PLEG Basics – An Introduction to the Program Logic Event Generator V7.35

Introduction

Program Logic Event Generator (PLEG) is a powerful and flexible tool for initiating **Actions** on the basis of the state of one or more **Inputs**. Inputs may be logical states (**Triggers**), variable values (**Device Properties**) or based on time (**Schedules**). The **Conditions** under which the **Actions** will be executed are described by expressions that can include logical, arithmetic, string or time-sequence terms. PLEG can be used for both simple and complex scenarios - the principles are the same.

PLEG has many advantages over standard Vera scenes (with or without Lua code). One of the most significant is that, following a Vera restart, PLEG will restart its Schedules accurately and process any changes that occurred during the restart.

PLEG is not difficult to use but it does require you to translate your requirements into logical expressions. This may require a little practice so it is often better to start with simple scenarios and work your way up. I recommend setting up a PLEG with a few *VirtualSwitch* or *MultiSwitch* devices so that you can test your logic before trying it out on your real devices. The *VariableContainer* plugin can also be used as a source or recipient of analogue values whilst you test your logic.

Forum members have asked how to use PLEG for almost every possible scenario and have rarely been disappointed. There is a very good chance that something close to your requirements has already been discussed so a thorough search using *Google* may pay dividends. Even with a pre-tested recipe, though, you will need to understand how it works. To help newcomers, I will attempt to explain in this guide the principles and practice of using PLEG.

The guide consists of the following sections: (Click the links to go to the page)

UI7

PLEG works equally well on both UI5 and UI7 versions of Vera firmware. There are differences in appearance and certain buttons may be in different places but, generally, the explanations in this guide apply to both versions (except where noted). The one major difference is in the Action editor. When running in UI5, PLEG uses Vera's normal scene editor to create and edit Actions. With UI7 this is not possible and so PLEG incorporates a special UI7 Action editor. The differences in the two approaches are highlighted in the section on Actions.

Names

Names of **Triggers**, **Device Properties**, **Schedules** and **Conditions** must be unique and may not start with a number or contain any spaces. Case is not significant: LightOn is the same as lighton or LIGHTON.

When you create a new item, PLEG offers a default name. This starts with a lower-case letter that depends on the type of item: Triggers start with t; Schedules start with s; Device Properties use p; Conditions have c. The letter is followed by an incrementing number. You may change the default name as required but many users find that keeping the first letter helps to differentiate between the different types when they are used in Conditions.

If you attempt to create an item with a name that has already been used in this PLEG, the name of the new item will have a numeric suffix. E.g. If you try to create *tLightOn*, and it already exists, the new name will be *tLightOn1*. Further duplications will get you incremented numbers. You may see this happen if you delete an item and then try to create a new one with the same name. The solution is to Save/Restart Vera and refresh your browser page after the deletion and before creating the new item.

When you change the name of an existing item, PLEG attempts to change all references to it in Conditions and Actions. This generally works well but there are exceptions. These include where the item is used in Lua code and where it is used as an argument in an advanced Action. Use PLEG's Status report to check whether there are any places where the old name is still being used and correct these manually.

Triggers

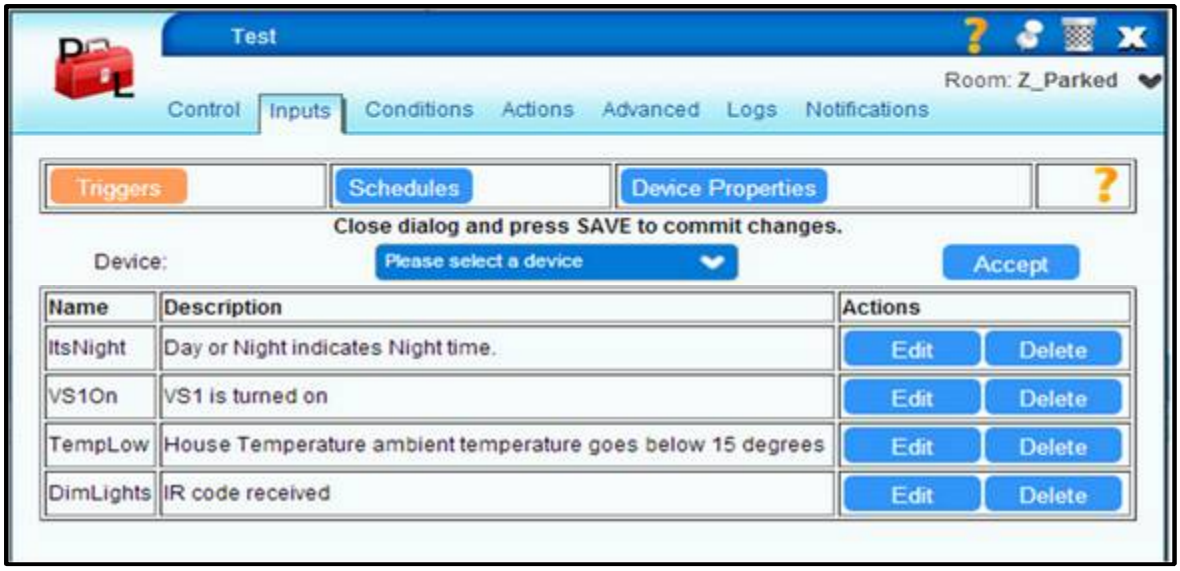
PLEG Triggers are references to logical events. They can be either true or false. The time when the state last changed is noted as the Trigger's *timestamp*.

Each device and plugin in Vera pre-defines a set of available Triggers. A Trigger may reflect the status of various elements of a device or plugin - depending on the type of device concerned. Examples include: *on/off, open/closed, tripped/not-tripped*. This type of Trigger may be set to reflect either sense of a status - a Trigger could be true when the device is turned off.

Triggers may also be associated with a level and a comparison. Examples include: *temperature goes-above 20*; *light-level goes-below 100*. In some devices, a Trigger may be set for a particular value. Example: *mode equals "Heat"*.

Create a PLEG trigger by selecting **Inputs -> Triggers** then selecting a **Device** from the pull-down list. The options in **Event Type** will depend on the type of device selected. Select the type of event for which this Trigger is required. Enter a **Name** for this Trigger. It will help later if this name has some obvious meaning - e.g. *BedLightOn*. Select **which state** to determine the sense of this Trigger or, if the Trigger is a comparison, enter the threshold value. Finally click on **Accept**.

It is not necessary to create Triggers for both senses of each status or comparison. You will see later that logical operators may be used to invert the sense of a Trigger in Condition expressions. The *timestamp* of a Trigger's false/true or true/false transition can also be included in Condition expressions by using the **#** or **#!** operators.

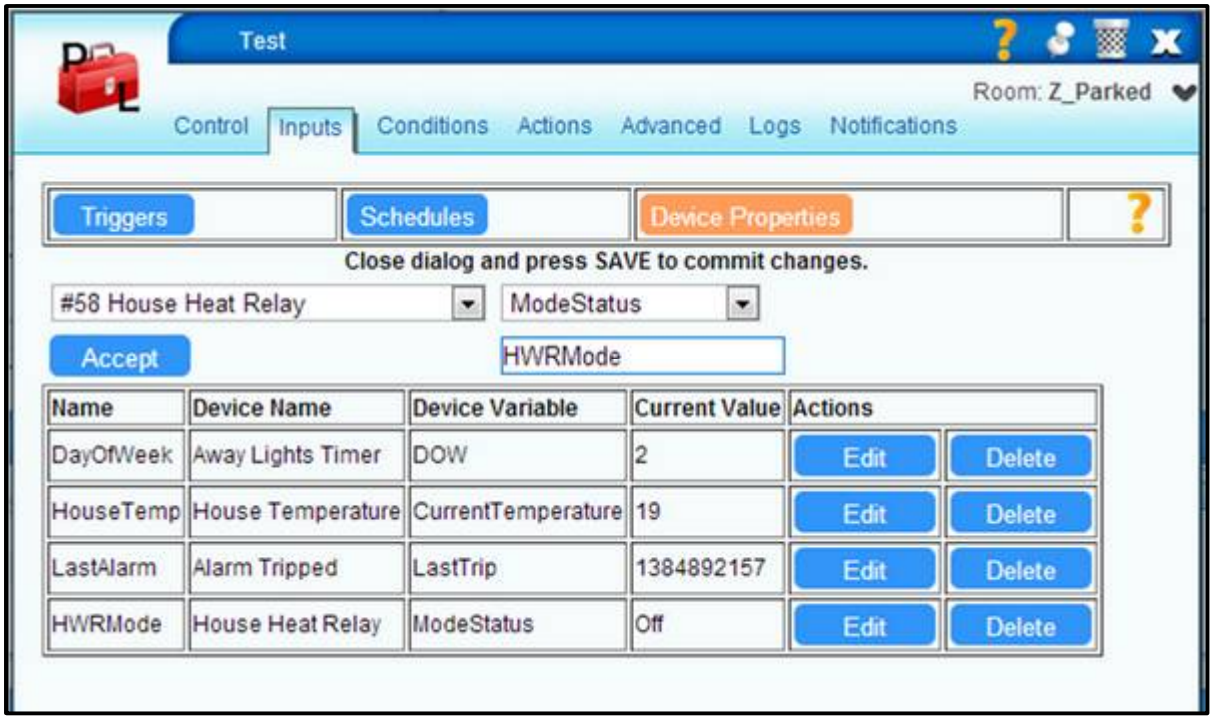


Device Properties

PLEG Device Properties may be used to access variables from devices or plugins. These will be represented as analogue values even if they reflect on/off states. The time when the value last changed is noted as the Device Property's *timestamp*.

