

Test Plan Reference

PLT

0.7.3

2021-03-30

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Revision History

Revision History

Revision 0.7.3 2021-03-30

- Document ATSAME5 and ATSAME5_DAP targets
- Document EFM32 target
- Document PIC18F25K20 and PIC18F25K20_KP2 targets

Revision 0.7.2 2020-06-22

- **program**: Document EFR32 target
- **uart**: Document `timeoutms` field
- Document `numeric()`

Revision 0.7.1 2020-05-09

- Expand **extractKey**: documentation
- **program**: Add PSoC4 target
- Document **webhook** command

Revision 0.7.0 2020-04-28

- Document **calibration**: sections
- **program, erase**: Add PSoC6 and CMSIS targets
- **measure**: Document unit suffixes, clarify reference argument

Revision 0.6.9 2020-03-30

- Remove **ESP32_HomeKit** target
- **program**: Allow any number of firmware elements
- **program**: Add PN7360, PN7362, PN7460 and PN7462 targets
- **serial set**: Set serial number
- **pin**: Can control **SWD_NRST** and **UARTx_RTS**

Revision 0.6.8 2020-02-24

New commands:

- **canCfg** - Configure CAN interface
- **canClear** - Configure CAN interface
- **canMatch** - Match received CAN message
- **canSend** - Send CAN message
- **ftdiCfg** - Configure external FTDI

Revision 0.6.5 2019-10-07

- Add STM32F2 and ST32F2_STLink targets

Revision 0.6.4 2019-10-08

No change

Revision 0.6.3 2019-10-07

- document `noflush` option for uart and uartExpect commands
- eval command
- uart: extract multiple keys
- ble test: Low-level BLE testing

Revision 0.6.2 2019-10-03

- document JLink/ST-Link target variants
- update initial example
- scan: ANY format
- serial request: user key extraction

Revision 0.5.7 2019-08-22

- `label` command: Document ZPL templates
- add Nordic nRF91 Cortex-M33 targets

Revision 0.5.6 2019-08-19

- Document retry mechanism for test items and test item steps
- Document GATT-level BLE commands
- Document `image` command test step to set background images
- Document setting Label substitutions with the `label` command test step
- add AVRATmega168P/PB targets

Revision 0.5.2 2019-05-13

- ``measure``: Document ``reference`` argument
- Document ``nfc`` command

Revision 0.5.1

2019-04-16

- Add ``CC1352`` target
- Document ``define`` command

Revision 0.5.0

2019-03-31

- Document ``freq`` command
- Document ``measure`` command
- Document ``mux`` command
- Document ``pin`` command
- Document ``power`` command
- Document ``short`` command
- Document ``uartCfg`` command

Revision 0.4.9

2019-03-28

- Document ``serial request`` command
- Update UART port names

Revision 0.4.8

2019-03-08

Renamed to Test Plan Reference

Revision 0.4.7

2019-03-08

Split off from System Manual

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Preface

Document describing the test suite definition for use with the Production Line Tool.

1. Test Plan Reference

1.1 Test Plan YAML definition

Example: A minimal test suite, with a single test item, scanning a bar code.

```
title: "PLT demo: Scan"
suite:
- ident: SCAN-T1
  title: Scan MAC address
  steps:
  - command: scan ANY
```

1.1.1 Test Plan Structure

PLT test suites are encoded as YAML text files, starting with the test suite title.

```
title: "PLT demo: Scan"
```

The `title:` is followed by the `suite:` section, containing the test items in the test plan.

1.1.1.1 Test Items

Test items are identified with an `ident:` line, can contain a descriptive `title`, and should contain one or more test item steps.

The `ident:` field can be omitted, in which case test items will be automatically enumerated. A top-level `identPrefix:` field can be used to set common prefix for auto-generated test item identifiers.

During test execution, all test item steps need to complete successfully for the test item to succeed.

1.1.1.2 Test Item Steps

Test item steps consist of `command:` or `uartcmd:` blocks. A Test Item can contain multiple Test Item steps.

1.1.1.3 Retries

Retry counts can be set for at the test item or at the test item step level, by adding a `retry:` field.

```
title: "Retries"
identPrefix: "R"
suite:
- title: Test Item retries
  retry: 3
  steps:
  - command: sleepms 1000
  - command: operator Manual
- title: Test Item retries
  steps:
  - command: sleepms 1000
  - command: operator Manual
  retry: 3
```

1.1.2 Basic Example

A basic In-Circuit Test suite for the PLT demo board.


```

title: "v0.1.8 (Green)"
identPrefix: "ICT"
suite:
- title: Identify DUT
  steps:
  - command: identify nRF52
- title: Erase nRF52
  steps:
  - command: erase nRF52
- title: Program DEMO-BOARD FW nRF52
  steps:
  - command: program nRF52 s132_nrf52_6.0.0_softdevice.hex,ly10-demo-fw-0.1.8.hex
- title: BLE discovery
  steps:
  - command: bledis %BLEMAC% 30 # Wait up to 30 seconds for BLE discovery to complete

```

1.1.3 Calibration

Some test setups may require additional calibration, which can be specified in the YAML test plan with an optional top-level `calibration:` section.

```

calibration:
- [ppc: <ppcID>]
  [impedance: <impedanceOffset>]
  [voltage: <voltageOffset>]
  [voltageDATP07: <voltageOffset>]
  [voltageDATP08: <voltageOffset>]
  [voltageDATP09: <voltageOffset>]
  [voltageDATP10: <voltageOffset>]
  [voltageDATP11: <voltageOffset>]
  [voltageDATP12: <voltageOffset>]
  [voltageMUX0: <voltageOffset>]
  [voltageMUX1: <voltageOffset>]
  [voltageMUX2: <voltageOffset>]
  [voltageMUX3: <voltageOffset>]
  [current: <currentOffset>]
  [current3V3: <currentOffset>]
  [current5V: <currentOffset>]
  [currentVARV: <currentOffset>]
- ...

