mbed OS
Introduction to peripheral testing

ARM

Mac Lobdell

Partner Enablement Lead

Austin, Texas, USA

Silicon Partner Workshop - Wyboston Lakes
March 2017

Agenda

- Goals & project overview
- What can we test?
- Hardware requirements
- How to run automated tests

Goals

- Increase test coverage of mbed OS & supported platforms
- Extend tests to external signals (first step to hardware-in-the-loop)
- Improve user experience

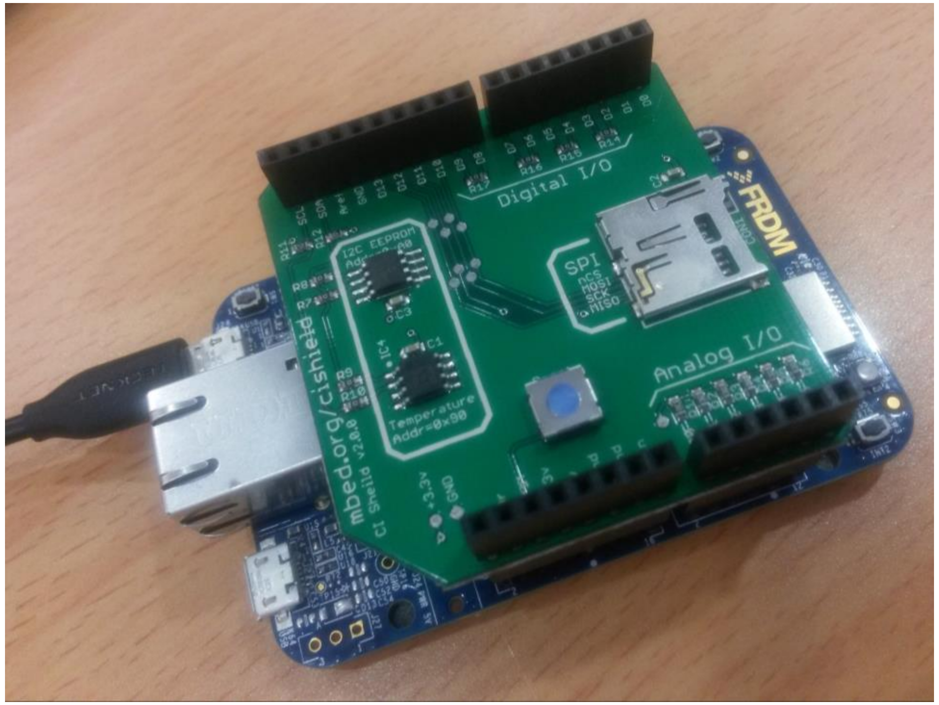
Project Overview

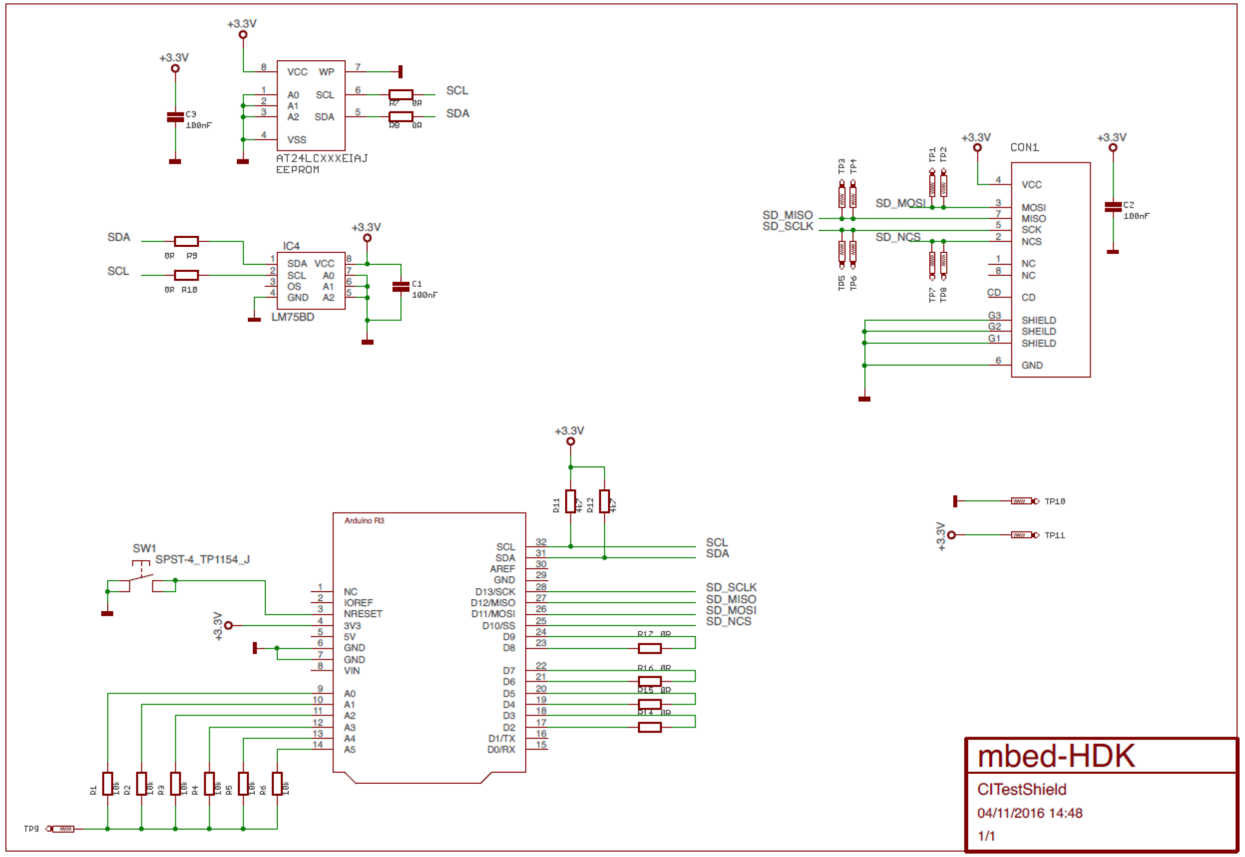
- Test peripheral drivers and verify Basic Expected behavior
  - Drivers may not be fully implemented
  - Timing issues (e.g. limitation on frequency, clocks, etc)
