Application Note

AS3935

Franklin Lightning Sensor

www.austriamicrosystems.com
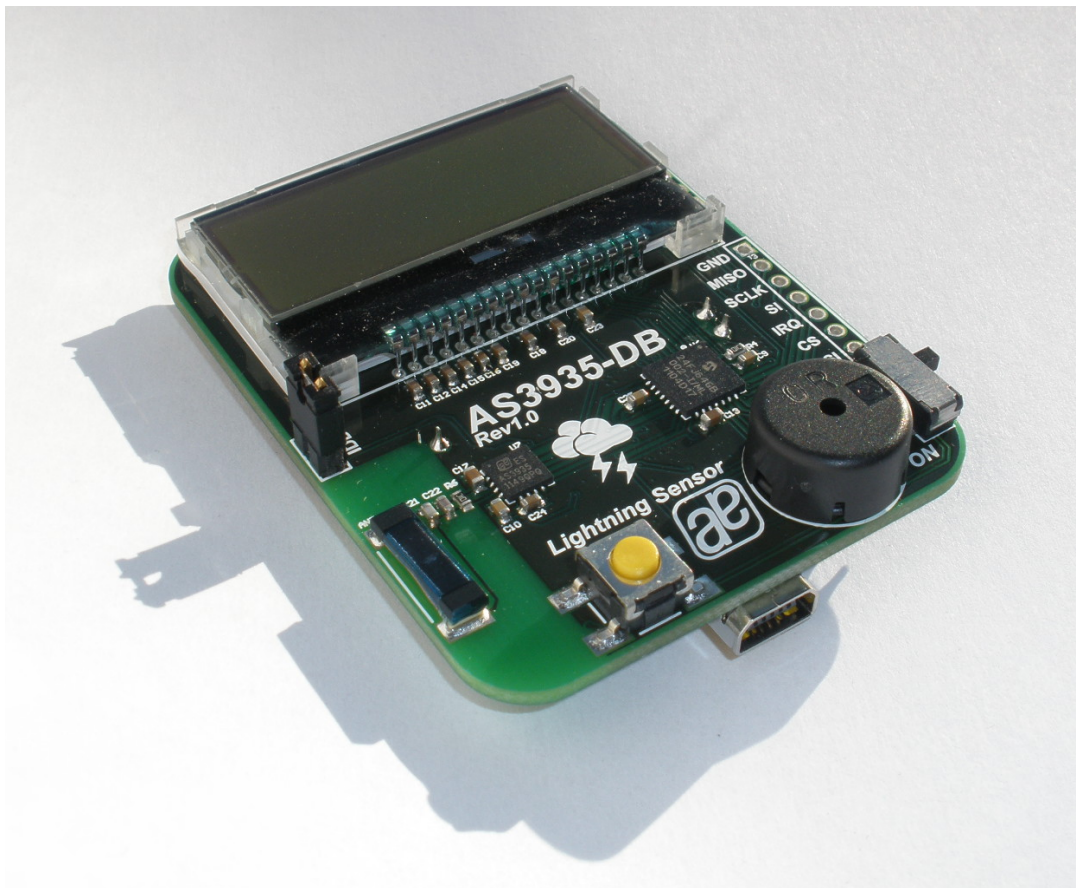
Table of Content

Features

- Fully operational Lightning Sensor
- Supplied by a 3V CR2032 battery with long battery life time >1000 hours
- Buzzer alarm for early warning of storm
- 128x32 display with blue backlight for detail information about storm warning
- Automatic antenna and RCO's tuning implemented
- USB connection for adjusting AS3935 detail settings
- Handheld Lightning Emulator
- Emulation of Lightning with different distance (far, close, closest) and Noise generation

Programmable Lightning Sensor AS3935 Key features

- Lightning Sensor warns of lightning storm activity within a radius of 40km
- Distance estimation to the head of the storm down to 1km
- Detects both cloud-to-ground and intra-cloud (cloud-to-cloud) flashes
- Embedded man-made disturber rejection algorithm
- Programmable detection levels enable threshold setting for optimal controls
- SPI and I²C interface is used for control and register reading
- Antenna Tuning to compensate variations of the external components
- Supply voltage range 2.4V to 5.5V
- Power-down, listening, and active mode