```

The following fields can be set in a calibration entry:

Field	Description
<code>ppc:</code>	Define the PPC for which this calibration entry should be applied. If omitted, the section defines the default offsets, to which a PPC-specific calibration section would be added.
<code>impedance:</code>	Specifies the offset for impedance measurements.
<code>voltage:</code>	Specifies the offset for voltage measurements.
<code>voltageDATP07:</code>	Specifies the offset for voltage measurements on the voltageDATP07 measurement channel. Overrides the offset specified in the voltage: field.
<code>voltageDATP08:</code>	Specifies the offset for voltage measurements on the voltageDATP08 measurement channel. Overrides the offset specified in the voltage: field.
<code>voltageDATP09:</code>	Specifies the offset for voltage measurements on the voltageDATP09 measurement channel. Overrides the offset specified in the voltage: field.
<code>voltageDATP10:</code>	Specifies the offset for voltage measurements on the voltageDATP10 measurement channel. Overrides the offset specified in the voltage: field.
<code>voltageDATP11:</code>	Specifies the offset for voltage measurements on the voltageDATP11 measurement channel. Overrides the offset specified in the voltage: field.
<code>voltageDATP12:</code>	Specifies the offset for voltage measurements on the voltageDATP12 measurement channel. Overrides the offset specified in the voltage: field.

Field	Description
voltageMUX0:	Specifies the offset for voltage measurements on the voltageDATP09 measurement channel. Overrides the offset specified in the voltage: field.
voltageMUX1:	Specifies the offset for voltage measurements on the voltageDATP10 measurement channel. Overrides the offset specified in the voltage: field.
voltageMUX2:	Specifies the offset for voltage measurements on the voltageDATP11 measurement channel. Overrides the offset specified in the voltage: field.
voltageMUX3:	Specifies the offset for voltage measurements of the voltageDATP12 measurement channel. Overrides the offset specified in the voltage: field.
current:	Specifies the offset for current measurements.
current3V3:	Specifies the offset for current measurements of the current3V3 measurement channel. Overrides the offset specified in the current: field.
current5V:	Specifies the offset for current measurements of the current5V measurement channel. Overrides the offset specified in the current: field.
currentVARV:	Specifies the offset for current measurements of the currentVARV measurement channel. Overrides the offset specified in the current: field.

With the following argument values:

Argument	Description
ppcID	PPC identifier for a ppc: field, to define a calibration specific to a particular PPC.
impedanceOffset	Offset for impedance measurements. Can be specified with nOhm , uOhm/μOhm , mOhm , Ohm , kOhm/KOhm or MOhm suffixes. If no suffix is specified, the offset is assumed to be specified in Ohm.
voltageOffset	Offset for voltage measurements. Can be specified with nV , uV/μV , mV , V , kV/KV or MV suffixes. If no suffix is specified, the offset is assumed to be specified in Volt.
currentOffset	Offset for current measurements. Can be specified with nA , uA/μA , mA or A suffixes. If no suffix is specified, the offset is assumed to be specified in Ampere.

Example:

```

title: "test plan with calibration"
identPrefix: "ICT-T"
calibration:
# Default offsets
- impedance: -100 # 100 Ohm
  voltage: +20mV # Default for all voltage channels
  voltageDATP01: +40mV
  voltageMUX2: +20mV
  voltageMUX3: +30mV
  currentVARV: -20mA
# Additional offsets specific to a particular PPC
- ppc: 39c8db # Additional offsets for this PPC
  impedance: +1200hm
  voltageDATP08: -10mV
  current5V: +100mA
suite:
- title: Impedance Measurement
  steps:
    - command: mux 0 RATP02
    - command: mux 1 RATP17
    - command: mux 2 RA
    - command: mux 3 RVREF
    - command: short 0 2 set
    - command: short 1 3 set
    - command: measure impedance 10-200hm

```

1.2 Test Commands

1.2.1 ble gatt - GATT-level BLE Tests

Perform GATT-level BLE interactions with the DUT.

Usage:

```
- command: ble gatt connect addr:<address> [<timeout> [<minRSSI>]]  
  [retry: <retryCount>]  
  
- command: ble gatt connect name:<name> [<timeout> [<minRSSI>]]  
  [retry: <retryCount>]  
  
- command: ble gatt disconnect  
  [retry: <retryCount>]  
  
- command: ble gatt discover  
  [retry: <retryCount>]  
  
- command: ble gatt match char:<charUUID> <matchHex>  
  [retry: <retryCount>]  
  
- command: ble gatt read char:<charUUID> <matchHex>  
  [retry: <retryCount>]  
  
- command: ble gatt sub char:<charUUID>  
  [retry: <retryCount>]  
  
- command: ble gatt write char:<charUUID> <valueHex>  
  [retry: <retryCount>]
```

Argument	Description
<i>name</i>	GAP name advertised by DUT.
<i>address</i>	BLE MAC address used by the DUT.
<i>timeout</i>	Timeout, in seconds
<i>minRSSI</i>	RSSI treshold (optional)
<i>connect</i>	Connect to GATT peripheral
<i>disconnect</i>	Disconnect from GATT peripheral
<i>discover</i>	Discover GATT services and characteristics
<i>match</i>	Match a value for a subscribed characteristic
<i>read</i>	Read a GATT characteristic
<i>sub</i>	Subscribe to notifications from a GATT characteristic
<i>write</i>	Write to a GATT characteristic
<i>retryCount</i>	Number of times to retry the test step (optional)

