serve as TaskBuilder outputs.
3. All variables states are readable by TaskBuilder programs (can write rules that are triggered by the state condition). They serve as TaskBuilder inputs.
4. Alarm names are listed here: TaskBuilder Alarm Names.

18.2 Table of TaskBuilder Standard Variables

The following table lists the standard variables and their associated behaviors.

Standard variable	Summary	Non-writable states	Writable states	Events accepted	Events generated	Parameters
`alarms` (custom)[a]	State of the designated alarms	`disabled`	`inactive, active`	`raise, clear`		
`alarms` (non-custom)[a]	State of the designated alarms	`inactive, active, disabled`				
`call-profile`	P25 call properties		`1 .. 32`		`change`	

[a]Alarm names are defined inTaskBuilder Alarm Names

Standard variable	Summary	Non-writable states	Writable states	Events accepted	Events generated	Parameters
carrier-tx-generator	Generate unmodulated carrier test signal		stopped, running	start - start the tx generator stop - stop the tx generator	expire - the time is up	carrier-tx-generator: <*name-string*> duration: <*integer*> followed by: :ms (milliseconds) :s (seconds) :min (minutes) :hour (hours)
channel	Current base station channel		1 .. 1000	up, down	change	
counter	Number of times something has happened		0, 1 .. 65535	up, down, reset		counter: <*name-string*>
dig-in-1.. dig-in-12	Digital inputs	high, low			change - the input state changed	
dig-out-1.. dig-out-13	Digital outputs		high, low	toggle - change high to low and vice versa		

Standard variable	Summary	Non-writable states	Writable states	Events accepted	Events generated	Parameters
`fm-tx-generator`	Generate test signal with optional subaudible encoding		`stopped`, `running`	`start` - start the tx generator `stop` - stop the tx generator	`expire` - the time is up	fm-tx-generator: <*name-string*> duration: <*integer*> followed by: :ms (milliseconds) :s (seconds) :min (minutes) :hour (hours) (optional) subaudible: ctcss-670, ctcss-693 ... ctcss-2541, dcs-017 ... dcs-754, none* * default
`function-code-receive`	Indicate a received function code between base stations			`0, 1 .. 255`		
`function-code-send`	Send the designated function code between base stations			`0, 1 .. 255`	`0, 1 .. 255`	
`operation`	Initialization and exit actions.	`running` - respond to start up `stopping` - respond to exit				

Standard variable	Summary	Non-writable states	Writable states	Events accepted	Events generated	Parameters
`p25-phase1-tx-generator`	Generate a p25 phase 1 test signal for various tx signal variations		`stopped`, `running`	`start` - start the tx generator `stop` - stop the tx generator	`expire` - the time is up	p25-phase1-tx-generator: <*name-string*> duration: <*integer*> followed by: :ms (milliseconds) :s (seconds) :min (minutes) :hour (hours) (optional) tx-signal: p-25 standard*, p25-tone, high-deviation, low-deviation, silence, modulation-fidelity * default
`rx-gate-state`	RF received signal present	`closed`, `open`, `subaudible-bypassed`, `carrier-bypassed`				
`rx-operation`	Allow received signal		`normal`, `disabled`			
`rx-squelch-mode`	Receiver monitor - override receiver gate		`normal`, `subaudible-bypass`, `carrier-bypass`			

Standard variable	Summary	Non-writable states	Writable states	Events accepted	Events generated	Parameters
`rx-subaudible-detector`	Produces an event in response to a detected subaudible code				`detect`	rx-subaudible-detector: *<name-string>* code: ctcss-670 : ctcss-2541 dcs-17 : dcs-754
`timer`	Generate event after specified time		`stopped`, `running`	`start` - start the timer `stop` - stop the timer	`expire` - the time is up	
`tone-remote`	Control base station by tone signaling				`single-550 .. single-2050`, `dual-550-550 .. dual-2050-2050`	
`tone-remote-key-operation`	Allow tone remote keyed signal		`normal`, `disabled`			
`tone-remote-key-state`	Tone remote transmit signal present	`inactive`, `active`				

Standard variable	Summary	Non-writable states	Writable states	Events accepted	Events generated	Parameters
tx-input[a]	Request to transmit is present (analog or digital line interface, diagnostic test, CWID. tx-input is different from tx-status if transmission is prevented (disabled by configuration or TaskBuilder).	de-keyed, keyed				
tx-key-operation	Allow Tx Key (analog line)		normal, disabled			
tx-key-state	Analog line signal present	inactive, active				
tx-operation	Allow transmit signal		normal, disabled			
tx-status	Transmitting	de-keyed, keyed				

[a]The synchronized transmit is the only diagnostic test that can set tx-input to keyed, since all the others take the base off-line

19 TaskBuilder Alarm Names

This chapter defines the alarm names used by TaskBuilder.

