Multi-sensor predictive maintenance kit with IO-Link stack v.1.1

Features

- Kit content:
  - Sensor node (marked STEVAL-IDP005V2; not available for separate sale)
  - Communication adapter board (marked STEVAL-UKI001V2; not available for separate sale)
  - STLINK-V3MINI programming and debugging interface
  - Cables and connector
- Main supply voltage: 18 - 32 V
- Main components of the sensor node:
  - 32-bit ARM® Cortex®-M4 core for signal processing and analysis (STM32F469AI)
  - Ultra-wide bandwidth (up to 6kHz), low-noise, 3-axis digital vibration sensor (IIS3DWB)
  - Absolute digital pressure sensor (LPS22HB)
  - Relative humidity and temperature sensors (HTS221)
  - Digital microphone sensors (IMP34DT05)
  - IO-Link PHY device (L6362A)
  - EEPROM (M95M01-DF) for data storage
  - Step-down switching regulator and LDO regulator (L6984 and LDK220)
  - ESD protection (ESDALC6V1-1U2, SMBJ33CA)
- Complete set of firmware demo examples based on 3D accelerometer library with advanced frequency and time domain signal processing for predictive maintenance, including:
  - Programmable FFT size (256, 512, 1024, 2048), overlapping and averaging
  - Programmable windowing (Flat Top, Hanning, Hamming, Rectangular)
  - Speed RMS moving average, acceleration max. peak
  - Programmable threshold for warning and alarm conditions in spectral band
- Microphone algorithms for:
  - PDM to PCM
  - Sound pressure level (SPL)
  - Audio FFT
- IO-Link device stack v1.1 protocol and IO-Link Device Descriptor (IODD) for all measurements included (provided by TEConcept GmbH)
- M12 standard industrial connector
- SWD connector for debugging and programming capability
- Reset button
- Expansion connector with GPIO, ADC, I²C bus, timer
- Designed to meet IEC industrial standard requirements

Description

The STEVAL-BFA001V2B is an industrial reference design kit for condition monitoring (CM) and predictive maintenance (PdM), in a layout that is designed to meet IEC61000-4-2/4 and EN60947 requirements for industrial applications.

Product summary	
Multi sensor predictive maintenance kit with embedded IO-Link stack v.1.1	STEVAL-BFA001V2B
High-performance advanced line, ARM Cortex-M4 core with DSP and FPU, 2 Mbytes Flash, 384+4 kB of RAM, DMA controller, up to 17 timers	STM32F469AI
Ultra-wide bandwidth, low-noise 3-axis digital accelerometer for industrial applications	IIS3DWB
IO-Link communication transceiver device	L6362A
Compact in-circuit debugger and programmer for STM32	STLINK-V3MINI
Software package for STEVAL-BFA001V2B evaluation kit	STSW-BFA001V2

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www.st.com

Product summary	
Applications	Condition monitoring and predictive maintenance
	Smart industry

The hardware consists of a highly compact (50 x 9 x 9 mm) industrial sensor board specifically designed for real industrial applications, and the necessary debugging tools, cables, plugs and adapters for an industrial communications scenario. The connection is managed using a standard multipolar cable with one wire used for IO-Link data.

The STSW-BFA001V2 firmware package (freely available on www.st.com) includes dedicated algorithms for advanced time and frequency domain signal processing and analysis of the high bandwidth 3D digital accelerometer for vibration monitoring. The package includes pressure, relative humidity and temperature sensor monitoring samples as well as audio algorithms for acoustic emission (AE).

The firmware runs on the high performance STM32F469AI, ARM® Cortex®-M4, 32-bit microcontroller. The sensor data analysis results can be displayed on a user PC terminal emulator via wired connectivity or the related IO-Link master board interface.

IO-Link device stack v1.1. (for evaluation purposes, with some limitations) is included in object library format with IO-Link Device Descriptor (IODD) for all measurements and with dedicated examples to demonstrate device interoperability with any master tool. It supports BLOB transfer for vibration and acoustic FFT data, event generator and parameter configuration.

The package includes a GUI to demonstrate the IO-Link device features when connected to the STEVAL-IDP004V2 multi-port master evaluation board.

1 Solution overview

1.1 Block diagram

The STEVAL-BFA001V2B kit enables predictive maintenance (early detection of failures on the equipment under monitoring), managing key parameters coming from environmental, vibration and acoustic sensors. It is suitable for monitoring motors, pumps and fans, and can accelerate the development of predictive maintenance solutions and PoCs.

The kit performs advanced time and frequency domain signal processing for vibration analysis, running on embedded high performance MCU with configurable thresholds for alarms and warnings, demonstrating the process at edge level.

The tiny and compact form factor has been designed to allow placement of the sensor node very close to the equipment to be monitored.

The power management phase generates the low voltage needed for digital sensors and MCU from an industrial 18 to 32 V input voltage range.

The IO-Link device stack protocol is included with the STSW-BFA001V2 dedicated firmware to demonstrate the IO-Link device features.