Example: Validate BLE Device Information Service

```

title: "DIS Validation"
suite:
- ident: ICT-T1
  title: Identify DUT
  steps:
  - command: identify nRF52
- ident: ICT-T2
  title: Program LY10-DEMO-BOARD FW
  steps:
  - command: program nRF52 s132_nrf52_6.0.0_softdevice.hex,ly10-demo-fw-0.1.7.hex
- ident: ICT-T3
  title: Validate BLE DIS
  steps:
  - command: ble gatt connect addr:%ble_mac% 10
  - command: ble gatt discover
  # GAP:Device Name
  - command: ble gatt read char:2a00 4c5931302d44454d4f5f424f415244 # "LY10-DEMO_BOARD"
  # GAP Appearance
  - command: ble gatt read char:2a01 0000
  # GAP:Peripheral Preferred Connection Parameters
  - command: ble gatt read char:2a04 0600080200009001
  # GAP:Central Address Resolution
  - command: ble gatt read char:2aa6 01
  # DIS:Manufacturer Name String
  - command: ble gatt read char:2a29 424344 # "BCD"
  # DIS:Model Number String
  - command: ble gatt read char:2a24 4c5931302d44454d4f5f424f415244 # "LY10-DEMO_BOARD"
  # DIS:Hardware Revision String
  - command: ble gatt read char:2a27 32303139 # "2019"
  # DIS:Firmware Revision String
  - command: ble gatt read char:2a26 302e312e37 # "0.1.7"
  # DIS:Software Revision String
  - command: ble gatt read char:2a28 312e322e33 # "1.2.3"
  - command: ble gatt disconnect

```

1.2.2 ble test - Low-level BLE Tests

Perform Low-level BLE tests.

Usage:

```

- command: ble test recv <channel>
  [retry: <retryCount>]

- command: ble test xmit <channel> [<length> [<payload>]]
  [retry: <retryCount>]

- command: ble test stop
  [retry: <retryCount>]

```

Argument	Description
<i>channel</i>	BLE channel
<i>length</i>	Test packet payload length
<i>payload</i>	Test packet payload type
<i>retryCount</i>	Number of times to retry the test step (optional)

1.2.3 bledis - Test BLE Discovery

Establishes a BLE connection to the DUT and discovers GATT services.

Usage:

```

- command: bledis %BLEMAC%|<name> [<timeout> [<minRSSI>]]
  [retry: <retryCount>]

```

Argument	Description
<i>name</i>	GAP name advertised by DUT. %BLEMAC% to specify the DUT's BLE MAC address instead
<i>timeout</i>	Timeout, in seconds
<i>minRSSI</i>	RSSI treshold (optional)
<i>retryCount</i>	Number of times to retry the test step (optional)

Example: BLE discovery of identified BLE HW MAC address.

```
- ident: ICT-T1
  title: Identify DUT
  steps:
    - command: identify nRF52
- ident: ICT-T2
  title: BLE Discovery
  steps:
    - command: bledis %BLEMAC% 30 -60
```

1.2.4 canCfg - Configure CAN interface

Configure the PLT CAN interface speed.

Usage:

```
- command: canCfg <port> <bitrate>
  [retry: <retryCount>]
```

Argument	Description
<i>port</i>	PLT CAN interface; currently only CAN0 is available.
<i>bitrate</i>	CAN bit rate, in bits per second.
<i>retryCount</i>	Number of times to retry the test step (optional)

1.2.5 canClear - Configure CAN interface

Clear the buffer of received CAN frames.

Usage:

```
- command: canClear <port>
  [retry: <retryCount>]
```

Argument	Description
<i>port</i>	PLT CAN interface; currently only CAN0 is available.
<i>retryCount</i>	Number of times to retry the test step (optional)

1.2.6 canMatch - Match received CAN message

Test if a particular CAN message has been received.

Usage:

```
- command: canMatch <port> <msgId> [<b> <b> ...]
  [extractKey: <key>]
  [retry: <retryCount>]
```

Argument	Description
<i>port</i>	PLT CAN interface; currently only CAN0 is available.
<i>msgId</i>	CAN Message Arbitration ID
<i>b</i>	Payload bytes

Argument	Description
<i>key</i>	Key in which to store the matching CAN message (optional)
<i>retryCount</i>	Number of times to retry the test step (optional)

1.2.7 canSend - Send CAN message

Send a CAN data frame.

Usage:

```
- command: canSend <port> <msgId> [<b <b> ...]
  [extractKey: <key>]
  [retry: <retryCount>]
```

Argument	Description
<i>port</i>	PLT CAN interface; currently only CAN0 is available.
<i>msgId</i>	CAN Message Arbitration ID
<i>b</i>	Payload bytes
<i>key</i>	Key in which to store the transmitted CAN message (optional)
<i>retryCount</i>	Number of times to retry the test step (optional)

1.2.8 define - Define user key

Manually defines a test plan key, which will be emedded in the test report and serial number requests performed as part of the current test plan.

Usage:

```
- command: define <key> <value>
```

Argument	Description
<i>key</i>	Name of the test plan key.
<i>value</i>	Value for the key; can be any kind of string value.

```
- ident: ICT-T0
  title: Set variables
  steps:
    - command: define work_order 1011X02
- ident: ICT-T1
  title: Invoke webhook with work_order key
  steps:
    - command: webhook request
```

1.2.9 erase - Erase DUT Flash

Erase DUT MCU on-board flash.

Usage:

```
- command: erase <target> [UART0|UART1]
  [retry: <retryCount>]
```

```
- command: erase CMSIS
  pack: <cmsis_pack>
  target: <cmsis_target>
  [retry: <retryCount>]
```

Argument	Description
<i>target</i>	Target to erase

Argument	Description
UART0, UART1	Port for UART targets
<i>cmsis_pack</i>	For <code>cmsis</code> target: CMSIS Pack file
<i>cmsis_target</i>	For <code>cmsis</code> target: Target name, as defined in CMSIS Pack file
<i>retryCount</i>	Number of times to retry the test step (optional)

Supported *target* values:

<i>target</i>	Description
ATSAME5	Atmel SAM D5x/E5x (SWD)
ATSAME5_DAP	Atmel SAM D5x/E5x (USB, DAPlink)
AVRATmega168P_ISP	Atmel AVR ATmega168P(A) (JTAG:ISP)
AVRATmega168P_XPm	Atmel AVR ATmega168P(A) (USB, XPmini)
AVRATmega168PB_ISP	Atmel AVR ATmega168PB (JTAG:ISP)
AVRATmega168PB_XPm	Atmel AVR ATmega168PB (USB, XPmini)
CC1352	TI CC1352 RFSoc
CMSIS	CMSIS-DAP programmer, requires pack: and target: fields (USB)
DA14580	Dialog DA14580 RFSoc
ESP32	Espressif ESP32 RFSoc (JTAG)
ESP32_JTAG	Espressif ESP32 RFSoc (JTAG)
ESP32_UART	Espressif ESP32 RFSoc (UART)
LPC11xx	NXP LPC11xx MCU (SWD)
nRF52	Nordic nRF52 RFSoc (SWD)
nRF52_JLink	Nordic nRF52 RFSoc (USB, JLink)
nRF91	Nordic nRF9160 RFSoc:Cortex-M33 (SWD)
nRF91_JLink	Nordic nRF9160 RFSoc:Cortex-M33 (USB, JLink)
PIC18F25K20	Microchip PIC18F25K20 (JTAG:ICSP)
PIC18F25K20_PK2	Microchip PIC18F25K20 (USB, PICKit2)
PSoc4	Cypress PSoC4 (SWD)
PSoc6	Cypress PSoC6 (SWD)
PSoc6_KP3	Cypress PSoC6 (USB, KitProg3)
STM32F2	ST STM32F2xx MCU (SWD)
STM32F2_STLink	ST STM32F2xx MCU (USB, ST-Link)
STM32F4	ST STM32F4xx MCU (SWD)
STM32F4_STLink	ST STM32F4xx MCU (USB, ST-Link)
STM32L4	ST STM32L4xx MCU (SWD)
STM32L4_STLink	ST STM32L4xx MCU (USB, ST-Link)

Example: Erase STM32L4 on-board flash.

```
- ident: ICT-T1
  title: Erase
  steps:
    - command: erase STM32L4
```

1.2.10 eval - Evaluate Expression

Evaluate an expression.

```
- command: eval <expression>
[extractKey: <key>]
```

Argument	Description
<i>expression</i>	Expression to evaluate
<i>key</i>	Key in which to store the evaluated expression value

Supported operators:

Operator	Description
+	Addition, concatenation
-	Subtraction, Negation
/	Division
*	Multiplication
**	Power
%	Modulo
&	Bitwise And
	Bitwise Or
^	Bitwise Xor
~	Bitwise Not
>>	Right shift
<<	Left shift
!	Inversion
&&	Logical And
	Logical Or
?	Ternary True
:	Ternary False
??	Null coalescence
>	Greater than
<=	Less than or equal
>=	Greater than or equal
=~	Regex match
!~	Regex mismatch

Supported functions:

Function	Description
<code>numeric(value [, unit])</code>	Convert <i>value</i> to a numeric value. Optional <i>unit</i> for converting measurement results

Example:


```

title: "Eval"
suite:
- ident: E0
  title: Eval
  steps:
    - command: define test "AC1D"
    - command: eval "test != 'FOOBAR'"
    - command: eval "test == 'AC1D'"
    - command: define ONE 1
    - command: eval "numeric(ONE)+2"
      extractKey: SUM
    - command: eval "SUM == 3"
- ident: E1
  title: Evaluate measurement
  steps:
    - command: measure voltageDATP08 <4V
      extractKey: VOLTAGE
    - command: eval "numeric(VOLTAGE, 'mV') < 4000"

```

1.2.11 freq - Frequency Monitor Control

Set the channel to use for frequency measurements.

Usage:

```

- command: freq 0|1
  [retry: <retryCount>]

```

Argument	Description
0	Use CLK0
1	Use CLK1
<i>retryCount</i>	Number of times to retry the test step (optional)

Example: Measure CLK1 frequency

```

title: Measure frequency
suite:
- ident: ICT-T1
  title: Measure CLK1 frequency
  steps:
    - command: freq 1
    - command: sleeps 1000
    - command: measure frequency 7.90-8.10MHz

```

1.2.12 ftdiCfg - Configure external FTDI

Configure an externally connected FTDI FT4232H module.

Usage:

```

- command: ftdiCfg FTDI1 <target> [<UARTxx>][,<UARTxx>[,<UARTxx>[,<UARTxx>]]]
  [retry: <retryCount>]

```

Argument	Description
<i>target</i>	FTDI interface; only FTDI1 can be configured.
<i>UARTxx</i>	UART port to use for each FTDI port: UART2, UART3, .. , or _ to skip.
<i>retryCount</i>	Number of times to retry the test step (optional)

1.2.13 identify - Identify DUT

Identify DUT MCU and/or RF peripherals.

The MCU identifier is stored in the `mcu_id` key, and the BLE MAC address (if available) is stored in the `ble_mac` key.

Usage:

```
- command: identify <target> [UART0|UART1]
  [retry: <retryCount>]
```

Argument	Description
<i>target</i>	Target to identify
UART0, UART1	Port for UART targets
<i>retryCount</i>	Number of times to retry the test step (optional)

Supported *target* values:

<i>target</i>	Description
AVRATmega168P_ISP	Atmel AVR ATmega168P(A) (JTAG:ISP)
AVRATmega168P_XPm	Atmel AVR ATmega168P(A) (USB, XPmini)
AVRATmega168PB_ISP	Atmel AVR ATmega168PB (JTAG:ISP)
AVRATmega168PB_XPm	Atmel AVR ATmega168PB (USB, XPmini)
CC1352	TI CC1352 RFSoc
ESP32_UART	Espressif ESP32 RFSoc (UART)
nRF52	Nordic nRF52 RFSoc (SWD)
nRF52_JLink	Nordic nRF52 RFSoc (USB, JLink)
nRF91	Nordic nRF9160 RFSoc:Cortex-M33 (SWD)
nRF91_JLink	Nordic nRF9160 RFSoc:Cortex-M33 (USB, JLink)
STM32F2	ST STM32F2xx MCU (SWD)
STM32F2_STLink	ST STM32F2xx MCU (USB, ST-Link)
STM32F4	ST STM32F4xx MCU (SWD)
STM32F4_STLink	ST STM32F4xx MCU (USB, ST-Link)
STM32L4	ST STM32L4xx MCU (SWD)
STM32L4_STLink	ST STM32L4xx MCU (USB, ST-Link)