PLEG will accept almost any type of variable as a Device Property. If the value is numeric, it may be used in expressions for calculations or numeric comparisons. String values may be compared to each other, or to constants, by the use of special operators. Example variables that may be used as a Device Property include: *CurrentSetpoint, LoadLevelStatus, LastUpdate, BatteryLevel, ModeStatus*.

Create a PLEG Device Property by selecting **Inputs -> Device Properties** then selecting a **Device** from the pull-down list. The options in the next pull-down box will depend on the type of device selected. Select the variable this Device Property should reflect. Click **Create**. To change the name of the new Device Property, click **Edit**, change the name from the default and click **Accept**.



Schedules

PLEG provides a comprehensive set of options for time Schedules. Each Schedule should have a **Start Type** and may optionally have a **Stop Type**. If there is no **Stop Type** specified, the Schedule will only be true for one cycle of PLEG evaluation. When both **Start Type** and **Stop Type** are specified, the Schedule will remain true throughout the inclusive period. The time when the Schedule last became true is noted as the Schedule's *timestamp*.

Start Type and **Stop Type** mostly provide the same options. The exceptions are noted below:

- **Interval** - Repetitively becomes true every hh:mm:ss. Will be pinned to exact times so each hour will be on the hour, etc.
- **Day of Week** - Selectable for any or all days of the week. The time is specified as shown below.
- **Day of Month** - Selectable for a comma-separated list of days. The time is specified as shown below.
- **Absolute** - On a specified date and time. The year may be specified or left as ***** to signify any year.
- **Self-Trigger** - Start Type only. Does not start automatically. Started by the use of a special PLEG action (see later).
- **Self-ReTrigger** - Start Type only. As **Self-Trigger** but may be restarted whilst running to provide *Watchdog* functionality.

There are several options for specifying the time for **Day of Week** and **Day of Month** types:

- **At a certain time of day** - The time is specified in **Hours, Minutes and Seconds**.
- **At sunrise** - At the moment of sunrise as predicted for your location.
- **Before sunrise** - The specified **Hours, Minutes and Seconds** earlier than sunrise.
- **After sunrise** - The specified **Hours, Minutes and Seconds** later than sunrise.
- **At sunset** - At the moment of sunset as predicted for your location.
- **Before sunset** - The specified **Hours, Minutes and Seconds** earlier than sunset.
- **After sunset** - The specified **Hours, Minutes and Seconds** later than sunset.

With the exception of **Self-Trigger** and **Self-Retrigger**, all of the types may include an optional **Random Delay** in the form hh:mm:ss. When this is specified, the start or stop times will be delayed by a random time between zero and hh:mm:ss.

The **Self-Trigger** Schedule provides the means to start the timer on a specific event. This can be useful for providing a lock-out of parts of your logic until the timer has run its course. This form of Schedule is started by the **Start Timer** action for the PLEG device on which the Schedule is defined - specifying the name of the **Self-Trigger** Schedule. The **Start Timer** action also allows the predefined **Stop Type Interval** to be optionally overridden by the time value entered in the action's **intervalTime** field. While a **Self-Trigger** timer is running, additional **Start Timer** actions for it will be ignored. In the case of a **Self-ReTrigger** timer, additional **Start Timer** actions for it will restart the timer. This can be used to implement *Watchdog* functionality: If the timer is started by some periodic event, the absence of this event for the period set by the **Stop Type Interval** will allow the timer to complete and the Schedule to become false.

If a Schedule does not have a **Stop Type**, it will not have an *off event*. Such a Schedule will only cause the evaluation of a Condition in which it is used when it turns on and its state will, at that point, always be true. If *At0730* is a daily Schedule for 07:30 without a **Stop Type**, the Condition:

Morning At0730

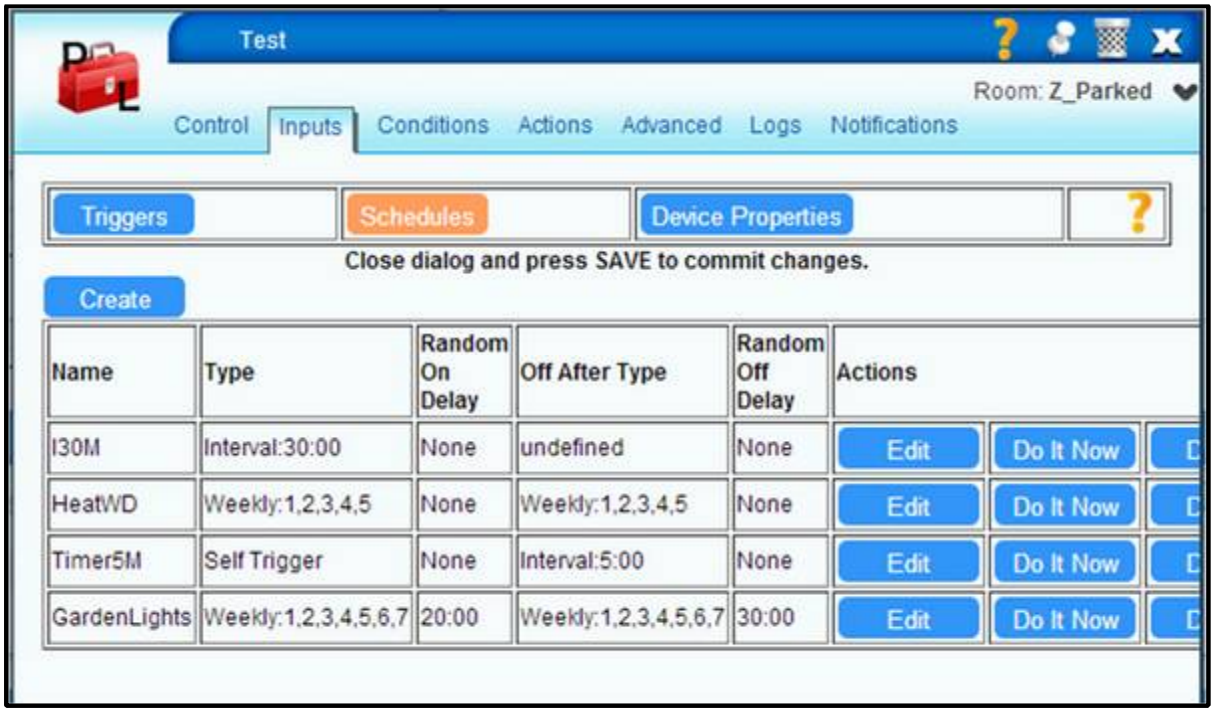
will become true at 07:30 on the first day and stay that way forever. Any associated Action will only fire on the first day. There are two ways around this: Check the **Repeats** option for the Condition so that it will fire its Action each time *At0730* becomes true; Add a **Stop Type** to *At0730* – say an Interval of one minute – so that it will re-evaluate the Condition when it turns off and set it to false.

There is an advantage in setting a Schedule's **Stop Type** to *Interval* rather than an absolute time. If PLEG happens to restart just before an absolute time, the stop event may not occur until the following day. With an *Interval*, PLEG is able to recover from the restart and set the state of the Schedule correctly.