Franklin Lightning Sensor Description

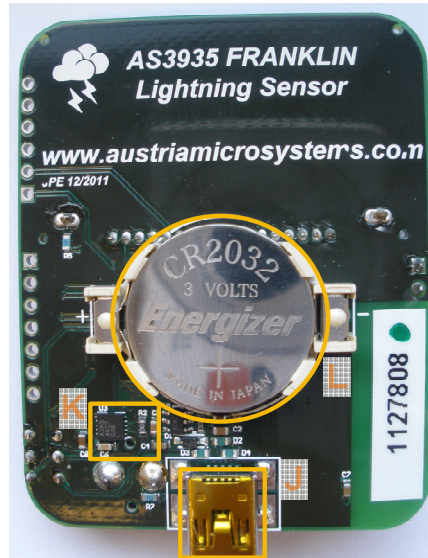## Board Description

Figure 1: Lightning Sensor, Top

Figure 2: Lightning Sensor, Bottom

Component Description Top

Label	Name	Info
A	**ON/OFF**	Power on/off the Demoboard.
B	**BUTTON**	Short Press: The actual time of the RTC is shown. Long Press (>1s): The statistics of the AS3935 is cleared
C	**IDD**	IDD Jumper for current measurement of AS3935
D	**BUZZER**	Audio Information for Lightning and Disturber
E	**LCD**	128x32 Display, blue backlight
F	**500kHz Antenna**	100uH LF Antenna for AS3935
G	**AS3935**	Lightning Sensor
H	**MCU**	Microcontroller PIC24FJ64GB002
I	**AS3935 Interface**	SPI Interface to AS3935

Component Description Bottom
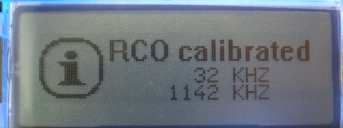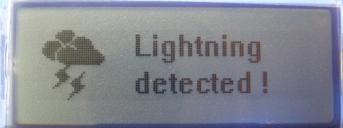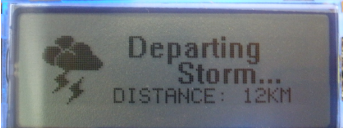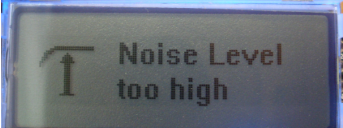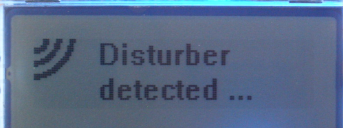
Label	Name	Info
J	**USB – Connector**	USB Interface for the GUI
K	**AS1362, AS1746**	Power Management; Analog Switch
L	**CR2032 BATTERY**	Insert CR2032 in here

Buzzer

Label	Modulation	Info
D	1x 500ms ON	Lightning detected
	2x 150ms ON	Lightning detected: Distance to the previous lightning has changed
	4x 50ms ON	Disturber was detected

Note: The buzzer alarm can be modified or turned off via the GUI.

LCD

Label	Description	Sign
Booting	After power on the demo board, the austriamicrosystems logo and the firmware version will be displayed.	
Antenna Tuning	After the startup the antenna of the AS3935 is automatically tuned. The tuning uses the internal array of capacitors to achieve 500kHz as resonance frequency. The resonance frequency and the internal capacitance are shown on the LCD.	
RCOs Calibration	After the antenna tuning the internal RC-Oscillators are calibrated. The SRCO is calibrated to 32kHz and the TRCO is calibrated to 1.1MHz. Both frequencies are displayed.	
USB connected	The demo board can be connected via USB. As soon as the USB bus is connected the sensor is turned off and all settings of the AS3935 can be saved in the GUI. If the demo board is power cycled when the USB plug is already connected, the LCO and RCO calibration is not executed, in order to allow the user to do those calibrations via the GUI.	
Listening Mode	After the calibration, the Lightning sensor is set in listening mode. No storm is within detection range.	
Lightning This symbol indicates a lightning – the text give further information.	Lightning has been detected. The distance estimation and movement of the head of the storm is shown afterwards.	
	The distance to the head of the storm gets closer.	
	The distance to the head of the storm gets farther.	
Noise Floor Detected	Continuous noise is jamming the AS3935 AFE; during this time the sensor cannot detect the presence of lightning activities.	
Disturber Detected	Disturbers have been received by the AS3935 and rejected by the disturber rejection embedded algorithm.	