1.2.14 image - Set background image

Usage:

```
- command: image set <filename>
- command: image clear
```

Argument	Description
set	Set background image
clear	Clear background image
<i>filename</i>	Filename of the PNG or JPEG element to show

Example: Background for operator test

```
title: "OLED Image"
suite:
- ident: ICT-T1
  title: Show image
  steps:
    - command: image set fighter.png
    - command: operator "Manual test"
```

1.2.15 label - Set Label Substitutions

Usage:

```
- command: label keys <key> [<key>...]
```

The label command defines additional keys to substitute in the ZPL sent to the barcode printer, in addition to the default substitution keys.

Key	Description
DUT_PRODUCT	Product name
DUT_VERSION	Version
DUT_SERIAL	DUT Serial number
MAC_ADDRESS	MAC address
BLEMAC	BLE MAC address
FAILURE_MSG	Test failure

Example: Substitute CODE

```
title: "Custom barcode substitution"
suite:
- ident: ICT-T0
  title: Define label keys
  steps:
  - command: define CODE 12345
  - command: label keys CODE
```

The default ZPL generated by the PLT upon completion of a YAML test plan specification can be overridden by uploading `template-pass.zpl` and `template-fail.zpl` elements as part of the Release deployed through PLTcloud.

Example `template-fail.zpl` element:

```
^FX template-fail.zpl - ZPL Template for failing DUTs
^XA^LH40,30
^MD2
^F00,10^ADN,30,8^FDCODE^FS
^F00,80^ADN,30,8^FDN/G^FS
^XZ
```

Example `template-pass.zpl` element:

```
^FX template-pass.zpl - ZPL Template for DUTs that pass testing
^XA
~SD22
^CF0,30
^F040,20^FDProduct:DUT_PRODUCT^FS
^F040,30^FDVersion:DUT_VERSION^FS
^F040,40^FDS/N:DUT_SERIAL^FS
^F040,50^FDMAC Address:MAC_ADDRESS^FS
^F040,60^FDBLE Address:BLEMAC^FS
^F040,70^FDFailure:FAILURE_MSG^FS
^F040,80^FDCode:CODE^FS
^F040,170^BY2
^BCN,50,N,N,N
^FDMAC_ADDRESS^FS
^XZ
```

1.2.16 measure - Probe Measurement

Usage:

```
- command: measure <channel> [<signal>] <range> [<reference>]
  [extractKey: <key>]
  [retry: <retryCount>]
```

Argument	Description
<i>channel</i>	Measurement channel
<i>signal</i>	DDTPxx or RDTPxx probe for pin measurement
<i>range</i>	Acceptable range
<i>reference</i>	Reference voltage for impedance measurements (default: 5V)
<i>key</i>	Key in which to store the measurement results (optional)
<i>retryCount</i>	Number of times to retry the test step (optional)

The **measure** command supports the following channels:

<i>channel</i>	Description
current3V3	3V3 current draw
current5V	5V current draw
currentVARV	VARV current draw
frequency	Frequency (CLK0 or CLK1)
impedance	Impedance measurement (RVREF/RA)
pin	Digital pin measurement (DDTPxx/RDTPxx)
voltageDATP07	DATP07 voltage
voltageDATP08	DATP08 voltage
voltageDATP09	DATP09 voltage
voltageDATP10	DATP10 voltage
voltageDATP11	DATP11 voltage
voltageDATP12	DATP12 voltage
voltageMUX0	MUX0 voltage
voltageMUX1	MUX1 voltage
voltageMUX2	MUX2 voltage
voltageMUX3	MUX3 voltage

The following suffixes are supported for electrical measurement ranges:

Kind	Suffix	Description
Frequency	Hz	Hertz (default)
Frequency	kHz, KHZ	Kilohertz
Frequency	MHz	Megahertz
Frequency	GHz	Gigahertz
Voltage	nV	Nanovolt
Voltage	uV, µV	Microvolt
Voltage	mV	Millivolt
Voltage	V	Volt (default)
Voltage	kV, KV	Kilovolt
Voltage	MV	Megavolt
Current	nA	Nanoampere
Current	uA, µA	Microampere
Current	mA	Milliampere
Current	A	Ampere (default)
Impedance	nOhm	Nanoohm

Kind	Suffix	Description
Impedance	u0hm, µ0hm	Microohm
Impedance	m0hm	Milliohm
Impedance	0hm	Ohm (default)
Impedance	k0hm, K0hm	Kiloohm
Impedance	M0hm	Megaohm

Example: Electrical measurements

```

title: Electrical measurements
suite:
- ident: ICT-T1
  title: Measure CLK0 frequency
  steps:
    - command: freq 0
    - command: sleepms 1000
    - command: measure frequency 32.75-32.78kHz
- ident: ICT-T2
  title: Measure Impedance
  steps:
    - command: mux 0 RATP02
    - command: mux 1 RATP18
    - command: mux 2 RA
    - command: mux 3 RVREF
    - command: short 0 2 set
    - command: short 1 3 set
    - command: measure impedance 750-1000m0hm 3.3V
    - command: short 0 2 release
    - command: short 1 3 release
    - command: sleepms 1500
    - command: measure impedance 2-100hm 3300
- ident: ICT-T3
  title: Measure Currents
  steps:
    - command: measure current3V3 <1A
    - command: measure current5V 0.1-0.5A
    - command: measure currentVARV >100mA
- ident: ICT-T4
  title: Measure Voltages
  steps:
    - command: mux 0 DATP00
    - command: mux 1 DATP01
    - command: mux 2 RATP00
    - command: mux 3 RATP17
    - command: measure voltageMUX0 >1V
    - command: measure voltageMUX1 <3300mV
    - command: measure voltageMUX2 >100mV
    - command: measure voltageMUX3 1500-1800mV
    - command: measure voltageDATP07 200-6000mV
    - command: measure voltageDATP08 -0.2-0.1V
    - command: measure voltageDATP09 0-4V
    - command: measure voltageDATP10 -0.1-3.3V
    - command: measure voltageDATP11 0-3.4V
    - command: measure voltageDATP12 -0.1-3.4V

