User Manual for ExBoard v1.1a

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Date	Version	Changes
01/09/2018	1.0	Initial Release
31/10/2018	1.1a	Code snippets

Contents

1 Introduction

The Ex-Board is the first Wireless and Wi-Fi Proportional Solenoid Valve Controller for all hydraulics, oleo-dynamics, diesel and gasoline applications. With a single board is possible to remotely control up to four valves and solenoids or any other inductive or resistive loads, check the current consumption, the valve status, the system temperature, run algorithms thanks to its powerful CPU and trigger events depending on the board inputs. It supports ROS, the Robot Operating System, since it comes with a ROS node which allows the user to control the outputs and read the board status; it is also possible to run custom code by using Arduino Language or directly C/C++ code.

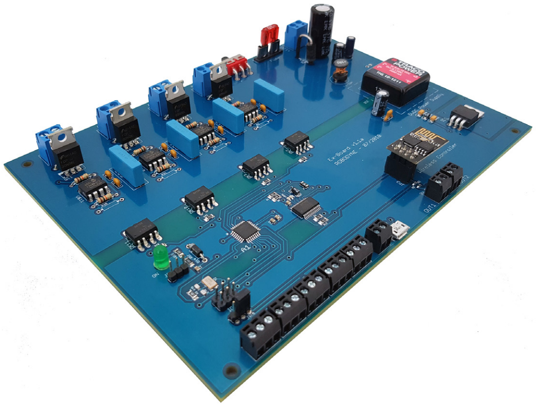


Figure 1: The Ex-Board v1.1a with the Wi-Fi module

2 Board description

The Ex-Board is able to provide up to four PWM outputs channels for proportional solenoid control with proportional current and with a digital pulse width modulated (PWM) signal which can vary from 50 to 10kHz (5-95%). Obviously, these same outputs can control also ON/OFF valves by setting the duty cycle to 0% and to 100%; the outputs have been designed to control both inductive and resistive loads so the board can be used for general purpose applications. Ex-board can accept power supply voltages from 9.0 to 18 VDC. Please, note that the voltage supplied by the power supply will be used across the four output channel, so, if your load accepts only 12VDC, please power the board with this same voltage. The Ex-board driver utilizes high frequency switching output (PWM) to provide a DC current output of 2 Amps. By writing custom code, it is possible to adjust the zero setting, maximum output current and the frequency to suit all the requirements. A status LED indicates when the board is powered on/off and a couple of LEDs indicates the transmitted and received data. The unit is available as a stand alone PCB Board or as a Packaged Driver enclosed in an IP67 rated metal housing. The box and DIN rail versions comply with CE directives for EMC. The Board can be easily programmed and configured by using C/C++ language or Arduino IDE or it can be delivered already programmed and ready-to-use. The board also accepts RC inputs up to 5 channels to allow the usage of any commercial RC remote transmitter to control each valve.

