

---

## Reference design kit for Gimbal controller for drones and handheld applications

### Introduction

The [STEVAL-GMBL02V1](#) reference design kit is a complete triple motor field-oriented control (FOC) demonstration and evaluation platform. The kit is as an integrated environment for three axis Gimbal controller applications in the 6.0 V to 8.4 V<sub>DC</sub> bus voltage range (2 LiPo batteries), which you can increase up to 11 V with a maximum output current of 1.3 A for each motor drive.

The design features the [STM32F303RE](#) microcontroller with ARM® Cortex®-M4 32-bit core and the [STSPIN233](#) low voltage three phase and three sense motor driver.

The [STEVAL-GMBL02V1](#) is equipped with a USB interface for real-time data exchange. The kit includes an [STEVAL-UKI001V1](#) ST-LINK adapter for serial wire debug (SWD) and corresponding cable. If you mount the [STEVAL-UKI001V1](#) on the ST-LINK/V2-1 debugging section of an [STM32 Nucleo-64](#) board, you can program and debug the [STM32F303RE](#) microcontroller with a compatible toolset via USB.

# 1 Reference design kit overview

The [STEVAL-GMBL02V1](#) reference design kit lets you the three-axis Gimbal controller for drones or small handheld cameras like smartphones and action cams. The kit includes demonstration firmware to drive three motors with field-oriented control (FOC) driven by the [STM32F303RE](#) microcontroller.

The Gimbal GUI software allows you to set PI controllers and adjust application parameters via a USB connection with your PC.

## 1.1 Package components

The [STEVAL-GMBL02V1](#) package has all the main components that you need to experience the demo through the platform firmware and dedicated GUI.

The package includes:

An STEVAL-GMBL01V1 reference design board (50 x 50 mm)

An STEVAL-UKI001V1 adapter for the ST-LINK programming and debugging tool

A 0.050" 10-pin flat cable

## 1.2 Hardware features

- Up to three-axis Gimbal controller.
- Compact (50 x 50 mm) design, suitable for mounting on:
  - drones
  - handheld cameras
- Three [STSPIN233](#) low voltage three phase and three sense motor drivers.
- [STM32F303RE](#) microcontroller with ARM® Cortex®-M4 core able to simultaneously drive three PMSM motors:
  - MCU runs a high efficiency field oriented control (FOC) algorithm compatible with the most common position sensors on Gimbal motors (PWM or analogic inputs)
  - compatible with open loop sensorless algorithm
- Operating voltage from 6.0 V to 8.4 V (2 LiPo batteries).
  - maximum output current 1.3 A<sub>RMS</sub>.
- Protection mechanisms:
  - triple single shunt current sensing network
  - non-dissipative overcurrent protection
  - short-circuit protection
  - thermal shutdown
  - hardware overvoltage and polarity inversion protection
- Measurement units:
  - on-board inertial measurement unit [LSM6DSL](#) (frame IMU)
  - compatible with external SPI/I2C inertial measurement units (camera IMU)
- Interfaces:
  - STEVAL-UKI001V1 Serial Wire Debug (SWD) board with cable
  - USB connector for real-time data communication
  - three connectors for Pitch, Roll and Tilt axis target angle inputs (PWM mode)
  - one channel DAC output and one GPIO test point for debugging purpose
- 2 Kbit serial I2C bus EEPROM for data storage
- WEEE and RoHS compliant

## 1.3 Software features

- Firmware:
  - firmware to drive three motors with field-oriented control (FOC)
  - support for position sensors on three Gimbal motors (PWM inputs)
  - accurate position control algorithm
  - support for triple single shunt current sensing network
  - decoding of on-board inertial measurement unit [LSM6DSL](#) (frame IMU)
  - decoding of the external SPI inertial measurement units based on [LSM6DSL](#) on [STEVAL-MKI178V1](#) or [STEVAL-MKI178V2](#) board (for camera IMU)
  - USB communication for real-time data exchange with the Gimbal GUI
  - application data stored in the on-board 2 Kbit serial I2C bus EEPROM
  - auto-start control when not connected to the GUI
- Gimbal GUI
  - start/stop Gimbal control
  - real time setting of the PID regulators for pitch, roll and yaw
  - set target angles for pitch, roll and yaw
  - display measured camera and frame IMU angles
  - save and load application data in flash
  - restore factory settings

## 1.4 System requirements

To run the demo, you need the following items:

- A camera IMU sensor (the firmware is compatible with [STEVAL-MKI178V1](#) or [STEVAL-MKI178V2](#))
- A mechanical Gimbal frame
- Three three-phase motors with internal permanent magnet and with magnetic encoder position (FW is compatible with the PM2804 motor with AS5048A encoder)
- A USB type A to mini-B male cable
- An [STM32 Nucleo-64](#) board with ST-LINK/V2-1 in circuit debugger/programmer
- A two-cell LiPo battery or 8 V DC power supply
- A Windows PC (version 7 or higher) PC
- The ST-LINK utility for binary firmware download (find the latest embedded software version on [www.st.com](http://www.st.com)).

## 2 STEVAL-GMBL01V1 Gimbal controller board architecture

Figure 1. STEVAL-GMBL01V1 top side components

- U1: LD1117 low drop voltage regulator
- U2: LD39050 500 mA low quiescent current and low noise voltage regulator
- U3: USBLC6-4 very low capacitance ESD protection
- U4: STM32F303RE MCUs ARM® Cortex®-M4
- U5: LSM6DSL iNEMO 6DoF inertial module (on board frame IMU)
- U6: M24C02-R 2 Kbit serial I2C bus EEPROM
- U7, U8 and U9: STSPIN233 low voltage three phase and three sense motor drivers
- Q2: STS8DN3LLH5 dual N-channel 30 V, 0.0155  $\Omega$  typ., 10 A STripFET™ V Power MOSFET

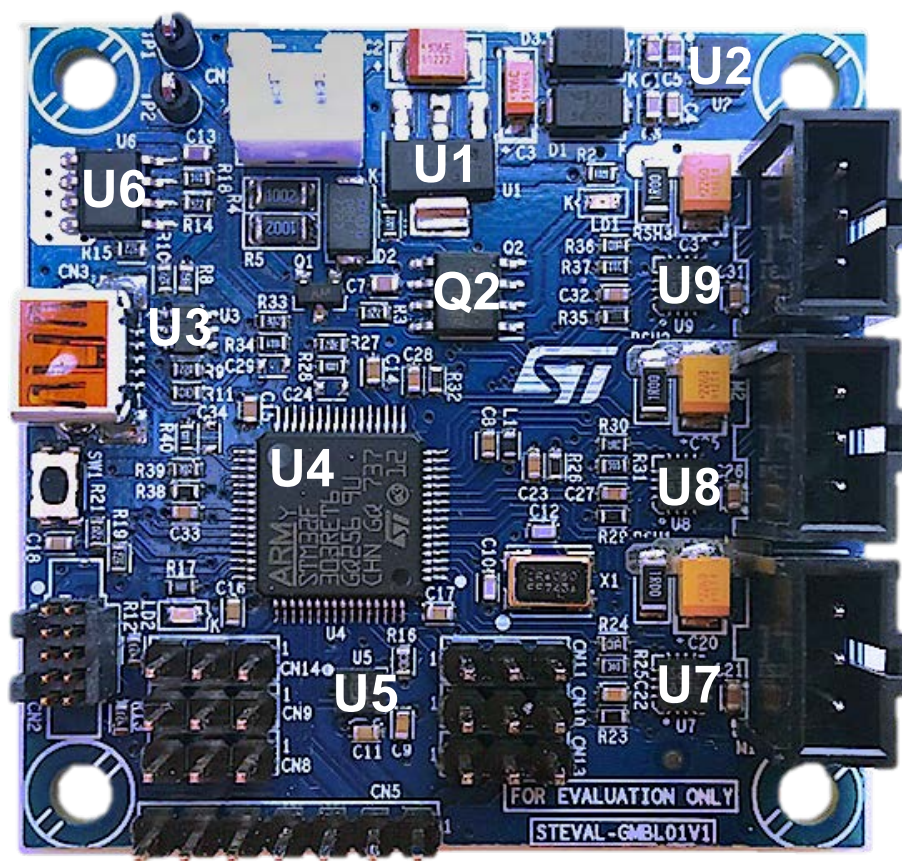
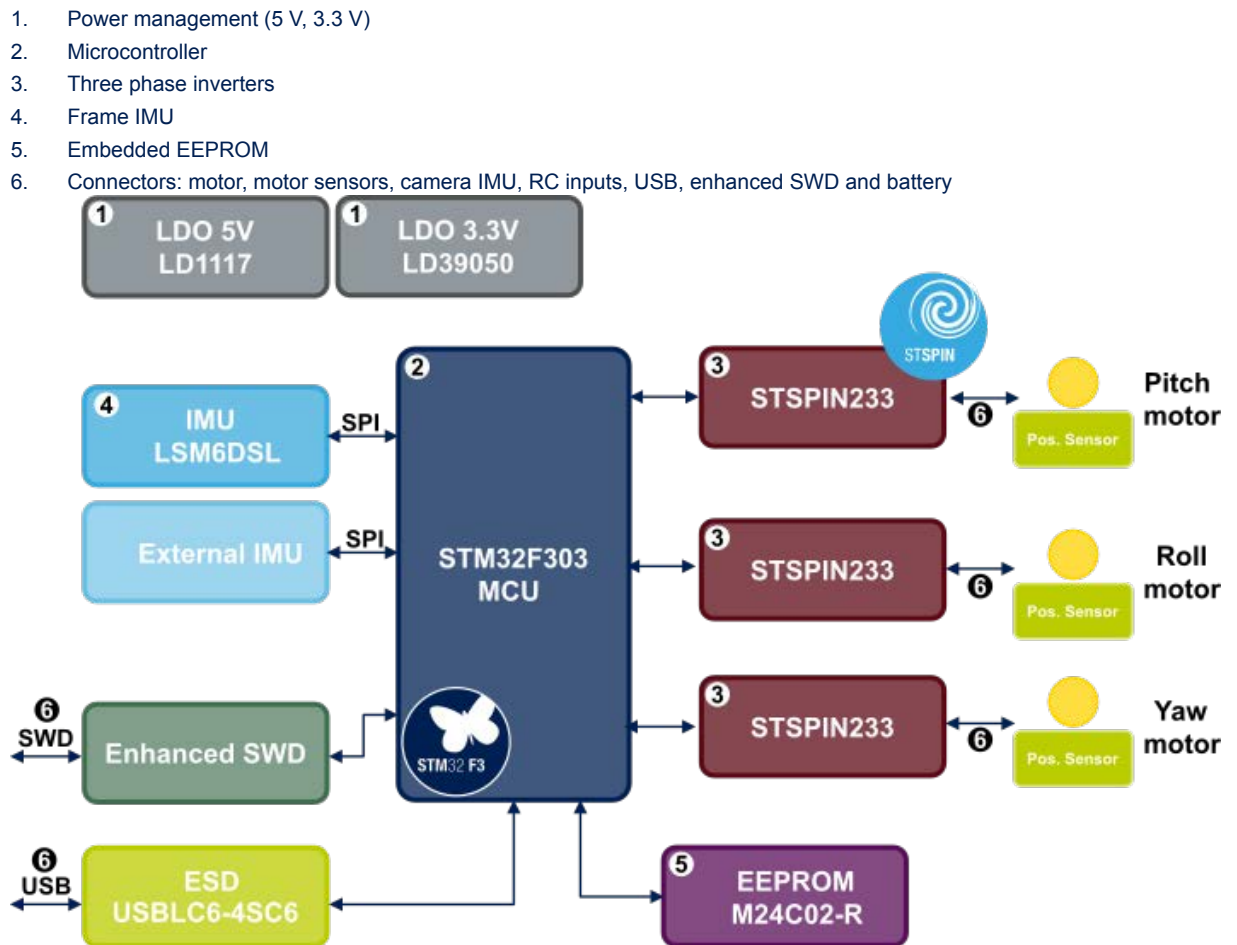


