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EN-20131022-4

Revision number

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Date

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SYSTEM DESCRIPTION

XBB LIGHTSWITCH

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Purpose

The purpose of this system description is to present the technical details relating to the XBB Lightswitch. The document describes all performance features of the XBB Lightswitch, how it is manufactured, and details of its peripherals (such as diagnostics software/hardware).

Many of the features described in this document are patented or patent pending. The document provides a comprehensive description of the technical details on which the XBB Lightswitch is based.

The XBB Lightswitch is a small, flexible unit for controlling auxiliary lights, reversing lights, working lights, etc. for the automotive aftermarket. The XBB Lightswitch has three outputs, controlled by a small current sensor mounted on the cable that triggers the outputs of the unit.

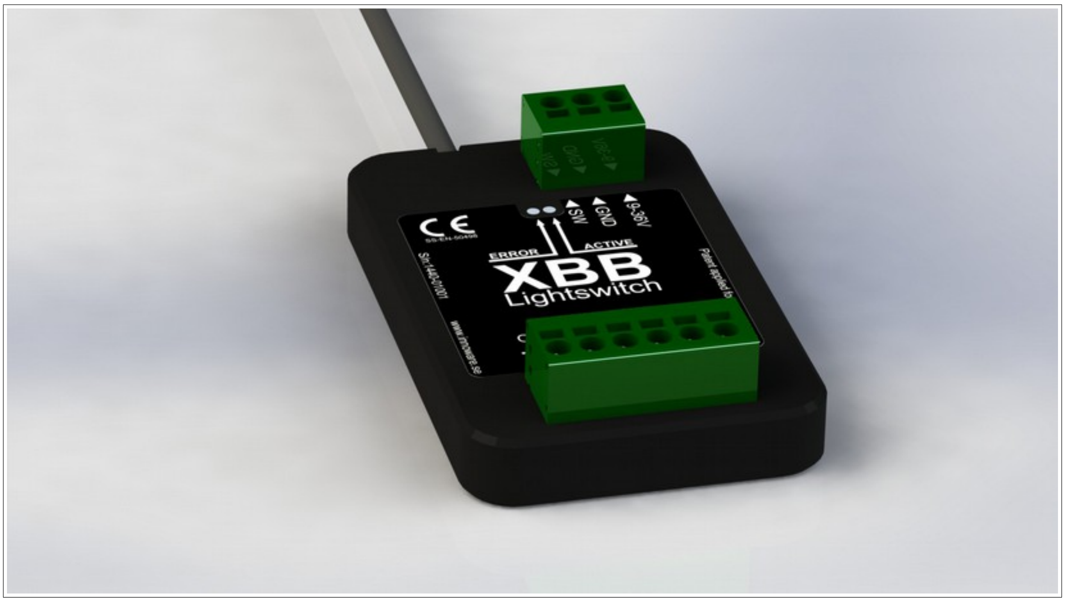

Fig 1. XBB Lightswitch, Production Version

The XBB Lightswitch is designed to save time for the workshop, and has several unique built-in features to facilitate installation.

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Important

This section contains information that is important for you to know when reading the system description and before working with the XBB Lightswitch.

It includes the safety information that applies when you are working on and with the XBB Lightswitch and its surrounding parts.

Safety information

Follow the instructions to avoid injury or damage to equipment:

!	***WARNING!*** *There are ESD sensitive components inside the XBB Lightswitch*

!	***WARNING!*** *Contains electronics. Must be recycled. Do not dispose in household garbage*

!	***WARNING!*** *Never work on XBB Lightswitch with the power supply on*

Current sensor

Overview

The current sensor is a key component of the XBB Lightswitch, and its function is based on the Hall Effect Principle. The XBB Lightswitch contains an array of Hall Effect sensors that measure the magnetic field generated when a current flows in a cable.

The current sensor is temperature compensated and has its own internal reference voltage and operational amplifier. The current sensor gain is adjustable depending on the application.

The current sensor can be equipped with a thin mu-metal foil to prevent external magnetic interference. The mu-metal foil should be used in applications that use a current sensor set for high gain.