```

Example: Digital pin measurement

```

title: Digital pin measurements
suite:
- ident: ICT-T1
  title: Configure Digital pins as inputs
  steps:
    - command: pin RDTP21 input pullup
    - command: pin DDTP04 input
- ident: ICT-T2
  title: Read Digital pins
  steps:
    - command: measure pin RDTP21 low
    - command: measure pin DDTP04 high

```

1.2.17 mux - Multiplex Control

Select a probe or signal for a multiplex channel.

Usage:

```
- command: mux <channel> <signal>
```

Argument	Description
<i>channel</i>	Multiplex channel (0..3)
<i>signal</i>	Probe or signal

The following signals and probes can be assigned to a multiplex channel:

<i>signal</i>	MUX	Description
DATP00..DATP06	0, 1	Direct Analog Test Probes
RATP00..RATP31	0, 1	Routed Analog Test Probes
DDTP00..DDTP08	2, 3	Direct Digital Test Probes
RVREF	all	Impedance measurement, reference voltage
RA	all	Impedance measurement, test voltage
GND	all	Ground
3V3OUT	all	3.3V power rail
5VOUT	all	5.0V power rail
VARVDIV	all	VARV power rail, after 1/3 voltage divider

Example: Multiplex control

```

title: Multiplex control example
suite:
- ident: ICT-T1
  title: Setup MUX
  steps:
    - command: mux 0 DATP02
    - command: mux 1 DATP03
    - command: mux 2 RA
    - command: mux 3 RVREF
    - command: short 0 2 set
    - command: short 1 3 set
- ident: ICT-T2
  title: Measure impedance DATP02..DATP03
  steps:
    - command: measure impedance 10-200kOhm

```

1.2.18 nfc - NFC Handling

Manipulate NFC cards.

Usage:

```
- command: nfc write <TAGTYPE> <payload>...  
  [retry: <retryCount>]
```

Argument	Description
<i>tagtype</i>	Tag type (NTAG203, NTAG213 or NTAG216)
<i>payload</i>	NDEF payload (text:....)
<i>retryCount</i>	Number of times to retry the test step (optional)

Example: Program NDEF message with two text records.

```
- ident: ICT-T1  
  title: Write NFC  
  steps:  
    - command: define CODE 123  
    - command: nfc write NTAG213 text:"Sample Text" text:%CODE%
```

1.2.19 operator - Operator Test

Instruct operator to perform a manual test step.

Usage:

```
- command: operator <message>  
  [retry: <retryCount>]
```

Argument	Description
<i>message</i>	Message to show on the PLT display
<i>retryCount</i>	Number of times to retry the test step (optional)

Example: Instruct operator to inspect housing.

```
- ident: ICT-T1  
  title: Visual Inspection (manual)  
  steps:  
    - command: operator "Inspect Housing"
```

1.2.20 pin - Digital pin control

Configure a Digital probe.

Usage:

```
- command: pin <probe> input [pullup]  
- command: pin <probe> output [low|high]
```

Argument	Description
<i>probe</i>	Probe (DDTPxx, RDTPxx, UARTx_RTS or SWD_NRST)
<i>input</i>	Configure as input
<i>pullup</i>	Enable pull-up (only for RDTPxx pins)
<i>output</i>	Configure as output
<i>low</i>	Set low
<i>high</i>	Set high

Example: Control digital pins

```
title: Control digital pins
suite:
- ident: ICT-T1
  title: Configure digital inputs
  steps:
    - command: pin DDTP05 input
    - command: pin DDTP03 input
    - command: pin RDTP04 input pullup
- ident: ICT-T2
  title: Control digital outputs
  steps:
    - command: pin DDTP00 output high
    - command: pin DDTP02 output low
    - command: pin RDTP01 output high
    - command: pin SWD_NRST output low
    - command: pin UART1_RTS output high
```

1.2.21 power - Power Control

Control power applied to the Device Under Test.

Usage:

```
- command: power off
- command: power <rail> [on|off|<level>]
```

Argument	Description
<i>rail</i>	Power rail
on	Turn on the specified power rail
off	Turn off all or specified power rail
<i>level</i>	Voltage level for VARV : 2..12.0

Supported *rail* values:

<i>rail</i>	Description
3V3	3.3V power rail
5V	5V power rail
VARV	Variable power rail
12V	12V power rail
SWD	SWD (3.3V) power rail
JTAG	JTAG (3.3V) power rail
UART0	UART0 (3.3V) power rail
UART1	UART1 (3.3V) power rail

Example: Apply power


```

title: Power control example
suite:
- ident: ICT-T1
  title: Apply power
  steps:
    - command: power 3V3 on
    - command: power 5V on
    - command: power VARV 10.2
- ident: ICT-T2
  title: Wait
  steps:
    - command: sleepms 1000
- ident: ICT-T3
  title: Power off
  steps:
    - command: power off

```

1.2.22 program - Program DUT

Erase and Program DUT MCU on-board flash.

Usage:

```

- command: program <target> [UART0|UART1] [offset:]<img>[, [offset:]<img>[, ...]]
[noerase]
[retry: <retryCount>]

```

```

- command: program CMSIS [offset:]<img>
  pack: <cmsis_pack>
  target: <cmsis_target>
[retry: <retryCount>]

```

Argument	Description
<i>target</i>	Target to program
UART0, UART1	Port for UART targets
<i>offset</i>	Optional: Offset image
<i>img</i>	Firmware Element
...	Optional: Additional offsets, images
<i>cmsis_pack</i>	For <code>cmsis</code> target: CMSIS Pack file
<i>cmsis_target</i>	For <code>cmsis</code> target: Target name, as defined in CMSIS Pack file
<i>retryCount</i>	Number of times to retry the test step (optional)

Firmware images can be provided as Intel HEX (`.hex`), ELF (`.elf` / `.axf`) or binary files (requiring an offset).

