

Test object

VC3 is a battery-operated wireless AI dual camera for streaming sports matches. It is operated by a smartphone (BLE/Wi-Fi) and streams video/audio to internal memory and/or via 4G/5G.

VC3 comes in 3 variants:

- VC3 Galileo (entry): Approved Wi-Fi & BLE module, USB-C, TX2 NX 4GB
- VC3 Hubble (mid): Approved Wi-Fi & BLE module, approved 4G/5G modem, USB-C, TX2 NX 8GB
- VC3 Webb: TBD

VC3 Hubble will be supplied with a dedicated USB-PD charger and Ethernet adaptor.

Product category

Multimedia (audio/video, information and communication technology equipment) for world-wide use.

Use cases

VC3 is mounted on the top of a pole placed in the middle of one side of the football field. It is controlled by an app on a mobile phone connected via BLE. The video and audio are processed by an NVIDIA chipset and streamed via 4G/5G or Wi-Fi/WLAN.

The video and audio can also be recorded and uploaded via USB-C/Ethernet adaptor to the Internet.

VC3 is charged by a USB-PD charger or an appropriate power bank.

Max charging rate is 0.5C (2 hours for full charge).

Charging can also be performed during normal use.

Critical components

1. 5G FR1/4G radio module: Telit FN990Axx
 1. Data: <https://www.telit.com/fn990axx-download-zone/>
 2. EU DoC: <https://www.telit.com/fn990axx-download-zone/>
 3. FCC ID: RI7FN990A28
 4. IC ID: 5131A-FN990A28
 5. Other approvals: NCC, JATE/TELEC, KCC, RCM, PTCRB, GCF, various MNOs

2. WLAN/Wi-Fi/BLE radio module: Silex SX-PCEAC2
 1. Data: <https://www.silextechnology.com/connectivity-solutions/embedded-wireless/sx-pceac2>
 2. EU DoC: <https://www.silextechnology.com/productspecs/sx-pceac2-product-specifications>
 3. FCC ID: N6C-SXPCEAC2
 4. IC ID: 4908A-SXPCEAC2
 5. Other approvals: Japan
3. Antennas: PCB antennas - MAIN (4G/5G), AUX (4G/5G), WIFI (WLAN/BLE)
 1. Data: Radiated power (TRP) and sensitivity measurements (TIS) must be performed.
4. Lithium-Ion Battery: 4S2P pack (<100 Wh) for VC3 Mid and 4S1P pack for VC3 Entry
 1. Data: **To be provided**
 2. Transport and safety: **To be provided**
 3. BMS incorporated in pack
5. Charger and USB cable: CE-Link 65 W USB-PD and USB-C cable made for Veo
6. Ethernet adaptor: **To be specified**

We assume that all critical components are already tested and approved in EU (CE-marked) and North America (FCC/ISED and UL/NRTL certified), and thus only supplementary testing is needed.

The use of approved radio modules with PCB antennas must be evaluated according to:

- EU RED Guide to the Radio Equipment Directive 2014/53/EU (20181219 RED guide)
- FCC KDB 996369 D04 Module Integration Guide

Charger is world-wide approved.

The power consumption in standby mode must be limited to 0.5 W (device without information display).

The standby power consumption limit is 8 W if network (wired or wireless) is available.

Risk analysis

The risk analysis includes these 4 use cases:

- In operation mounted on pole discharging the battery
- In operation mounted on pole charging the battery
- Not in operation charging indoor
- In operation charging indoor

The main risks are:

1. Overheating of the Li-Ion battery causing fire
2. Too high spurious emissions due to impedance mismatch of RF circuitry or antennas
3. Frequency intermodulation due to short distance between radio modules/antennas
4. Receiver sensitivity reduced due to noisy environment

Risk 1

The battery cells and battery pack must fulfill the relevant safety standards. A BMS circuit must be implemented to keep the battery cell voltages, currents, and temperatures within their specified safe operating ranges. Charging/discharging must be limited if the safe operating ranges are reached and interrupted if the safe operating ranges are exceeded. The battery pack and BMS must have a fire enclosure fulfilling V-1 or VTM-1 of UL 94 (ISO 9773). A checklist/test must be made according to IEC/EN 62368-1.

Risk 2

The Main and Aux antenna performance will be verified by measurements and the results must be provided in a test report. The Wi-Fi antenna performance will be verified by selected radiated emission testing in the 2.4 and 5 GHz bands.

Measurements according to FCC CFR 47 §2.1053 (FCC KDB 971168 D01 v02r02 section 5.8).

Risk 3

Spurious emission testing will be performed with selected combinations of transmitter frequencies from the Wi-Fi/WLAN and Cellular modules.

Risk 4

The radiated emissions from VC3 will be measured during the mandatory EMC testing to be performed and will reveal if the environment is too noisy.