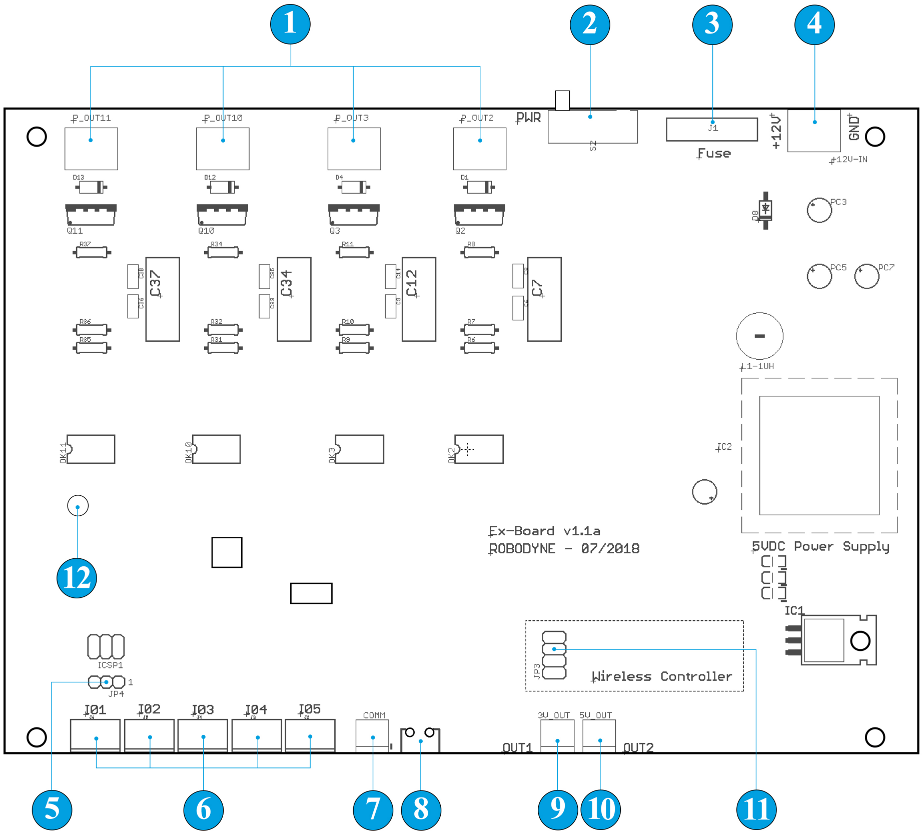


Figure 2: The Ex-Board v1.1a

Figure 2 shows the board layout which exposes all the I/Os, the headers and the communication ports.

1. The four output connectors are used to connect ON/OFF or proportional valves, DC brushed motors, inductive or resistive loads up to 2A for each output. The voltage across each output connector is the same used for the power supply.

2. The main switch must be used to power on and off the board.

3 The board system is protected by the main fuse which usually is rated at 10A.

4 The main connector is used for the power supply; the board input is filtered and the logic circuit is fully isolated and voltage regulated from the power circuit, so different types of batteries can be used: AGM, GEL, LiPo, NiMh, NiCd. The input voltage must be 9-18 VDC. The polarity is specified by the labels printed on the board: +12V and GND .

5 JP4 is a 3-pin header used to allow the board system to communicate with the Wi-Fi connector. The jumper must be placed on pins 1 and 2.

6 The input connectors can be used to read data from sensors or from RC receivers for remote control.

7 The COM1 port is directly connected to the RX and TX port on the ATmega328 microcontroller.

8 The USB connector is used to communicate with the board, to read from the Serial Monitor available in the Arduino IDE and to program the board with custom code. The board accepts the Arduino code, please refer to section 5 for pin mapping.

9 The regulated output connector for 3.3VDC at max 1A.

10 The regulated output connector for 5.0VDC at max 1A.

11 The wireless connector is used to host the ESP8266-01 module; please always mount the ESP module accordingly with the dashed square area. Refer to section 4 The Wi-Fi Module for the correct mounting orientation.

12 The status LED is ON when the board is connected to the main power supply.

3 Technical specifications

Table 1 shows all the main technical specifications for the Ex-Board.

It is important to note that the output voltage is 12 VDC while the power supply only accepts 9-18 VDC as input voltage; please do not exceed the maximum voltage value to avoid overheating and damages to the board. The board is protected against over-current and over-voltage by a blade fuse rated at 10A. Depending on the final application, the user can install a smaller fuse to protect the board and the devices; please, do not use a fuse larger than 10A without the authorization of the manufacturer. Table 2 reports all the main features related to the board.

Parameter	**Min**	**Max**	**Unit**
Input voltage	9	18	VDC
Continuous Output Current	-	2.1	A
Output voltage	0	12	VDC
Digital Logic Input Low Level	0	1.5	VDC
Digital Logic Input High Level	1.8	2.1	VDC
PWM Frequency	-	10	kHz
PWM Output	-	4	-
Digital and Analog Input	-	5	-
Voltage for inputs	0	5	VDC
Duty Cycle	0	100	%
Main Fuse	0	10	A
Secondary Output voltage	0	5	VDC
Secondary Output current	0	0.5	A

Table 1: Technical specifications

Feature	**Description**
Channel Input type	Digital, Analog, PWM
Controller	ATMEGA AVR Microcontroller
Connectivity	Wi-Fi 802.11, RC Inputs
Software Language	C/C++, Arduino IDE, ROS
Noise Suppression	Opto-isolated, EMC suppressor
Communication	USB type B
Dimensions	195 x 140 x 10 mm

Table 2: Ex-Board main features

4 The Wi-Fi module

Ex-Board supports the ESP8266-01 Wi-Fi module to allow the board to exchange data over a network as shown in Figure 2.