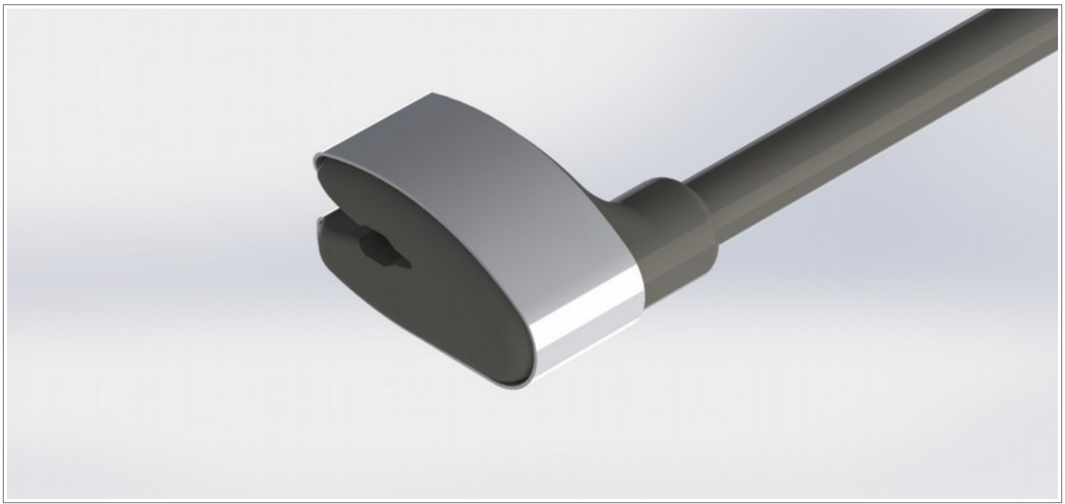

Fig 2. Current sensor with Mu-metal foil

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Technical data

The current sensor is made of flexible plastic to enable measurement of cable sizes from 0.5 mm² to 2.5 mm² (AWG 20-13).

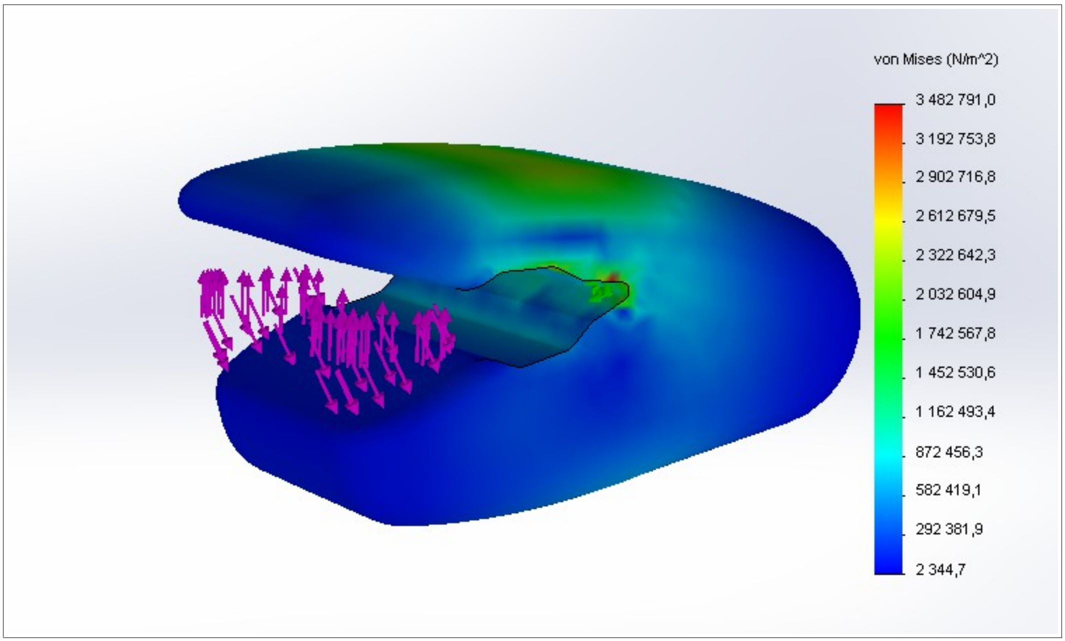

Fig 3 and 4. Top: Current sensor, front view. Bottom: Current sensor analysis of different cable sizes.

The design of the sensor allows various cable sizes to be centered over the sensor area. The output from the current sensor is linear to the current flowing in the cable.

When no current is flowing through the cable being measured, the current sensor has an output of 2.5 volts. Depending on the direction of the current, the output changes positively or negatively.