Real Time Clock (RTC)

The demoboard has a built in RTC that must be synchronized with a PC. Once the RTC is set to the current time, it is possible to monitor lightning over time.

Note: The RTC is reset to midnight of 1. January 2012 and the history is cleared when the demo board is switched off and on again.
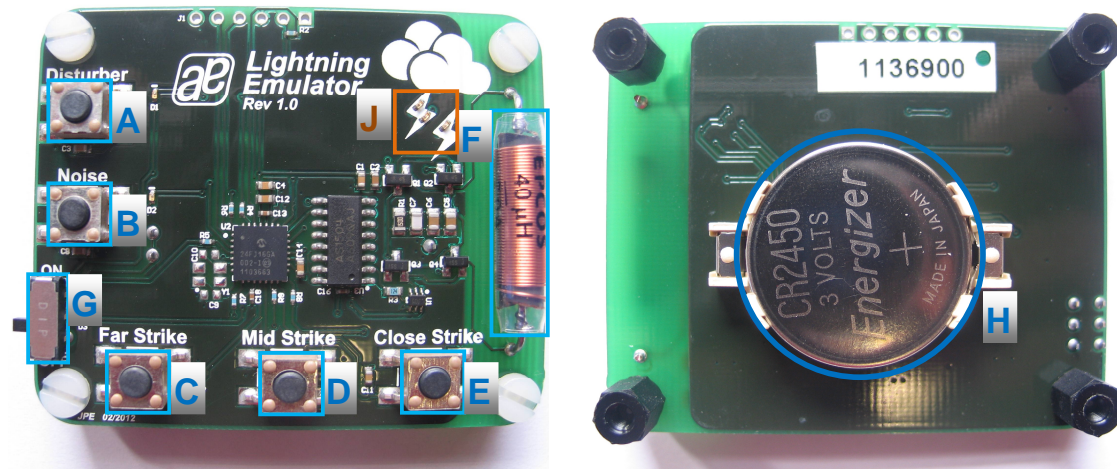
Lightning Emulator

Board Description

Figure 3: Lightning Emulator Description Top

Lightning Emulator Description

Label	Name	Description
A	**Disturber**	Emulates a disturber on the antenna; red LED is flashing up
B	**Noise**	Emulates noise on the antenna; red LED keeps flashing until noise disappears again (3s)
C	**Far Strike**	Emulates a pattern of a lightning with far distance
D	**Mid Strike**	Emulates a pattern of a lightning with closer distance
E	**Close Strike**	Emulates a pattern of a lightning with the closest distance
F	**Antenna**	The different patterns are modulated on the 500kHz carrier that is transmitted via the LF antenna.
G	**On/Off Switch**	Turn both switches to ON to supply the lightning emulator; As soon as the demo board is switched on, the ON LED flashes up once a second to indicate being turned on.
H	**Battery holder CR2016**	Supply the emulator with 3 stacked CR2016 batteries to generate 9V.

LEDs

Label	Name	Info
G	**ON**	Blue led flashes up once a second
A	**Disturber**	Flash up red if disturber is emulated
B	**Noise**	Flash up for 3s, as long as noise is emulated
J	**Strike**	Flash up yellow if far strike is emulated
		Flash up orange if mid strike is emulated
		Flash up red if close strike is emulated

How to get started with Franklin Lightning Sensor demo kit

- Insert the 3V battery (CR2032) in the battery holder **"C"** on the AS3935 demo board.

- Insert a 3V battery in the battery holder **"G"** on the Lightning Emulator.

- Position the lightning emulator and the AS3935 demo board in such a way that both antennas are in parallel to each other. Keep a distance of 10-15 cm between both boards.

- Turn on the AS3935 Lightning Sensor via the ON/OFF – switch **"A"**. When you switch on the board you will see on the LCD the austriamicrosystems logo followed by the LCO and the RCO calibration. After successful calibration the AS3935 goes into sense mode awaiting a lightning.

  Note: The LCO should be tuned to 500 kHz, the TRCO to 1.1 MHz and the SRCO to 32 kHz. If this procedure wants to be done manually, connect the USB plug before power ON the demo board via switch **"A"**.

- Turn on the Lightning Emulator via the ON/OFF – switch **"F"**. When turned on, the green LED will be continuously on.

  Note: Make sure the battery of the Lightning Emulator is full. Otherwise lightning might not be recognized correctly.

