SPARK

Technical Specification

Alma Automotive s.r.l.

Via Terracini 2/c - 40131 Bologna - Italy
Tel. +39 051 9923806 / Fax +39 051 0544839
info@alma-automotive.it
www.alma-automotive.it

REV	DATE	CHANGE DESCRIPTION:
1.0	26/06/2018	Initial version
1.1	23/07/2018	Added sw requirements
1.2	17/01/2020	TEMPx channels limits updated
1.3	15/06/2020	Better pinout description
1.4	11/04/2022	CE updates, PH max profile update
1.5	17/10/2023	Updated SW requirements
1.6	22/05/2024	Template update. Removed LIN, CAN 2-3 Added wire specification for each PIN

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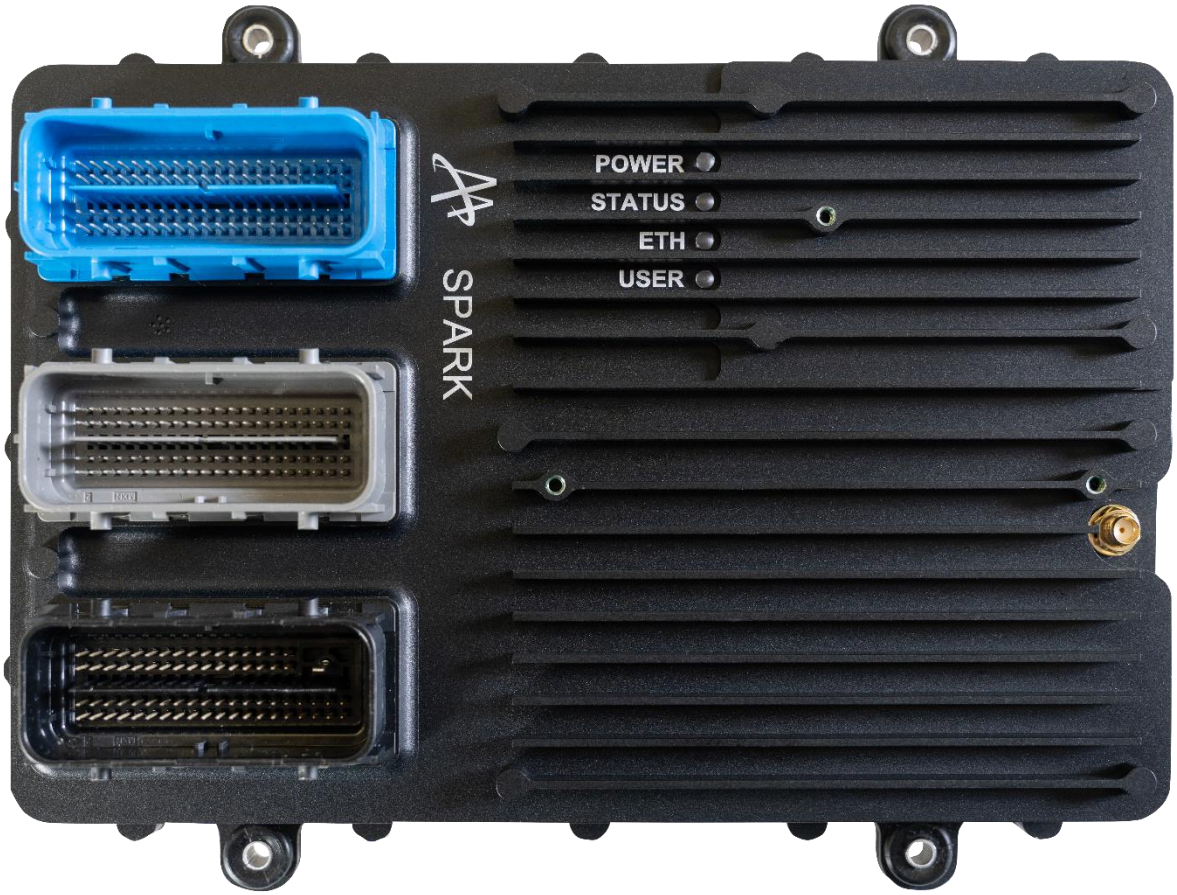
1. SPARK Overview

SPARK is an open-source ECU that contains all the features needed to run modern internal combustion engines. It provides analog circuitry to read signals from the sensors and power circuitry to drive all the actuators commonly used in the automotive market. It is based on National Instruments sbRIO-9651 which features a Zynq 7020 SoC. The user can write his custom code for both the real time and the FPGA parts.



2. Standard Application

The SPARK programmable ECU, produced by Alma Automotive, is a cutting-edge solution for research and development (R&D) in engine control systems. This open-source device offers complete programmability through LabView code, allowing users to customize every aspect of engine control according to their specific needs. A distinctive feature of SPARK is the ability to incorporate compiled Matlab/Simulink models, enabling easy integration of advanced simulations and complex algorithms directly into the control unit.

SPARK is designed to control injectors, coils, throttle body and valves and to acquire a wide range of sensors providing precise and reliable management of engine parameters. This detailed management capability is essential for optimizing fuel efficiency, reducing emissions, and increasing engine power. Thanks to its flexible architecture, SPARK adapts to a wide range of engines and configurations, making it an indispensable tool for engineers and researchers working on engine innovation.

Using SPARK in an R&D context allows for experimentation and the development of new engine control systems with an unprecedented level of precision and customization. The control unit offers a robust and versatile platform to test new ideas, enhance engine performance, and accelerate the technological development process. In summary, SPARK represents an excellent solution for those seeking advanced and highly customizable engine control.

3. Hardware Specification

3.1 Environmental Specifications

Property	Note	Maximum	Minimum
Operating Humidity	Relative, non-condensing	90%	10%
Storage Humidity	Relative, non-condensing	95%	5%
Ambient Operating Temperature	Forced air cooling	85°C	-20°C
Storage Temperature		90°C	-40°C
Altitude		5000m	

3.2 Operative conditions

3.2.1 Absolute Maximum Ratings

T_A = 25°C, unless otherwise noted.