Wire connection table

Wire color	Function	Min	Typ	Max	Unit
Red	Supply voltage	4.75	5	5.5	V
Black	GND	-	-	-	GND
Brown	Signal output (Vs)	0.5	2.5	4.5	V

Dimensions without cable.

Weight	Approx. 1 g
Length	16 mm
Height	9 mm
Width	1 mm
Housing material	Polyamide (OM646)
Protection class	IP65
Cable	Shielded 3x0.14 mm^2
Operating temperature	-40 to 125 ºC

Electrical data

Parameter	Min	Typ	Max	Unit
Current consumption	-	15	19	mA
Magnetic flux density range	-	±3.3	-	mT
Linearity error	-1.5	±0.4	1.5	%
Frequency bandwidth	-	40	-	KHz

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The output voltage versus current flow in the measured cable depends on various conditions, such as cable thickness and chosen sensor gain output.

To calculate correct voltage output, the following formula can be used.

A current flowing in a cable generates a flux density around it: $B=\left(\frac{\mu 0}{2\pi}\right)\cdot\left(\frac{Ip}{(r+d)}\right)$

Ip	the current to be measured (A)
r	the distance from the center of the wire (m)
d	the distance from Hall array to sensor floor (0,0005 m)
µ0	the permeability of vacuum (H/m)

The voltage output depends on the current gain, and the formula to calculate Vs is:

$$Vs=2{,}5\pm((600\cdot B)\cdot Gain)$$

Typical cable dimensions. (Calculation variables, Ip = 1 A, gain = 20).

Cable Type	Dimension	Radius (r)	Vs
RKUB	0,50 mm²	0,9 mm	2.5V±1.71 V
RKUB	0,75 mm²	1,0 mm	2.5V±1.60 V
RKUB	1,00 mm²	1,05 mm	2.5V±1.55 V
RKUB	1,50 mm²	1,3 mm	2.5V±1.33 V
RKUB	2,50 mm²	1,55 mm	2.5V±1.17 V

Manufacture

The current sensor is manufactured using conventional manufacturing methods and standard PCB, with standard SMD components in conventional pick and place machines. The cable is soldered to the PCB before Macromelt hot melt molding.

Macromelt hot melt molding is inexpensive, and is a fast method that guarantees a moisture-proof and waterproof environment for the current sensor electronics.

The Macromelt hot melt molding is carried out in two steps. Two different molds were made: a pre-stage mold to stabilize the PCB, and then a mold that shapes the current sensor.

Advantages

The current sensor has many advantages and features that make it ideal to use in the aftermarket industry in many types of applications.

- Low cost
- Small size
- Excellent linearity
- No power loss in primary circuit
- Isolated current measurement

Mu-metal

Mu-metal is a nickel-iron alloy with high magnetic permeability.
In harsh magnetic areas with a high-gain current sensor, the Mu-metal foil prevents external magnetic fields from influencing the current measurement.

The mu-metal foil is 0.1 mm thick and various techniques have been tested for shaping the mu-metal during manufacture – laser cutting, etching and stamping.

Next generation

The next generation current sensor will incorporate the mu-metal directly into the molding process.
A 4-20 mA current sensor as a standalone current sensor is also planned.

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Application examples

The current sensor can be used in many different applications. We have reviewed and analyzed various areas where the current sensor can be used, and the aftermarket of the automotive industry has great application potential.

- Auxiliary lights control
- Reversing lights control
- Working lights control
- Trailer lighting control

Industrial applications

- Battery supplied applications
- Motor control
- Power meter
- Overcurrent fault protection
- Threshold detection
- Motors and fans
- Air conditioning
- Leaking refrigerant