Figure 2. STEVAL-GMBL01V1 block diagram



## 2.1 Power management

The STEVAL-GMBL01V1 power management board can accept from 6 to 11 V<sub>DC</sub> input through connector CN1, so it is compatible with a 2-cell LiPo battery (7.4 V nominal). The power manager outputs 5 V and 3.3 V.

You can also supply the microcontroller using via USB. In this case, the motors are not powered, but you can use the microcontroller to program the firmware and communicate with the GUI.

The power manager has hardware protection against the inversion of the battery polarity. Do not supply a voltage higher than 11 V to avoid permanent damage. LED LD1 signals an overvoltage condition.

## 2.2 STM32F303RE microcontroller

The **STM32F303RE** microcontroller features an ARM® Cortex®-M4 32-bit core with floating point support. Other features of the microcontroller are listed below:

- 64+16 KB of internal SRAM and 512 KB Flash
- 4 ADCs, 2 DACs and 7 comparators
- 4 operational amplifiers with programmable gains
- SWD debugging through the SWD connector (CN2) on the board connector (CN2 also routes UART pins)

The board also has a reset button (SW1) to restart the microcontroller.

## 2.3 Enhanced SWD connector

The STEVAL-UKI001V1 adapter board has a 1.27 mm, 10-contact, 2-row board-to-board connector.

The connector can be used to program the microcontroller on the STEVAL-GMBL01V1 board via the STEVAL-UKI001V1 adapter board connected to a programming tool like ST-LINK/V2-1.

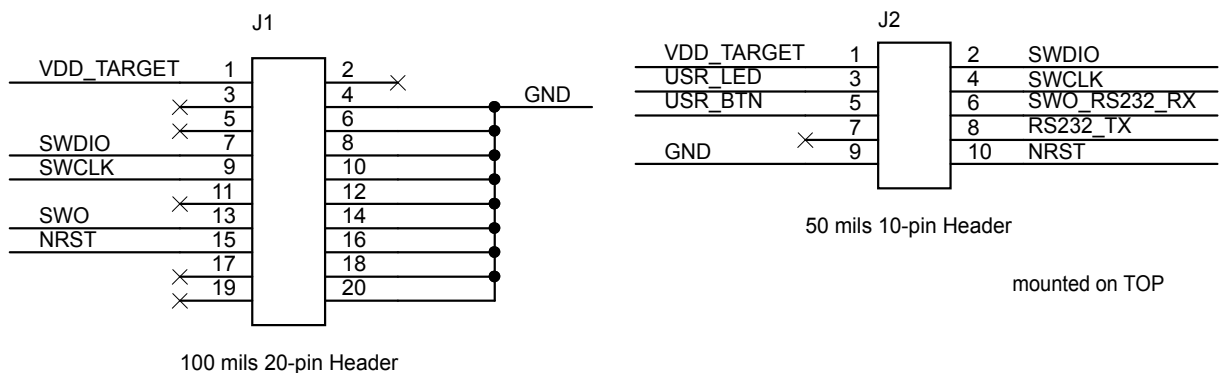
The connector can also be used as an expansion connector that routes the UART pins and allows the STEVAL-GMBL01V1 to connect with a PC COM port.

A further IO for USER\_LED is also routed.

**Note:**

*For real-time data exchange, the kit firmware uses a direct USB connection via CN3, not the enhanced SWD connector.*

**Figure 3. 10 to 20 pin Serial Wire Debug (SWD) adapter**



## 2.4 STSPIN233 three phase inverters

The output stage of the STEVAL-GMBL01V1 consists of three integrated **STSPIN233** inverters. Each inverter can drive one three phase motor.

Each stage is able to provide up to 1.3 Arms alternate current (1.8 A peak). Each stage has a current measurement network with single shunt topology that takes advantage of the embedded operational amplifier with programmable gain in the **STM32F303RE** microcontroller.

The **STSPIN233** device has the following protection mechanisms:

- Non-dissipative overcurrent
- Short-circuit
- Thermal shutdown
- Hardware overvoltage
- Polarity inversion

## 2.5 Camera IMU

The camera IMU obtains camera orientation data with respect to the inertial system (the ground for instance), which the firmware uses to stabilize the camera.

The camera IMU must be fixed to the camera and connected to the CN5 connector on the STEVAL-GMBL01V1 board.

**Note:**

*The STEVAL-GMBL01V1 is compatible with any IMU with SPI or I2C communication channels, but the firmware is currently only compatible with an **LSM6DSL** device. You can use a **STEVAL-MKI178V1** or **STEVAL-MKI178V2** with embedded **LSM6DSL**.*

### RELATED LINKS

[3.3 How to set up and connect the camera IMU on page 13](#)

## 2.6 Frame IMU

The **LSM6DSL iNEMO 6DoF** inertial module is the on-board inertial measurement unit. The firmware running on the **STM32F303RE** microcontroller uses the module data to calculate the orientation angles of the frame on which the STEVAL-GMBL01V1 is mounted.

The frame IMU data is not mandatory, but the information may be used to extend the functionality of the Gimbal firmware.

The GUI also shows the frame IMU data.

## 2.7 Embedded EEPROM

The firmware stores application parameters that are set in the GUI in the **M24C02-R** 2 Kbit EEPROM on the STEVAL-GMBL01V1 board.

## 2.8 STEVAL-UKI001V1

This tool is an adapter for Serial Wire Debug (SWD) from 10-pin 50-mil socket to 20-pin 100-mil socket (mounted on ST-LINK/V2) or to 6-pin 100-mil (mounted on ST-LINK/V2-1 on the STM32 Nucleo-64 board).

The ST-LINK/V2-1 of the STM32 Nucleo-64 board offers more features. However, you need to ensure that the target application routes the UART RX, UART TX, user button and user LED tracks correctly on the SWD.

You can use ST-LINK/V2-1 through the STEVAL-UKI001V1 board to program and debug the target application. You can also use the ST-LINK/V2-1 as a UART interface adapter via the STM32 Virtual COM Port Driver. This allows you to keep using the USB cable that connects the kit to your PC. To use this configuration, ensure that pins 2 and 3 of CN14 and pins 1 and 2 of CN15 are shorted. Refer to the schematic below.