Parameter	Rating	Note
Supply voltage	32V	On VCC_ECU pins to ground
Under voltage lockout	6V	
Over voltage lockout	30V	
Supply current	1A	Sum of all currents on VCC_ECU pins
5V sensor supply current	1.5A	Sum of all currents on 5V_OUT pins
10V sensor supply current	1A	Sum of all currents on 10V_OUT pins
Maximum current on each pin	11A	RMS
USB 5V supply maximum output current	1A	
GPS Antenna supply voltage	3.3V	
GPS Antenna maximum supply current	100mA	

3.3 Electrical Characteristics

3.3.1 High-Power I/O electrical specifications

DC/DC

Parameter	Rating	Note
Maximum output power	500W	
Maximum output voltage	100V	
Minimum output voltage	Vbatt	
Output voltage resolution	1V	

INJ Drivers

Parameter	Rating	Note
Maximum output current	18A	Peak duration: max 500us Angle based rate: max 416 inj/s (5injs per cycle @10000rpm) Time based rate: min 15ms of period and max 35% duty @11A of peak
Maximum output voltage	100V	
Output current resolution	0.1A	
Output current ripple		Strongly dependent on injector inductance

IGN Drivers

Parameter	Rating	Note
Maximum output current	10A	Do not exceed 200ms of duration
Clamp voltage	380V	

If multiple IGN Drivers are active at the same time, the sum of all currents should not exceed 20A.

Low Side Drivers

Parameter	Rating	Note
Nominal load current	7A	
Maximum load current	42A	Load inductance < 20uH
Maximum switching frequency	12KHz	

High Side Drivers

Parameter	Rating	Note
Maximum load current	10A	
Maximum switching frequency	12KHz	

H-Bridge Drivers

Parameter	Rating	Note
Nominal load current	5A	
Maximum load current	8A	Internally limited
Maximum switching frequency	20KHz	
Current feedback resolution	5mA	Iout < 5A

Lambda controller

Parameter	Rating	Note
Maximum heater current	6A	
Heater current measurement resolution	10mA	
Maximum heater pwm frequency	200Hz	

Lambda controller on the SPARK ECU is designed to work with Bosch LSU4.9 lambda probes. Other lambda probes can be used; ask info to Alma-Automotive srl.

3.3.2 Low-Power I/O electrical specifications

Fast ADC channels

Parameter	Rating	Note
Input voltage range	+/-10V	
Absolute maximum input voltage	+/-20V	
Input impedance	1Mohm	
Resolution	18bit	
Maximum sampling rate	200KHz	

Slow ADC channels

Parameter	Rating	Note
Input voltage range	0-5V	
Absolute maximum input voltage	+/- 10V	
Input impedance	6Kohm	
Resolution	12bit	
Maximum sampling rate	1KHz	Software limited

Temperature channels

Parameter	Rating	Note
Accepted sensor types		RTD, NTC, Diodes and any kind of TC
Cold junction compensation		Internal or external
Input voltage range	0-3.3V	
Absolute maximum input voltage	-0.3-3.6V	*Permanent damage occurs if driven outside this range*
Resolution	16bit	
Maximum sampling rate	6Hz	Best case (only 1 channel enabled)
Maximum error	+/- 1°C	Strongly dependent on sensor type and configuration

VRS channels

Parameter	Rating	Note
Absolute maximum voltage	+/- 50V	For each input pin with respect to ground
Input impedance	100Kohm	
Maximum input frequency	15Khz	

GPIOs

Parameter	Rating	Note
Absolute maximum voltage	+/- 20V	
V_{OHmin}	4.8V	100uA load
I_{OHmax}	2mA	
V_{IHmin}	3.5V	
V_{ILmax}	1.7V	
Maximum frequency	5MHz	

3.4 Communication BUS Characteristics

Type	Number	Note
ETH	1	1000BASE-T
CAN	2	High speed 2.0, up to 1Mbit/s, software programmable termination
RS232	1	
USB	1	2.0