- Now you can start to press the switches, farther strike, close strike and closer strike (button **"B, C, D"**) on the Emulator, simulating a lightning which will be detected by the sensor. The display will flash up showing the signs described above and the buzzer will trigger an alarm.

  If noise is emulated (button **"A"**) the AS3935 demo board will show "Disturber detected".

GUI Description

- Install the GUI and start the software. As soon as the demo board is connected the USB and AS3935 Symbol in the corner becomes green.
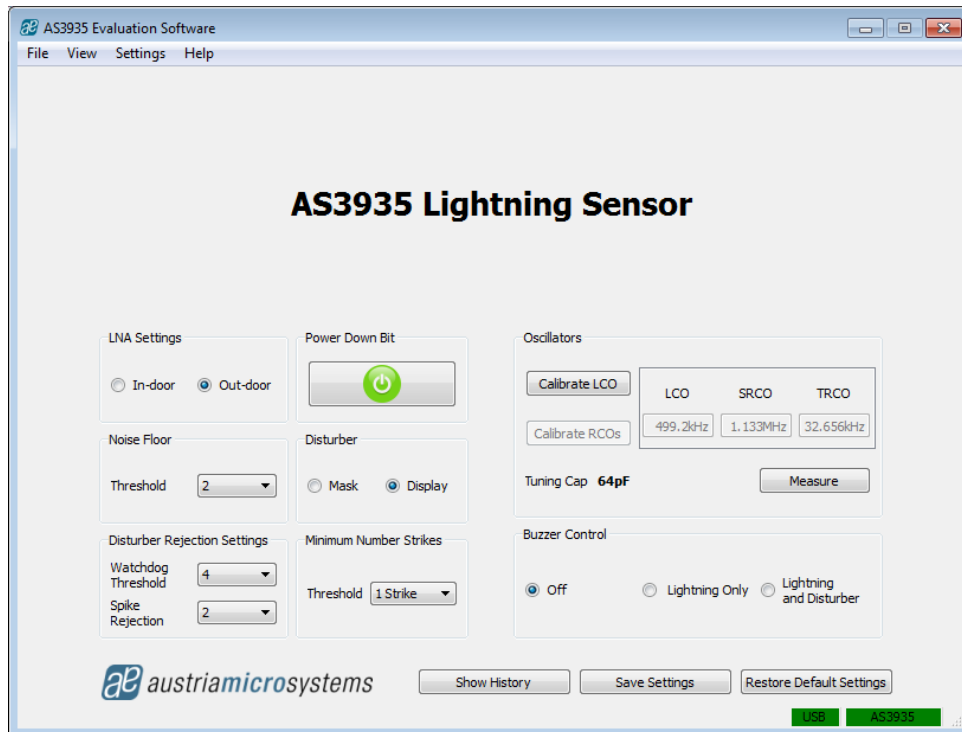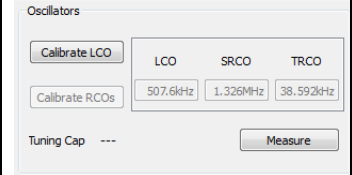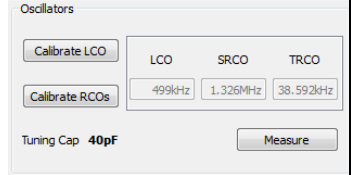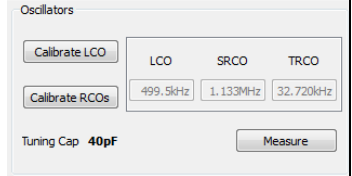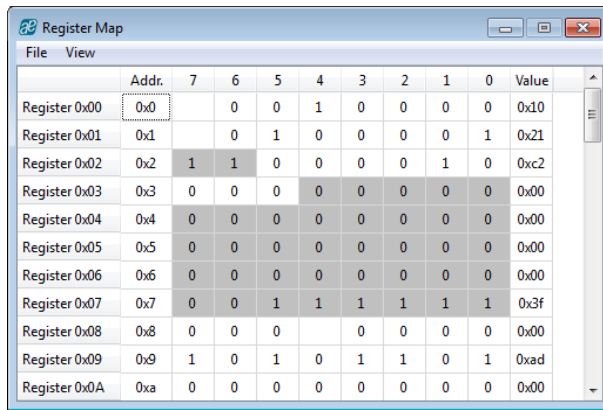- The LCD will show the USB connection and the sensor is turned off.