Create a PLEG Schedule by selecting **Inputs -> Schedules** then clicking **Create**. Select the required **Start Type** from the pull-down list and then enter or select the appropriate options and values. If an inclusive timer is required, repeat the process for **Stop Type**. Click **Accept**. To change the name of the new Schedule, click **Edit**, change the name from the default and click **Accept**.

When you create a new Schedule it will have no history. The Schedule will not be true even if the current time lies between the Start and Stop times. You can force a Schedule true or false by clicking its **Do It Now** button. Each time this is clicked, it will toggle the state of the Schedule.

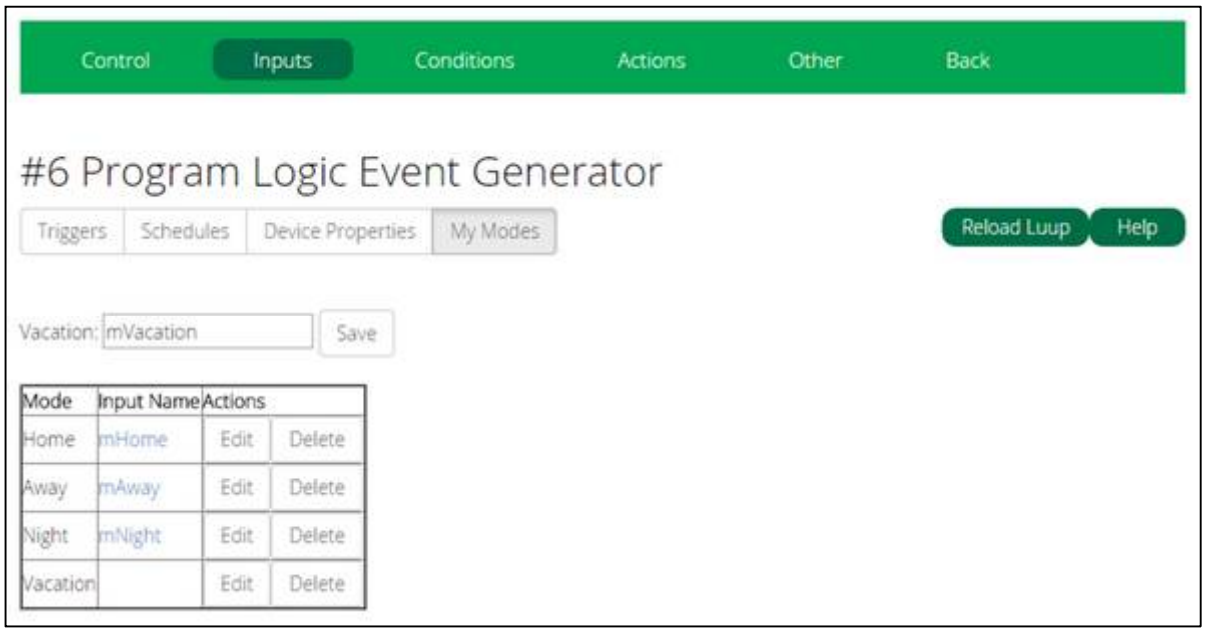
When testing new PLEG logic, it often helps to temporarily set Schedule Start and Stop times to the near future. Once you are sure the logic works, you can edit the Schedules to set the actual times required.



UI7 Modes

UI7 provides a built-in House Mode with four options: *Home, Away, Night* and *Vacation*. When PLEG runs on UI7, it includes an additional **My Modes** tab in **Inputs** to allow Trigger names to be assigned to each of the four modes.

To assign or change the name of a mode, click the **Edit** key. Enter the new name in the field that appears and then click the **Save** button.



Conditions

PLEG Conditions are where you define the logic that connects inputs and actions. Conditions have a name and an expression. The expression contains one or more terms separated by operators. A term can be a Trigger, Device Property, Schedule, constant or Condition name. Operators can be logical, arithmetic or string. There are some special forms of expression that are evaluated on the basis of *timestamps* rather than current value.

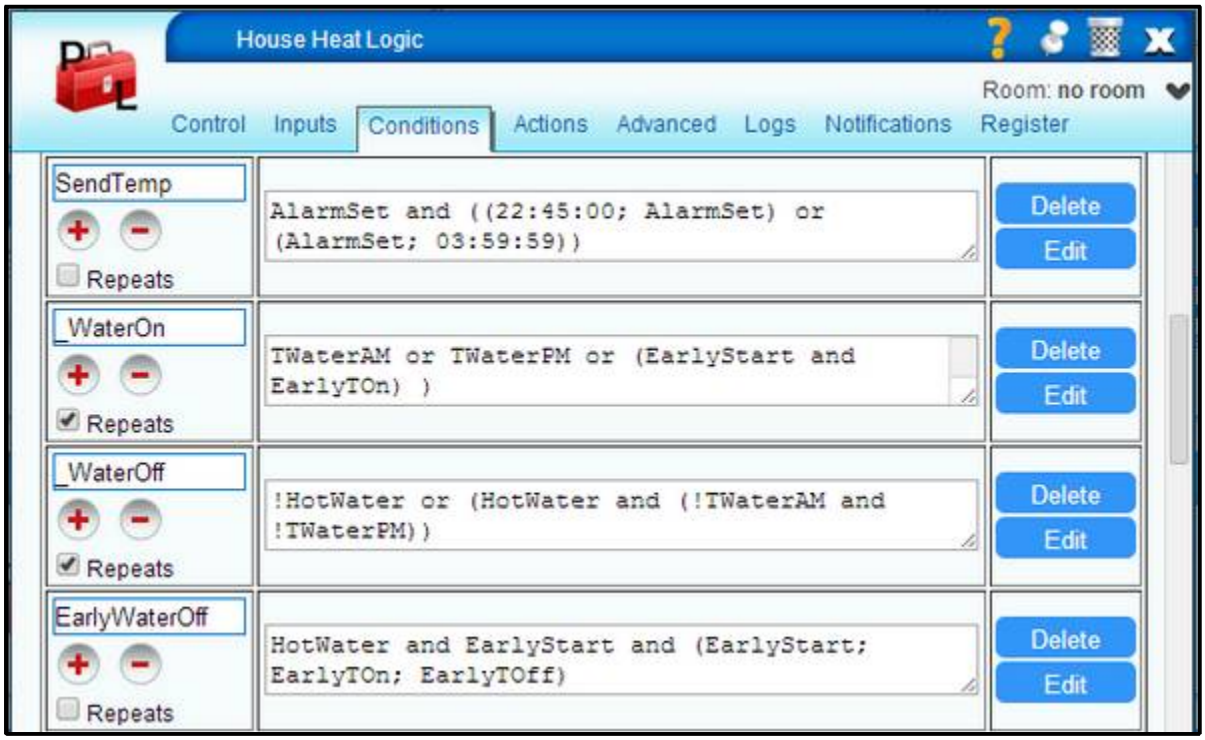
A normal Condition will *fire* when the value of its expression changes from false (0) to true (not 0). The time when the state last changed is recorded as the Condition's *timestamp*.

If a Condition's **Repeats** check-box is checked, it will *fire* every time the value of its expression changes and is not zero. Its *timestamp* will be the time when this last happened.

Conditions are evaluated from the top down. If you use the value or *timestamp* of one Condition in another, the order of the Conditions is significant. If you refer to the value or *timestamp* of a Condition that is below your expression, you will be using the results of the previous evaluation run.

PLEG will start an evaluation cycle when one of the Triggers, Device Properties or Schedules, that is used as a term in at least one Condition, changes**.** A Condition will only be evaluated if it includes a term that has changed since the last evaluation run.

Create a Condition by selecting the **Conditions** tab and clicking **Add Row**. Change **Condition Name** on the left as required and type your expression into **Condition Expression.** You can also use the built-in editor by clicking the **Edit** button. You can change the order of Conditions by clicking the **+** or **–** buttons. The **–** button will raise a Condition up the list and the **+** button will lower it.



Logical Expressions

In its simplest form, a Condition will contain logical terms and operators and have a logical result.

LightsOn ItsNight and Away

LightsOn will be true whenever *ItsNight* is true and *Away* is true. If either *ItsNight* or *Away* are false, **LightsOn** will be false.

The logical operators are:

- **not** (9) Negates the following term so true becomes false and vice versa.
- **!** (9) Exactly equivalent to **not.**
- **and** (3) The result will only be true if both the preceding and following terms are true.
- **or** (2) The result will be true if either of the preceding or following terms are true.