3.5 Memory Storage

Type	Number	Note
SoC storage	512 MB	
Flash storage	32 GB	

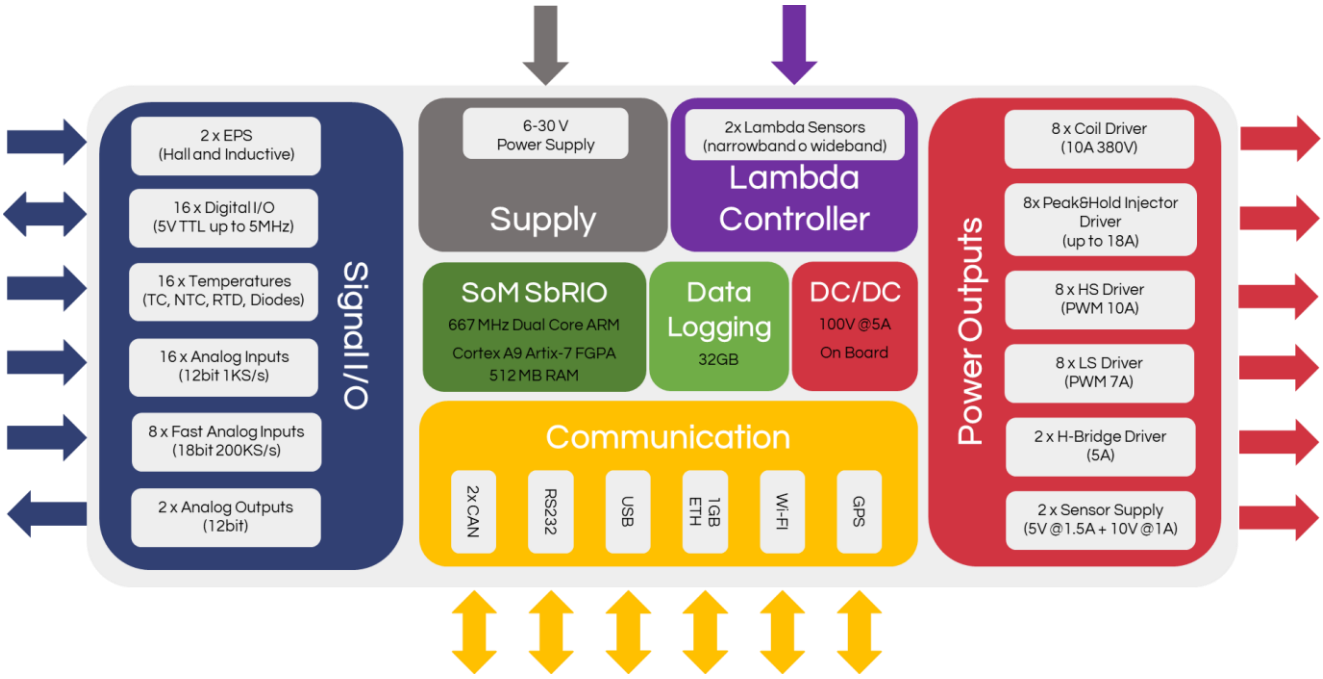
3.6 I/O Characteristics

A block diagram of a programmable engine control unit (ECU) visually represents the various components and their interconnections to manage engine operation. The core of the ECU consists of a microcontroller paired with a System on Module (SOM) from National Instruments (NI). This advanced setup processes data in real-time and commands actuators to optimize engine performance.

The input sensors are crucial and include temperature sensors, pressure sensors, airflow sensors, throttle position sensors, and more. These sensors continuously send information to the microcontroller and the NI SOM. The microcontroller, in collaboration with the SOM, analyzes this data using complex and custom algorithms to determine the optimal operating parameters for the engine.

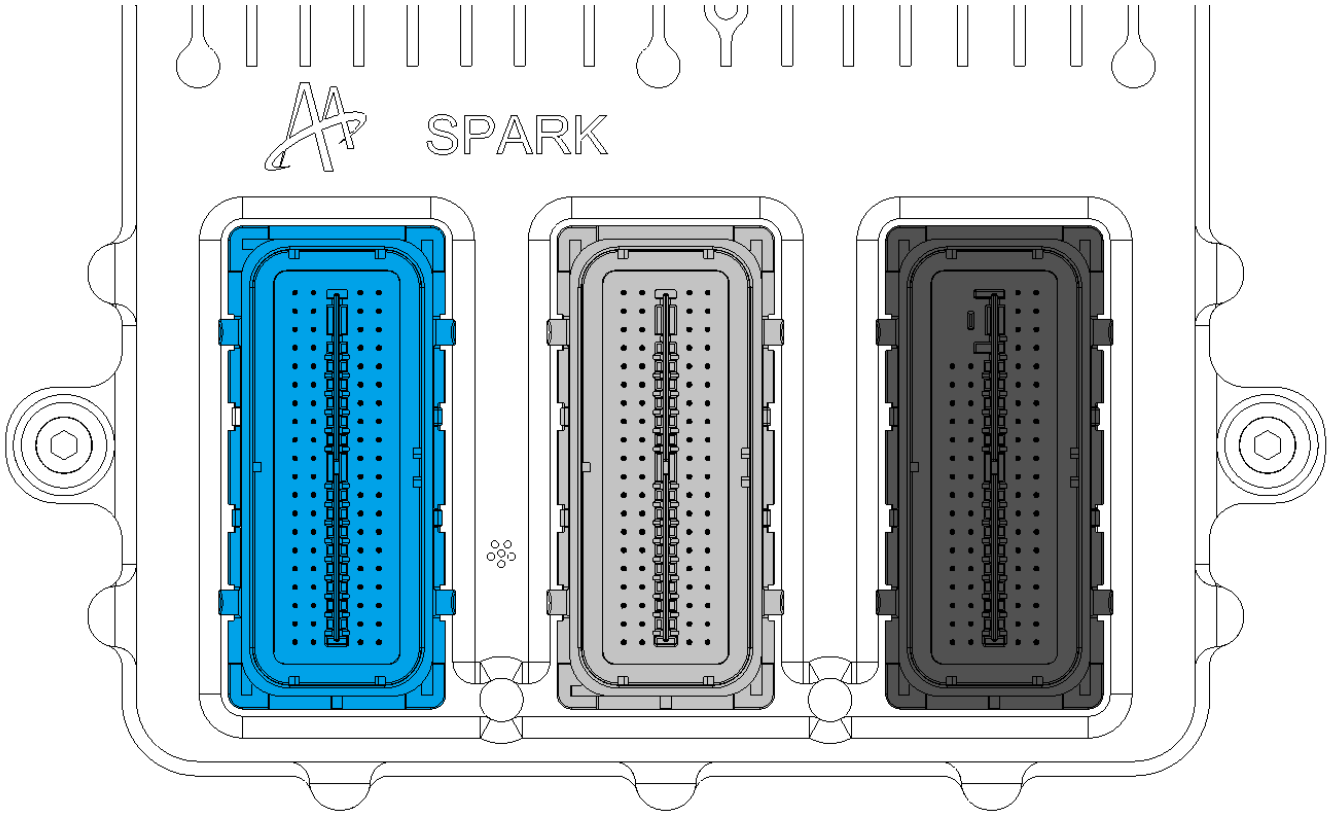
Once the data is processed, output signals are generated to control various actuators such as fuel injectors, air control valves, ignition systems, turbochargers etc.

Additionally, the ECU is equipped with a communication system, based on CAN bus, Ethernet and RS232, which allows real-time diagnostics and communication with other vehicle systems or host computers. This enables integrated management and continuous monitoring of the engine, improving the vehicle's overall reliability and performance.



3.7 Connectors

3.7.1 Connectors overview



On the SPARK unit there are 4 connectors. In the above figure the main connectors are visible with the corresponding color code.