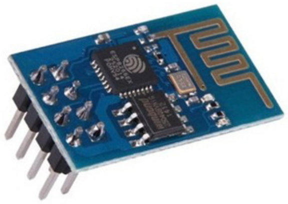
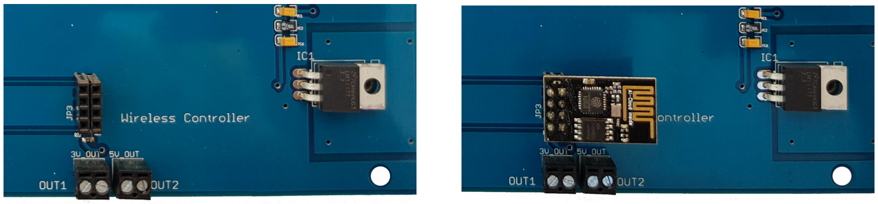


Figure 3: ESP8266 Wi-Fi Module

This module is very robust and powerful since it offers full TCP/IP capability and it works in two modes: Station (STA) and Access Point (AP). In short, AP mode allows it to create its own network and have other devices connect to it and STA mode allows the ESP8266 to connect to a Wi-Fi network. So, it can function as a client or as an access point or even both. This is a short list about all the main features of the ESP8266 module usually included with the board:

- 32-bit RISC CPU: Tensilica Xtensa LX106 running at 80 MHz
- 64 KiB of instruction RAM, 96 KiB of data RAM
- External QSPI flash – 512 KiB to 4 MiB* (up to 16 MiB is supported)
- IEEE 802.11 b/g/n Wi-Fi
- Integrated TR switch, balun, LNA, power amplifier and matching network
- WEP or WPA/WPA2 authentication, or open networks
- 16 GPIO pins
- SPI, I^{2}C
- I^{2}S interfaces with DMA (sharing pins with GPIO)
- UART on dedicated pins, plus a transmit-only UART can be enabled on GPIO2
- 1 10-bit ADC

The Wi-Fi connector is placed on the right-bottom of the board and it is indicated by the ”JP3” tag as showed in Figure 3a; moreover, please always mount the ESP8266 module with the correct orientation in order to match its pinout configuration. As reported in Figure 3b, the antenna always need to face towards the voltage regulator placed on the right side of the board.



(a) The JP3 Tag on the board (b) The ESP8266 placed on the board

Figure 4: The Wi-Fi connector on the Ex-Board

On the Ex-Board, this module communicates over a virtual serial port by using SoftwareSerial library on pins 10 and 11. This is a sample code which allows the user to use Arduino Terminal Window to directly communicate with the ESP8266. Please make sure that SoftwareSerial library is correctly installed in your Arduino IDE before to run the following code.

```
#include <SoftwareSerial.h>
SoftwareSerial mySerial(10, 11); // RX, TX
void setup() {
  // Open serial communications and wait for port to open:
  Serial.begin(9600);
  while (!Serial) {
    ; // wait for serial port to connect. Needed for native USB port only
  }
  Serial.println("Hello, I'm HYDRA v1.0!");
  // set the data rate for the SoftwareSerial port
   mySerial.begin(9600);
  }
void loop() { // run over and over
  if (mySerial.available()) {
    Serial.write(mySerial.read());
  }
  if (Serial.available()) {
    mySerial.write(Serial.read());
  }
}
```

In order to check if everything is working fine, it is possible to use the Terminal Window to send AT basic commands to the module. Table 3 reports a list of common AT commands that is possible to send to the module to retrieve information about its status.

AT command	Description
AT	response OK
AT+CWLAP	list nearby available WiFi networks
AT+GMR	check the firmware version
AT+CIFSR	get current allocated IP address

Table 3: List of common AT commands for the ESP8266 module

See here a complete list with AT instruction set.