Market requirements

The product must be certified for world-wide use and thus the relevant requirements in the following areas must be fulfilled:

- Europa (EU & UK)
- North America (US & CA)
- Latin America (Middle & South America)
- Middle East (primarily Israel, Qatar, KSA, UAE)
- China
- Japan

- South Korea
- ANZ
- Singapore
- Hong Kong
- Taiwan
- Thailand
- Malaysia
- South Africa

The following EU Directives must be fulfilled:

- Radio Equipment Directive (RED) – refers to:
 - EMC Directive (EMCD)
 - Low Voltage Directive (LVD)
- RoHS (not part of this investigation)
- WEEE (not part of this investigation)

Other EU Directives may be applicable.

The following FCC and UL rules must be fulfilled:

- CFR 47 Part 15/22/24/27/90
- UL 62368-1 (similar to IEC/EN 62368-1)

Other rules may apply.

The UK regulations for UKCA marking must be fulfilled:

- UK SI 2017, No: 1206: Radio Equipment Regulations 2017

Other regulations may apply.

Testing/measurements

Supplementary testing must be performed according to relevant parts of:

- ETSI/EN 301 908-13 (4G/LTE EU radio)
- ETSI/EN 301 489-52 (4G/LTE EU EMC)
- CFR 47 Part 22/24/27/90 (5G/4G/LTE FCC)
- ETSI/EN 300 328 (Wi-Fi/BLE EU radio)
- ETSI/EN 301 893 (WLAN EU radio)
- ETSI/EN 301 489-17 (WLAN/Wi-Fi/BLE EU EMC)
- CFR 47 Part 15 (WLAN/Wi-Fi/BLE FCC)
- IEC/EN/UL 62368-1 (Safety)

The testing must be performed by an accredited EU and FCC lab capable of providing CB or ILAC reports.

The relevant radio testing will be the spurious emission measurements with the operating frequencies being the high, middle, and low frequencies of a selection of the radio bands used – see tests listed below.

The testing must cover all antennas.

It must be possible to set the operating frequency, transmitter output power and modulation of the radio modules manually or by means of a radio communication tester. The output power can be reduced if too high emission levels are measured.

To reduce the overall testing time a worst-case matrix including antennas, operating frequencies and orientations should be suggested by the test lab. Simultaneously testing of multiple products must also be considered to reduce the overall testing time.

Tests and measurements:

- Transmitter spurious emissions for single carrier (EU) – *EN 301 908-13 clause 5.3.3.1 (4G/5G)*
- Transmitter unwanted emissions in the spurious domain (EU) – *EN 300 328 clause 5.4.9 (Wi-Fi/BLE)*
- Transmitter unwanted emissions (EU) – *EN 301 893 clause 5.4.5 & 5.4.6 (WLAN)*
- Field strength of spurious emission (FCC) - *§2.1053 (4G/5G)*
- Conducted emission (FCC) - *§15.107 & 15.207 (EMC general)*
- Radiated emission (FCC) - *§15.109 & 15.209 (EMC general)*
- Radiated emission (FCC) - *§15.209 & 15.407 (WLAN/Wi-Fi/BLE)*
- Conducted emission (EU) – *EN 301 489-1 clause 8.3 (EMC general)*
- Radiated emission (EU) – *EN 301 489-1 clause 8.2 (EMC general)*
- Radiated immunity (EU) – *EN 301 489-1 clause 9.2 (EMC general)*
- ESD (EU) – *EN 301 489-1 clause 9.3 (EMC general)*
- Fast transients (EU) – *EN 301 489-1 clause 9.4 (EMC general)*
- Radio frequency (EU) – *EN 301 489-1 clause 9.5 (EMC general)*
- Surges (EU) – *EN 301 489-1 clause 9.8 (EMC general)*

The 4G measurements should be performed with operating frequencies in these LTE bands:

- Band 3 (1800 MHz) – middle frequency
- Band 7 (2600 MHz) – highest frequency
- Band 12 (700 MHz) – lowest frequency
- Band 30 (2300 MHz) – intermodulation with Wi-Fi (2.4 GHz)
- Band 41 (2500 MHz) – intermodulation with Wi-Fi (2.4 GHz)

Measurements according to FCC CFR 47 §2.1053 (FCC KDB 971168 D01 v02r02 section 5.8).

The 5G measurements should be performed with operating frequencies in these FR1 bands:

- Band n1 (2100 MHz)

- Band n2, n25 (1900 MHz)
- Band n3 (1800 MHz)
- Band n7, n38 (2600 MHz)
- Band n40 (2300 MHz) – intermodulation with Wi-Fi (2.4 GHz)
- Band n41 (2500 MHz) – intermodulation with Wi-Fi (2.4 GHz)
- Band n48, n78 (3500 MHz)
- Band n66 (1700/2100 MHz)
- Band n77 (3700 MHz)
- Band n79 (4700 MHz) – intermodulation with Wi-Fi (2.4 GHz)

Measurements according to FCC CFR 47 §2.1053 (FCC KDB 971168 D01 v02r02 section 5.8).