Reference	Series	Color	Function
J1	Molex MX123	Blue	Analog signals I/O
J2	Molex MX123	Gray	Mixed signals I/O
J3	Molex MX123	Black	Power I/O
J4	SMA	Gold	GPS + Wi-Fi

3.7.2 J1 Connector Pinout

(Analog I/O, Blue)

PIN#	Name	Direction	Description
1	GND	Ground	Sensor ground
2	GND	Ground	Sensor ground
3	V7-	I	Fast ADC analog input 7 (differential)
4	V6-	I	Fast ADC analog input 6 (differential)
5	V5-	I	Fast ADC analog input 5 (differential)
6	V4-	I	Fast ADC analog input 4 (differential)
7	V3-	I	Fast ADC analog input 3 (differential)
8	V2-	I	Fast ADC analog input 2 (differential)
9	V1-	I	Fast ADC analog input 1 (differential)
10	V0-	I	Fast ADC analog input 0 (differential)
11	GND	Ground	Sensor ground
12	GND	Ground	Sensor ground
13	AIN15	I	Slow ADC analog input 15 (single ended)
14	AIN13	I	Slow ADC analog input 13 (single ended)
15	AIN11	I	Slow ADC analog input 11 (single ended)
16	AIN9	I	Slow ADC analog input 9 (single ended)
17	AIN7	I	Slow ADC analog input 7 (single ended)
18	AIN5	I	Slow ADC analog input 5 (single ended)
19	AIN3	I	Slow ADC analog input 3 (single ended)
20	AIN1	I	Slow ADC analog input 1 (single ended)
21	GND	Ground	Sensor ground
22	GND	Ground	Sensor ground
23	V7+	I	Fast ADC analog input 7 (differential)
24	V6+	I	Fast ADC analog input 6 (differential)
25	V5+	I	Fast ADC analog input 5 (differential)
26	V4+	I	Fast ADC analog input 4 (differential)
27	V3+	I	Fast ADC analog input 3 (differential)
28	V2+	I	Fast ADC analog input 2 (differential)
29	V1+	I	Fast ADC analog input 1 (differential)
30	V0+	I	Fast ADC analog input 0 (differential)
31	GND	Ground	Sensor ground
32	GND	Ground	Sensor ground
33	AIN14	I	Slow ADC analog input 14 (single ended)
34	AIN12	I	Slow ADC analog input 12 (single ended)
35	AIN10	I	Slow ADC analog input 10 (single ended)
36	AIN8	I	Slow ADC analog input 8 (single ended)
37	AIN6	I	Slow ADC analog input 6 (single ended)
38	AIN4	I	Slow ADC analog input 4 (single ended)
39	AIN2	I	Slow ADC analog input 2 (single ended)
40	AIN0	I	Slow ADC analog input 0 (single ended)
41	GND	Ground	Sensor ground

42	TEMP_COM	I	Temperature channels common ground
43	TEMP15	I/O	Temperature channel 15
44	TEMP13	I/O	Temperature channel 13
45	TEMP11	I/O	Temperature channel 11
46	TEMP9	I/O	Temperature channel 9
47	TEMP7	I/O	Temperature channel 7
48	TEMP5	I/O	Temperature channel 5
49	TEMP3	I/O	Temperature channel 3
50	TEMP1	I/O	Temperature channel 1
51	DAC2	O	DAC Output 1
52	DAC1	O	DAC Output 0
53	5V_OUT	Supply	5V Sensor supply output
54	5V_OUT	Supply	5V Sensor supply output
55	5V_OUT	Supply	5V Sensor supply output
56	5V_OUT	Supply	5V Sensor supply output
57	5V_OUT	Supply	5V Sensor supply output
58	5V_OUT	Supply	5V Sensor supply output
59	5V_OUT	Supply	5V Sensor supply output
60	5V_OUT	Supply	5V Sensor supply output
61	GND	Ground	Sensor ground
62	TEMP_COM	I	Temperature channels common ground
63	TEMP14	I/O	Temperature channel 14
64	TEMP12	I/O	Temperature channel 12
65	TEMP10	I/O	Temperature channel 10
66	TEMP8	I/O	Temperature channel 8
67	TEMP6	I/O	Temperature channel 6
68	TEMP4	I/O	Temperature channel 4
69	TEMP2	I/O	Temperature channel 2
70	TEMP0	I/O	Temperature channel 0
71	GND	Ground	Sensor ground
72	GND	Ground	Sensor ground
73	GND	Ground	Sensor ground
74	GND	Ground	Sensor ground
75	GND	Ground	Sensor ground
76	GND	Ground	Sensor ground
77	GND	Ground	Sensor ground
78	GND	Ground	Sensor ground
79	GND	Ground	Sensor ground
80	GND	Ground	Sensor ground

3.7.3 J2 Connector Pinout

(Mixed I/O, Grey)

PIN#	Name	Direction	Description
1	ETH_TX0-	I/O	Ethernet pair 0 negative
2	ETH_TX1-	I/O	Ethernet pair 1 negative
3	ETH_TX2-	I/O	Ethernet pair 2 negative
4	ETH_TX3-	I/O	Ethernet pair 3 negative
5	GND	Ground	Ground
6	N/A		
7	N/A		
8	CAN0_L	I/O	CAN Bus 0 low (SoM)
9	CAN1_L	I/O	CAN Bus 1 low (SoM)
10	USB_5V	O	USB 5V Supply output
11	USB_D-	I/O	USB D-
12	GND	Ground	Ground
13	GPIO0	I/O	TTL GPIO 0
14	GPIO2	I/O	TTL GPIO 2
15	GPIO4	I/O	TTL GPIO 4
16	GPIO6	I/O	TTL GPIO 6
17	GPIO8	I/O	TTL GPIO 8
18	GPIO10	I/O	TTL GPIO 10
19	GPIO12	I/O	TTL GPIO 12
20	GPIO14	I/O	TTL GPIO 14
21	ETH_TX0+	I/O	Ethernet pair 0 positive
22	ETH_TX1+	I/O	Ethernet pair 1 positive
23	ETH_TX2+	I/O	Ethernet pair 2 positive
24	ETH_TX3+	I/O	Ethernet pair 3 positive
25	GND	Ground	Ground
26	N/A		
27	N/A		
28	CAN0_H	I/O	CAN Bus 0 high (SoM)
29	CAN1_H	I/O	CAN Bus 1 high (SoM)
30	GND	Ground	Ground
31	USB_D+	I/O	USB D+
32	GND	Ground	Ground
33	GPIO1	I/O	TTL GPIO 1
34	GPIO3	I/O	TTL GPIO 3
35	GPIO5	I/O	TTL GPIO 5
36	GPIO7	I/O	TTL GPIO 7
37	GPIO9	I/O	TTL GPIO 9
38	GPIO11	I/O	TTL GPIO 11
39	GPIO13	I/O	TTL GPIO 13
40	GPIO15	I/O	TTL GPIO 15
41	L1_HEAT-	I	Lambda 1 heater negative (low side driver)