Figure 4: GUI of the AS3935 Lightning Sensor

The following parameters can be defined on the AS3935 Lightning Sensor:

- **Power Down**
  In Power down Mode (R0<0>=1), the entire AS3935 is switched off. The typical current consumption is 800nA. After Power up again, the TRCO is not calibrated, that must be done by the user pressing the button "Calibrate RCOs" and respectively "Calibrate LCO" if needed.

- **LNA Settings**
  The LNA settings have to be changed according to the location of the lightning sensor (outdoor vs. indoor) as described in the AS3935 datasheet.

- **Noise Floor:**
  The threshold for the trigger of the noise floor interrupt can be selected via this drop down menu.

- **Disturber:**
  If the Disturbers are masked, no interrupts will occur if a disturber is detected.

- **Disturber Rejection Setting:**
  With the watchdog threshold level WDTH (R1<3:0>) it is possible to increase the robustness to disturbers. The AS3935 is capable of rejecting impulse signals, like spikes, picked up by the antenna. This spike rejection can be improved via this SREJ Level defined in R2<3:0>. By default, R2<3:0> = 0x2. Larger values of SREJ correspond to more robust spike rejection.

- **Minimum Number of Strikes:**
  It is possible to allow the AS3935 to issue lightning interrupts only if a minimum number of lightning have been detected in the last 15 minutes. This field allows setting it to 1, 5, 9 or 16 minimum numbers of lightnings.

- **Oscillators:**
  If the AS3935 demo board is connected via USB to the GUI before power on the demo board, the oscillators are not calibrated. This can then be done manually via the GUI. First step is to measure the default resonance frequency of the oscillators by pressing *"Measure"*. The oscillators will show inaccurate values. Pressing *"Calibrate LCO"* will tune the antenna to 500 kHz, which will allow the user to calibrate also the RCOs by pressing *"Calibrate RCOs"*. The added tuning caps will be shown below. See the tuning sequence below:

Measure default values	Calibrate LCO	Calibrate RCOs
Oscillators Calibrate LCO Calibrate RCOs LCO 507.6kHz SRCO 1.326MHz TRCO 38.592kHz Tuning Cap --- Measure	Oscillators Calibrate LCO Calibrate RCOs LCO 499kHz SRCO 1.326MHz TRCO 38.592kHz Tuning Cap 40pF Measure	Oscillators Calibrate LCO Calibrate RCOs LCO 499.5kHz SRCO 1.133MHz TRCO 32.720kHz Tuning Cap 40pF Measure

- **Buzzer Control:**
  The buzzer alarm can be modified for lightning only or can be completely turned off. The buzzer settings can be saved.

- **Save Settings / Restore Default Settings:**
  All settings of the AS3935 and the buzzer can be saved by pressing *"Save Settings"*. To reset the values to the factory settings press *"Restore Default Settings"*.

- **Firmware Update:**
  In order to update the firmware, open Help/Firmware Update (Ctrl+F) and select the new firmware revision.

- **Show History:**
  The history of the occurred strikes can be read out via the GUI and saved to a log file.

- **Register Map:**
  The entire register map can be readout via View/Register Map (Ctrl+M) and can be modified.

	Addr.	7	6	5	4	3	2	1	0	Value
Register 0x00	0x0		0	0	1	0	0	0	0	0x10
Register 0x01	0x1		0	1	0	0	0	0	1	0x21
Register 0x02	0x2	1	1	0	0	0	0	1	0	0xc2
Register 0x03	0x3	0	0	0	0	0	0	0	0	0x00
Register 0x04	0x4	0	0	0	0	0	0	0	0	0x00
Register 0x05	0x5	0	0	0	0	0	0	0	0	0x00
Register 0x06	0x6	0	0	0	0	0	0	0	0	0x00
Register 0x07	0x7	0	0	1	1	1	1	1	1	0x3f
Register 0x08	0x8	0	0	0		0	0	0	0	0x00
Register 0x09	0x9	1	0	1	0	1	1	0	1	0xad
Register 0x0A	0xa	0	0	0	0	0	0	0	0	0x00