  - Concurrency usage: multiple instances of same driver may have issues
  - Corner cases (e.g. pin resources may not be correctly initialized/de-initialized)
- Catch regressions as more features are being added and refactoring is happening
- Prepare for Continuous Integration testing on github contributions
- To become standard requirement of mbed Enabled
- Documentation and examples available here: https://github.com/ARMmbed/ci-test-shield

Arduino headers - CI Test Shield

- The CI shield wiring diagram:

https://github.com/ARMmbed/mbed-HDK/blob/master/Production%20Design%20Projects/CITestShield/v2.0.0/CITestShield%20V_2_0_0%20SCH.pdf



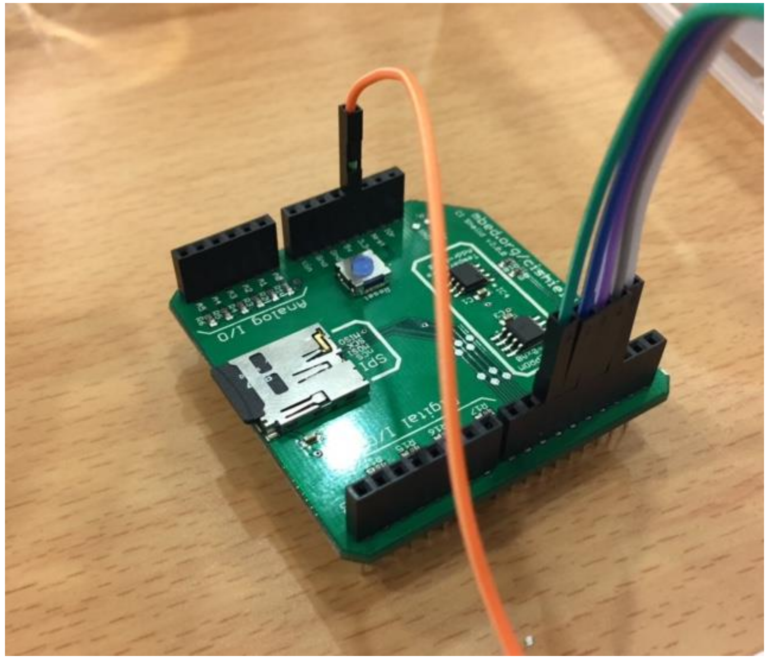


What can be tested today?