42	L1_HEAT+	Supply out	Lambda 1 heater positive (internally connected to VBATT)
43	L1 UN	I	Lambda 1 Nernst voltage input
44	L1 VM	O	Lambda 1 virtual ground output
45	L1 IA	I	Lambda 1 reference resistor
46	L1 IP	O	Lambda 1 pump current output
47	GND	Ground	VCC_ECU Ground
48	GND	Ground	VCC_ECU Ground
49	VRS0+	I	VRS 0 positive input
50	VRS1+	I	VRS 1 positive input
51	GND	Ground	Ground
52	RS232_TX	O	SoM RS232 TX
53	RS232_RX	I	SoM RS232 RX
54	GND	Ground	Ground
55	N/A		
56	N/A		
57	GND	Ground	Ground
58	GND	Ground	Ground
59	5V_OUT	Supply out	5V Sensor supply output
60	5V_OUT	Supply out	5V Sensor supply output
61	L0_HEAT-	I	Lambda 0 heater negative (low side driver)
62	L0_HEAT+	Supply out	Lambda 0 heater positive (internally connected to VBATT)
63	L0 UN	I	Lambda 0 Nernst voltage input
64	L0 VM	O	Lambda 0 virtual ground output
65	L0 IA	I	Lambda 0 reference resistor
66	L0 IP	O	Lambda 0 pump current output
67	VCC_ECU	Supply input	Logic supply voltage
68	VCC_ECU	Supply input	Logic supply voltage
69	VRS0-	I	VRS 0 negative input
70	VRS1-	I	VRS 1 negative input
71	GND	Ground	Ground
72	RESET#	I	SoM Reset (active low)
73	GND	Ground	Ground
74	HB1_A	I/O	H-Bridge 1 output A
75	HB1_B	I/O	H-Bridge 1 output B
76	HB0_A	I/O	H-Bridge 0 output A
77	HB0_B	I/O	H-Bridge 0 output B
78	GND	Ground	Ground
79	10V_OUT	Supply out	10V Sensor supply output
80	10V_OUT	Supply out	10V Sensor supply output

3.7.4 J3 Connector Pinout

(Power I/O, Black)

PIN#	Name	Direction	Description
1	HS0	O	High side driver 0
2	HS1	O	High side driver 1
3	HS2	O	High side driver 2
4	HS3	O	High side driver 3
5	HS4	O	High side driver 4
6	HS5	O	High side driver 5
7	HS6	O	High side driver 6
8	HS7	O	High side driver 7
9	IGN7	O	Ignition driver 7
10	IGN6	O	Ignition driver 6
11	IGN5	O	Ignition driver 5
12	IGN4	O	Ignition driver 4
13	IGN3	O	Ignition driver 3
14	IGN2	O	Ignition driver 2
15	IGN1	O	Ignition driver 1
16	IGN0	O	Ignition driver 0
17	GND	Ground	High side driver 0 ground
18	GND	Ground	High side driver 1 ground
19	GND	Ground	High side driver 2 ground
20	GND	Ground	High side driver 3 ground
21	GND	Ground	High side driver 4 ground
22	GND	Ground	High side driver 5 ground
23	GND	Ground	High side driver 6 ground
24	GND	Ground	High side driver 7 ground
25	VBATT OUT	Supply	Ignition coil 7 supply voltage
26	VBATT OUT	Supply	Ignition coil 6 supply voltage
27	VBATT OUT	Supply	Ignition coil 5 supply voltage
28	VBATT OUT	Supply	Ignition coil 4 supply voltage
29	VBATT OUT	Supply	Ignition coil 3 supply voltage
30	VBATT OUT	Supply	Ignition coil 2 supply voltage
31	VBATT OUT	Supply	Ignition coil 1 supply voltage
32	VBATT OUT	Supply	Ignition coil 0 supply voltage
33	GND	Ground	Power section ground
34	GND	Ground	Power section ground
35	GND	Ground	Power section ground
36	GND	Ground	Power section ground
37	VBATT	Supply	Low side driver 0 supply voltage
38	VBATT	Supply	Low side driver 1 supply voltage
39	VBATT	Supply	Low side driver 2 supply voltage
40	VBATT	Supply	Low side driver 3 supply voltage
41	VBATT	Supply	Low side driver 4 supply voltage

42	VBATT	Supply	Low side driver 5 supply voltage
43	VBATT	Supply	Low side driver 6 supply voltage
44	VBATT	Supply	Low side driver 7 supply voltage
45	INJ0+	I/O	Injector driver 0 positive
46	INJ1+	I/O	Injector driver 1 positive
47	INJ2+	I/O	Injector driver 2 positive
48	INJ3+	I/O	Injector driver 3 positive
49	INJ4+	I/O	Injector driver 4 positive
50	INJ5+	I/O	Injector driver 5 positive
51	INJ6+	I/O	Injector driver 6 positive
52	INJ7+	I/O	Injector driver 7 positive
53	VBATT IN	Supply input	Power section supply voltage
54	VBATT IN	Supply input	Power section supply voltage
55	VBATT IN	Supply input	Power section supply voltage
56	VBATT IN	Supply input	Power section supply voltage
57	LS0	I	Low side driver 0
58	LS1	I	Low side driver 1
59	LS2	I	Low side driver 2
60	LS3	I	Low side driver 3
61	LS4	I	Low side driver 4
62	LS5	I	Low side driver 5
63	LS6	I	Low side driver 6
64	LS7	I	Low side driver 7
65	INJ0-	I/O	Injector driver 0 negative
66	INJ1-	I/O	Injector driver 1 negative
67	INJ2-	I/O	Injector driver 2 negative
68	INJ3-	I/O	Injector driver 3 negative
69	INJ4-	I/O	Injector driver 4 negative
70	INJ5-	I/O	Injector driver 5 negative
71	INJ6-	I/O	Injector driver 6 negative
72	INJ7-	I/O	Injector driver 7 negative
73	GND	Ground	Power section ground