WebUI name	TaskBuilder active variable name
PA	**PA**
PA not detected	alarm-pa-not-detected
Firmware invalid	alarm-pa-firmware-invalid
Calibration invalid	alarm-pa-calibration-invalid
Forward power low	alarm-pa-forward-power-low
Power foldback	alarm-pa-power-foldback
Reverse power high	alarm-pa-reverse-power-high
Shutdown	alarm-pa-shutdown
VSWR high	alarm-pa-vswr-high
Driver current high	alarm-pa-driver-current-high
Final 1 current high	alarm-pa-final1-current-high
Final 2 current high	alarm-pa-final2-current-high
Current imbalance	alarm-pa-current-imbalance
Supply voltage low	alarm-pa-supply-voltage-low
Supply voltage high	alarm-pa-supply-voltage-high
Driver temperature high	alarm-pa-driver-temperature-high
Final 1 temperature high	alarm-pa-final1-temperature-high
Final 2 temperature high	alarm-pa-final2-temperature-high

WebUI name	TaskBuilder active variable name
PMU	**PMU**
PMU not detected	alarm-pmu-not-detected
Firmware invalid	alarm-pmu-firmware-invalid
Mains supply failed	alarm-pmu-mains-supply-failed
Power up fault	alarm-pmu-power-up-fault
Shutdown imminent	alarm-pmu-shutdown-imminent
Temperature high	alarm-pmu-temperature-high
Battery protection mode	alarm-pmu-battery-protection-mode
Battery voltage low	alarm-pmu-battery-voltage-low
Battery voltage high	alarm-pmu-battery-voltage-high
Output current high	alarm-pmu-output-current-high
Output voltage low	alarm-pmu-output-voltage-low
Output voltage high	alarm-pmu-output-voltage-high
System	**System**
Ambient temperature low	alarm-ambient-temperature-low
Ambient temperature high	alarm-ambient-temperature-high
External reference absent	alarm-external-reference-absent
1PPS pulse absent	alarm-1pps-pulse-absent
QoS jitter	alarm-qos-jitter
QoS lost packets	alarm-qos-lost-packets
Transmit buffer	alarm-transmit-buffer
Fallback controlled	alarm-fallback-controlled
Duplicate node priority	alarm-duplicate-node-priority
NTP unsynchronized	alarm-ntp-unsynchronized
Site synchronization unaligned	alarm-site-synchronization-unaligned
TxR cable absent	alarm-txr-cable-absent
Cartesian loop unstable	alarm-cartesian-loop-unstable

WebUI name	TaskBuilder active variable name
Reciter	**Reciter**
Channel invalid	alarm-channel-invalid
Temperature high	alarm-reciter-temperature-high
Simulcast unsynchronized	alarm-simulcast-unsynchronized
Transmitter calibration invalid	alarm-transmitter-calibration-invalid
Receiver calibration invalid	alarm-receiver-calibration-invalid
Hardware configuration invalid	alarm-hardware-configuration-invalid
25 MHz synthesizer out of lock	alarm-25-mhz-synthesizer-out-of-lock
61.44 MHz synthesizer out of lock	alarm-61-44-mhz-synthesizer-out-of-lock
TxF synthesizer out of lock	alarm-txf-synthesizer-out-of-lock
TxR synthesizer out of lock	alarm-txr-synthesizer-out-of-lock
Rx synthesizer out of lock	alarm-rx-synthesizer-out-of-lock
Receiver unsynchronized	alarm-receiver-unsynchronized
Custom	**Custom**
CUSTOM - Alarm 1	alarm-custom-alarm-1
CUSTOM - Alarm 2	alarm-custom-alarm-2
CUSTOM - Alarm 3	alarm-custom-alarm-3
CUSTOM - Alarm 4	alarm-custom-alarm-4
CUSTOM - Alarm 5	alarm-custom-alarm-5
CUSTOM - Alarm 6	alarm-custom-alarm-6
CUSTOM - Alarm 7	alarm-custom-alarm-7
CUSTOM - Alarm 8	alarm-custom-alarm-8
CUSTOM - Alarm 9	alarm-custom-alarm-9
CUSTOM - Alarm 10	alarm-custom-alarm-10
CUSTOM - Alarm 11	alarm-custom-alarm-11
CUSTOM - Alarm 12	alarm-custom-alarm-12
Front panel	**Front panel**
Fan 1	alarm-fan-1
Fan 2	alarm-fan-2
Fan 3	alarm-fan-3
FP not detected	alarm-front-panel-not-detected
Invalid firmware	alarm-front-panel-invalid-firmware