Figure 1. STEVAL-BFA001V2B main board (sensor node) block diagram

The sensor node is marked STEVAL-IDP005V2; it is not available for separate sale
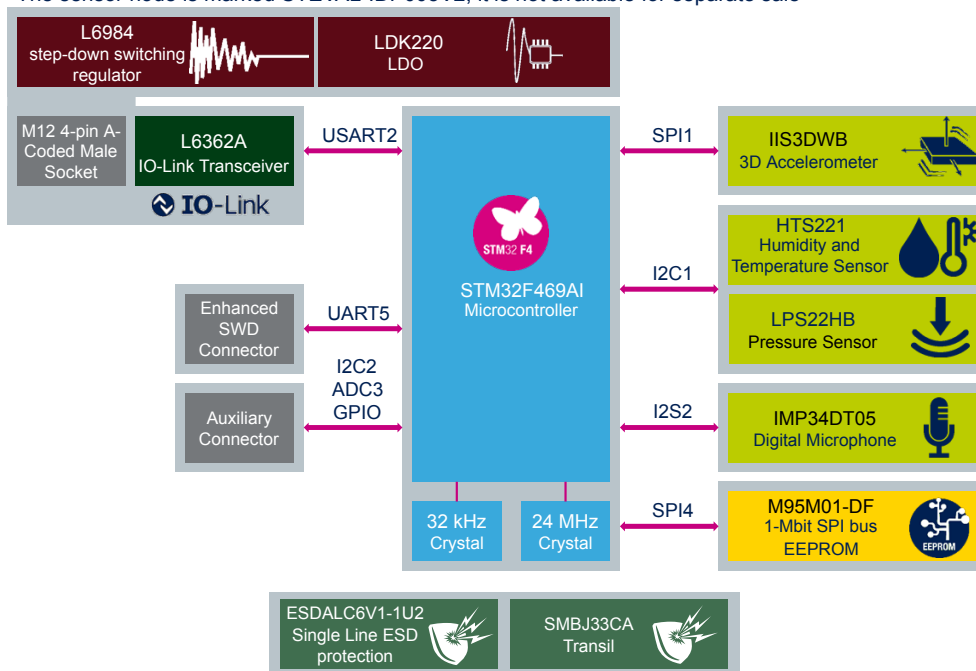
1.2 Schematic diagrams

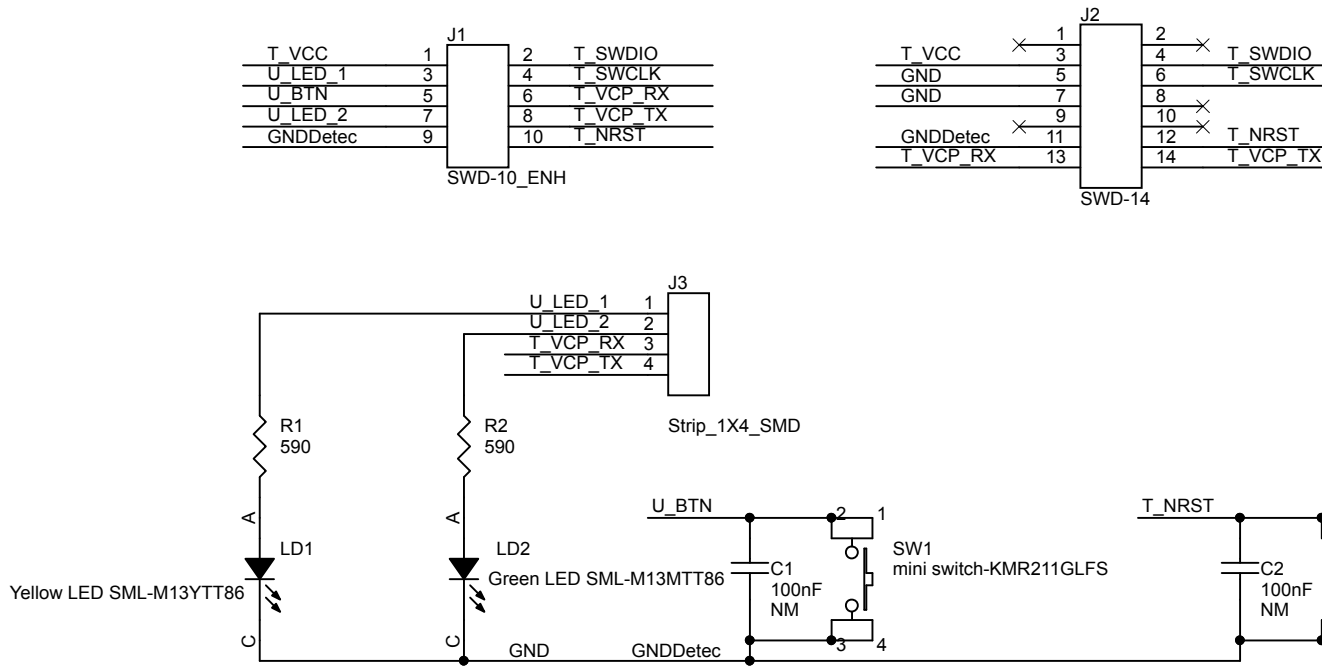**Figure 2. STEVAL-UKI001V2 (adapter board) circuit schematic**