- Peripheral drivers
  - DigitalIO, BusInOut, InterruptIn, PwmOut - tested by loopback on pins D2-9
  - AnalogIO - tested by resistor star network
  - I2C - tested with temperature sensor and EEPROM memory
  - SPI – tested with SD Card
  - UART – indirectly tested by the test framework

Testing without Arduino headers

- Testing is still possible but need to wire hardware
- Make sure wiring is done prior to running to tests



Testing Level 1: Assumptions

- Assumptions = Behaviours required to run the tests
  - Can instantiate object for interface class?
  - Is pin connected?
  - Special test requirements / limitations of CI Test Shield
    - To run the AnalogIn test, the pins are required to have DigitalOut capability

Testing Level 2 : API

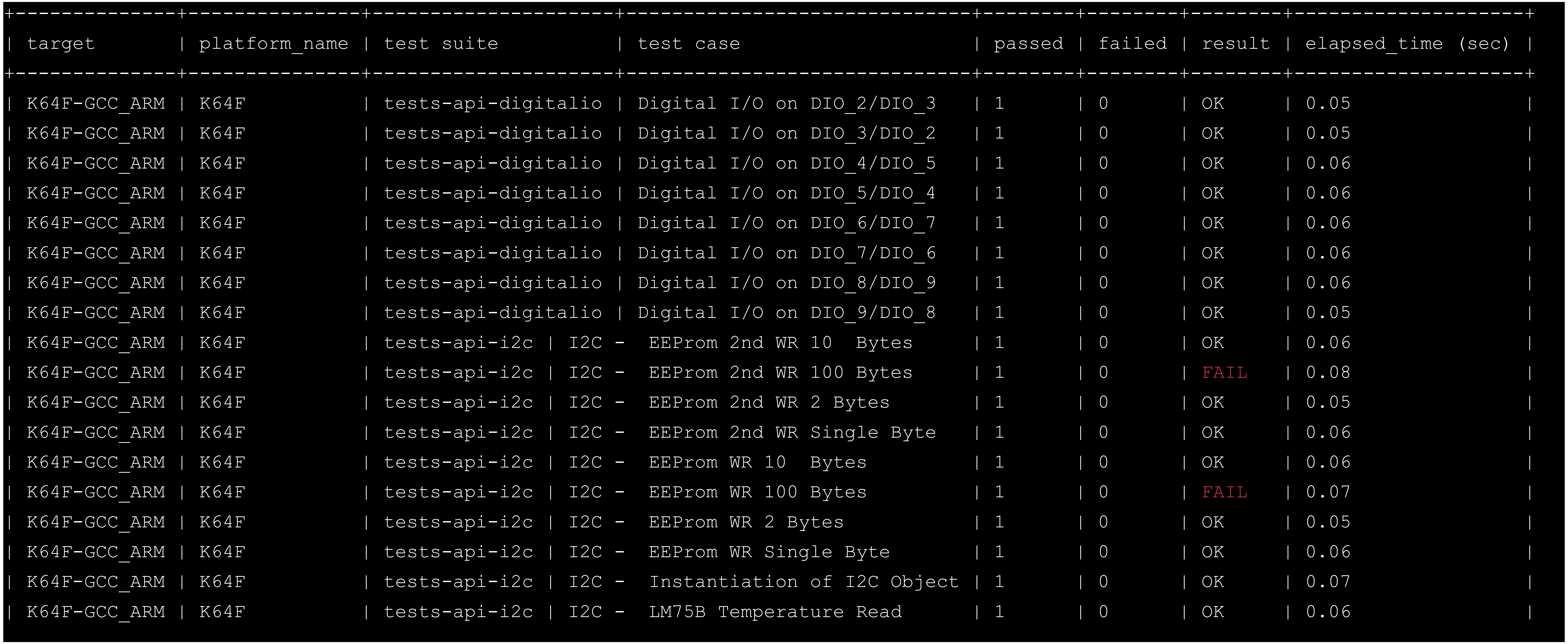
- API Tests = Testing peripheral driver interfaces
  - Reading / writing data
  - Verify signal levels
  - Verify interrupts
  - Check timing
  - Basic measurements