Supported *target* values:

<i>target</i>	Description
ATSAME5	Atmel SAM D5x/E5x (SWD)
ATSAME5_DAP	Atmel SAM D5x/E5x (USB, DAPlink)
AVRATmega168P_ISP	Atmel AVR ATmega168P(A) (JTAG:ISP)
AVRATmega168P_XPm	Atmel AVR ATmega168P(A) (USB, XPmini)
AVRATmega168PB_ISP	Atmel AVR ATmega168PB (JTAG:ISP)
AVRATmega168PB_XPm	Atmel AVR ATmega168PB (USB, XPmini)
CC1352	TI CC1352 RFSoc
CMSIS	CMSIS-DAP programmer, requires <code>pack:</code> and <code>target:</code> fields (USB)
DA14580	Dialog DA14580 RFSoc
EFM32	Silicon Labs EFM32 MCU (SWD)

target	Description
EFR32	Silicon Labs EFR32 RFSoc (SWD)
ESP32	Espressif ESP32 RFSoc (JTAG)
ESP32_JTAG	Espressif ESP32 RFSoc (JTAG)
ESP32_UART	Espressif ESP32 RFSoc (UART)
LPC11xx	NXP LPC11xx MCU (SWD)
nRF52	Nordic nRF52 RFSoc (SWD)
nRF52_JLink	Nordic nRF52 RFSoc (USB, JLink)
nRF91	Nordic nRF9160 RFSoc:Cortex-M33 (SWD)
nRF91_JLink	Nordic nRF9160 RFSoc:Cortex-M33 (USB, JLink)
PIC18F25K20	Microchip PIC18F25K20 (JTAG:ICSP)
PIC18F25K20_PK2	Microchip PIC18F25K20 (USB, PICKit2)
PN7360	NXP PN7360 (SWD)
PN7362	NXP PN7362 (SWD)
PN7460	NXP PN7460 (SWD)
PN7462	NXP PN7462 (SWD)
PSoC4	Cypress PSoC4 (SWD)
PSoC6	Cypress PSoC6 (SWD)
PSoC6_KP3	Cypress PSoC6 (USB, KitProg3)
STM32F2	ST STM32F2xx MCU (SWD)
STM32F2_STLink	ST STM32F2xx MCU (USB, ST-Link)
STM32F4	ST STM32F4xx MCU (SWD)
STM32F4_STLink	ST STM32F4xx MCU (USB, ST-Link)
STM32L4	ST STM32L4xx MCU (SWD)
STM32L4_STLink	ST STM32L4xx MCU (USB, ST-Link)

Example: Program NXP LPC11C24 over SWD, using built-in PLT programmer.

```
title: "NXP LPC11C24 (SWD)"
identPrefix: ICT-
suite:
- title: Power via SWD_VDD
  steps:
    - command: power SWD on
- title: Program firmware
  steps:
    - command: program lpc11xx blinky.hex
```

Example: Program NXP LPC11C24 over a USB-attached CMSIS-DAP programmer, using the Keil Keil.LPC1100_DFP.1.4.0.pack CMSIS Pack file.

```
title: "NXP LPC11C24 (CMSIS-DAP)"
identPrefix: ICT-
suite:
- title: Power via 3V3
  steps:
    - command: power 3V3 on
- title: Program firmware
  steps:
    - command: program cmsis blinky.hex
      pack: Keil.LPC1100_DFP.1.4.0.pack
      target: LPC11C24FBD48/301
```

1.2.23 scan - Scan Barcode

Scan a barcode using USB-attached barcode scanner.

Usage:

```
- command: scan <format>
  [extractKey: <key>]
  [retry: <retryCount>]
```

Argument	Description
<i>format</i>	Format of code to scan
<i>key</i>	Key in which to store the barcode value (optional)
<i>retryCount</i>	Number of times to retry the test step (optional)

Supported *format* values:

<i>format</i>	Description
ANY	Any barcode
%MAC_ADDRESS%	48-bit MAC address (XX:XX:XX:XX:XX:XX)

```
title: Scan serial number
suite:
- steps:
  - command: scan ANY
    extractKey: MY_BARCODE
  - command: serial set %MY_BARCODE%
```

1.2.24 serial - Request or set serial number

Set serial number, from test plan or through PLTcloud.

Under Project Settings in PLTcloud, serial number allocation can be configured to use either monotonic counters, or through a webhook.

Usage:

```
- command: serial request [<KEY>:<jsonKey>]...
- command: serial set <value>
```

Argument	Description
<i>request</i>	Request serial number through PLTcloud backend
<i>KEY</i>	Test plan user key to extract from webhook response
<i>jsonKey</i>	Webhook response "extra" map key
<i>set</i>	Request serial number through PLTcloud backend

When using serial request, and a webhook is selected in PLTcloud, a JSON request will be sent containing:

```
{
  "dut_id": "<DUT IDENTIFIER>",
  "serial_number": "<SERIAL NUMBER>",
  "ble_mac": "<BLE MAC>",
  "mcu_id": "<MCU ID>",
  "MYCUSTOMKEY": "my custom value"
}
```

The API endpoint should return something like:

```
{
  "serial_number": "<SERIAL NUMBER>",
  "extra": {
    "name": "Ben"
  }
}
```

To extract the name field, use the serial request command as below:

```
title: Eventbrite
suite:
- ident: SCAN
  title: Scan
  steps:
    - command: scan ANY
      extractKey: BARCODE
- ident: WEBHOOK
  title: Lookup barcode
  steps:
    - command: serial request NAME:name
    - command: operator %NAME%
- ident: PRINT
  title: Print badge
  steps:
    - command: label keys NAME
```