Figure 3. STEVAL-IDP005V2 (main board) circuit schematic

Power Management

VIN: 18 V - 32 V
from IO-Link connector

VIN

VDD: 3.3 V

IO-Link

VIN

IN2
OUT/IQ
DIAG
OL

Microcontroller

IO-Link_COM_TX
IO-Link_COM_RX
IO-Link_DIAG
IO-Link_OL

ACC_CK
ACC_SI
ACC_SO
ACC_CS
ACC_INT1
ACC_INT2

SMBCLK
SMBDATA
SMBALERT
SMB_IO

ENV_CK
ENV_SD
HUM-TEMP_DRDY

PRESS_DRDY

MIC_CK
MIC_SD

PB1
PB0

Sensors

ACC_SPC
ACC_SDI
ACC_SDO
ACC_CS
ACC_INT1
ACC_INT2

AUX_CLK
AUX_DATA
AUX_ALER
AUX_IO

HUM-TEMP
HUM-TEMP
HUM-TEMP

PRES_SCL
PRES_SDA
PRES_INT_

MIC_CLK
MIC_DOUT

PB1
PB0

EEPROM

EEPROM_SCK
EEPROM_SDI
EEPROM_SDO
EEPROM_CS
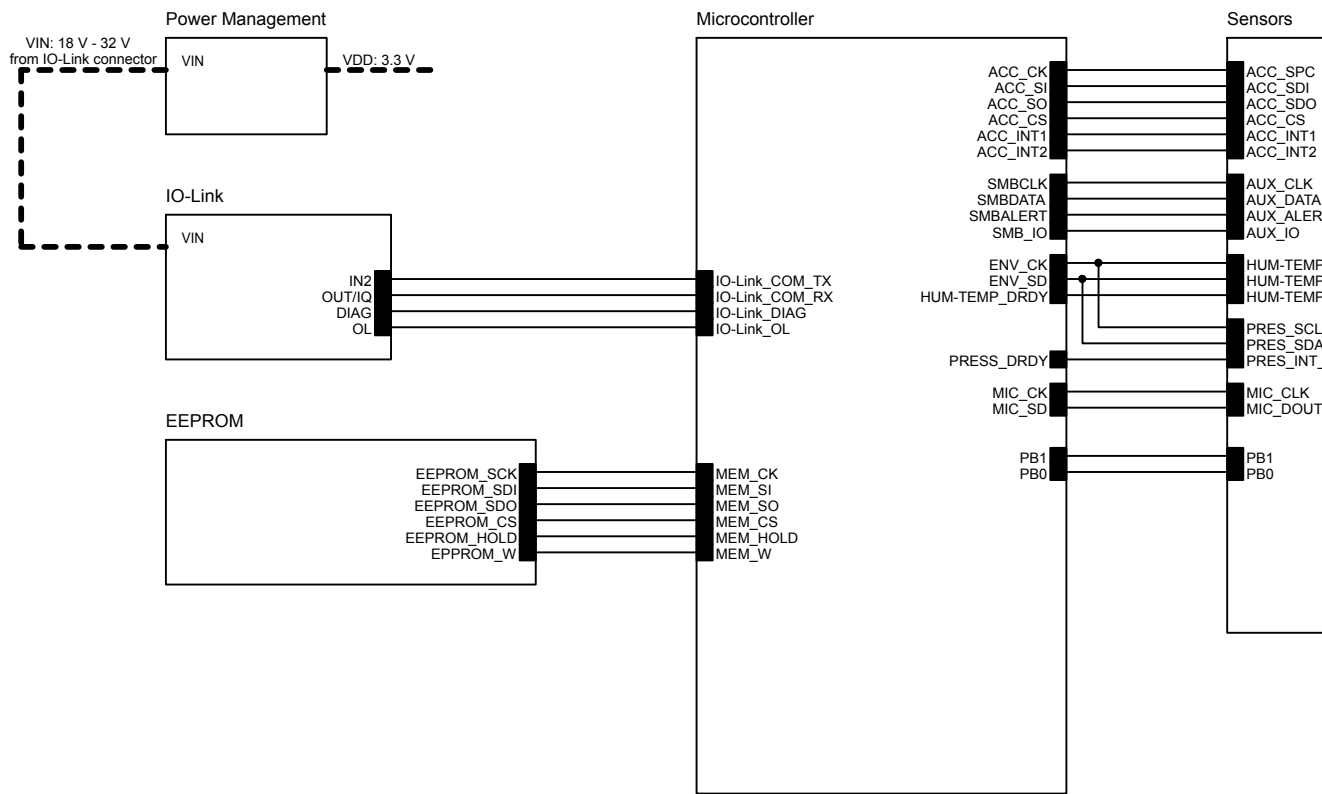EEPROM_HOLD
EPPROM_W

MEM_CK
MEM_SI
MEM_SO
MEM_CS
MEM_HOLD
MEM_W

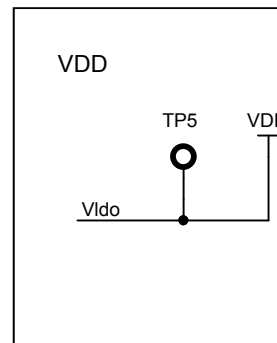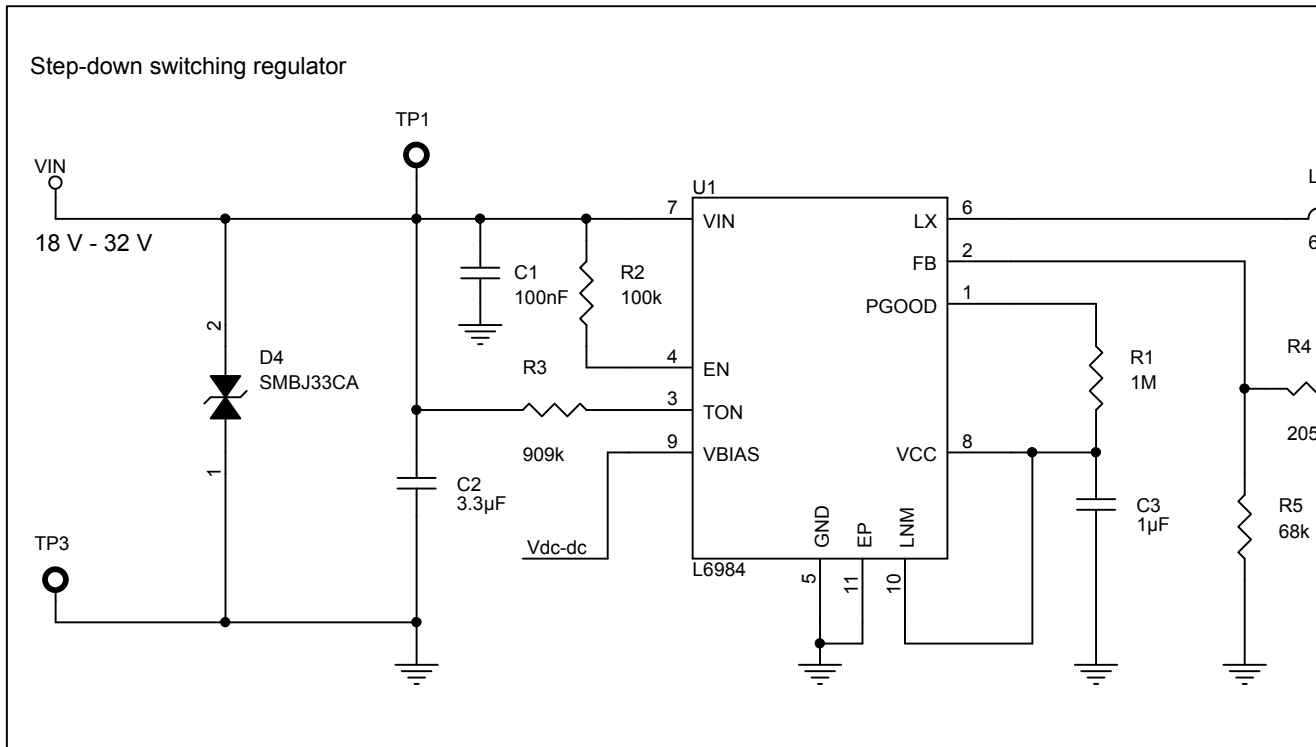**Figure 4. STEVAL-IDP005V2 (main board) circuit schematic - power management**