Getting started

- Download the CI tests, compile and run!

```
$ mbed import https://github.com/ARMmbed/ci-test-shield
$ cd ci-test-shield
$ mbed test -t <toolchain> -m <target> -n tests-*
```

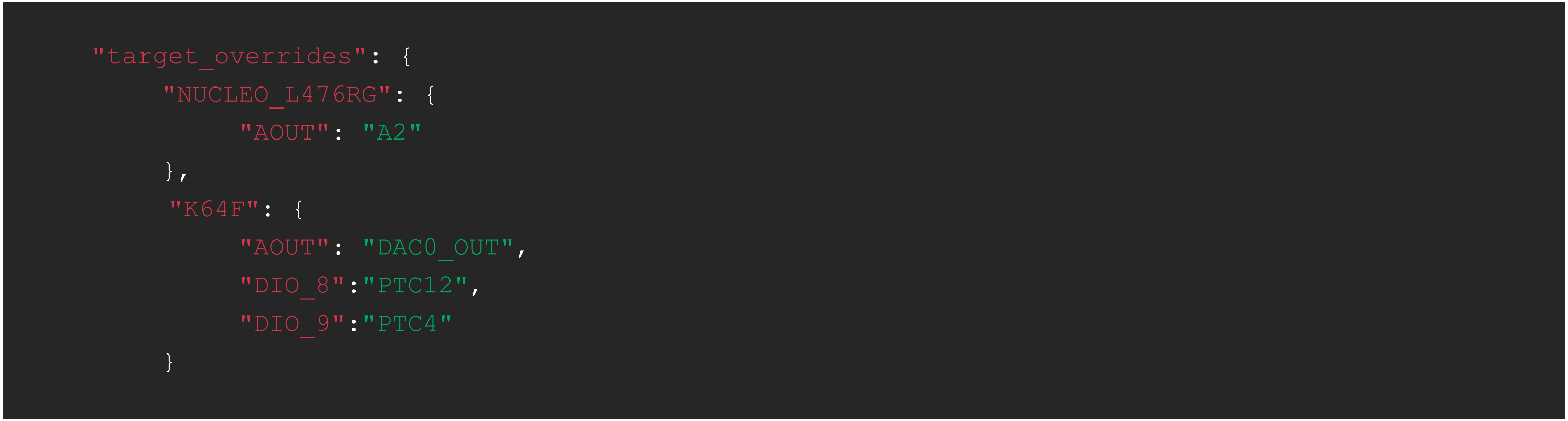
Example Test Results



```
+--------------+---------------+---------------------+------------------------------+--------+--------+--------+--------------------+
| target       | platform_name | test suite          | test case                    | passed | failed | result | elapsed_time (sec) |
+--------------+---------------+---------------------+------------------------------+--------+--------+--------+--------------------+
| K64F-GCC_ARM | K64F          | tests-api-digitalio | Digital I/O on DIO_2/DIO_3   | 1      | 0      | OK     | 0.05               |
| K64F-GCC_ARM | K64F          | tests-api-digitalio | Digital I/O on DIO_3/DIO_2   | 1      | 0      | OK     | 0.05               |
| K64F-GCC_ARM | K64F          | tests-api-digitalio | Digital I/O on DIO_4/DIO_5   | 1      | 0      | OK     | 0.06               |
| K64F-GCC_ARM | K64F          | tests-api-digitalio | Digital I/O on DIO_5/DIO_4   | 1      | 0      | OK     | 0.06               |
| K64F-GCC_ARM | K64F          | tests-api-digitalio | Digital I/O on DIO_6/DIO_7   | 1      | 0      | OK     | 0.06               |
| K64F-GCC_ARM | K64F          | tests-api-digitalio | Digital I/O on DIO_7/DIO_6   | 1      | 0      | OK     | 0.06               |
| K64F-GCC_ARM | K64F          | tests-api-digitalio | Digital I/O on DIO_8/DIO_9   | 1      | 0      | OK     | 0.06               |
| K64F-GCC_ARM | K64F          | tests-api-digitalio | Digital I/O on DIO_9/DIO_8   | 1      | 0      | OK     | 0.05               |
| K64F-GCC_ARM | K64F          | tests-api-i2c | I2C -  EEProm 2nd WR 10  Bytes     | 1      | 0      | OK     | 0.06               |
| K64F-GCC_ARM | K64F          | tests-api-i2c | I2C -  EEProm 2nd WR 100 Bytes     | 1      | 0      | FAIL   | 0.08               |
| K64F-GCC_ARM | K64F          | tests-api-i2c | I2C -  EEProm 2nd WR 2 Bytes       | 1      | 0      | OK     | 0.05               |
| K64F-GCC_ARM | K64F          | tests-api-i2c | I2C -  EEProm 2nd WR Single Byte   | 1      | 0      | OK     | 0.06               |
| K64F-GCC_ARM | K64F          | tests-api-i2c | I2C -  EEProm WR 10  Bytes         | 1      | 0      | OK     | 0.06               |
| K64F-GCC_ARM | K64F          | tests-api-i2c | I2C -  EEProm WR 100 Bytes         | 1      | 0      | FAIL   | 0.07               |
| K64F-GCC_ARM | K64F          | tests-api-i2c | I2C -  EEProm WR 2 Bytes           | 1      | 0      | OK     | 0.05               |
| K64F-GCC_ARM | K64F          | tests-api-i2c | I2C -  EEProm WR Single Byte       | 1      | 0      | OK     | 0.06               |
| K64F-GCC_ARM | K64F          | tests-api-i2c | I2C -  Instantiation of I2C Object | 1      | 0      | OK     | 0.07               |
| K64F-GCC_ARM | K64F          | tests-api-i2c | I2C -  LM75B Temperature Read      | 1      | 0      | OK     | 0.06               |
```