All operators have a precedence (as shown in parentheses) that dictates the order in which they will be applied. Higher numbers are applied first. So in the expression **A and not B or C**, *B* is negated then and-ed with *A* and the result is or-ed with *C*. Parentheses may be used to force the evaluation of expressions in a certain way: **A and not (B or C)** is quite different from the previous version.

Parentheses may be used liberally to make expressions more readable and to simplify expressions:

A and B or A and C and D or A and D and E may be written as **A and (B or (D and (C or E)))**

You may use any practical number of terms, or pairs of parentheses, in an expression.

Numerical Comparisons

You can test the values of Device Properties or other Conditions by using numerical comparisons.

LightsOn Away and (LightLevel < 100)

LightsOn will be true whenever *Away* is true and *LightLevel* is less-than 100. If either *Away* is false or *LightLevel* is higher than 99, **LightsOn** will be false.

The numerical comparison operators are:

- **==** Is equal to.
- **!=** Is not equal to.
- **>** Is greater than.
- **>=** Is greater than, or equal to.
- **<** Is less than.
- **<=** Is less than, or equal to.

The numerical comparison operators have a precedence of (4) so they will be applied after arithmetic operators but before logical ones – unless forced by parentheses.

Arithmetic Expressions

All PLEG terms (Triggers, Device Properties, Schedules, Conditions, expressions) have a value. For logical (boolean) terms, the value is 0 when false or 1 when true. Device Properties, Conditions and expressions may have a range of values. Provided the values are valid numbers, they may be used in arithmetic expressions.

HeatOn (TempF – 32) * 5 / 9 < TempLimit

HeatOn will be true whenever *TempF* , converted from Fahrenheit to centigrade, is less-than the value of *TempLimit. TempLimit* could be a Device Property reflecting the setpoint of a metric thermostat or another Condition statement where the limit was calculated.

The arithmetic operators are:

- **-** (9) Unary negation of the following term. Positive becomes negative and vice versa.
- **#** (9) Return the false-to-true (on) timestamp of the following term.
- **#!** (9) Return the true-to-false (off) timestamp of the following term.
- **%** (8) Modulus. The remainder of integer division by the following term.
- ***** (7) Multiply by the following term.
- **/** (7) Divide by the following term.
- **+** (6) Add the following term.
- **-** (6) Subtract the following term.

All operators have a precedence (as shown in parentheses) that dictates the order in which they will be applied. Higher numbers are applied first. You should note that all arithmetic operators will be applied before any comparison or logical ones. If in doubt, just add parentheses.

Conditional Expressions

The conditional expression returns one of two different values depending on the true/false state of the first term. It may help to consider it as an *if - then – else.* The format is: XX ? YY : ZZ which has the value YY if XX is true and ZZ if XX is false. The first term must evaluate to true or false.

The conditional expression has a precedence of (1) so will be evaluated after all other operators. It will be necessary to use parentheses in most cases when using conditional expressions with other operators.

HeatOn HouseTemp < (ItsNight ? 14 : 20)

HeatOn will be true whenever *HouseTemp* is less than 14 if *ItsNight* is true or 20 if *ItsNight* is false.

Conditional expressions can be cascaded if required.

HeatOn HouseTemp < (ItsNight ? 14 : (WeekEnd ? 21 : 19))

As with the previous example, the temperature setpoint is 14 when *ItsNight* is true but will depend on the state of *Weekend* when *ItsNight* is false. When *WeekEnd* is true, the daytime setpoint will be 21 otherwise it will be 19.

Conditional expressions can be cascaded to almost any necessary level. Use parentheses to ensure that they are evaluated in the required order and to help with readability.

The first term in a conditional expression may be any expression that has a logical (Boolean) result.

HeatOn HouseTemp < ((LightLevel < 100) ? 14 : 20)

HeatOn will be true whenever *HouseTemp* is less than 14, if *LightLevel* is less than 100, or 20 if *LightLevel* is greater than 99.

Condition Values

So far all the examples have been written to give the Conditions a Boolean (true/false) value. A Condition may take any value, though. This feature can be used to calculate values for use in other Condition expressions.

SetPoint (Home ? (ItsNight ? 14 : (WeekEnd ? 21 : 19)) : 5)
HeatOn HouseTemp < SetPoint

SetPoint is used to calculate the required temperature threshold used by **HeatOn**. This will be 5 if *Home* is false. If *Home* is true, it will be 14 when *ItsNight* is true. If *Home* is true but *ItsNight* is false, it will be 21 when *WeekEnd* is true or 19 if not.

String Expressions

When the value of a Device Property, Condition or expression is a sequence of characters that is not a valid number, you can only employ it by using string expressions.

> **HeatOn** HouseTemp < 20 and HWRMode eq "Off"

HeatOn will be true whenever *HouseTemp* is lower than 20 and *HWRMode* contains the string *Off*

The string operators are:

- **..** (5) Concatenate the following string term.
- **eq** (4) Is equal to.
- **ne** (4) Is not equal to.
- **gt** (4) Is greater than.
- **ge** (4) Is greater than, or equal to.
- **lt** (4) Is less than.
- **le** (4) Is less than or equal to.
- **=~** (4) Contains the following substring.

The string comparison operators have a precedence of (4) so they will be applied after any concatenation operators but before logical ones – unless forced otherwise by parentheses.

Equal-to (**eq**) and not-equal-to (**ne**) work as you would expect: Two strings are equal when they are identical. Note that case is significant in string comparisons. "Off" is not equal to "off" or "OFF".

Greater-than (**gt**) and less-than (**lt**) are a little more complex: They are compared using a lexical sort order – like a dictionary or index. Note that lower-case characters are greater-than upper-case ones.

- "Off" is greater than "Ofe"
- "Off" is greater than "Oeg"
- "Off" is less than "Ofg"
- "Off" is greater than "OfG"

The substring operator (**=~**) searches the item or expression on the left to see if it contains the substring on the right. If the substring is wrapped with forward slashes (/), it is evaluated as a Lua regular expression (as used with string.match(…)).

> **IsOn** DevStatus =~ "On"

IsOn will be true if *DevStatus* contains the string *On*. This could be in the form *Mode=On*.

String literals (constants) must be delimited with single or double quotation marks. e.g. 'Heat' or "Heat". There is no difference in the value of these two literals.

When used in logical (Boolean) expressions, a term with a string value is logically true if it has a length greater than zero. So “x” is true but “” is false. This can give unexpected results if you mistakenly treat a Device Property as if it were a Trigger. If **Status** is a Device Property with possible values of “0” or “1” and it is used in a Condition like this:

AutoOn Status and Motion…

Status will always be true because it is a string with a length greater than zero. You should instead use either of the following forms:

AutoOn Status eq “1” and Motion…
AutoOn Status == 1 and Motion…

Working With Time

Up to now we have been concerned with the values of terms in our expressions. Sometimes, though, we care about the times at which events occurred. This is where PLEG really shines.

As has been noted in the preceding sections, whenever a Trigger, Schedule or Condition changes state, the time at which this happened is noted as a *timestamp*. Also, whenever the value of a Device Property, State Variable or Condition with **Repeats** checked changes, the timestamp is recorded. These timestamps are the foundation of PLEG's ability to work with time.

PLEG stores timestamps as *Epoch* times with millisecond resolution. Epoch time comes from the early days of Unix and start from January 1st 1970 at 00:00:00 GMT. The integer part of an Epoch time or PLEG timestamp is a count of the number of seconds since the start. The decimal portion of PLEG's timestamp extends the resolution to a count of milliseconds.

So PLEG can compare timestamps with millisecond accuracy over almost any period of time. It should be obvious, but just in case, 22:00:01 on January 2nd, 2015 is earlier than 22:00:00 on January 3rd, 2015. That is, a comparison of timestamps includes the date as well as the time.

As you will see in the following section, the timestamp associated with the change of an item's state or value is automatically used when the item is used in a *Sequence Expression.* It is also possible to use the value of a timestamp in an arithmetic expression. Two special operators are provided for this purpose. The **#** and **#!** operators were mentioned in the section on Arithmetic Expressions but their use is not always obvious.

If a Trigger called *tSwitch* has just turned off, the expression **(#!tSwitch - #tSwitch)** returns the number of seconds that it was turned on. Likewise, if *tSwitch* has just turned on, the expression **(#tSwitch - #!tSwitch)** returns the number of seconds that it was turned off. There is an example below that shows how this may be used to calculate a duty-cycle.