Step-down switching regulator

TP1

VIN
18 V - 32 V

C1
100nF

R2
100k

D4
SMBJ33CA

R3

C2
3.3µF

909k

TP3

Vdc-dc

U1

7 VIN

4 EN

3 TON

9 VBIAS

L6984

GND 5
EP 11
LNM 10

LX 6

FB 2

PGOOD 1

VCC 8

R1
1M

C3
1µF

R4

205

R5
68k

LDO

TP2

Vdc-dc

SB2

0R

C5
1µF

U2

6 IN

4 EN

3 ADJ/NC

LDK220

OUT 1

NC 2

GND 5

Vldo
3.3 V

C6
1µF

VDD

TP5

Vldo

VDD
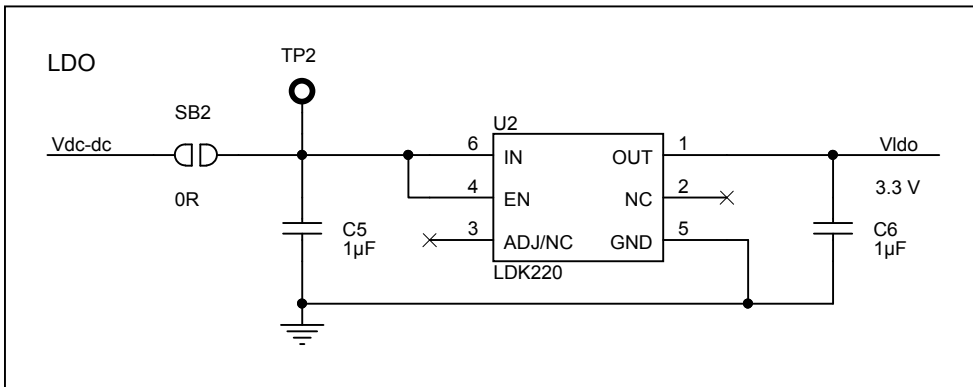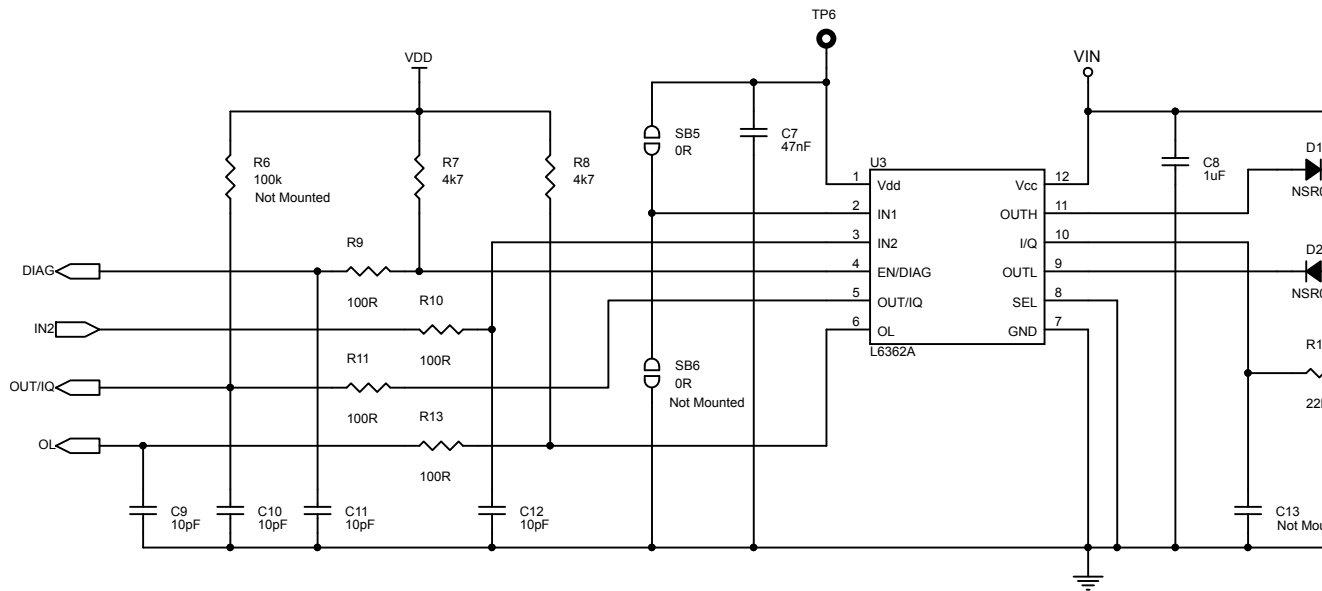
Figure 5. STEVAL-IDP005V2 (main board) circuit schematic - IO-Link