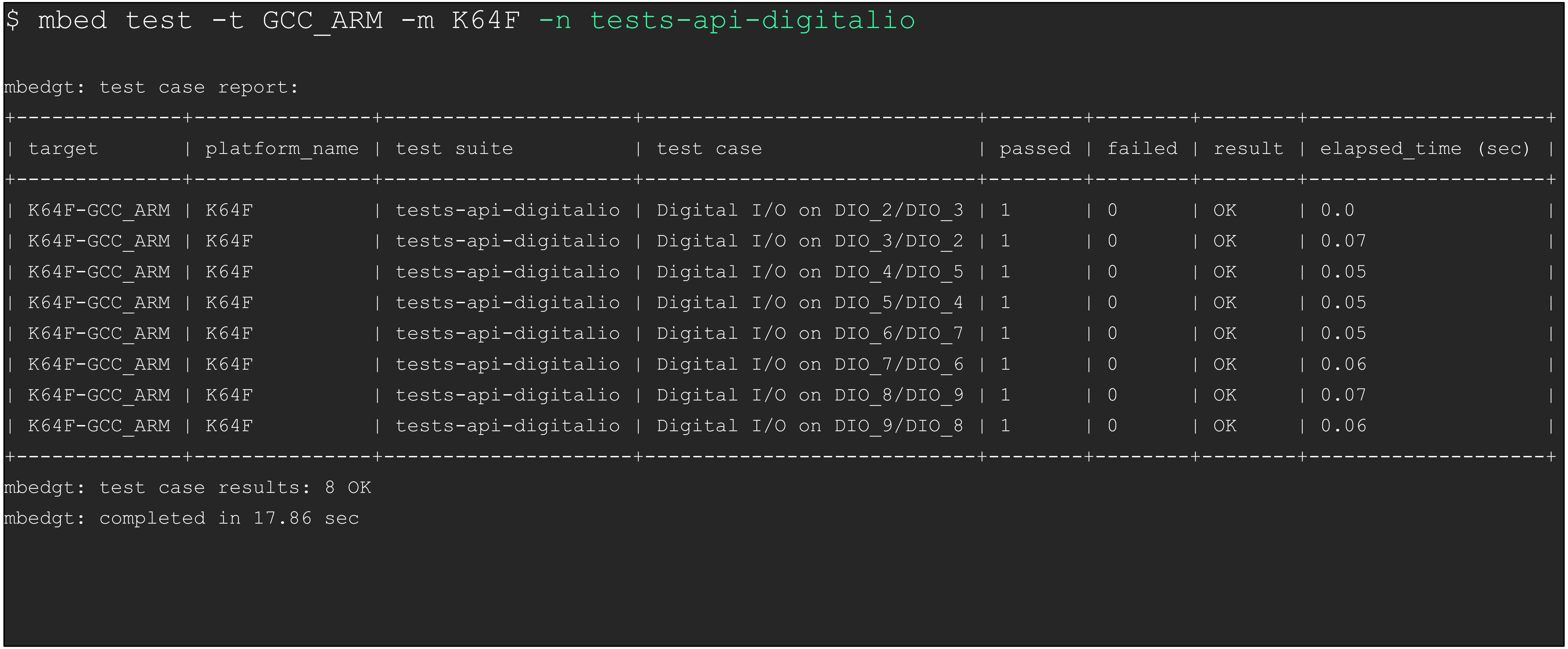
Handling pin name / location differences