5 Pin mapping

Table 4 shows how each port and connector on the EX-Board is mapped related to the ATMEGA328p as used in the Arduino Environment. Please, refer to this table when using the Arduino IDE.

Type	Name	Arduino
PWM OUT	P_OUT11	D9
PWM OUT	P_OUT10	D5
PWM OUT	P_OUT3	D6
PWM OUT	P_OUT2	D3
INPUT	I01	D8
INPUT	I02	D12
INPUT	I03	D7
INPUT	I04	D4
INPUT	I05	D2
COMM-TX	I01	D1
COMM-RX	I02	D0

Table 4: Ex-Board main features

6 Code snippets for Arduino

```
#include <TimerOne.h>

void setup() {
 pinMode(9, OUTPUT); // PWM OUTPUT FOR PROPORTIONAL VALVE P_OUT11
 pinMode(3, OUTPUT); // PWM OUTPUT FOR PROPORTIONAL VALVE P_OUT2
 pinMode(8, INPUT); // INPUT I01
 pinMode(A0, OUTPUT); // ON/OFF VALVE on P_OUT10
 Timer1.initialize(10000); //120 Hz -> 8333
 }

void loop() {

  sensor = pulseIn(8, HIGH, 25000); // read from the sensor
   if (sensor < 1520 && sensor > 400) {
   digitalWrite(A0, HIGH);  // activate the ON/OFF valve on P_OUT10
   }
   else {
   digitalWrite(A0, LOW); // turn off the ON/OFF valve on P_OUT10
   }

if ( sensor == 600 ){
  delay(50);
  Timer1.pwm(9, 255); // set duty cycle = 25% at 120Hz on P_OUT11
  analogWrite(3, 512); // set duty cycle at 100% on P_OUT2
}
delay(100);
}
```

7 Drawings

Figure 5 shows the mechanical dimensions in millimeters for the ExBoard v1.1a. Different size and bolt patterns are available, please ask to Robodyne SRL.

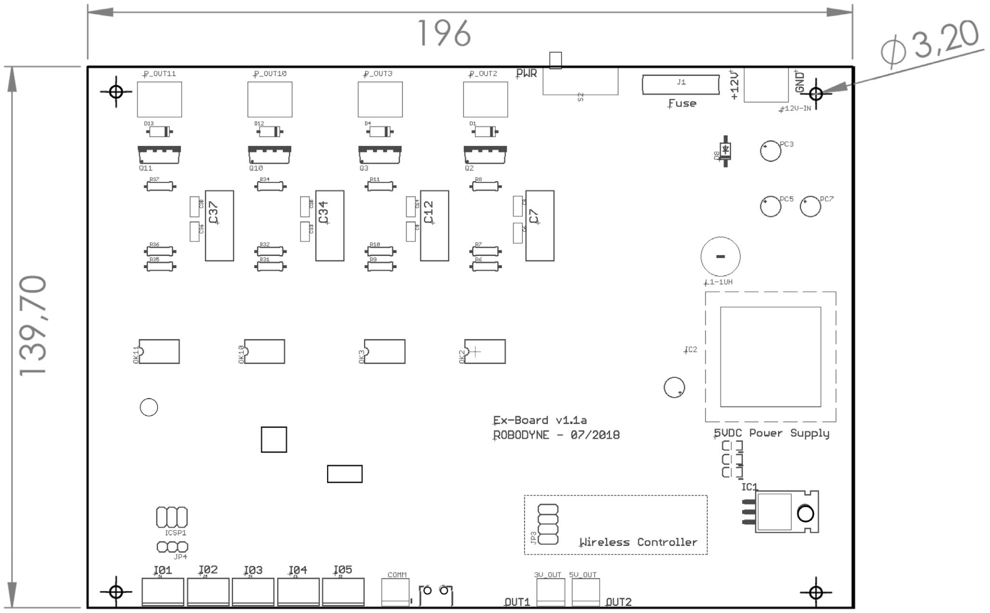


Figure 5: Overall dimensions for ExBoard