Figure 6. STEVAL-IDP005V2 (main board) circuit schematic - sensors

3D accelerometer

R24
VDD
10k

ACC_CS
ACC_SPC
ACC_SDI

U4

SDA
SCL
CS
14 13 12

ACC_SDO
1 SDO/SA0
2 RES1
3 RES2
4 INT1

NC2 11
NC1 10
INT2 9
VDD 8

ACC_INT2

ACC_INT1

IIS3DWB

VDDIO GND1 GND2
5 6 7

VDD

VDD

C15
100nF

VDD

C14
100nF

SPI

MEMS pressure sensor

VDD

U8
1 Vdd_IO
10 VDD

C20
100nF

C21
4.7uF

SCL/SPC 2
SDA/SDI/SDO 4
SDO/SA0 5
CS 6
INT_DRDY 7

PRES_SCL
PRES_SDA

PRES_INT_DRDY

RES 3
GND1 8
GND2 9

LPS22HB

I²C

MEMS microphone

VDD

C18
100nF

C19
1uF

U7
1 VDD

CLK 3
DOUT 4
LR 2

MIC_CLK
MIC_DOUT

GND 5

IMP34DT05

R16
10k

I²S

Humidity and temperature s

VDD

C17
100nF

U6
1 VDD

SCL/SPC
SDA/SDI/SDO
CS
DRDY

GND 5

HTS221

Auxiliary SMBus

VDD

J2

VDD

AUX_CLK
AUX_DATA

1
3
5
7
9

2
4
6
8
10

AUX_IO
PB1
PB0AUX_ALERT

M50-3200545

U5
1 I/O1
2 GND
3 I/O2

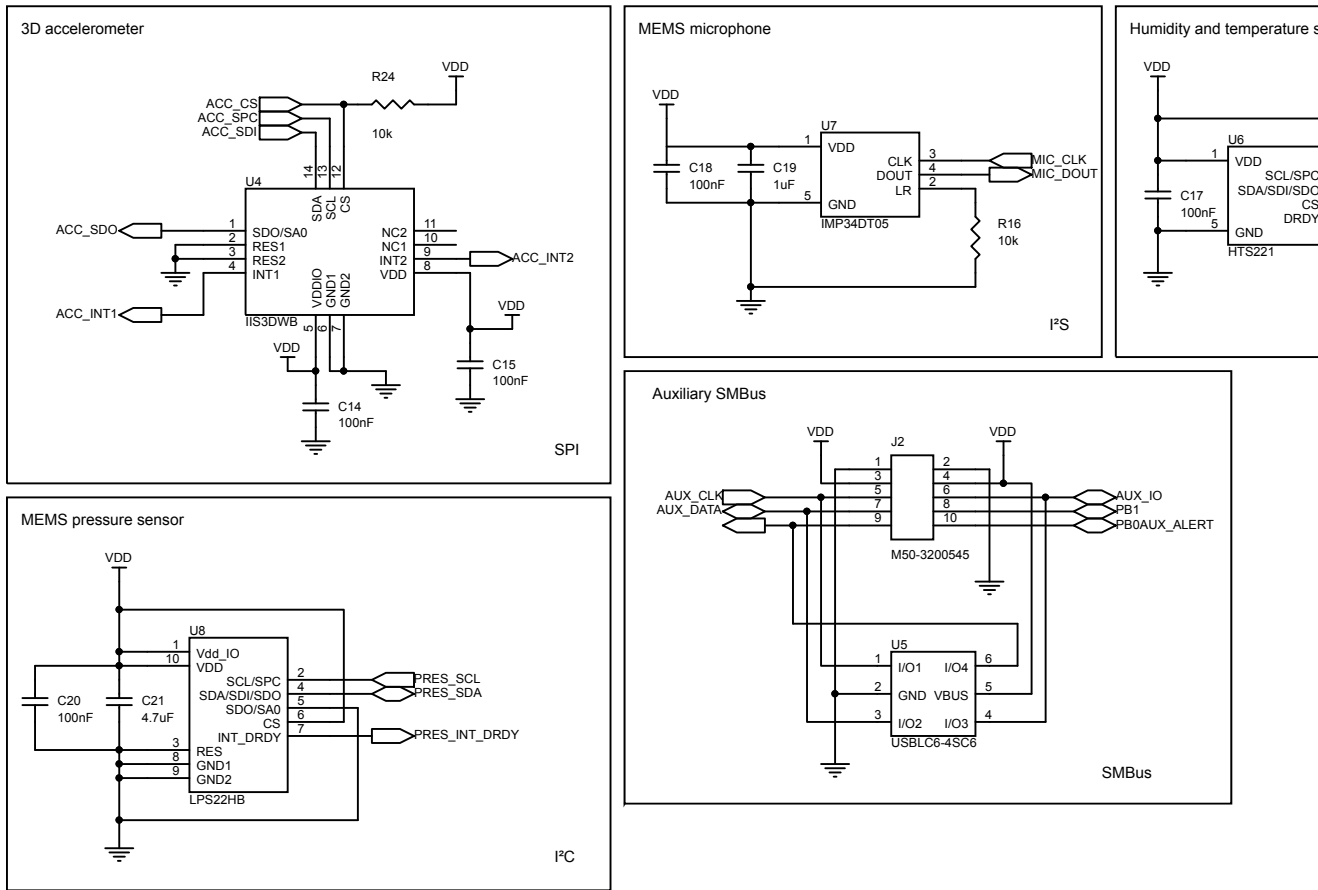I/O4 6
VBUS 5
I/O3 4

USBLC6-4SC6

SMBus

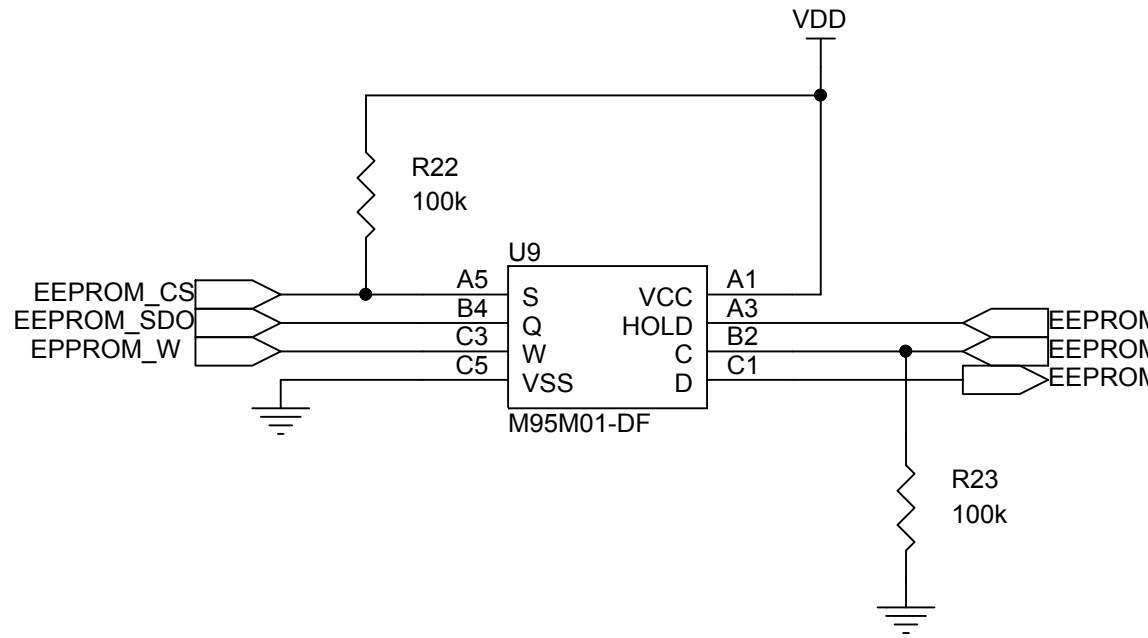**Figure 7. STEVAL-IDP005V2 (main board) circuit schematic - EEPROM**