You could also determine how long the timer *sTimer* has been running by using the expression **(#Now - #sTimer).**

Should you need to know, the expression (#Now % 86400) will return the number of seconds since midnight.

Sequence Expressions

A sequence expression is a list of terms separated by commas or semi-colons. It may be followed by one or two time constraints. A term can be the name of a Trigger, Device Property, Schedule, State Variable or Condition. Normally the sequence expression will consider the *timestamp* of the last false/true (on) transition of the term. If the term is preceded by an exclamation mark (!), it refers to the timestamp of the last true-to-false (off) transition instead. A term can also be an absolute time as hh:mm:ss. It cannot be an expression. Sequence expressions are evaluated solely on the timestamps associated with the terms. The current value of the terms is irrelevant.

If the terms are separate by commas, the sequence expression will be true when all the terms have timestamps that meet the time constraints. The order of the terms and timestamps doesn't matter. This is called an *un-ordered* sequence expression.

If the terms are separated by semi-colons, the sequence expression will be true when the timestamps for the terms are in the same order as the terms and meet the time constraints. This is called an *ordered* sequence expression.

One, two or no time constraints may follow the list of terms. The constraints are written in the form: **< hh:mm:ss** or **> hh:mm:ss**.

< hh:mm:ss indicates that the time between the oldest and newest timestamps for the terms in the list must be less than *hh:mm:ss*.

> hh:mm:ss indicates that the time between the oldest and newest timestamps for the terms in the list must be greater than *hh:mm:ss*.

LockDoor DoorClosed; AlarmSet < 10

LockDoor will become true if *AlarmSet* becomes true less than 10 seconds after *DoorClosed* becomes true. This is not a practical example, though, because it disregards the current state of *DoorClosed* and *AlarmSet* so would be true when *AlarmSet* becomes true even if *DoorClosed* was false – but had once been true.

LockDoor DoorClosed and AlarmSet and (DoorClosed; AlarmSet < 10)

LockDoor will become true when *DoorClosed* and *AlarmSet* are true and happened, in that order, within 10 seconds. Parentheses are important when mixing sequence, logical and arithmetic expressions.

LightOn (Motion1 or Motion2 or Motion3) and (Motion1, Motion2, Motion3 < 1:00)

LightOn will become true if Motion1, Motion2 and Motion3 are all tripped, in any order, within one minute.

LightOff LightOn and (LightOn; !Timer)

LightOff will become true if Timer ends after LightOn became true.

There is a special predefined term that may be used in sequence expressions. **Now** is effectively an interval timer with a one-minute period. Its presence in an expression will cause the expression to be evaluated every minute. **Now** will have a *timestamp* of the current time when the evaluation takes place. Note that **Now** is not a variable containing the current time although you could use **#Now** to get its timestamp which is effectively the same thing.

LightOff LightOn and (LightOn; Now > 5:00)

LightOff will become true if *LightOn* remains true for 5 minutes.

Lockout Motion; Now < 2:00

Lockout will be true for two minutes after *Motion* becomes true.

Note that as **Now** only *fires* once per minute, it is not suitable for precise timing. The expression: **Event; Now > 1:00** could become true at any time between 1:01 and 2:00 after *Event* becomes true.

Absolute times may also be used as terms in a sequence expression.

Away AlarmSet and (08:00:00; AlarmSet; 21:00:00)

Away will become true if *AlarmSet* becomes true between 08:00:00 and 21:00:00.

A combination of absolute times and **Now** could be used as an alternative to using a **Schedule** but, as it causes an evaluation cycle once a minute, it would use considerably more CPU cycles.

DayTime (06:00:00; Now; 21:30:00)

DayTime will be true between 06:00:00 and 21:30:00.

When absolute times are used in a sequence expression, they are considered to occur in the same 24 hour period. The expression (22:00:00; AlarmTripped; 06:00:00) will never be true as 06:00:00 is always earlier than 22:00:00. If you want to specify a time period that crosses midnight, use the following construction:

OverNightAlarm AlarmTripped and Not (06:00:00; AlarmTripped; 22:00:00)

This becomes true if *AlarmTripped* is true and this did not occur between 06:00:00 and 22:00:00 – in other words it did occur after 22:00:00 or before 06:00:00.

As mentioned above, a term in a sequence expression may not be an expression. So this is not valid:

DoorAlarm AlarmArmed and (Door1 or Door2) and (AlarmArmed;(Door1 or Door2))

Instead of this, place the expression in a preceding Condition:

AnyDoor Door1 or Door2

DoorAlarm AlarmArmed and AnyDoor and (AlarmArmed; AnyDoor)

Multiple Trigger Expressions

Sometimes we want to recognise when a number of events have occurred in a certain period of time. PLEG provides a means to do that with a special expression.

TriggerOrDevicePropertyOrCondition @ Count > hh:mm:ss < hh:mm:ss

The first term is the name of a Trigger, Device Property or Condition whose events we wish to count. **Count** is the number we are testing for. **> hh:mm:ss** and **< hh:mm:ss** are time constraints for the counted events. The time constraints are applied by checking the *timestamps* of the oldest and newest of the counted events. Either or both of the time constraints may be used.

> hh:mm:ss indicates that we want to test if the counted events occurred in a period greater than *hh:mm:ss*.

< hh:mm:ss indicates that we want to test if the counted events occurred in a period less than *hh:mm:ss*.

SoundSiren MotionDetector @ 3 < 5:00

SoundSiren will become true if *MotionDetector* becomes true three times in a five minute period.

Special Conditions

PLEG has two reserved Condition names: **ARM** and **BYPASS**. If you create conditions with these names, they will directly control PLEG's **Arm/Bypass** state without you needing to define an Action. When **ARM** becomes true, it will set PLEG to *Arm*. When **BYPASS** becomes true, it will set PLEG to *Bypass*.

State Variables

PLEG provides a State Variable mechanism through the use of a special form of Condition naming: **StateName$***StateValue*. When such a Condition becomes true, it sets the value of **StateName** to *StateValue*. The value of the State Variable may be tested in logical expressions using **StateName eq "StateValue"**. The value of **StateName** will be initialized to the *StateValue* of the first Condition with a **StateName$***StateValue* name.

In the following Conditions, **State** will initially have the value "S1". If **Step** is a Trigger, each time it becomes true the value of **State** will cycle through "S2", "S3", "S1", "S2", etc.

State$S1 Step and (State eq "S3") and (State; Step)
State$S2 Step and (State eq "S1") and (State; Step)
State$S3 Step and (State eq "S2") and (State; Step)

You may define Actions for each **StateName$***StateValue* combination and they will fire when that Condition becomes true. You may also define an Action for **StateName** which will fire whenever its value is changed – behaving in the same way as a Condition with **Repeats** checked.

Exporting Conditions

The value of a Condition may be *Exported* by PLEG so that it may be used by another PLEG (as a Device Property) or Lua code in a scene (as a device variable). This is achieved by checking **Enable Export** on the Conditions tab and then checking **Export** for each Condition that you want to export.

When exported, the value of a Condition is placed in a device variable for the PLEG in which it is defined. The ServiceId of the variable is *urn:rts-services-com:serviceId:User* and its name is that of the Condition – including case.

If PLEG device number 123 exports a Condition named *cAutoAway*, this could be accessed in Lua code by:

```
Local autoAway = luup.variable_get("urn:rts-services-com:serviceId:User","cAutoAway",123)
```

In another PLEG device, it could be accessed by creating a Device Property for the originating PLEG (device 123) and selecting the property *cAutoAway* from the list.

Changing the name of a Condition that is exported will result in a new device variable being created. The old one will remain until the PLEG is deleted but will no longer be updated. You have been warned!

Actions

Actions are how PLEG makes things happen. They are associated with Conditions and will be performed when the Conditions *fire*. A normal Condition *fires* when its value changes from false to true. A Condition with **Repeats** checked will *fire* whenever it is evaluated as true or non-zero. If an Action has been created for a Condition, it will be performed whenever the Condition *fires*.

Actions are events. They are performed when they are *fired*. If an Action turns on a lamp, that's all it does. When the Condition that *fired* the action is no longer true, there is no automatic mechanism to undo the Action. If you want the lamp turned off, you must create a Condition and associated Action to do that. You can have a single Action turn a device on or off by using the **{(yourexpression)}** feature to set *newTargetValue* according to *yourexpression* (see later).

An Action consists of one or more device actions. These operations may be **Immediate** or **Delayed**. There are many different possible device actions depending on the type of the target device. Examples include: *Turn On*, *SetCurrentSetpoint*, *SetLoadLevelTarget*.