**Figure 4. STEVAL-UKI001V1 schematic**

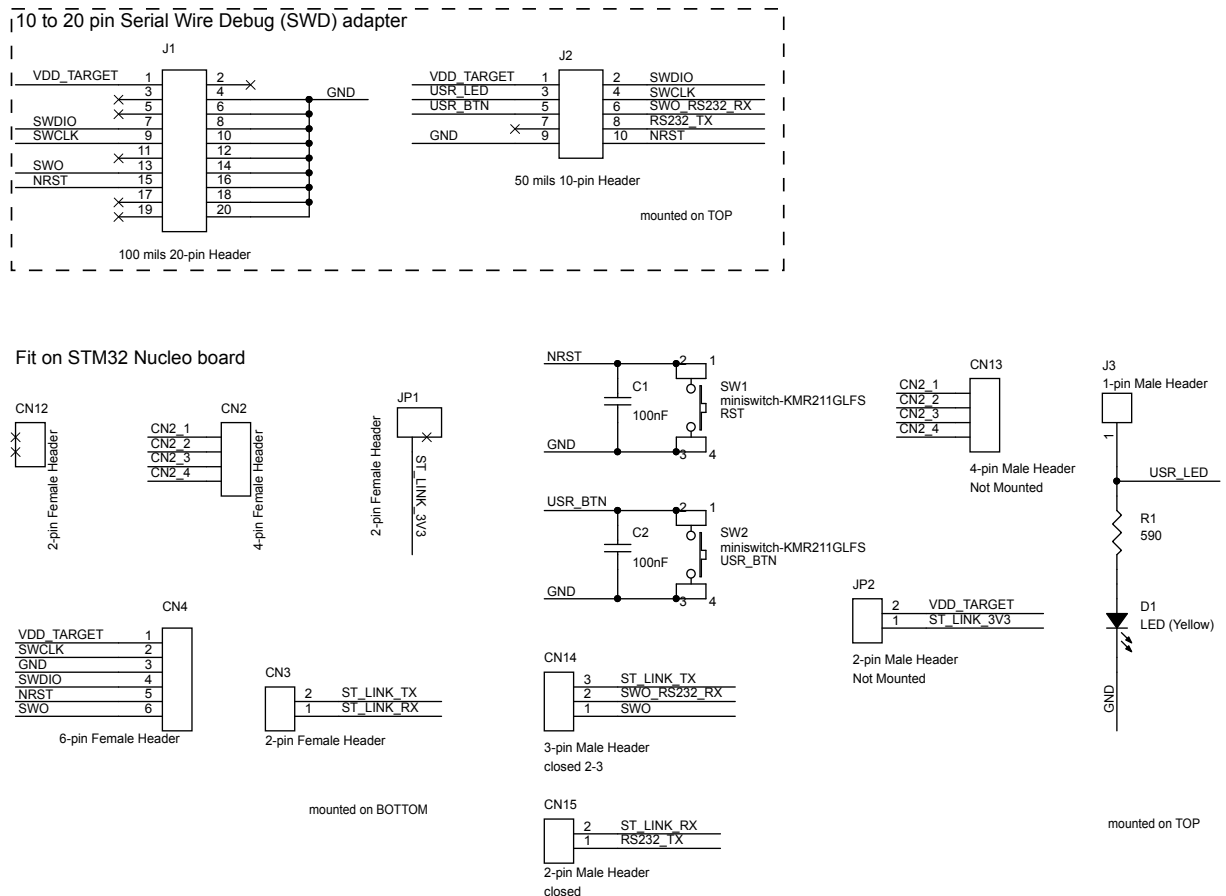


Figure 5. STEVAL-UKI001V1 top view

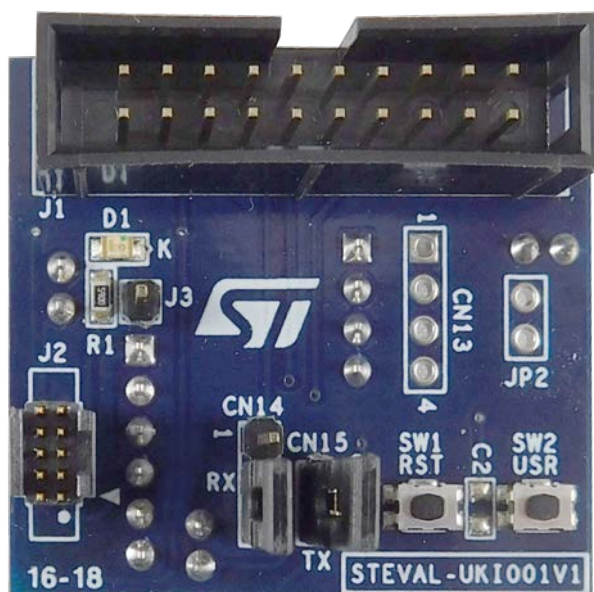


Figure 6. STEVAL-UKI001V1 bottom view



#### RELATED LINKS

[3.1 How to set up and connect the STEVAL-UKI001V1 on page 9](#)

## 3 How to set up the STEVAL-GMBL02V1 reference design kit

### 3.1 How to set up and connect the STEVAL-UKI001V1

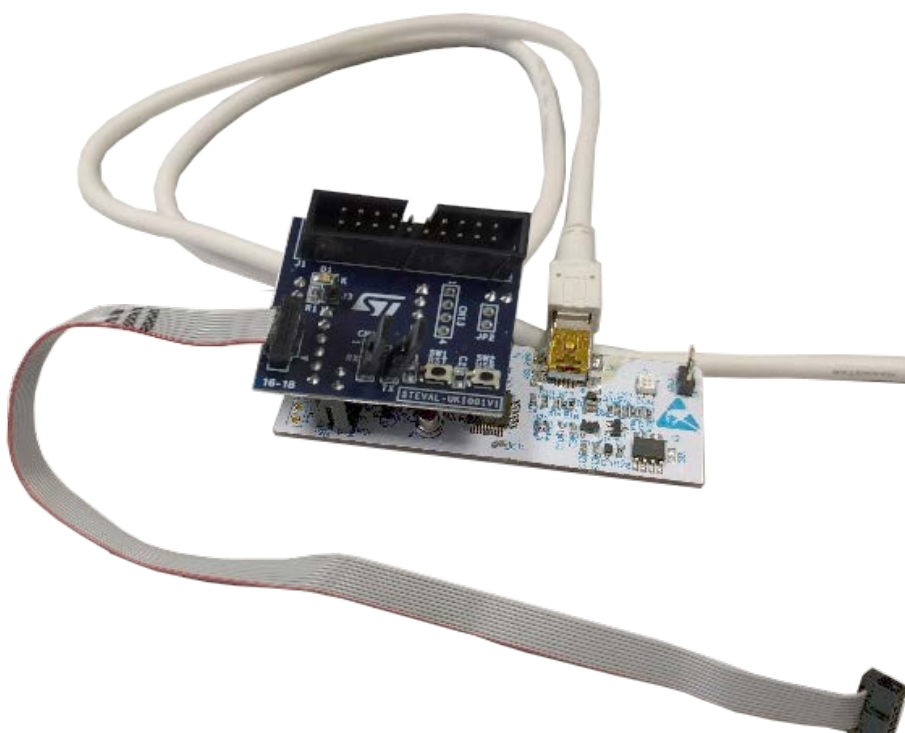
The STEVAL-GMBL01V1 needs to be programmed before you use it the first time or if you want to restore the original version of the firmware.

**Note:** *Restoring the firmware to factory values does not automatically restore the application data.*

To program the STEVAL-GMBL01V1, you can use the ST-LINK/V2-1 debugging hardware available on any [STM32 Nucleo-64](#) board. You can snap off the ST-LINK/V2-1 section from the [STM32 Nucleo-64](#) board or follow the instructions in the [STM32 Nucleo-64](#) board user manual to determine how to use the ST-LINK/V2-1 to program or debug another host microcontroller.

**Step 1.** Plug the STEVAL-UKI001V1 on ST-LINK/V2-1 (from the [STM32 Nucleo-64](#) board) as shown in the following figure.

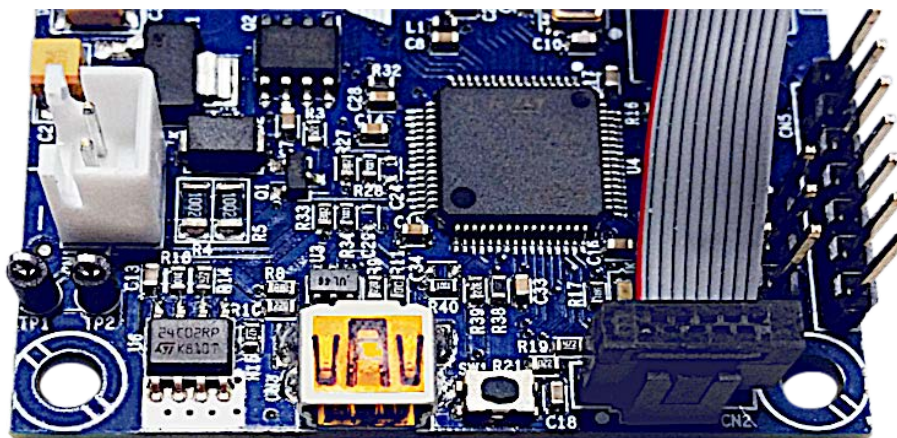
**Figure 7. STEVAL-UKI001V1 assembly**



**Step 2.** Connect the ST-LINK/V2-1 to your PC through the USB Type-A male to Type-B mini cable.

**Step 3.** Connect the 10-pin flat wire cable to the STEVAL-GMBL01V1 CN2 as shown in the following figure.

**Figure 8.** STEVAL-GMBL01V1 CN2 - SWD connector for STEVAL-UKI001V1



## RELATED LINKS

[2.8 STEVAL-UKI001V1 on page 7](#)

## 3.2 How to assemble and connect the frame motors

The Gimbal firmware works with three-phase motors with embedded magnetic position sensors able to generate a PWM signal with duty cycle proportional to the mechanical position of the motor (for example, the AS5048A). Each motor has a specific function:

1. M1 regulates the pitch of the Gimbal frame
2. M2 regulates the roll of the Gimbal frame
3. M3 regulates the yaw of the Gimbal frame

**Step 1.** Ensure you have a motor with the same characteristics as those listed below.

**Table 1.** List of compatible motors

Part Number	Description	Supplier
PM2804	PM2804 with AS5048A encoder	SMC Powers
PM2805	PM2805 with AS5048A encoder	SMC Powers

**Step 2.** Refer to the motor manufacturer documentation to identify the three motor phase wires and the three motor sensor wires.