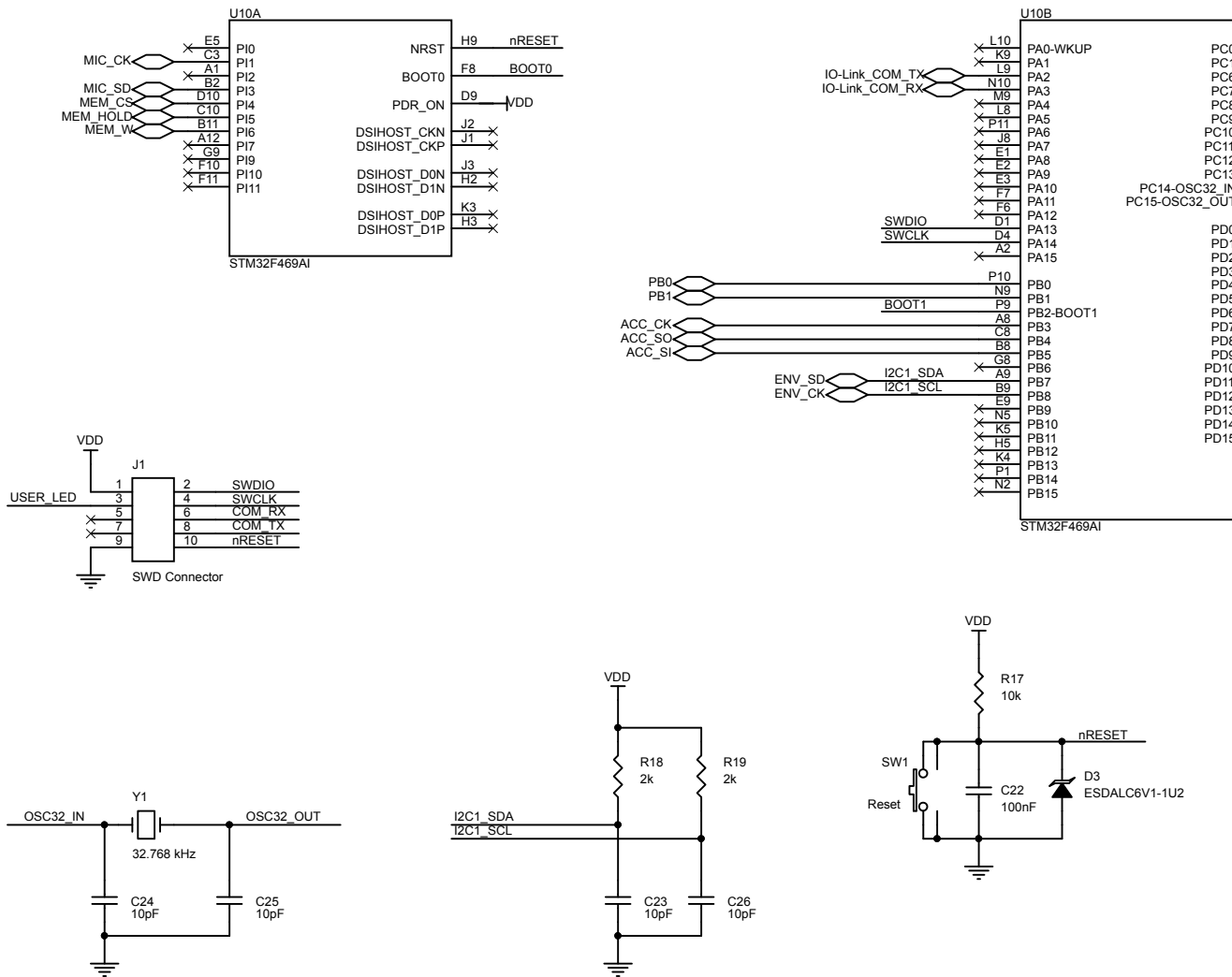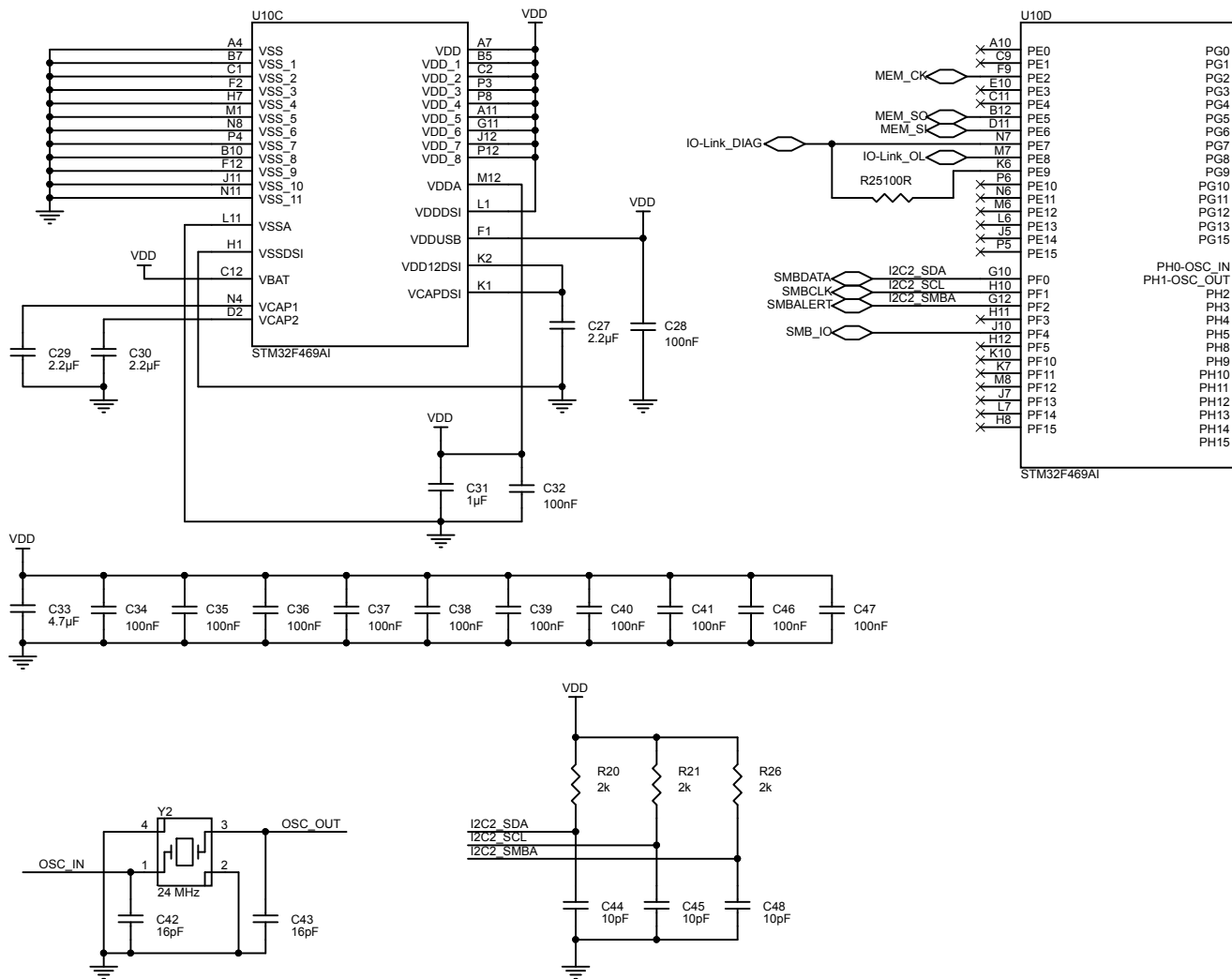**Figure 8. STEVAL-IDP005V2 (main board) circuit schematic - microcontroller (1 of 2)**

Figure 9. STEVAL-IDP005V2 (main board) circuit schematic - microcontroller (2 of 2)

Revision history

Table 1. Document revision history

Date	Version	Changes
20-Nov-2019	1	Initial release.
27-Apr-2020	2	Updated cover page features. Added Figure 7. STEVAL-IDP005V2 (main board) circuit schematic - EEPROM.

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