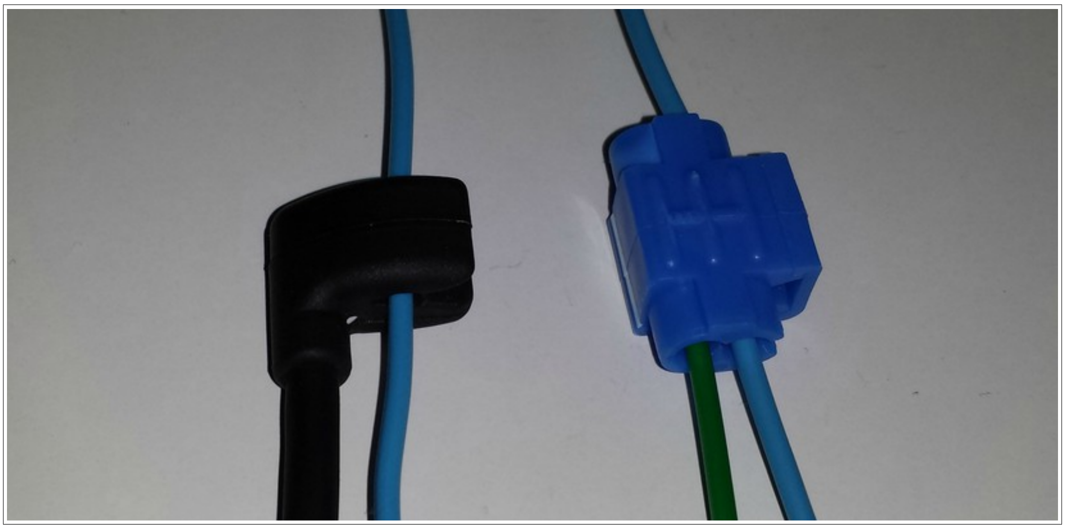

Fig 5. Current sensor (left) compared with a traditional cable thief (right).

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XBB Lightswitch

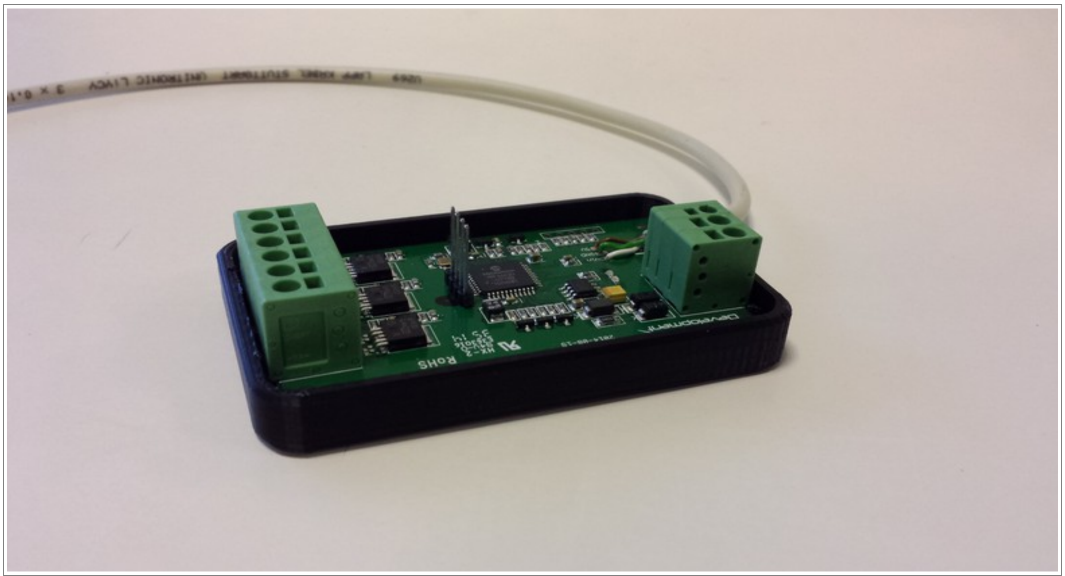

Fig 6. XBB Lightswitch, production version before encapsulation, with diagnostic pins.

Technical data

Overview

The XBB Lightswitch is manufactured using low-cost components to ensure high availability and minimize production costs. The first production version is designed and engineered with small manufacturing batches in mind.

Well-established techniques such as cable connections enable us to provide a solid and robust solution at a low price, with easy installation requiring no special tools or expensive crimping pliers.

The XBB Lightswitch is designed to meet the requirements of the SS-EN 50498 standard.

Specifications

Weight	Approx. 92 g
Operating voltage	12 / 24V
Length	90 mm
Height	20 mm
Width	55 mm
Housing material	ABS / Polyurethane
Connections	Phoenix SPT 2,5/ X-V-5,0
Protection class	IP65
Standby current	22 mA
Sensor cable length	1000 mm

Functions

Many different features are built into the XBB Lightswitch – voltage monitoring, current monitoring for each output, alternator ripple monitoring for DRL function, short-circuit protected inputs, outputs and power input.

Input voltage control

The XBB Lightswitch monitors the battery voltage continuously. It checks if the voltage is above or below threshold values. The threshold of a 12V system is between 9 and 16 volts, while the threshold is between 18 and 34 volts on a 24V system.