3.7.5 Connectors Reference Pinout

J1 Analog I/O (MX123 80 PIN BLUE)							
AIN1	20	40	AIN0	5V_OUT	60	80	GND
AIN3	19	39	AIN2	5V_OUT	59	79	GND
AIN5	18	38	AIN4	5V_OUT	58	78	GND
AIN7	17	37	AIN6	5V_OUT	57	77	GND
AIN9	16	36	AIN8	5V_OUT	56	76	GND
AIN11	15	35	AIN10	5V_OUT	55	75	GND
AIN13	14	34	AIN12	5V_OUT	54	74	GND
AIN15	13	33	AIN14	5V_OUT	53	73	GND
GND	12	32	GND	DAC0	52	72	GND
GND	11	31	GND	DAC1	51	71	GND
V0-	10	30	V0+	TEMP1	50	70	TEMP0
V1-	9	29	V1+	TEMP3	49	69	TEMP2
V2-	8	28	V2+	TEMP5	48	68	TEMP4
V3-	7	27	V3+	TEMP7	47	67	TEMP6
V4-	6	26	V4+	TEMP9	46	66	TEMP8
V5-	5	25	V5+	TEMP11	45	65	TEMP10
V6-	4	24	V6+	TEMP13	44	64	TEMP12
V7-	3	23	V7+	TEMP15	43	63	TEMP14
GND	2	22	GND	TEMP_COM	42	62	TEMP_COM
GND	1	21	GND	GND	41	61	GND

Color legend:

Temperature channel
Temperaure channels ground
DAC Output
Single ended analog input
Differential analog input
Power Supply output
Ground

J2 Mixed I/O (MX123 80 PIN GREY)							
GPIO14	20	40	GPIO15	5V_OUT	60	80	10V_OUT
GPIO12	19	39	GPIO13	5V_OUT	59	79	10V_OUT
GPIO10	18	38	GPIO11	GND	58	78	GND
GPIO8	17	37	GPIO9	GND	57	77	HB0_B
GPIO6	16	36	GPIO7	N/A	56	76	HB0_A
GPIO4	15	35	GPIO5	N/A	55	75	HB1_B
GPIO2	14	34	GPIO3	GND	54	74	HB1_A
GPIO0	13	33	GPIO1	RS232_RX	53	73	GND
GND	12	32	GND	RS232_TX	52	72	RESET#
USB_D-	11	31	USB_D+	GND	51	71	GND
USB_5V	10	30	GND	VRS1+	50	70	VR1-
CAN1_L	9	29	CAN1_H	VRS0+	49	69	VRS0-
CAN0_L	8	28	CAN0_H	GND	48	68	VCC_ECU
N/A	7	27	N/A	GND	47	67	VCC_ECU
N/A	6	26	N/A	L1 IP	46	66	L0 IP
GND	5	25	GND	L1 IA	45	65	L0 IA
ETH_TX3-	4	24	ETH_TX3+	L1 VM	44	64	L0 VM
ETH_TX2-	3	23	ETH_TX2+	L1 UN	43	63	L0 UN
ETH_TX1-	2	22	ETH_TX1+	L1_HEAT+	42	62	L0_HEAT+
ETH_TX0-	1	21	ETH_TX0+	L1_HEAT-	41	61	L0_HEAT-

Color legend:

5V sensor supply output
10V sensor supply output
Logic power supply input
H-Bridge
VRS Sensors
TTL GPIO
CAN Bus
Ethernet
USB
RESET
RS232
Not Available
Ground

J3 Power I/O (MX123 80 PIN BLACK)							
GND	73		GND	INJ7+	52	72	INJ7-
				INJ6+	51	71	INJ6-
				INJ5+	50	70	INJ5-
				INJ4+	49	69	INJ4-
IGN0	16	32	VBATT OUT	INJ3+	48	68	INJ3-
IGN1	15	31	VBATT OUT	INJ2+	47	67	INJ2-
IGN2	14	30	VBATT OUT	INJ1+	46	66	INJ1-
IGN3	13	29	VBATT OUT	INJ0+	45	65	INJ0-
IGN4	12	28	VBATT OUT	VBATT OUT	44	64	LS7
IGN5	11	27	VBATT OUT	VBATT OUT	43	63	LS6
IGN6	10	26	VBATT OUT	VBATT OUT	42	62	LS5
IGN7	9	25	VBATT OUT	VBATT OUT	41	61	LS4
HS7	8	24	GND	VBATT OUT	40	60	LS3
HS6	7	23	GND	VBATT OUT	39	59	LS2
HS5	6	22	GND	VBATT OUT	38	58	LS1
HS4	5	21	GND	VBATT OUT	37	57	LS0
HS3	4	20	GND	GND	36	56	VBATT IN
HS2	3	19	GND	GND	35	55	VBATT IN
HS1	2	18	GND	GND	34	54	VBATT IN
HS0	1	17	GND	GND	33	53	VBATT IN

Color legend:

Injectors
Ignition output (low side)
High side driver output
Low side driver output
Battery voltage
Ground

3.7.6 Recommended Connectors Counterparts

Connector	Mating P/N	Vendor
J1	34566-0703	Molex
J2	34566-0803	Molex
J3	34566-0103	Molex
Wire dressing	34565-0003	Molex
AWG18 pin	33467-0005	Molex
AWG20/22 pin	33467-0003	Molex

3.7.7 Wiring Specification

Each Spark's pin is designed for a maximum of 11A rms.

Supply line (pin 67/68) must be protected with a dedicated fuse line (1A recommended).

Power line (pin 53/54/55/56) must be protected with a dedicated fuse line calculated on loads used in the application. Usage of all 4 pins in parallel is recommended.

Following the suggested minimum required wire size for each channel.