Referencing an alarm that is not defined on that platform means that the TaskBuilder program will fail with a parse error. Examples are:

- alarm-system-site-synchronization-unaligned with DMR firmware
- alarm-front-panel-not-detected with TB7300 base station

20 Specifications and Limits

Parameter	Value	Description
Event response latency	100 ms nominal	The time that TaskBuilder may take to respond to an event. May increase if base station is heavily loaded
Throughput	50 events per second nominal	Number of rules that can be triggered. May decrease if base station is heavily loaded
Maximum outstanding events	20	Events may be discarded if there are more pending events than the value listed

21 TaskBuilder Comparison With Task Manager

21.1 Comparisons with Task Manager

Task Manager, on previous Tait base stations, provides an approximately equivalent facility to TaskBuilder:

- active variables are the foundation of TaskBuilder, with states and events attached to active variables. Variables are active because the TaskBuilder design encourages you to associate behaviors (actions) with each distinct variable state.
- in TaskBuilder, the difference between states (which establish conditions for rules) and events (which trigger rules) is explicit
- composite states derive directly from Task Manager. User programs could synthesize the equivalent states explicitly using events, but it would be clumsy.
- Task Manager has a greater range of inputs and actions
- the design of TaskBuilder pays attention to the naturalness with which program rules can be articulated
- typing program text is still less intuitive and more error prone than selecting input rules and actions using the service kit WebUI
- the performance envelope of TaskBuilder is controlled. The current rate of event processing is approximately 50 events per second (see the base station specifications manual).

21.2 General Elements

This table lets you compare Task Manager and TaskBuilder and find the equivalents in each language.

The entries in the table are not necessarily direct equivalents but are ways to achieve the same result.

Task Manager equivalent	TaskBuilder equivalent	Notes
Comment	`// This is a comment`	Make programs more readable
Custom action	Multiple actions: `when: event then: { action-1, action-2 }`	Do multiple things in response to a condition
Enable / disable task	comment out program text to ignore it	Debugging and control over the running program

Task Manager equivalent	TaskBuilder equivalent	Notes
Task	`when: event then: action given: state when: event then: action`	The basic unit of logic in Task Manager and Task Builder
Task action	Expressed within TaskBuilder rule: `when: event then: action`	Interact with the running program or with the base station.
Task list	Program file	Edit using the in-built TaskBuilder editor or edit off-line using a text editor

21.3 Task Manager Inputs

A number of TaskBuilder variables appear as both inputs and outputs, because TaskBuilder programs can both change standard variables, and respond to those changes.

When a single Task Manager input has multiple corresponding TaskBuilder values, logical combinations of Task Manager custom inputs provide the equivalents.

Task Manager equivalent	TaskBuilder equivalent	Notes
Alarm inputs	alarm standard variables	
Analog line interface channel seized	`tx-key-state.active` `tx-key-state.inactive`	Report the state of analog line Tx key input
Analog line interface tone remote detected	`tone-remote`, `tone-remote-key-state`	TaskBuilder variables capture function codes and key tone
Analog line unlocked	`tx-key-operation.normal` `tx-key-operation.disabled`	Allow Tx key (analog line)
Analog received	none	Report the kind of RF received signal
Analog transmitted	none	Report the kind of RF transmitted signal
APCO received	none	Report the kind of RF received signal