If the battery voltage is outside these thresholds, the outputs will be disabled and the alarm indicator lights up.

Outputs

All the outputs on the XBB Lightswitch are short-circuit protected and current controlled. If the current level exceeds 13.5 A for 200 ms, the output will be inactivated. Output number 1 is a special output with DRL functionality.

NB. The outputs can be connected in parallel to drive a larger load.

Input switch

The input switch allows the user to activate or inactivate the outputs manually. If the user applies UB to the input, the output will be activated; if it is grounded, the outputs will be inactivated permanently.

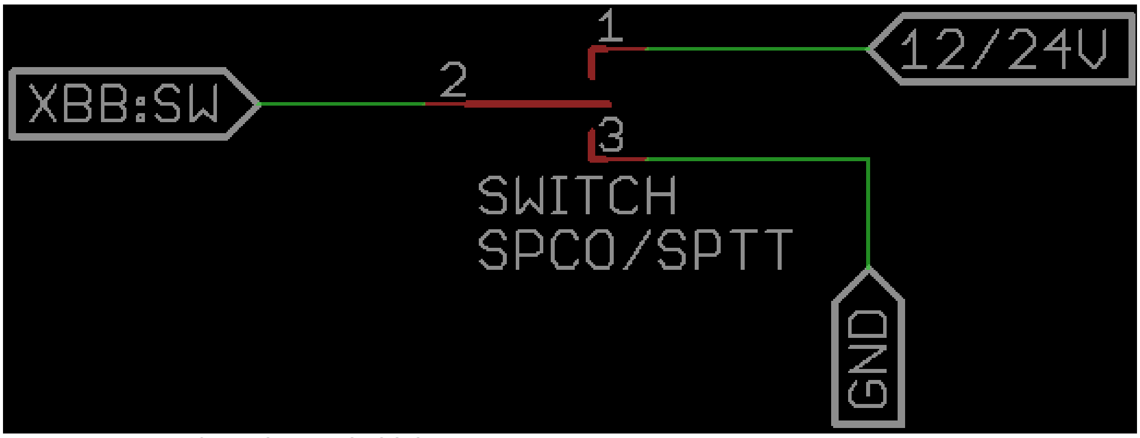

Fig 7. Example connection of input SW with SPCO/SPTT switch.

By using a common SPCO/SPTT switch, all functions can be accessed with just one single switch.

DRL function

If output number 1 consumes less than 1 A at the pre-operational state, this output will act as DRL (Day Time Running Lights) output when the system is in operational state.

The user can then fit two auxiliary lights with the incandescent light/position light function, and connect them to output number 1. The XBB Lightswitch will automatically detect when the vehicle engine is running and activate the output. The XBB Lightswitch detects the alternator ripple and voltage level in the electrical system to activate the DRL output.

LED indication

The XBB Lightswitch has two LED indications, green and red. When the green LED is blinking with 1 Hz, the system is in a pre-operational state. When the system is in operational state, the green LED indicates the state of the output.

The red LED blinking with 1 Hz indicates a fault in the system, such as under-voltage, over-voltage, high current on outputs or short circuit.

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Vehicle installation

Overview

The XBB Lightswitch is specially designed for fast and simple installation without special tools. The vehicle's original wiring harness will not be affected by the installation, and no warning system or warranties will be compromised.

Mounting and connectors

Mounting with adhesive tape or magnets (production version uses adhesive tape).