Simple device actions may be defined using the same selection interface used for Vera scenes. More complex operations are defined through the **ADVANCED** tab/menu where all available action calls for a device may be selected and the associated parameters specified. PLEG provides a special mechanism for action parameters with the term: **{(yourexpression)}** where **yourexpression** is a PLEG expression that evaluates to a suitable value for the operation being performed.

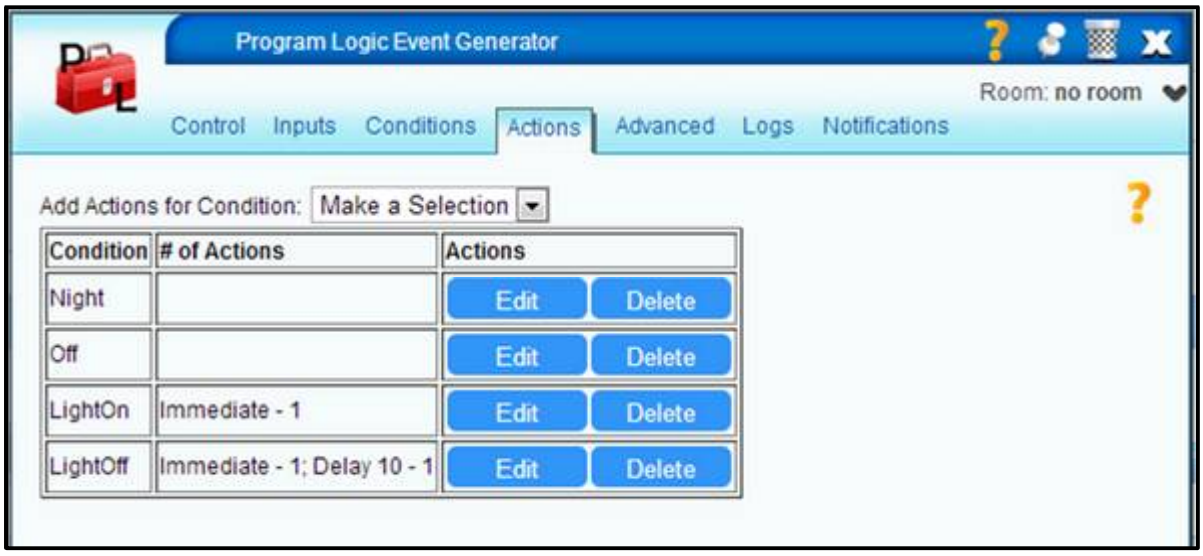
Create an Action by selecting the **Actions** tab. If there is already an entry in the table for the Condition for which you want the Action, click the **Edit** button to the right. Otherwise, use the **Make a Selection** pull-down to select the required Condition.

On UI5

This will display the same page used for defining device actions in scenes. You can control timing of the device actions using the drop-down box at the top left. If you simply want to turn a device on or off, or set a dimmer level, you can select this by clicking on the appropriate button of the device. You can select multiple device actions on this page.

More complex device actions can be defined on the **ADVANCED** tab. Here you can select the device on the **Pick a device:** pull-down and then click **Add**. Now there is a pull-down containing all of the device actions supported by the device. When you select one, if it requires a parameter, a blank field will appear. Enter the required parameter in this field. The parameter may be a number or a string depending on the selected device action. This is where you can enter **{(yourexpression)}** if you want the parameter value to be calculated by PLEG using *yourexpression*.

When you have defined all required device actions for this Condition, click the **FINISHED** tab. Your new device actions should be shown in the list for the selected Condition with *Immediate* or whatever delay you chose.



On UI7

This will display PLEG's UI7 Action editor. If you want your Action to be executed without delay, click the **Immediate** tab. If you want the Action delayed, enter the delay time where it shows *HH:MM:SS* and click **Add Interval** – then select the **Delay xx** tab**.** You only need to add an interval if it has not already been defined.

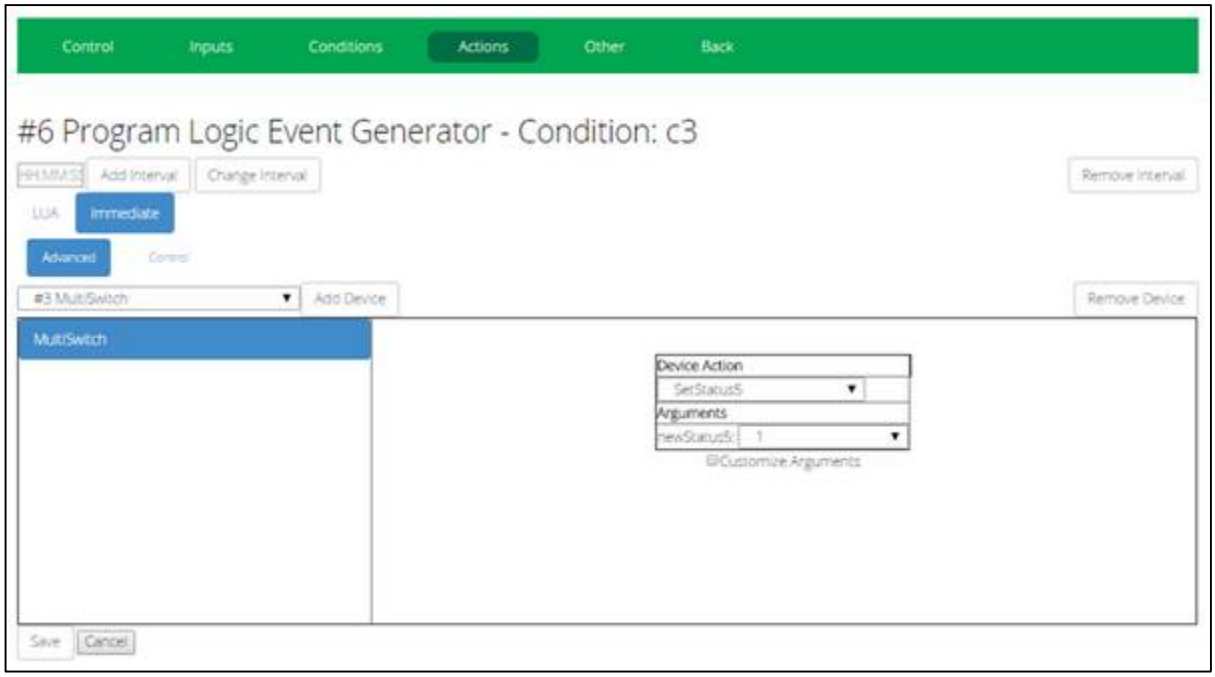
Now you have two optional tabs: **Advanced** and **Control**. The **Advanced** tab provides a greater range of options for device actions. The **Control** tab is for simple operations supported by the devices normal UI buttons. In either case, select the target device with the **Please select a device** pull-down and click **Add Device**.

On the **Advanced** tab, you can now select a device action with the **Please Select an Action** pull-down. Boxes for any arguments will now be presented. These may be in the form of pull-downs with expected values or they could be text fields. Select or enter the values.

If you want a value that does not appear in the pull-down list, check **Customize Arguments** which will change the field to a text box and allow you to enter any value. You may also enter the special {(expression)} for a calculated argument.

On the **Control** tab, you can select the device action using the buttons shown on the device tile. The resulting device action will be the same as if you had clicked the button on the device in Vera's UI.

When you have finished creating/editing Actions for a Condition, click the **Save** button at the bottom. Your new device actions should be shown in the list for the selected Condition with *Immediate* or whatever delay you chose.



UI5 and UI7

PLEG provides some special device actions when it is selected as a target for an Action.

- **StartTimer** Start the *Self-Trigger* or *Self-Retrigger* Schedule specified by **timerName.** Optionally set the interval to **intervalTime.**
- **RunScene** Run the Vera scene specified by **SceneNameOrNumber**
- **SetVariable** Set a device variable as specified by the arguments for **ServiceId**, **VariableName**, **Value** and **Device** (number).
- **SetHouseMode** UI7 Only**.** Set Vera *House Mode* to value specified by **Mode** argument. 1 = *Home*, 2 = *Away*, 3 = *Night*, 4 = *Vacation*.

There are some other special PLEG actions but these are not intended for use from within PLEG.

Note that if you restart a running *Self-Retrigger* Schedule using an optional **intervalTime** argument that is less than the remaining time, it will have no effect on the timer.