Task Manager equivalent	TaskBuilder equivalent	Notes
APCO transmitted	none	Report the kind of RF transmitted signal
Automatic CWID unlocked	none	Respond to changes in CWID
Auxiliary supply unlocked	none	Control over PMU auxiliary supply
Channel changed, Select channel	`channel.change`, `channel`	Respond to a channel change or to a specific channel
Counter at maximum	`my-counter.nnn`	Respond to a specific counter value. Function is not identical. If TaskBuilder program needs to prevent a counter continuing to increment, program must provide its own logic.
Custom input	`composite-state: alarm.major = ...`	Arbitrary combination of input states
Custom inputs	Composite states	TaskBuilder composite states create new states out of arbitrary combinations of existing standard and active variables
DFSI connected	none	Respond to presence of a DFSI connection
Digital input high	`dig-in-n.high` `dig-in-n.low`	Report the state of digital input
Digital input value	`composite: dig-value-3 = dig-in-0 AND dig-in-1`	Respond to the numeric value of set of inputs
Digital output high	`dig-out-n.high` `dig-out-n.low`	Report the state of digital output
Flag	`active: temp has-states: { hot, cold }`	User defined variable with two states

Task Manager equivalent	TaskBuilder equivalent	Notes
Function code received	`function-code-receive`	Function code event from this or another base station
Function code sent	`function-code-send`	Function code event to another base station

Monitor on	`rx-squelch-mode.normal`
	`rx-squelch-mode.subaudible-bypass`
	`rx-squelch-mode.carrier-bypass`
		Receiver squelch mode

Network element in Run mode	`operation.running` `operation.stopping`	Allows a program to respond to start-up and shut-down
PA carrier present	`tx-status.keyed` `tx-status.de-keyed`	Report whether base station is transmitting
Received NAC	`rx-subaudible-code.nac-nnn`	Received P25 subaudible signaling
Receiver unlocked	`rx-operation.normal` `rx-operation.disabled`	Control over receiver
RF repeat	none	RF repeat state
Rx Gate valid	`rx-gate-state.closed` `rx-gate-state.open`	Respond to received RF signal
Subaudible encoding unlocked	none	Control over transmitted subaudible signaling

Subaudible tone detected	`rx-subaudible-code.ctcss-nnn`
	`rx-subaudible-code.dcs-nnn`
	`rx-subaudible-code.colour-code-nn`
	`rx-subaudible-code.nac-nnn`	

Task Manager equivalent	TaskBuilder equivalent	Notes

Subaudible/NAC decoding unlocked	`rx-gate-state.subaudible-bypassed`
	`rx-gate-state.closed`
	`rx-gate-state.open`
		Monitor squelch

Timer expired	`my-timer.start`
	`my-timer.stop`
	`my-timer.expire`
		Interact and respond to timers

Transmitter unlocked	`tx-operation.normal` `tx-operation.disabled`	Control over transmit signal path
Trunking control channel	none	
Trunking site controller present	none	
Vote won by Analog line	`tx-key-state.active` `tx-key-state.inactive`	TaskBuilder `tx-key-state` is not a direct equivalent. It reports whether a signal is present, not whether the same signal is being transmitted.
Vote won by Control panel	none	
Vote won by Digital line	none	
Vote won by RF	none	

21.4 Task Manager Outputs

Task Manager outputs (equivalently, TaskBuilder actions) allow Task Manager (TaskBuilder) to interact with the base station repeater.

TaskBuilder rules may react to any of the actions listed here

Task Manager equivalent	TaskBuilder equivalent	Notes

Go to channel
Go to next channel
Go to previous channel
	`channel => 10`
	`channel.up`
	`channel.down`
		Change channel

Task Manager equivalent	TaskBuilder equivalent	Notes
Go to call profile	`call-profile => 10`	User or individual call with MDC-1200 signaling at analog line
Go to channel group	none	Selection of channel group profile
Go to RF service profile	none	Selection of service profile associated with analog line

Set digital output high
Set digital output low
Toggle digital output
	`dig-out-01 => high`
	`dig-out-01 => low`
	`dig-out-01.toggle`
		Drive the digital output

Fan test now	none	Perform a fan test
Analog line lock	`tx-key-operation => normal` `tx-key-operation => disabled`	Override operation of analog line
Automatic CWID lock	none	Override operation of CWID
Auxiliary supply lock	none	Control the PMU auxiliary supply output
Channel group lock	`channel => 11`	Enable or disable channel group operation. Can achieve in TaskBuilder by changing channel.
Reciter lock	`rx-operation => normal` `rx-operation => disabled`	Control over RF receive
Subaudible encode lock	none	Control over transmitted subaudible signal