- If your platform is Arduino-compatible follow Arduino-style pin naming / pin functions
- Add deviations to mbed_app.json



```
"target_overrides": {
     "NUCLEO_L476RG": {
          "AOUT": "A2"
     },
     "K64F": {
          "AOUT": "DAC0_OUT",
          "DIO_8":"PTC12",
          "DIO_9":"PTC4"
     }
```

Example: run selective tests



```
$ mbed test -t GCC_ARM -m K64F -n tests-api-digitalio

mbedgt: test case report:
+--------------+---------------+---------------------+----------------------------+--------+--------+--------+--------------------+
| target       | platform_name | test suite          | test case                  | passed | failed | result | elapsed_time (sec) |
+--------------+---------------+---------------------+----------------------------+--------+--------+--------+--------------------+
| K64F-GCC_ARM | K64F          | tests-api-digitalio | Digital I/O on DIO_2/DIO_3 | 1      | 0      | OK     | 0.0                |
| K64F-GCC_ARM | K64F          | tests-api-digitalio | Digital I/O on DIO_3/DIO_2 | 1      | 0      | OK     | 0.07               |
| K64F-GCC_ARM | K64F          | tests-api-digitalio | Digital I/O on DIO_4/DIO_5 | 1      | 0      | OK     | 0.05               |
| K64F-GCC_ARM | K64F          | tests-api-digitalio | Digital I/O on DIO_5/DIO_4 | 1      | 0      | OK     | 0.05               |
| K64F-GCC_ARM | K64F          | tests-api-digitalio | Digital I/O on DIO_6/DIO_7 | 1      | 0      | OK     | 0.05               |
| K64F-GCC_ARM | K64F          | tests-api-digitalio | Digital I/O on DIO_7/DIO_6 | 1      | 0      | OK     | 0.06               |
| K64F-GCC_ARM | K64F          | tests-api-digitalio | Digital I/O on DIO_8/DIO_9 | 1      | 0      | OK     | 0.07               |
| K64F-GCC_ARM | K64F          | tests-api-digitalio | Digital I/O on DIO_9/DIO_8 | 1      | 0      | OK     | 0.06               |
+--------------+---------------+---------------------+----------------------------+--------+--------+--------+--------------------+
mbedgt: test case results: 8 OK
mbedgt: completed in 17.86 sec
```

Next Steps

- Test your platforms
- Provide your feedback
- Contributions are welcome

Questions?