**Figure 9. Example of motor phases and sensor wires**

1. Motor phases
2. Motor sensor



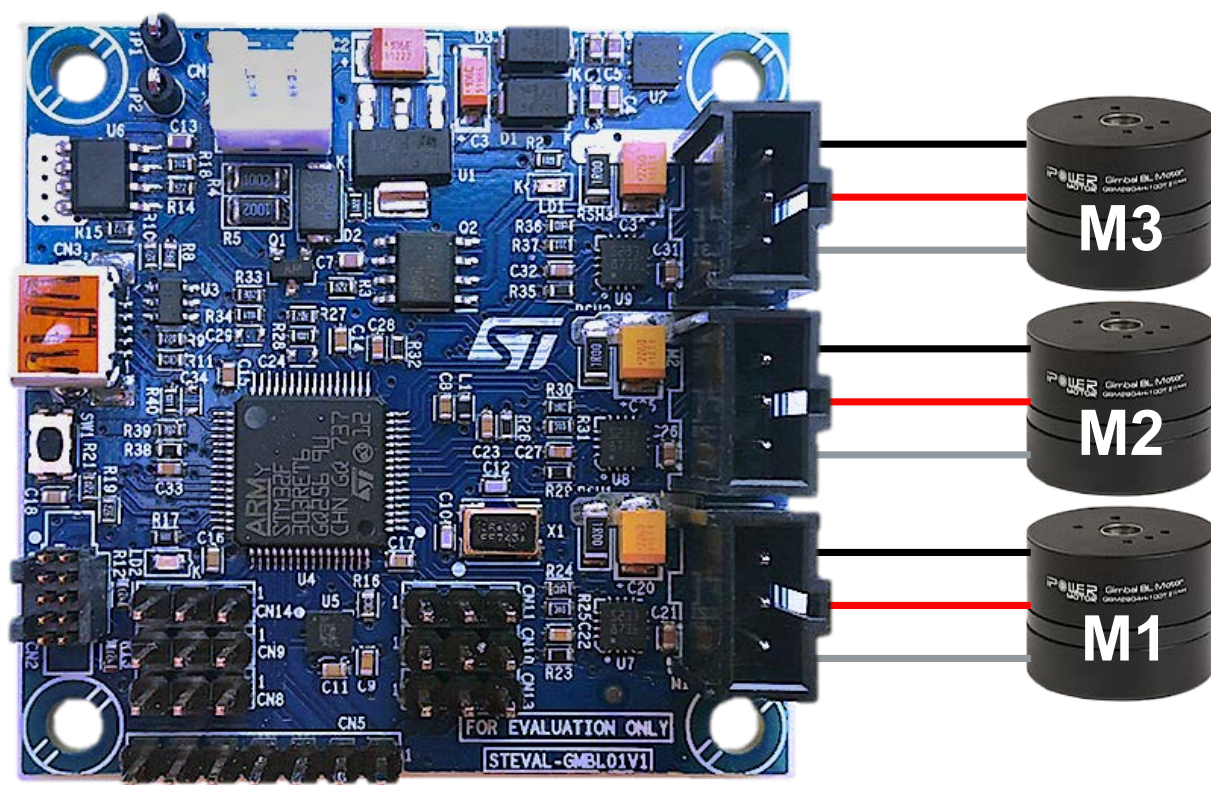
**Step 3.** Connect the 3 motor phases of each motor.

- Connect the 3 motor phases of the motor that regulates the pitch of the camera to connector M1 of the STEVAL-GMBL01V1.
- Connect the 3 motor phases of the motor that regulates the roll of the camera to connector M2 of the STEVAL-GMBL01V1.
- Connect the 3 motor phases of the motor that regulates the yaw of the camera to connector M3 of the STEVAL-GMBL01V1.

**Note:** If a motor runs in the wrong direction swap the black wire (phase A) with the white wire (phase C) for that motor.

**Figure 10. Motor connections**

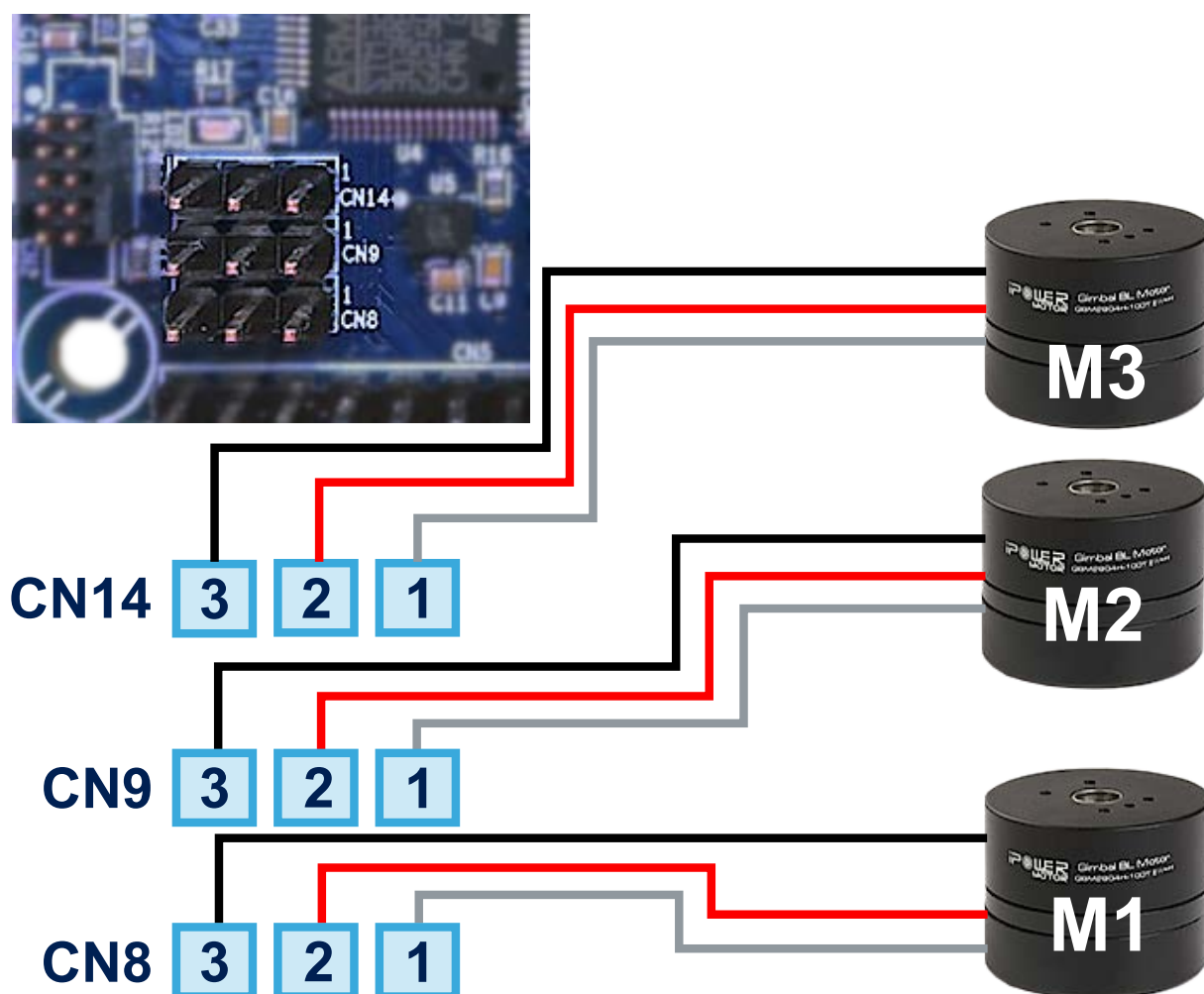
- M1 regulates the pitch of the Gimbal frame
- M2 regulates the roll of the Gimbal frame
- M3 regulates the yaw of the Gimbal frame



**Step 4.** Connect the 3 motor sensor signals for each motor.

- Connect the three signals of motor sensor that regulates the pitch (M1) to connector CN8 of the STEVAL-GMBL01V1.
- Connect the three signals of motor sensor that regulates the roll (M2) to connector CN9 of the STEVAL-GMBL01V1.
- Connect the three signals of motor sensor that regulates the yaw (M3) to connector CN14 of the STEVAL-GMBL01V1.

Figure 11. Motor sensor connections



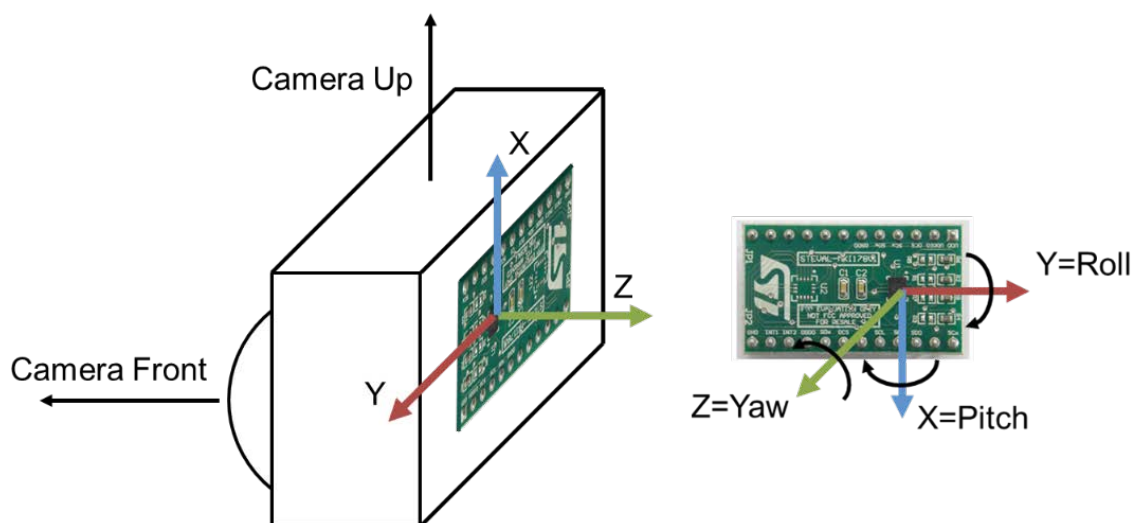
### 3.3 How to set up and connect the camera IMU

To run the demo, you need to attach an inertial measurement unit (IMU) with a MEMS sensor to your camera. The IMU determines the camera orientation angles with respect to an inertial reference system.