Subaudible/NAC decode lock
Monitor (squelch)
	`rx-squelch-mode => normal`
	`rx-squelch-mode =>subaudible-bypass`
	`rx-squelch-mode =>carrier-bypass`
		Squelch mode

Task Manager equivalent	TaskBuilder equivalent	Notes
Transmitter lock	`tx-operation => normal` `tx-operation => disabled`	Override the transmitter
RF repeat	none	Control over RF repeat
Send function code	`function-code-send.153`	Send a function code

Increment counter
Decrement counter
Reset counter
	`my-counter.up`
	`my-counter.down`
	`my-counter.reset`
		Interact with counter variables.
		TaskBuilder program must provide its own logic to limit the counter value if wanted.

Set flag Clear flag Toggle flag	`temp => hot` `temp => cold`	Interact with user-defined variables
Start timer Stop timer	`my-timer.start` `my-timer.stop`	Interact with user defined timers
Raise custom alarm Clear custom alarm	`alarm-custom-alarm-1.raise` `alarm-custom-alarm-1.clear`	TaskBuilder custom alarm severity is not configurable
Transmit CWID now	none	Continuous Wave Identification
Suspend Sync Tx test Resume Sync Tx test	none	Synchronized transmit test
Lock TM tx Key Unlock TM tx Key	`tx-key-operation => normal` `tx-key-operation => disabled`	Override operation of analog line (Tx key)
none	`carrier-tx-generator: beacon duration: 30:seconds` `when: rx-subaudible-code.ctcss-825 then: beacon.start`	Generate a test transmission

22 Change History

Release 3.65

Clear button added to Monitor > TaskBuilder.

The following Series 2 reciter variables have been added:

- `counter` - number of times something has happened
- `function-code-receive` - receive events from other base stations
- `function-code-send` - send events to other base stations
- `rx-subaudible-detector` - produces an event in response to a detected subaudible code
- `carrier-tx-generator` - generate an unmodulated carrier test signal
- `fm-tx-generator` - generate a test signal with optional subaudible encoding
- `p25-phase1-tx-generator` - generate a P25 Phase 1 test signal for various tx signal variations

Other reciters will generate the error message "not supported on this hardware version".

Release 3.60

- `tx-operation` - allow transmit signal
- `rx-operation` - allow received signal
- `rx-gate-state` - RF received signal present
- `tx-key-operation` - allow Tx Key (analog line)
- `tx-key-state` - analog line signal present
- `tone-remote-key-operation` - controls whether the tone-remote-key is disabled or works normally (according to the configuration)
- `tone-remote-key-state` - tone remote transmit signal present
- `rx-squelch-mode` - receiver monitor - override receiver gate

Release 3.55

- `tone-remote` - provides for console control via tone signaling. Applies to P25/AS-IP conventional operation
- `call-profile` - provides P25 call information for consoles using the analog line interface

Release 3.35

Reference the new Tait corporate website domain www.taitcommunications.com.

Release 3.25

- `dig-out-13` is an output-only digital pin with the ability to sink current for driving a relay
- trace: - statement allows programs to write directly to the log
- WebUI: [Undo] button allows you to revert to the last good TaskBuilder program

Release 3.20

TaskBuilder is intended for general release.

Leading zeroes

In base station release 3.20, some of the standard variable names have been changed to remove leading zeroes, for example;

- `channel.023` becomes `channel.23`
- `dig-in-03` becomes `dig-in-3`
- `dig-out-03` becomes `dig-out-3`

Case sensitivity

Names are case-insensitive. In release 3.20, names are converted internally to lower case, and displayed (WebUI, logs) in lower case. In future releases, names will still be case-insensitive, but the original case of the input text will be preserved.

TaskBuilder keywords are case-insensitive. They are displayed in lower case independently of the case in the input text.

TaskBuilder exit event

TaskBuilder can respond to exit events as well as start up events. On TaskBuilder exit, TaskBuilder will execute the actions for rules that include a `when: operation.stopping` clause.

TaskBuilder control over custom alarms

TaskBuilder program actions can now raise or clear base station custom alarms.