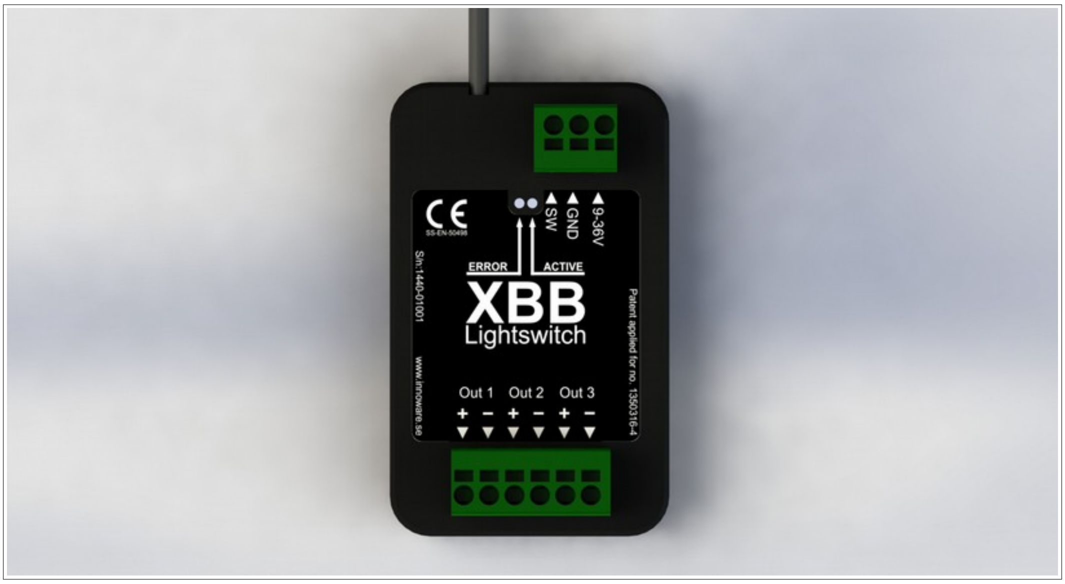

Fig 8. XBB Lightswitch, top view with label.

Depending on the cable type and size, no tools are required to connect them into the cable connection. With thinner cables, a regular screwdriver may be needed to open up the cable connections.

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Step-by-step installation

Installation of the XBB Lightswitch is easy.

- Install your auxiliary lights according to the manufacturer's instructions.
- Mount the current sensor on your vehicle's high beam cable.
- Use the adhesive tape to attach the XBB Lightswitch in a protected position in your engine compartment. Ensure that the sensor cable is shielded from wear and tear.

- Connect your auxiliary light cables to the XBB Lightswitch.
- Connect supply cables from the battery to the XBB Lightswitch with an appropriate fuse for your auxiliary lights. Please note that the fuse should not be inserted yet.

- With your vehicle engine switched off, check that you can activate your high beams properly, then switch off the high beams and insert the fuse.

- When the green LED flashes (approx. 1 Hz) the system is ready to detect the initial pulse from the high beams. If you have mounted DRL lights on output 1, they will blink for a short time.

- Switch on your vehicle's high beams for a few seconds.
- Check that your auxiliary lights switch on and off when the high beams are activated.
- Installation is now complete.

Fig 9. Installation of the current sensor on original high beam cable.

Diagnostics tools

A few diagnostic tools, both hardware and software, have been developed to analyze the current sensor. CAN functionality has been added to the XBB Lightswitch for fast diagnostics of sensor behavior.

To reduce production costs, the CAN transreceiver is mounted on a smaller PCB that can be connected to the XBB Lightswitch. NB. On the production version, you cannot fit the CAN breakout board after encapsulation.