The demo firmware supports the [LSM6DSL](#) iNEMO 6DoF inertial module.

- Step 1.** Attach a board with IMU [STEVAL-MKI178V1](#) or [STEVAL-MKI178V2](#) board with [LSM6DSL](#) module to your camera.  
Use the orientation shown in the figure below.

Figure 12. Camera IMU placement



- Step 2.** Connect the pins of the STEVAL-MKI178V1 or STEVAL-MKI178V2 connectors JP1-JP2 to the STEVAL-GMBL01V1 connector CN5.  
Refer to the following table for connection details.

Table 2. STEVAL-MKI178V1 or STEVAL-MKI178V2 connections

STEVAL-GMBL01V1 (CN5) pin	STEVAL-MKI178V1 or STEVAL-MKI178V2 JP1-JP2 pin	Function
1	1, 2	VDD=VDDIO=3.3V
2	21	SDA (PC12)
3	22	SDO (PC11)
4	20	SCL (PC10)
5	13	GND
6	19	CS (PA15)
7	Not connected	Not connected

#### RELATED LINKS

[2.5 Camera IMU on page 6](#)

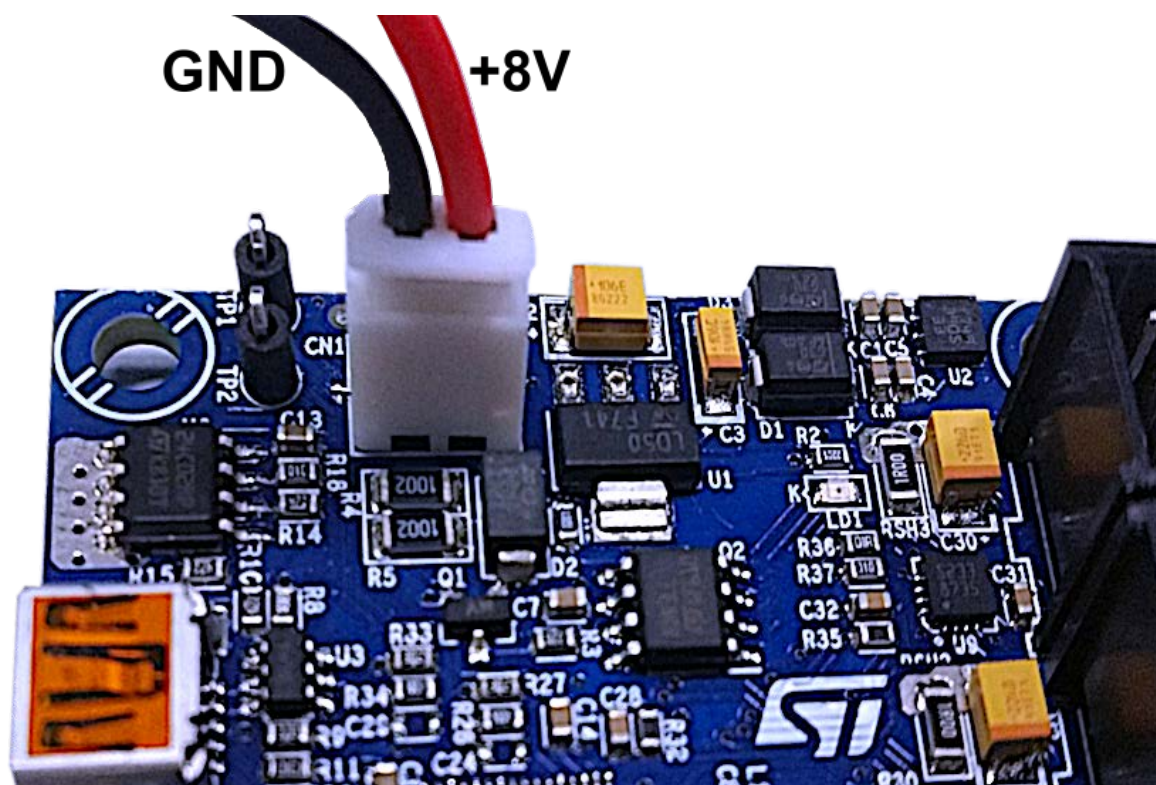
### 3.4

#### How to supply power to the STEVAL-GMBL01V1 board

The STEVAL-GMBL01V1 accepts 6 V to 11 V input power. You can use a 2-cell LiPo battery (7.4 V nom) or a DC power supply that is compatible with the input voltage range. The maximum current drawn by the is 3 A.

- Step 1.** Connect the battery or power supply to connector CN1 on the STEVAL-GMBL01V1 board.  
Use the polarity shown in the following figure.

Figure 13. Power supply connection for the STEVAL-GMBL01V1



- Step 2.** You can also connect a USB Type-A Male to Type-B mini cable to power the microcontroller only for programming and debugging with the ST-LINK or for a real-time data communication with the GUI. The power section of the board and the motors do not receive any power through the USB connection.

### 3.5 How to program the firmware

If LED LD2 does not blink when you connect the battery or the DC power supply, you must reprogram the microcontroller with the firmware code.

You can find the STEVAL-GMBL01V1.hex executable file for the firmware in the kit software package in the Executable firmware folder. You can also download the latest version of the firmware and GUI at the following location on the ST website: [STEVAL-GMBL02V1](#).

- Step 1.** Install the ST-LINK utility. You can find the installation instructions for the utility on [www.st.com](http://www.st.com).
- Step 2.** Install the ST-LINK USB driver and the STM32 Virtual COM port Driver for Windows. You can find the installation instructions for the drivers on [www.st.com](http://www.st.com).

## 4 STEVAL-GMBL02V1 GUI controls

The STEVAL-GMBL2V1 GUI software runs on Windows 7 or later. The GUI communicates with the firmware running on the evaluation board to retrieve information such as camera orientation angles and to send commands such as to begin start control.

To use the GUI, connect a USB cable Type-A Male to Type-B from your PC to connector CN3 on the STEVAL-GMBL01V1 board. The battery or the DC power supply can be supplied through connector CN1 if you want to drive the Gimbal.

Figure 14. STEVAL-GMBL02V1 GUI controls



1. **[Connect]**: establish communication with the board
2. **[Disconnect]**: close communication
3. **[Start]**: start control (manually – see **[AutoRun]** control) of the Gimbal camera
4. **[Stop]**: stop camera control
5. **[Camera IMU]**: gives the orientation angles of the camera (pitch, roll and yaw) with respect to the inertial reference. The values are updated in real time when communication is established.

6. **[Frame IMU]**: gives the orientation angles of the frame (pitch, roll and yaw) on which the board is mounted with respect the inertial reference (e.g., the ground). The values are updated in real time when communication is established.
7. **[Target Angles]**: where you can set the orientation angles (pitch, roll and yaw) for the camera with respect to the inertial reference (e.g., the ground). The target angles can be set numerically in the edit box or using the **[Slider]**. The camera will follow the target if the control of the camera is turned on (**[Start]** pressed) and real-time communication is active (**[Connect]** pressed).
8. **[Pitch PID]**: where you can set the coefficients (kp, ki and kd) for the position controller for the pitch angle.
9. **[Roll PID]**: where you can set the coefficients (kp, ki and kd) for the position controller for the roll angle.
10. **[Yaw PID]**: where you can set the coefficients (kp, ki and kd) for the position controller for the yaw angle.
11. **[AutoRun]**: where you can set the standalone behaviour of the firmware when you connect the battery or DC power supply (not when the USB is connected):
  - if it is checked (normal mode), the firmware automatically starts control of the Gimbal when the board is powered
  - if it is not checked (debug mode - default), the firmware does not automatically start control of the Gimbal when the board is powered. You can start control manually by clicking the **[Start]** button.
12. **[Factory Reset]**: restores the application settings to factory defaults.
13. **[Load]**: overwrites current GUI settings with application data (e.g., PID coefficients) stored in the embedded memory.
14. **[Store]**: saves the GUI settings (e.g., the PID coefficients) in the embedded memory, which retains the data even after the battery or DC power supply is removed.

## 5 How to run the demo application

You can run the demo application after you set up of the system, supply power to the board and connect the USB cable to the STEVAL-GMBL01V1 board at connector CN3.

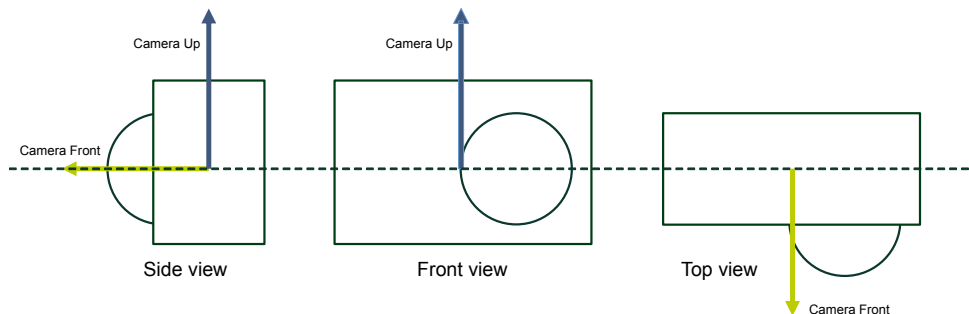
**Note:**

*If the AutoRun feature is enabled in the stored application settings (disabled by default), the Gimbal controller starts to adjust the camera as soon as the board is supplied. You should start with AutoRun disabled to check that Camera IMU is corrected correctly.*

**Step 1.** Run the Gimbal GUI and click the **[Connect]** button.

**Step 2.** Align the position of the camera with the horizon (or the ground), until all the Camera IMU angles in the GUI are zero.