Using serial set, the serial number can be set directly from the test plan, for example using a key extracted from a barcode scan:

```
title: Scan serial number
suite:
- steps:
    - command: scan ANY
      extractKey: BARCODE
    - command: serial set %BARCODE%
```

1.2.25 short - Connect Multiplex channels

Usage:

```
- command: short <muxA> <muxB> set|release
```

Argument	Description
<i>muxA</i>	Multiplex channel (0..3)
<i>muxB</i>	Multiplex channel (0..3)
set	Short specified multiplex channels
release	Release short between specified multiplex channels

Example: connect multiplex channels

```
title: Multiplex example
suite:
- ident: ICT-T1
  title: Control shorts
  steps:
    - command: short 0 1 set
    - command: short 1 3 set
    - command: sleepms 1000
- ident: ICT-T1
  title: 0-2 instead of 0-1
  steps:
    - command: short 0 1 release
    - command: short 0 2 set
```

1.2.26 sleepms - Delay

Temporarily suspend test suite execution.

Usage:

```
- command: sleepms <duration>
```

Argument	Description
<i>duration</i>	Duration, in milliseconds

1.2.27 uart - Send and Extract UART response

Extract data from UART.

Usage:

```
- uartcmd: uart UART0|UART1 [noflush]
  [expect: <expectText>]
  [extract: <extractText>]
  [extractKey: <key>...]
  [send: <sendText>]
  [retry: <retryCount>]
  [timeoutms: <timeout>]
```

Argument	Description
UART0, UART1	UART port
<i>expectText</i>	Text to expect, prior to extraction
<i>extractText</i>	Regular expression to extract
<i>key</i>	Key(s) in which to store extracted text
<i>sendText</i>	Text to send prior to extraction
<i>noflush</i>	Don't flush receive buffer before extraction
<i>retryCount</i>	Number of times to retry the test step (optional)
<i>timeout</i>	Timeout, in milliseconds (default: 1000ms)

Example: extract ICCID from cellular modem, storing in the **ICCID** key.

```
- uartcmd: uart UART0
  expect: "+CCID:"
  extract: "CCID: (\\d{20})\\r\\n"
  extractKey: ICCID
  send: "AT+ICCID\\r\\n"
```

1.2.28 uartAwait - Await UART response

Wait for a specific UART response.

Usage:

```
- command: uartAwait UART0|UART1 <seconds>
  [retry: <retryCount>]
```

Argument	Description
UART0, UART1	UART port
<i>seconds</i>	Time to await response, in seconds
<i>retryCount</i>	Number of times to retry the test step (optional)

Example:

```
- command: uartExpect UART0 Pressed
- command: operator "Press button"
- command: uartAwait UART0 1
```

1.2.29 uartCfg - Configure UART

Configure a UART port.

Usage:

```
- command: uartCfg UART0|UART1 <speed> [<triplet>]
- command: uartCfg UART0 tp
```

Argument	Description
UART0, UART1	UART port
<i>speed</i>	Baud rate
<i>triplet</i>	UART configuration triplet: 8N1 or 7E1
tp	Use alternate test points instead of UART. (Only for UART0)

Example:

```
- command: uartCfg UART1 9600 8N1
- command: uartCfg UART0 tp
```

1.2.30 uartExpect - Set expectation for uartAwait

Set a UART response to wait for with the `uartAwait` command.

Usage:

```
- command: uartExpect UART0|UART1 <expect> [noflush]
  [retry: <retryCount>]
```

Argument	Description
UART0, UART1	UART port
<i>expect</i>	String to expect with subsequent <code>uartAwait</code> command
<i>noflush</i>	Don't flush receive buffer before extraction
<i>retryCount</i>	Number of times to retry the test step (optional)

Example:

```
- command: uartExpect UART0 Pressed
- command: operator "Press button"
- command: uartAwait UART0 1
```

1.2.31 uartReadTimeout - Test if UART is not transmitting

Test if nothing is received from UART.

Usage:

```
- command: uartReadTimeout UART0|UART1 <seconds> [<sendText>]
  [retry: <retryCount>]
```

Argument	Description
UART0, UART1	UART port
<i>seconds</i>	Number of seconds to wait for incoming data
<i>sendText</i>	Text to send before waiting

Argument	Description
<i>retryCount</i>	Number of times to retry the test step (optional)

Example: Test if modem is shut down.

```
- command: uartReadTimeout UART0 1 "AT"
```

1.2.32 webhook - Invoke webhook

Invoke a webhook through PLTcloud. The webhook HTTPS endpoint is configured in Project Settings on PLTcloud.

Usage:

```
- command: webhook request [<KEY>:<jsonKey>]...
  [retry: <retryCount>]
```

Argument	Description
<i>request</i>	Invoke webhook through PLTcloud backend
<i>KEY</i>	Test plan user key to extract from webhook response
<i>jsonKey</i>	Webhook response "extra" map key
<i>retryCount</i>	Number of times to retry the test step (optional)

When a webhook is selected in PLTcloud, a JSON request will be sent containing:

```
{
  "dut_id": "<DUT IDENTIFIER>",
  "serial_number": "<SERIAL NUMBER>",
  "ble_mac": "<BLE MAC>",
  "mcu_id": "<MCU ID>",
  "MYCUSTOMKEY": "my custom value"
}
```

The API endpoint should return something like:

```
{
  "extra": {
    "name": "Ben"
  }
}
```

To extract the name field, use the webhook request command as below:

```
title: Eventbrite
suite:
- ident: SCAN
  title: Scan
  steps:
    - command: scan ANY
      extractKey: BARCODE
- ident: WEBHOOK
  title: Lookup barcode
  steps:
    - command: webhook request NAME:name
    - command: operator %NAME%
- ident: PRINT
  title: Print badge
  steps:
    - command: label keys NAME
```