Lua Code in Actions

PLEG Actions may also include Lua code. This is entered on the Action's **LUUP** (UI5) or **LUA** (UI7) tab. As with Vera scenes, if the Lua code returns false, the explicit device actions will not be performed. If the code returns true or nothing, the device actions will be performed.

You can access PLEG's Inputs and Conditions from Lua code using the following syntax where **XXXX** is the name of the item in upper-case (e.g. LightOn --> LIGHTON):

- **XXXX.state** The value of Input or Condition **xxxx**
- **XXXX.seq** The timestamp when **xxxx** last became true (on)
- **XXXX.oseq** The timestamp when **xxxx** last became false (off)
- **XXXX.seqh[n]** The nth *on* timestamp history for **xxxx** where n is between 1 and 10
  XXXX.seqh[1] is the same as **XXXX.seq**

These variables should be considered read-only. Assignment to these variables may lead to unpredictable PLEG behaviour. The on timestamp history in **XXXX.seqh[n]** is not preserved through a Vera restart.

Lua code in PLEG Actions may include Vera's **luup** functions so it is possible to get or set device variables and utilise other extension functions as you might do in Vera scene Lua. Global variables set in one Action will be available to Lua in other Actions of the same PLEG device.

Once you have finished entering or editing code in the **LUUP** tab, click **Save lua** (UI5) **or Save** (UI7).

Global variables defined in Vera scenes and Startup Lua are not available in PLEG's Lua context. PLEG has its own **Startup Lua** section where global variables and functions may be defined and then used by Lua code in Actions on the same PLEG. You can edit Vera's **Startup Lua** by clicking the button on the **Control** tab in UI5 or the **Actions** tab in UI7. Be sure to click on **Save** when you have finished.

Working with PLEG

Whenever you have created or edited any Triggers, Device Properties, Schedules, Conditions or Actions, you must save the changes, restart Vera and then reload your browser page (F5 key). If you do not perform this sequence, you may get erroneous or confusing results.

Saving changes and restarting is slightly different in UI5 and UI7. In UI5, close PLEG's device window (by clicking the **X** at the top right) and then click on Vera's **Save** button. In UI7, click the **Reload Luup** button on the **Inputs, Conditions or Actions** tab.

PLEG provides a very useful report when you click the **Status** button on the **Control** tab. The report shows the current state of all Triggers, Device Properties, Schedules, State Variables and Conditions and the *timestamps* of when they last changed. For Device Properties and State Variables, the *timestamp* of the previous change is also shown. The *timestamps* show the date and time including milliseconds. This information is very valuable when debugging your logic – particularly when you are using sequence expressions.

Remember that PLEG will only perform an evaluation cycle when some Trigger, Device Property or Schedule has changed and is used in one of the Condition expressions. An evaluation cycle is also triggered every minute if the special term Now has been used in a sequence expression.

Don't forget to **Arm** the PLEG before you test your logic. If PLEG is set to **Bypass**, none of the Actions will be executed. The special Condition **ARM** can be used to Arm a Bypassed PLEG as it does not require an Action.

PLEG's **Log** button may be used to display its own log entries. It will also allow you to select verbose **Debug** logging to either Vera's main *LuaUPnP.log* or a *Standalone* file. When you change **Debug**, you must click Vera's **Save/Reload** button for the change to take effect.

PLEG includes a **Backup** button that will save a copy of the configuration to a file in Vera's */etc/cmh-ludl* folder . When clicked, it will offer a default **Backup File Name** that may be changed if required. Click the second **Backup** button to complete the operation.

The **Restore** button may be used to reload a saved backup. After restoring a backup, Save, Reload and refresh as you would after any change to a PLEG configuration.

Licensing

Starting from April 1st 2014, PLEG versions greater than 4.5 will only provide the unrestricted features if a valid license has been purchased and registered. The license is a one-time purchase for use on a single Vera serial number and will remain valid for subsequent versions of the firmware. Each license allows the use of up to four devices which may be a mixture of PLEG and PLTS. Multiple licenses may be purchased to expand the number of permitted devices in increments of four.

To allow for proper evaluation of PLEG, the full feature set may be used without the purchase of a license for thirty days after installation. If PLEG was installed on your system earlier than March 2nd 2014, there will be no additional evaluation period after April 1st 2014.

If a license has not been registered, and PLEG has been installed for more than thirty days, the following restrictions will be applied from April 1st 2014:

- A maximum of three PLEG or PLTS devices may be used
- Each PLEG will be limited to five Inputs and five Conditions
- Devices that exceed these restrictions will be disabled

If a system includes more PLEG or PLTS devices than permitted by the registered license, only the number entitled by the license will run. Messages on the Vera UI Dashboard will show if any devices have been disabled.

Licenses may be purchased by clicking the **Registration Portal** button on the **Register** tab that is included on PLEG V6.0 and later. When the license code is received by email, enter it into the **Registration ID** field and click **Verify**. The registration status is shown on PLEG's **Status** report. The **Registration ID** is unique to the Vera serial number for which it was purchased. It has no value to anyone else so does not need to be obscured when posting Status reports.

Example – Simple Motion-Triggered Light

Turn on a light when a motion-detector is tripped at night. Turn it off if there has been no motion for 10 minutes. Ignore motion for 30 seconds after light is turned off. The light may be locked on by rapid on/off/on of the light switch (requires a light switch with instant or very rapid status reporting). The motion sensor should be configured with a short on-time (less than the interval time). None of the Conditions require **Repeats** to be checked.

Triggers

LightOn	Light is turned on
Motion	Motion Sensor is tripped
ItsNight	DayTime indicates night

Schedules

Timer	On: Self-ReTrigger Off: Interval 10:00

Conditions

AutoOn	!LightOn and ItsNight and Motion and (!LightOn; Motion > 30)
KeepOn	(LightOn and Motion and (LightOn; Motion)) or AutoOn
AutoOff	LightOn and !Timer and (LightOn; !Timer) and (!LightOn; LightOn > 10)

Actions

AutoOn	Turn Light on
KeepOn	PLEG StartTimer timerName=Timer
AutoOff	Turn Light off

Example – Light Controlled by Door Switches

Turn on a light if any of three doors are opened. Turn off the light when all doors are closed provided one or more was open for at least 20 seconds. Turn off the light if still on after one hour. None of the Conditions require **Repeats** to be checked.

Triggers

LightOn	Light is turned on
Door1	Door1 sensor is tripped
Door2	Door2 sensor is tripped
Door3	Door3 sensor is tripped

Conditions

AutoOn	Not LightOn and (Door1 or Door2 or Door3)
AllClosed	Not Door1 and Not Door2 and Not Door3
AutoOff	LightOn and ((LightOn; Now > 1:00:00) or (AllClosed and (AutoOn; AllClosed > 20)))

Actions

AutoOn	Turn light on
AutoOff	Turn light off

Example – Simple Heater Timer

Turn Heater on and off according to schedules for weekdays and weekends provided Home VirtualSwitch is on. Turn Heater off if Home is turned off after Heater is turned on by any means. None of the Conditions require **Repeats** to be checked.

Triggers

Home	Home VirtualSwitch is turned on
HeaterOn	Heater is turned on

Schedules

WeekdayAM	Start Type: Day of Week, Check Days Monday to Friday, Time: 06:30, Stop Type: Day of Week, Check Days Monday to Friday, Time: 08:00
WeekdayPM	Start Type: Day of Week, Check Days Monday to Friday, Time: 20:30, Stop Type: Day of Week, Check Days Monday to Friday, Time: 22:00
WeekdendAM	Start Type: Day of Week, Check Days Saturday &Sunday, Time: 07:30, Stop Type: Day of Week, Check Days Saturday &Sunday, Time: 09:30
WeekendPM	Start Type: Day of Week, Check Days Saturday &Sunday, Time: 19:30, Stop Type: Day of Week, Check Days Saturday &Sunday, Time: 23:00

Conditions

Away	Not Home
AutoOn	Home and (WeekdayAM or WeekdayPM or WeekendAM or WeekendPM)
AutoOff	Not AutoOn or (HeaterOn and Away and (HeaterOn; Away))

Actions

AutoOn	Turn Heater on
AutoOff	Turn Heater off

Example – Set Dimmer to Level Saved in VariableContainer

Triggers

Door	Door sensor is tripped
LightOn	Light is turned on

Device Properties

DimLevel	VariableContainer Variable1

Conditions

AutoOn	Door and Not LightOn
AutoOff	LightOn and (LightOn; Now > 5:00)

Actions

AutoOn	Light SetLoadLevelTarget newLoadlevelTarget={(DimLevel)}
AutoOff	Turn Light off

Example – Send Setpoint to Thermostatic Radiator Valve with Automatic Retry

Calculate temperature setpoint according to day/night and state of Home VirtualSwitch. Send required setpoint to TRV whenever it changes. Resend setpoint every five minutes until successfully set using **Self-Trigger** timer. None of the Conditions require **Repeats** to be checked.