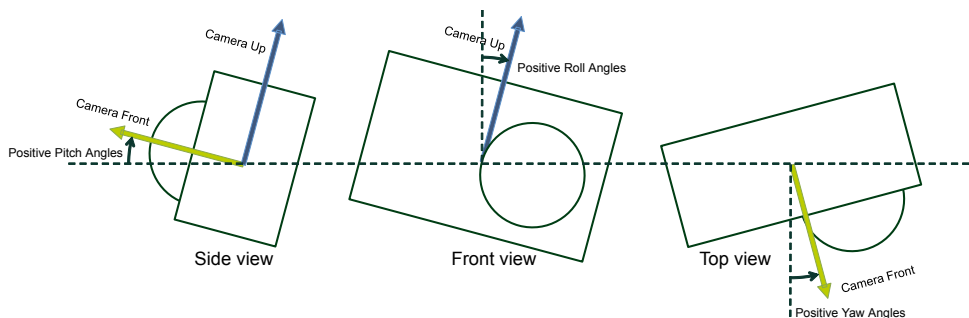
**Figure 15. Camera alignment with horizon**



**Step 3.** Move the camera and check that the angles shown in the GUI are the correct sign (positive or negative).

The figure below shows which directions should be positive.

**Figure 16. Sign conventions of orientation angles for the Camera IMU**



**Step 4.** If the Camera IMU angles in the GUI are correct, click the **[Start]** button in the GUI.

**Step 5.** Modify the **[Target Angles]** in the GUI using the sliders or the edit boxes and verify the response of the motors to match the settings.

You can also adjust the PID coefficients of each axis controller (pitch, roll or yaw) in the GUI.

**Step 6.** Save your settings in non-volatile memory by clicking the **[Store]** button in the GUI.

Use the **[Load]** button to load these settings later.

**Step 7.** Select the **[AutoRun]** check box.

The Gimbal controller starts automatically the next time you power on.

**Step 8.** Disconnect the USB cable and the power supply.

The system is now ready for a standalone control.

**Step 9.** Reconnect the power supply.

Camera control will start automatically.

If the Camera IMU angles in the GUI are not correct, you need to check the orientation of the Camera IMU board ([STEVAL-MKI178V1](#) or [STEVAL-MKI178V2](#) in our example).

If any of the motors run in the wrong direction, swap the black wire (phase A) with the white wire (phase C).

## 6 STEVAL-GMBL02V1 bill of materials

**Table 3. STEVAL-GMBL02V1 bill of materials**

Item	Q.ty	Ref.	Part / Value	Description	Manufacturer	Order code
1	1	-	STEVAL-GMBL01V1	Gimbal controller board	ST	STEVAL-GMBL01V1
2	1	-	STEVAL-UKI001V1	ST-LINK adapter board for serial wire debug (SWD)	ST	STEVAL-UKI001V1
3	1	-	10-pin	Flat Cable	Samtec	FFSD-05-D-08.00-01-N

### 6.1 STEVAL-GMBL01V1 bill of materials

**Table 4. STEVAL-GMBL01V1 bill of materials**

Item	Q.ty	Ref.	Part / Value	Description	Manufacturer	Order code
1	1	U1	LD1117S50TR	SOT-223	ST	LD1117S50TR
2	1	U2	LD39050PU33R	DFN6(3X3)	ST	LD39050PU33R
3	1	U3	USBLC6-4SC6	SOT23-6L	ST	USBLC6-4SC6
4	1	U4	STM32F303RET6	LQFP64	ST	<a href="#">STM32F303RET6</a>
5	1	U5	LSM6DSLTR	LGA-14L	ST	<a href="#">LSM6DSLTR</a>
6	1	U6	M24C02-RMN6TP	SO8	ST	<a href="#">M24C02-RMN6TP</a>
7	3	U7,U8,U9	STSPIN233	VFQFPN3X3 16L	ST	<a href="#">STSPIN233</a>
8	3	RSH1,RSH2,RSH3	1E	1206R	WALSIN	WF12P1R00FTL
9	2	R1,R2	2K2	0603R	Any	Any
10	4	R3,R9,R10,R21	22E	0603R	Any	Any
11	2	R4,R5	10K	1206R	Any	Any
12	2	R6,R7	0E	0603R	Any	Any
13	1	R8	1K5	0603R	Any	Any
14	2	R11,R16	100K	0603R	Any	Any
15	2	R12,R13	47K	0603R	Any	Any
16	3	R14,R15,R19	4K7	0603R	Any	Any
17	3	R27,R33,R39	3K	0603R	MULTICOMP	MCWR06X3001FTL
18	1	R17	560E	0603R	Any	Any
19	4	R18,R25,R31,R37	10K	0603R	Any	Any
20	6	R23,R26,R29,R32,R35,R38	18K	0603R	Any	Any
21	3	R24,R30,R36	100E	0603R	Any	Any
22	3	R28,R34,R40	1K	0603R	Any	Any
23	2	C1,C4	1uF	0603C	Any	Any

Item	Q.ty	Ref.	Part / Value	Description	Manufacturer	Order code
24	1	C2	10uF	Case B 1210 (3528-21)	AVX	TAJB106K025R
25	1	C3	10uF	Case A 1206 (3216-18)	AVX	TAJA106K016R
26	12	C5,C6,C7,C8,C9,C11,C13,C14,C15,C16,C17,C18	100nF	0603C	Any	Any
27	2	C10,C12	20pF	0603C	Any	Any
28	3	C20,C25,C30	22uF	1210C	AVX	TAJB226K020RNJ
29	9	C21,C22,C23,C26,C27,C28,C31,C32,C33	10nF	0603C	Any	Any
30	3	C24, C29, C34	N.M.	0603C		
31	2	D1,D3	STPS2L30A	SMA	ST	STPS2L30A
32	1	D2	SMAJ8.5CA	SMA	ST	SMAJ8.5CA-TR
33	1	LD1	LED_RED	0603	Any	Any
34	1	LD2	LED_BLUE	0603	Any	Any
35	1	L1	BEAD	0603L	Taiyo Yuden	BK1608HS601-T
36	1	CN1	BATT	TH 2.5mm Pitch	JST (JAPAN SOLDERLESS TERMINALS)	B2B-XH-A (LF)(SN)
37	1	CN2	1,27mm Pitch	1,27mm Pitch	Samtec	FTSH-105-01-F-D-K
38	1	CN3	USB MINI TYPE B	USB-MINI-B-SMD	Molex	51387-0530
39	1	CN5	7 pin Molex 2.54mm	2.54mm Pitch	Any	Any
40	6	CN8,CN9,CN10,CN11, CN13, CN14	3 pin Molex 2.54mm	2.54mm Pitch	Any	Any
41	3	M1,M2,M3	3 pin Molex 2.54mm	2.54mm Pitch	Molex	901361103
42	1	Q1	BS170F	SOT-23	DiodesZetex	BS170FTA
43	1	Q2	STS8DN3LLH5	SO8	ST	STS8DN3LLH5
44	1	SW1	Tactile Switch	SMD	C & K	KMR211GLFS
45	2	TP1, TP2	Test point	Hole 1.02mm	Keystone Electronics	5001
46	1	X1	8MHz	SMD	Diodes Inc. / Pericom	FY0800018

## 6.2

### STEVAL-UKI001V1 bill of materials

Table 5. STEVAL-UKI001V1 bill of materials

Item	Q.ty	Ref.	Part / Value	Description	Manufacturer	Order code
1	1	CN2	Connector	4-pin Female Header	Sullins Connector Solutions	PPPC041LFBN-RC

Item	Q.ty	Ref.	Part / Value	Description	Manufacturer	Order code
2	3	JP1, CN3, CN12	Connector	2-pin Female Header	Sullins Connector Solutions	PPPC021LFBN-RC
3	1	CN4	Connector	6-pin Female Header	Sullins Connector Solutions	PPPC061LFBN-RC
4	1	CN13	Connector	4-pin Male Header (not mounted)	Sullins Connector Solutions	PRPC004SAAN-RC
5	1	CN14	Connector	3-pin Male Header	Sullins Connector Solutions	PRPC003SAAN-RC
6	1	CN15	Connector	2-pin Male Header	Sullins Connector Solutions	PRPC002SAAN-RC
7	2	C1, C2	100nF, 16V, $\pm 10\%$	Ceramic X7R (not mounted)	Any	Any
8	1	D1	LED	Yellow	ROHM	SML-M13YTT86
9	1	JP2	2-pin Male Header	Not Mounted	Sullins Connector Solutions	PRPC002SAAN-RC
10	1	J1	100 mils 20-pin Header	-	Wurth Electronics Inc	612 020 216 21
11	1	J2	50 mils 10-pin Header	-	Samtec	FTSH-105-01-F-D-K
12	1	J3	1-pin Male Header	-	Sullins Connector Solutions	PRPC001SAAN-RC
13	1	R1	590, Film $\pm 1\%$	-	Any	Any
14	2	SW1, SW2	miniswitch	-	C&K	KMR211GLFS
15	2	N.D.	Jumper	-	Sullins Connector Solutions	QPC02SXGN-RC