J1 Minimum Wire Size							
AWG 24	20	40	AWG 24	AWG 22	60	80	AWG 22
AWG 24	19	39	AWG 24	AWG 22	59	79	AWG 22
AWG 24	18	38	AWG 24	AWG 22	58	78	AWG 22
AWG 24	17	37	AWG 24	AWG 22	57	77	AWG 22
AWG 24	16	36	AWG 24	AWG 22	56	76	AWG 22
AWG 24	15	35	AWG 24	AWG 22	55	75	AWG 22
AWG 24	14	34	AWG 24	AWG 22	54	74	AWG 22
AWG 24	13	33	AWG 24	AWG 22	53	73	AWG 22
AWG 24	12	32	AWG 24	AWG 22	52	72	AWG 22
AWG 24	11	31	AWG 24	AWG 22	51	71	AWG 22
AWG 24	10	30	AWG 24	***	50	70	***
AWG 24	9	29	AWG 24	***	49	69	***
AWG 24	8	28	AWG 24	***	48	68	***
AWG 24	7	27	AWG 24	***	47	67	***
AWG 24	6	26	AWG 24	***	46	66	***
AWG 24	5	25	AWG 24	***	45	65	***
AWG 24	4	24	AWG 24	***	44	64	***
AWG 24	3	23	AWG 24	***	43	63	***
AWG 24	2	22	AWG 24	***	42	62	***
AWG 24	1	21	AWG 24	AWG 24	41	61	AWG 24

J2 Minimum Wire Size							
AWG 24	20	40	AWG 24	AWG 22	60	80	AWG 22
AWG 24	19	39	AWG 24	AWG 22	59	79	AWG 22
AWG 24	18	38	AWG 24	AWG 22	58	78	AWG 22
AWG 24	17	37	AWG 24	AWG 22	57	77	AWG 18
AWG 24	16	36	AWG 24	N/A	56	76	AWG 18
AWG 24	15	35	AWG 24	N/A	55	75	AWG 18
AWG 24	14	34	AWG 24	AWG 22	54	74	AWG 18
AWG 24	13	33	AWG 24	AWG 24	53	73	AWG 22
AWG 24	12	32	AWG 24	AWG 24	52	72	AWG 24
USB	11	31	USB	AWG 22	51	71	AWG 22
USB	10	30	USB	AWG 22	50	70	AWG 22
AWG 24 *	9	29	AWG 24 *	AWG 22	49	69	AWG 22
AWG 24 *	8	28	AWG 24 *	AWG 20	48	68	AWG 20
N/A	7	27	N/A	AWG 20	47	67	AWG 20
N/A	6	26	N/A	AWG 22	46	66	AWG 22
AWG 24	5	25	AWG 24	AWG 22	45	65	AWG 22
ETH	4	24	ETH	AWG22 *	44	64	AWG22 *
ETH	3	23	ETH	AWG22 *	43	63	AWG22 *
ETH	2	22	ETH	AWG 18	42	62	AWG 18
ETH	1	21	ETH	AWG 18	41	61	AWG 18

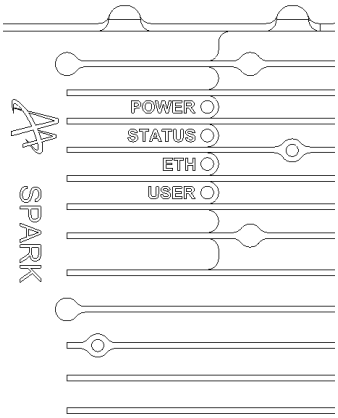
J3 Minimum Wire Size							
	73			AWG 18 *	52	72	AWG 18 *
				AWG 18 *	51	71	AWG 18 *
				AWG 18 *	50	70	AWG 18 *
				AWG 18 *	49	69	AWG 18 *
AWG 18	16	32	AWG 18	AWG 18 *	48	68	AWG 18 *
AWG 18	15	31	AWG 18	AWG 18 *	47	67	AWG 18 *
AWG 18	14	30	AWG 18	AWG 18 *	46	66	AWG 18 *
AWG 18	13	29	AWG 18	AWG 18 *	45	65	AWG 18 *
AWG 18	12	28	AWG 18	AWG 18	44	64	AWG 18
AWG 18	11	27	AWG 18	AWG 18	43	63	AWG 18
AWG 18	10	26	AWG 18	AWG 18	42	62	AWG 18
AWG 18	9	25	AWG 18	AWG 18	41	61	AWG 18
AWG 18	8	24	AWG 18	AWG 18	40	60	AWG 18
AWG 18	7	23	AWG 18	AWG 18	39	59	AWG 18
AWG 18	6	22	AWG 18	AWG 18	38	58	AWG 18
AWG 18	5	21	AWG 18	AWG 18	37	57	AWG 18
AWG 18	4	20	AWG 18	AWG 16 **	36	56	AWG 16 **
AWG 18	3	19	AWG 18	AWG 16 **	35	55	AWG 16 **
AWG 18	2	18	AWG 18	AWG 16 **	34	54	AWG 16 **
AWG 18	1	17	AWG 18	AWG 16 **	33	53	AWG 16 **

* Wire to be twisted with relative pair

** AWG 16 higher than theoretical maximum acceptable PIN. Alma Automotive suggests using this size

*** Size to be choose strongly depending on temperature sensors used

3.8 LED Indicators



On the SPARK front panel there are 4 LED indicators.

USER Led is connected to the FPGA pins and it is accessible by the user software.

For the other LEDs please refer to the following tables to decode their behaviour.

POWER Led

Led state	Condition
Off	No power on the board
Solid Green	Power good state
Solid Red	Overvoltage / Undervoltage

STATUS Led

Led state	Condition
Off	Device in Run mode
Solid Red	Booting
2 flashes	Safe mode, no software installed
3 flashes	Safe mode, user requested to enter in install mode
4 flashes	Safe mode, software crashed
Continuos blink	Unrecoverable error, return the unit for repair

ETH Led

Led state	Condition
Off	Ethernet port disconnected
Green solid	Connected without activity
Green blink	Connected with activity
Yellow off	Speed detected 10Base-T or 100Base-TX
Yellow on	Speed detected 1000Base-T

4. Software Requirement

Software	Requirement
Labview 2018 SP1 or higher	Required
Labview 2018 Real Time module or higher	Required
Labview 2018 FPGA module or higher	Requiredquired
NI-RIO 18 or higher	Required
NI-Embedded CAN for RIO 18 or higher	Required for CAN communication only
NI-XNET 18 or higher	Required for CAN DBC interface only
Model Interface Toolkit 18 or higher	Required for the integration of Matlab Simulink models
INCA (any version) or similar XCP Calibration tool	Recommended
WinSCP (any version)	Recommended
Putty (any version)	Recommended

5. Safety Guidelines

Caution: Do not operate the SPARK unit in a manner not specified in this document.