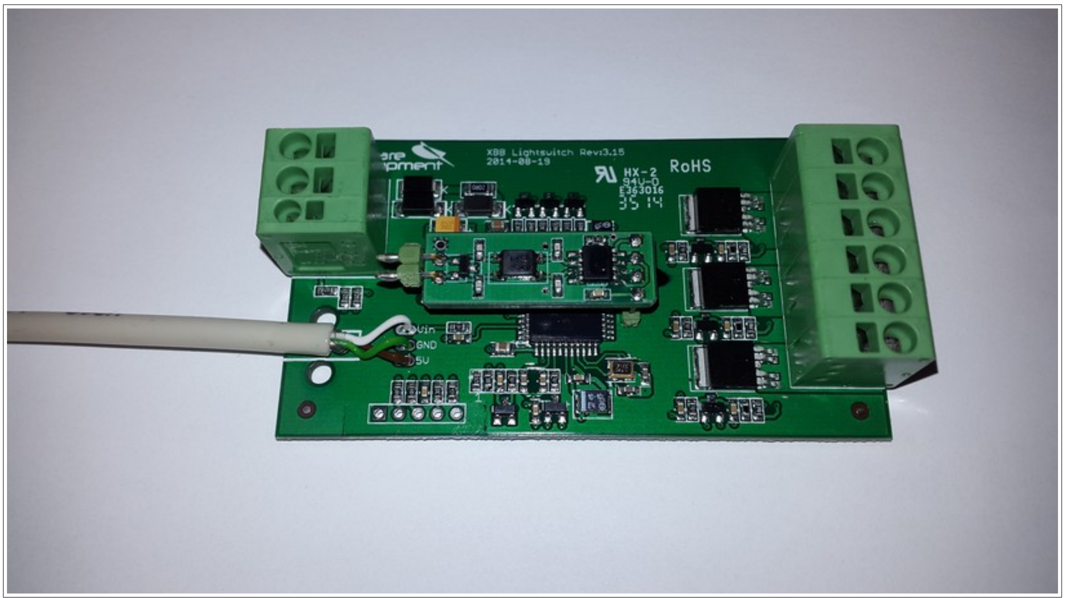

Fig 10. CAN breakout board mounted on XBB Lightswitch

CAN communication

CAN communication is only for development and diagnostics purposes, and the CAN communication is disabled on the production version. CAN messages use a 11-bit identifier and a speed of 250 kbit/s. Four different messages are sent from the XBB Lightswitch at a rate of 10 ms.

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CAN transmission messages

ID	ID-name	Cycle time in ms	Launch type	Signal byte no.	Signal bit no.	Signal name	Signal function	Signal length (bit)	Signal standard	Normalization	Value range
16#100h	1st	10	Cyclic	0	0	Current sensor	-	16	FFFFh	0...4095	0...4095
				2	0	On value	-	16	FFFFh	0...4095	0...4095
				4	0	Off value	-	16	FFFFh	0...4095	0...4095
				6	0	Triggerpoint	-	16	FFFFh	0...65535	0...65535
16#101h	2nd	10	Cyclic	0	0	Raw Voltage level	-	16	FFFFh	0...4095	0...4095
				2	0	Voltage level	-	8	FFh	0...255	0...255 V
				3	0	Output 1 current	-	8	FFh	0...255	0...255 A
				4	0	Output 2 current	-	8	FFh	0...255	0...255 A
				5	0	Output 3 current	-	8	FFh	0...255	0...255 A
				6	0	System output	-	1	1h		**B0 = Function On/Off**
				7	0	Mode state	-	8	FFh	0...255	**1 = Init timers 2 = Wait for sensor stabilization 3 = Sampling current sensor 4 = Waiting for first init. Activation 5 = Operational mode system running.**
16#102h	3rd	10	Cyclic	0	0	Output 1 state	-	1	1h		**B0 = Function On/Off**
				1	0	Output 2 state	-	1	1h		**B0 = Function On/Off**
				2	0	Output 3 state	-	1	1h		**B0 = Function On/Off**
				3	0	Green LED status	-	1	1h		**B0 = Function On/Off**
				4	0	Red LED status	-	1	1h		**B0 = Function On/Off**
				5	0	Under voltage error	-	1	1h		**B0 = Function On/Off**
				6	0	Over voltage error	-	1	1h		**B0 = Function On/Off**
				7	0	Activation trigger	-	1	1h		**B0 = Function On/Off**

CAN transmission messages cont...

ID	ID-name	Cycle time in ms	Launch type	Signal byte no.	Signal bit no.	Signal name	Signal function	Signal length (bit)	Signal standard	Normalization	Value range
16#103h	4th	10	Cyclic	0	0	Alternator ripple	-	16	FFFFh	0...4095	0...4095
				2	0	Init Trigger Point	-	16	FFFFh	0...4095	0...4095
				4	0	On trigger value	-	8	FFh	0...255	0...255
				5	0	Off trigger value	-	8	FFh	0...255	0...255
				6	0	Mode state	-	8	FFh	0...255	**1 = Init timers 2 = Wait for sensor stabilization 3 = Sampling current sensor 4 = Waiting for first init. Activation 5 = Operational mode system running.**
				7	0	-	-	-	-	-	-

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Traceability

Reference document

Denomination	Publication number
Referens instruktioner	Nr:SE-20131022-1
English translation	Nr:EN-20131022-4

Revision

The following significant changes have taken place since the previous version:

Rev	Page	Description of revision	Approved by tech. manager	Date	App. by doc. officer.	Date
1	ALL	Creation of doc.	KHS	13-10-22	KHS	13-10-22
2	ALL	Translation to English	KHS	14-10-28	KHS	14-10-30
3	ALL	Correction English lang.	KHS	14-11-04	KHS	14-11-04
4	8	Cable thickness, material	KHS	14-11-04	KHS	14-11-04
5	13,14,16	DRL function.	KHS	14-11-24	KHS	14-11-24