## 7.1 STEVAL-GMBL01V1 controller board schematic diagrams

**Figure 17. STEVAL-GMBL01V1 schematic - interfaces**

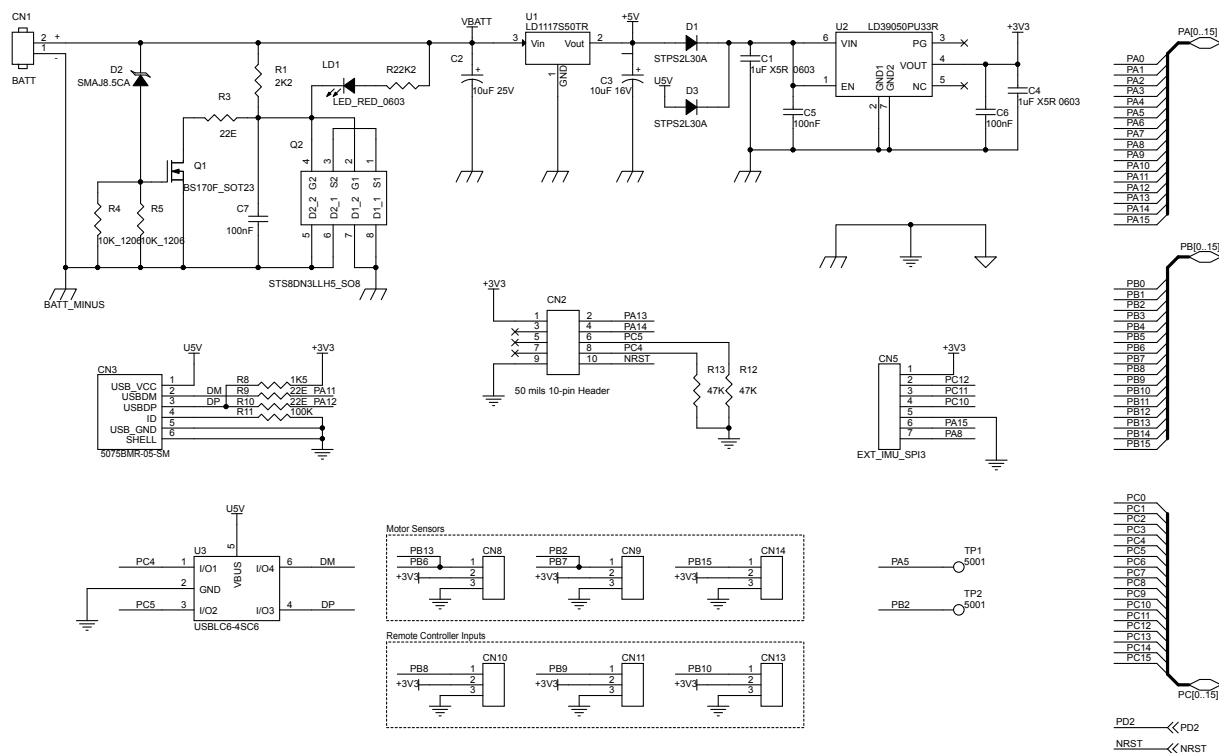


Figure 18. STEVAL-GMBL01V1 schematic – MCU, IMU sensor, EEPROM

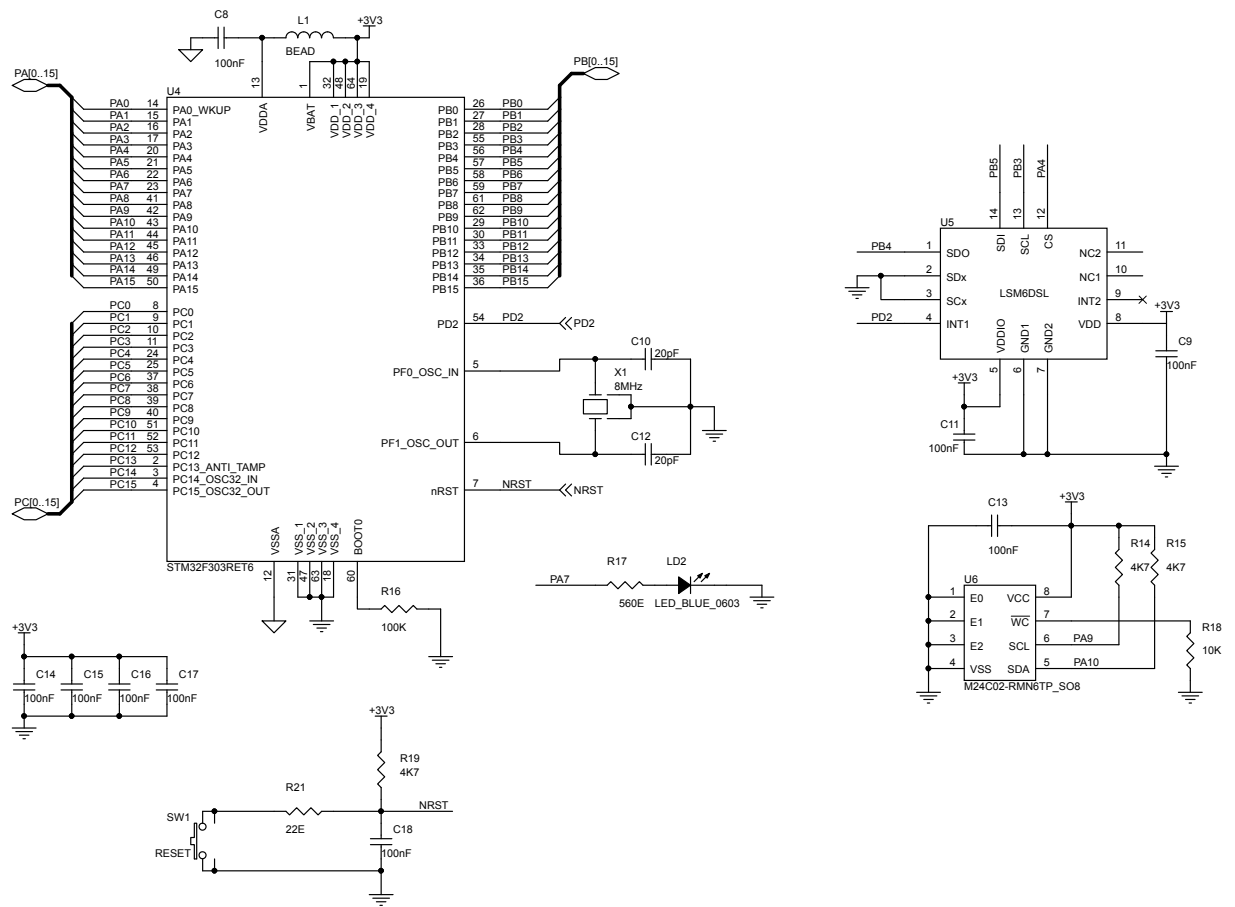
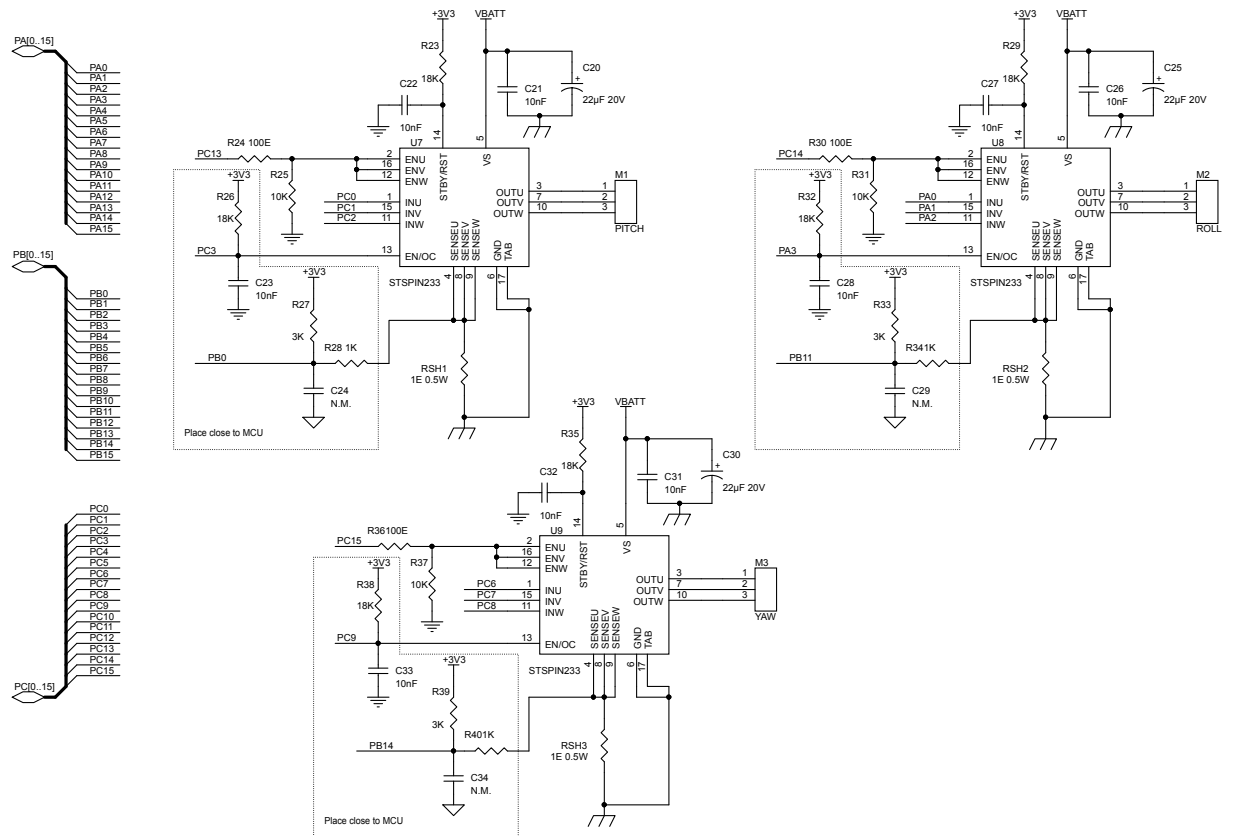
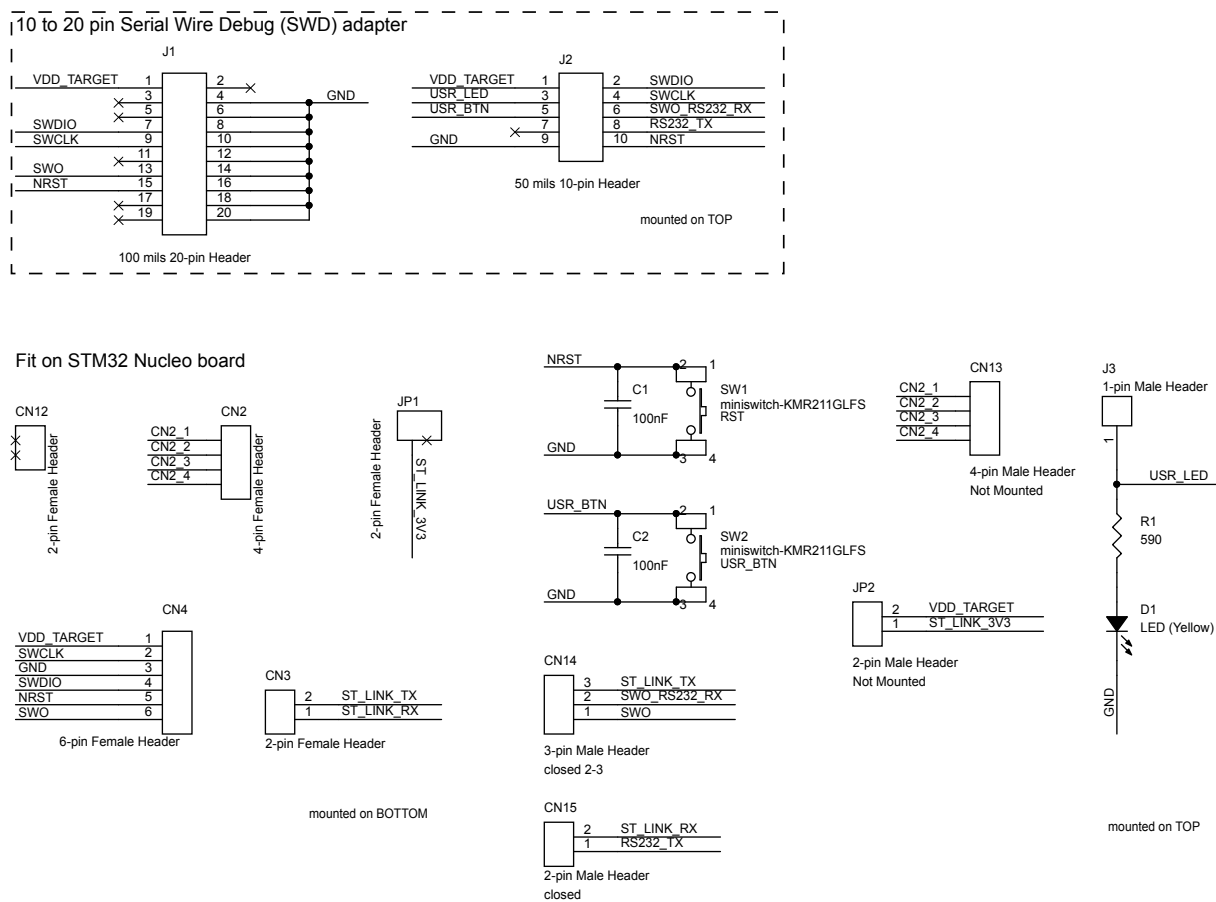