Product misuse can result in a hazard.

You can compromise the safety protection built into the product.

If the product is damaged in any way, return it for repair.

6. EMC & Environmental Guidelines

6.1 CE Compliance

This product meets the essential requirements of applicable European Directives as follows:

- 2014/35/EU Low-Voltage Directive
- 2014/30/EU Electromagnetic Compatibility Directive

6.2 Product Environmental Compliance

Alma Automotive complies with all laws and regulations regarding material declaration and the elimination of chemical and hazardous substances used in products and manufacturing. This includes:

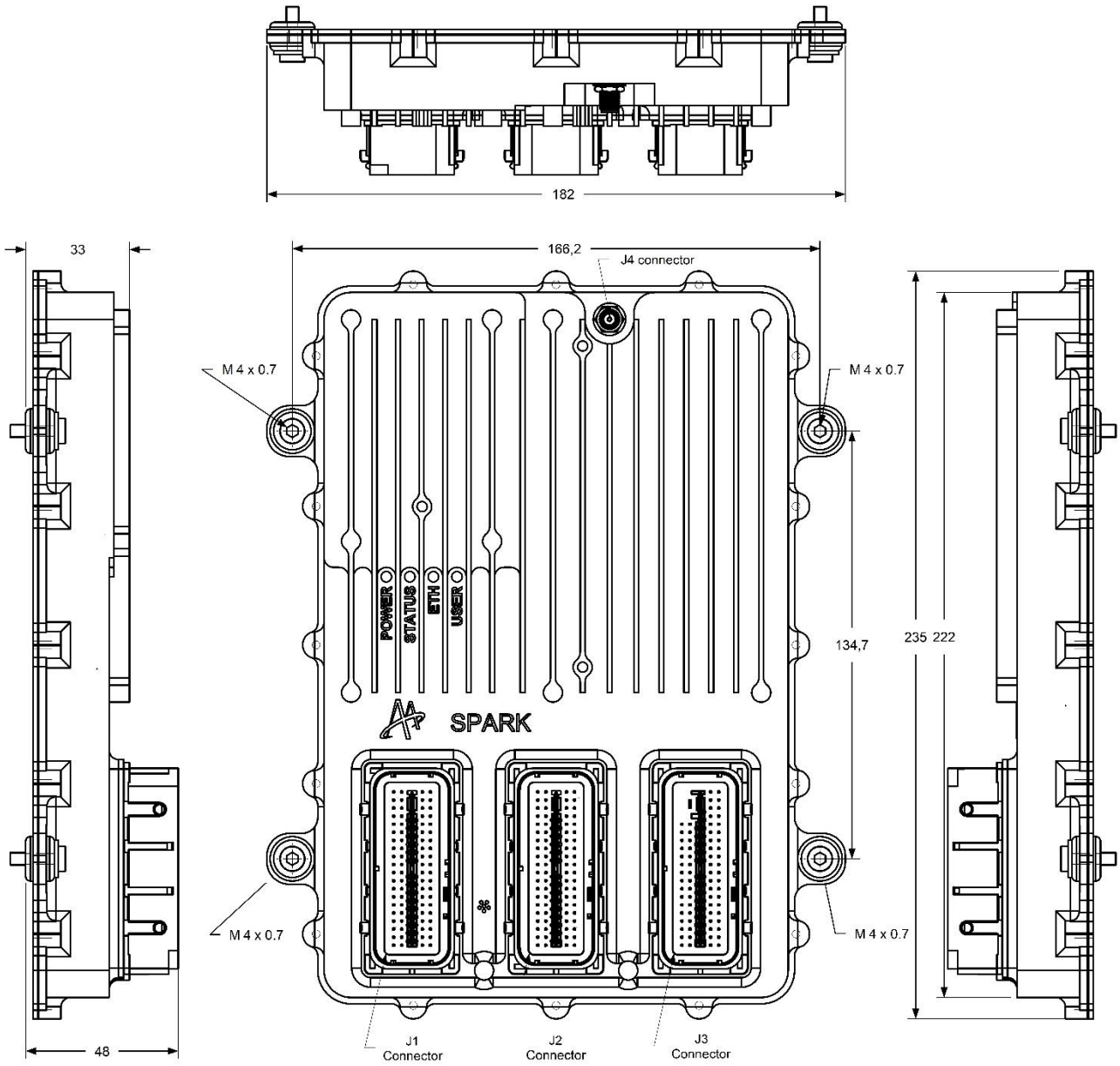
- Lead-Free (lead free production cycle)
- RoHS (Restriction of Hazardous Substances)
- REACH (European Union on the Registration, Evaluation, Authorization and Restriction of Chemicals)

6.3 Waste Electrical and Electronic Equipment

At the end of the product life cycle, all products must be sent to a WEEE recycling center. The recycling center must be compliant with WEEE Directive 2002/96/EC.

7. Physical Dimensions

Parameter	Value
Overall dimension	235 x 162 x (H) 46 mm
Weight	0,4 kg
Ingress protection code	IP65
Mounting points	4x M4x0.7
Connectors type	3x Molex MX123 Connectors (J1, J2, J3) 1x SMA Connector (J4)



Dimensions are in mm

Originally established in 2002 as a spin-off of University of Bologna, Alma Automotive represents the synergy between knowledge acquired in academic research activities and years of experience in developing applied solutions. The company has now evolved to offer both ready-to-use products and technical consulting services supported by bespoke hardware and software solutions.

Our expertise is focused on real time control and measurement electronics, simulation and custom-made test systems.
We provide powertrain testing services and competitor data analysis for motorsport.

Alma Automotive s.r.l.

Via Terracini 2/c - 40131 Bologna - Italy
Tel. +39 051 9923806 / Fax +39 051 0544839
info@alma-automotive.it
www.alma-automotive.it

Integration Partner
SYSTEM INTEGRATOR