The Wi-Fi (2.4 GHz) and WLAN (5 GHz) measurements should be performed on 3 channels each (high, middle & low).

Pre-testing should include the EMC testing for EU and FCC:

- Radiated emission (EU) – *EN 301 489-1 clause 8.2 (EMC general)*
- Conducted emission (EU) – *EN 301 489-1 clause 8.3 (EMC general)*
- Conducted emission (FCC) - *§15.107 (EMC general)*
- Radiated emission (FCC) - *§15.109 (EMC general)*

Both radio modules must be active (in Tx-mode) to simulate normal current consumption.

Certifications

The following certifications are needed:

- CE (EU)
- FCC (USA)
- ISED (Canada)
- UKCA (UK) – same as CE until January 1st, 2023
- RCM (AUS/NZ)
- MIC (Japan)
- KC (South Korea)
- CCC, SRRC/NAL (China)
- PTCRB/CTIA (MNOs in North America)
- GCF/3GPP (MNOs outside North America)

For FCC we can either use the Suppliers Declaration of Conformity (SDoC) process or a certification via a Telecommunication Certification Body (TCB). The latter will be the case if the PCB antennas are not similar (enough) to the antennas used for the EU and FCC testing of the radio modules.

For ISED only labeling with the IC number of the radio modules is required.

For CE we can either use the Declaration of Conformity (DoC) according to the requirements of RED or use a Notified Body (NB) for certification.

RCM marking can be based on either CE or FCC – frequency allocation according to FCC.

MIC certification - refer to:

<https://www.tele.soumu.go.jp/e/sys/equ/tech/>

KC certification - refer to

<https://www.korea-certification.com/en/>

CCC and SRRC/NAL certification - refer to:

<https://www.tuvsud.com/en/services/global-market-access/china>

PTCRB and GCF testing can be performed at DEKRA:

<https://www.dekra-product-safety.com/en-us/node/4067>

PTCRB certification - refer to:

<https://www.ptcrb.com/certification-program/>

https://www.ptcrb.com/wp-content/uploads/2021/12/How-to-Certify-an-Integrated-Device_V1.4.pdf

MNO approvals in North America:

- AT&T - <https://iotdevices.att.com/att-iot/TrendiTestInstructions.aspx>
Mandatory LTE/4G bands: 2, 4, 12, 17
- Verizon: <https://opendevelopment.verizonwireless.com/get-certified>
Mandatory LTE/4G bands: 2, 4, 13, 66
- T-Mobile: <https://wholesale.t-mobile.com/iot/device-certification/>
Mandatory LTE/4G bands: 2, 4, 12, 71

Label and manual

VC3 must be labeled with a permanently affixed label:

- Identification of the product, e.g., trade name, model, etc. (Veo Cam 3)
- The name, address, and phone number, or internet contact information of the responsible party
- A statement that the product complies with the rules/requirements (may be placed in the manual)
- CE-mark
- UKCA-mark
- FCC-logo
- FCC IDs of the radio modules
- IC numbers of the radio modules

- Other national marks, logos, and IDs (ISED, RCM, MIC, KC, CCC)

The label can be an electronic label (e-label) that is accessible from the customer's smartphone (host device). The following requirements then apply:

- The camera can only be used after connection to the customer's smartphone (via Veo Camera app)
- The camera must have a local connection to the smartphone via BT (BLE) or Wi-Fi
- Regulatory information* must be accessible to the customer without a code and within 3 steps from the main menu in the app
- Regulatory information* must be secured and implemented in a factory-set-unalterable format
- Instructions (user's manual) must be accessible via an URL reference on the camera - e.g. "scan this QR-code for instructions"
- Packaging must still be labeled for e.g. custom authorities - it can be an adhesive label

*Regulatory information from the label and disclaimers in the manual.

For devices authorized by EU DoC (CE-marking), the responsible party must be located within the EU.

For devices authorized by UK DoC (UKCA-marking), the responsible party must be located within the UK. CE-marking can still be used until the end of 2024.

For devices authorized under SDoC (FCC-labeling), the responsible party must be located within the USA.

To be stated in the SDoC for USA: *"This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation."*

The instructions (users manual) can also be displayed on the customer's smartphone.

The DoC and SDoC can be included in the manual.

Time schedule and cost

The first VC3 prototypes will be available for pre-testing in June 2023.

Final samples for testing will be available in September 2023.

We must expect a test lab lead time of 4 weeks and some labs have longer lead times.

Overall test time is estimated to be 6 weeks and additional 4 weeks for certification (paperwork).

Currently we expect the cost of the legal testing to be approx. DKK 520 000 for both variants of VC3.

Additional costs may apply for some of the certifications - typically EUR 2 000 per country.

In addition to this will be costs for PTCRB testing and certification, and in-country testing for China.

Quotations

The following labs has been contacted:

- TÜV SÜD (Fareham, UK)
- DEKRA (Malaga, ES)
- EKTOS (Hvidovre, DK) - can only be used for EMC part of the testing.

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