Triggers

Home	Home VirtualSwitch is turned on
ItsNight	Day or Night indicates night

Device Properties

SetPoint	TRV CurrentSetpoint

Schedules

Timer5M	Start Type: Self-Trigger, Stop Type: Interval, 5 Minutes

Conditions

Target	ItsNight ? 14 : (Home ? 20 : 16)
SendSP	(Target != LastTarget) or (!Timer5M and (!Timer5M; Now < 1:05) and (SetPoint != Target))
LastTarget	Target

Actions

SendSP	TRV SetCurrentSetpoint NewCurrentSetpoint={(Target)} PLEG StartTimer timerName=Timer5M

Target will be set to the required temperature setpoint according to the state of **ItsNight** and **Home**: If **ItsNight** is true, **Target** will be 14 otherwise it will be 20 if **Home** is true or 16 if not.

SendSP will become true if **Target** has changed since the last evaluation cycle or if the five minute timer **Timer5M** has just ended and the TRV setpoint does not equal **Target**. When **SendSP** becomes true, the new setpoint value from **Target** is sent to the TRV and **Timer5M** is started.

LastTarget is set to the current value of **Target** to allow a subsequent change to be detected.

Example – A Simple Alarm using a State Variable

The State Variable **Alarm** is set to the states "Idle", "Armed", "Error", "Tripped" or "Alert" by the state-change Conditions. Starting from "Idle", the state will change to "Armed" if the VirtualSwitch **Arm** is turned on and none of the monitored doors are open. If any door is open when **Arm** is turned on, the state will change to "Error". In the "Armed" state, an opened door will change the state to "Tripped" which will start a 30 second timer. If the timer ends before the **Arm** switch is turned off, the state will change to "Alert" and the associated action will send an SMS via Twilio. If **Arm** is turned off, the state will return to "Idle". State changes will trigger a Sonos Say action to speak the value of **Alarm**. None of the Conditions require **Repeats** to be checked.

Triggers

Arm	Alarm VirtualSwitch is turned on
Door1	Door1 sensor is Tripped
Door2	Door2 sensor is Tripped
Door3	Door3 sensor is Tripped

Schedules

Timer30S	Start Type: Self-Trigger, Stop Type: Interval, 30 Seconds

Conditions

AnyDoor	Door1 or Door2 or Door3
Alarm$Idle	Not Arm
Alarm$Armed	Alarm eq "Idle" and Arm and Not AnyDoor
Alarm$Error	Alarm eq "Idle" and Arm and AnyDoor
Alarm$Tripped	Alarm eq "Armed" and AnyDoor
Alarm$Alert	Alarm eq "Tripped" and (Alarm$Tripped; !Timer30S)

Actions

Alarm$Tripped	PLEG StartTimer timerName=Timer30S
Alarm$Alert	Twilio SendSMSMessage Message= "Call Police…"
Alarm	Sonos Say Text={('Alarm state is ' .. Alarm)}

Example – A Bathroom Fan Timer

This example uses the State Variable **Fan** and the Self-ReTrigger Schedule **Timer** to control a bathroom fan according to how long the bathroom light is turned on. A brief visit to the bathroom does not cause the fan to start. A visit over three minutes but less than ten will cause the fan to be run for ten minutes. A visit of over ten minutes will run the fan for thirty minutes. The fan can be run for ten minutes by switching the light on/off/on quickly. If the fan is turned on manually it will be turned off after twenty minutes. None of the Conditions require **Repeats** to be checked.

When the light is first turned on, **Fan** is set to '*Idle*' and **Timer** is started for three minutes. If **Timer** ends and the light is still on, the bathroom fan is turned on, **Fan** changes to '*Short*' and **Timer** is started for ten minutes. **Fan** will also be set to '*Short*', the fan turned on and **Timer** started for ten minutes if the bathroom light is turned off and back on within ten seconds while the fan is turned off.

When **Fan** is '*Short*' and **Timer** ends, if the light is still on, **Fan** changes to '*Long*' and **Timer** is started for twenty minutes otherwise **Fan** changes to '*Off*' and the fan is turned off.

Fan will also be set to '*Long*' and **Timer** started for twenty minutes if the bathroom fan is turned on manually.

When **Fan** is '*Long*' and **Timer** ends, **Fan** changes to '*Off*' and the fan is turned off regardless of whether the light is on or off.

Triggers

LightOn	Bathroom Light is turned on
FanOn	Bathroom Fan is turned on

Schedules

Timer	Start Type: Self-ReTrigger, Stop Type: Interval, 3 Minutes

Conditions

Fan$Off	FanOn and !Timer and ((Fan eq 'Short' and !LightOn and (Fan$Short; !Timer)) or (Fan eq 'Long' and (Fan$Long; !Timer)))
Fan$Idle	!FanOn and LightOn and (!FanOn; LightOn)
Fan$Short	(Fan$Idle and !Timer and (Fan$Idle; !Timer)) or (!FanOn and (!LightOn; LightOn < 10))
Fan$Long	(Fan eq 'Short' and !Timer and LightOn and (Fan$Short; !Timer)) or (FanOn and (Fan eq 'Off' or Fan eq 'Idle') and (Fan$Off; FanOn))

Actions

Fan$Off	Bathroom Fan off
Fan$Idle	PLEG StartTimer timerName=Timer intervalTime=3:00
Fan$Short	Bathroom Fan on PLEG StartTimer timerName=Timer intervalTime=10:00
Fan$Long	PLEG StartTimer timerName=Timer intervalTime=20:00

Example – Duty-Cycle Calculation

This example may appear obscure but it is actually an extract from one of my running PLEGs. I included it to show some of the lesser-used features of PLEG. This part of the logic captures the duty-cycle of a heater that is controlled by Secure SRT321 Z-Wave thermostat. The thermostat maintains the current temperature at setpoint by cycling the heater with a varying duty-cycle. I wanted to know the duty-cycle to help me tune the heating system.

Conditions **CountOn** and **CountOff** accumulate the total on and off times of the heater switch. This is done using the **#** and **#!** operators to obtain the timestamps of the on and off events. They are reset to zero every 30 minutes by the Schedule **I30M**. The duty-cycle is calculated in the Condition **Duty** from these two values unless switching has not occurred in which case the duty-cycle must be 0 or 1 depending on whether the heater is off or on.

The Condition **Report** takes the value of **Duty** just before it is reset by **I30M** becoming true. This is the value of the duty-cycle for the last 30 minutes. What use is it? It could be used by a subsequent Condition to adjust the heating setpoint; It could be exported for use by another PLEG or a scene; I log it to a file using Lua code in the Action for Condition **Report** – along with the thermostat setpoint, current temperature and outside temperature. Then I have an Excel spreadsheet that reads the file and plots all the values so I can see how my heating copes with changing conditions. The Condition **CleanLog** runs its Action Lua every morning at 00:01:00 to remove all the entries in the log file that are older than three days.

I warned you that it was obscure but study it. When you understand how it works, you are well on your way to becoming a PLEG Master!

Triggers

HeaterOn	Heater is turned on

Schedules

Daily0001	StartType: Weekly, every day, 00:01, StopType: Interval. 00:00:10
I30M	StartType: Interval, 00:30:00, StopType: Interval, 00:00:10

Conditions

Report	[R]	(I30M and (Duty; I30M)) ? Duty : Report
CountOn		I30M ? 0 : ((!HeaterOn and (I30M; !HeaterOn)) ? (CountOn + (#!HeaterOn - #HeaterOn)) : CountOn)
CountOff		I30M ? 0 : ((HeaterOn and (I30M; HeaterOn)) ? (CountOff + (#HeaterOn - #!HeaterOn)) : CountOff)
Duty	[R]	(CountOn == 0) ? (HeaterOn ? 1 : 0) : (CountOn / (CountOn + CountOff))
CleanLog		Daily0001

[R] means that **Repeat** is set on for that Condition.