Figure 19. STEVAL-GMBL01V1 schematic – motor control



## 7.2 STEVAL-UKI001V1 adapter board schematic diagram

**Figure 20. STEVAL-UKI001V1 schematic**



## Revision history

**Table 6. Document revision history**

Date	Version	Changes
14-Aug-2018	1	Initial release.

## Contents

<b>1</b>	<b>Reference design kit overview .....</b>	<b>2</b>
1.1	Package components .....	2
1.2	Hardware features .....	2
1.3	Software features .....	2
1.4	System requirements .....	3
<b>2</b>	<b>STEVAL-GMBL01V1 Gimbal controller board architecture .....</b>	<b>4</b>
2.1	Power management .....	5
2.2	STM32F303RE microcontroller .....	5
2.3	Enhanced SWD connector .....	5
2.4	STSPIN233 three phase inverters .....	6
2.5	Camera IMU .....	6
2.6	Frame IMU .....	6
2.7	Embedded EEPROM .....	7
2.8	STEVAL-UKI001V1 SWD adapter board .....	7
<b>3</b>	<b>How to set up the STEVAL-GMBL02V1 reference design kit .....</b>	<b>9</b>
3.1	How to set up and connect the STEVAL-UKI001V1 .....	9
3.2	How to assemble and connect the frame motors .....	10
3.3	How to set up and connect the camera IMU .....	13
3.4	How to supply power to the STEVAL-GMBL01V1 board .....	14
3.5	How to program the firmware .....	15
<b>4</b>	<b>STEVAL-GMBL02V1 GUI controls .....</b>	<b>16</b>
<b>5</b>	<b>How to run the demo application .....</b>	<b>18</b>
<b>6</b>	<b>STEVAL-GMBL02V1 bill of materials .....</b>	<b>20</b>
6.1	STEVAL-GMBL01V1 bill of materials .....	20
6.2	STEVAL-UKI001V1 bill of materials .....	21
<b>7</b>	<b>Schematic diagrams .....</b>	<b>0</b>
7.1	STEVAL-GMBL01V1 controller board schematic diagrams .....	23
7.2	STEVAL-UKI001V1 adapter board schematic diagram .....	25
	<b>Revision history .....</b>	<b>27</b>

## List of figures

<b>Figure 1.</b>	STEVAL-GMBL01V1 top side components . . . . .	4
<b>Figure 2.</b>	STEVAL-GMBL01V1 block diagram . . . . .	5
<b>Figure 3.</b>	10 to 20 pin Serial Wire Debug (SWD) adapter . . . . .	6
<b>Figure 4.</b>	STEVAL-UKI001V1 schematic . . . . .	7
<b>Figure 5.</b>	STEVAL-UKI001V1 top view . . . . .	8
<b>Figure 6.</b>	STEVAL-UKI001V1 bottom view . . . . .	8
<b>Figure 7.</b>	STEVAL-UKI001V1 assembly . . . . .	9
<b>Figure 8.</b>	STEVAL-GMBL01V1 CN2 - SWD connector for STEVAL-UKI001V1 . . . . .	10
<b>Figure 9.</b>	Example of motor phases and sensor wires . . . . .	11
<b>Figure 10.</b>	Motor connections. . . . .	12
<b>Figure 11.</b>	Motor sensor connections . . . . .	13
<b>Figure 12.</b>	Camera IMU placement . . . . .	14
<b>Figure 13.</b>	Power supply connection for the STEVAL-GMBL01V1 . . . . .	15
<b>Figure 14.</b>	STEVAL-GMBL02V1 GUI controls. . . . .	16
<b>Figure 15.</b>	Camera alignment with horizon. . . . .	18
<b>Figure 16.</b>	Sign conventions of orientation angles for the Camera IMU . . . . .	18
<b>Figure 17.</b>	STEVAL-GMBL01V1 schematic - interfaces . . . . .	23
<b>Figure 18.</b>	STEVAL-GMBL01V1 schematic – MCU, IMU sensor, EEPROM . . . . .	24
<b>Figure 19.</b>	STEVAL-GMBL01V1 schematic – motor control . . . . .	25
<b>Figure 20.</b>	STEVAL-UKI001V1 schematic . . . . .	26

## List of tables

<b>Table 1.</b>	List of compatible motors . . . . .	10
<b>Table 2.</b>	STEVAL-MKI178V1 or STEVAL-MKI178V2 connections . . . . .	14
<b>Table 3.</b>	STEVAL-GMBL02V1 bill of materials . . . . .	20
<b>Table 4.</b>	STEVAL-GMBL01V1 bill of materials . . . . .	20
<b>Table 5.</b>	STEVAL-UKI001V1 bill of materials . . . . .	21
<b>Table 6.</b>	Document revision history . . . . .	27

**IMPORTANT NOTICE – PLEASE READ CAREFULLY**

STMicroelectronics NV and its subsidiaries ("ST") reserve the right to make changes, corrections, enhancements, modifications, and improvements to ST products and/or to this document at any time without notice. Purchasers should obtain the latest relevant information on ST products before placing orders. ST products are sold pursuant to ST's terms and conditions of sale in place at the time of order acknowledgement.

Purchasers are solely responsible for the choice, selection, and use of ST products and ST assumes no liability for application assistance or the design of Purchasers' products.

No license, express or implied, to any intellectual property right is granted by ST herein.

Resale of ST products with provisions different from the information set forth herein shall void any warranty granted by ST for such product.

ST and the ST logo are trademarks of ST. All other product or service names are the property of their respective owners.

Information in this document supersedes and replaces information previously supplied in any prior versions of this document.

© 2018 STMicroelectronics – All rights reserved