Figure 6: Register Map

History Description

The demo board offers a volatile history that can be read out and its data can be saved into a log file.
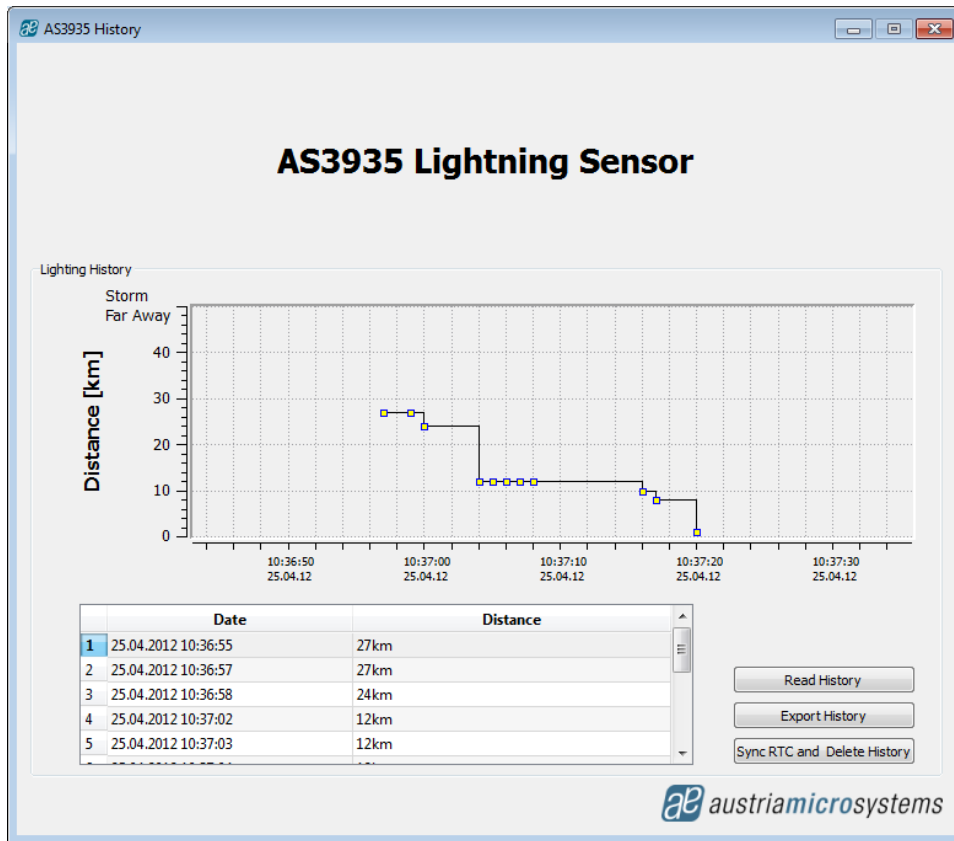

The history works as following:

- It is possible to synchronize the RTC of the board with the time of your PC pressing **"Sync RTC and Delete History"**. The existing history in the memory is automatically deleted. A short pressing of the button "B" on the Lightning Sensor demo board shows the actual time on the LCD display.

- Note: Right after every power up of the board the RTC is set to midnight of 1.January 2012, turning off the board the history will be deleted.

- Each event detected by the Lightning Sensor is saved into the memory. It is possible to read out the history connecting the GUI and press the button **"Read History"**. The graph shows the estimated distance to the head of the storm over the time.

- ▪ **Zoom into** the history by holding your left mouse button pressed.

- ▪ **Zoom out** of the history by pressing the right mouse button.

- ▪ Select some strikes in the graph and the details will be highlighted in the table below.

- ▪ All data can be exported into a log file by pressing **"Export History"**.

	A	B	C	D
1	AS3935 Lightning Sensor History			
2	Date [dd.mm.yyyy]	time [hh:mm:ss]	distance [km]	
3	25.04.2012	10:36:55	27	
4	25.04.2012	10:36:57	27	
5	25.04.2012	10:36:58	24	
6	25.04.2012	10:37:02	12	
7	25.04.2012	10:37:03	12	
8	25.04.2012	10:37:04	12	
9	25.04.2012	10:37:05	12	
10	25.04.2012	10:37:06	12	
11	25.04.2012	10:37:14	10	
12	25.04.2012	10:37:14	10	
13	25.04.2012	10:37:15	8	
14	25.04.2012	10:37:18	1	
15				

- ▪ It is possible to save maximum 190 lightning events in the memory. If the memory is full it will be displayed on the LCD to read out and delete the history. Please apply then **"Read History", "Export History"** and **"Sync RTC and Delete History".**
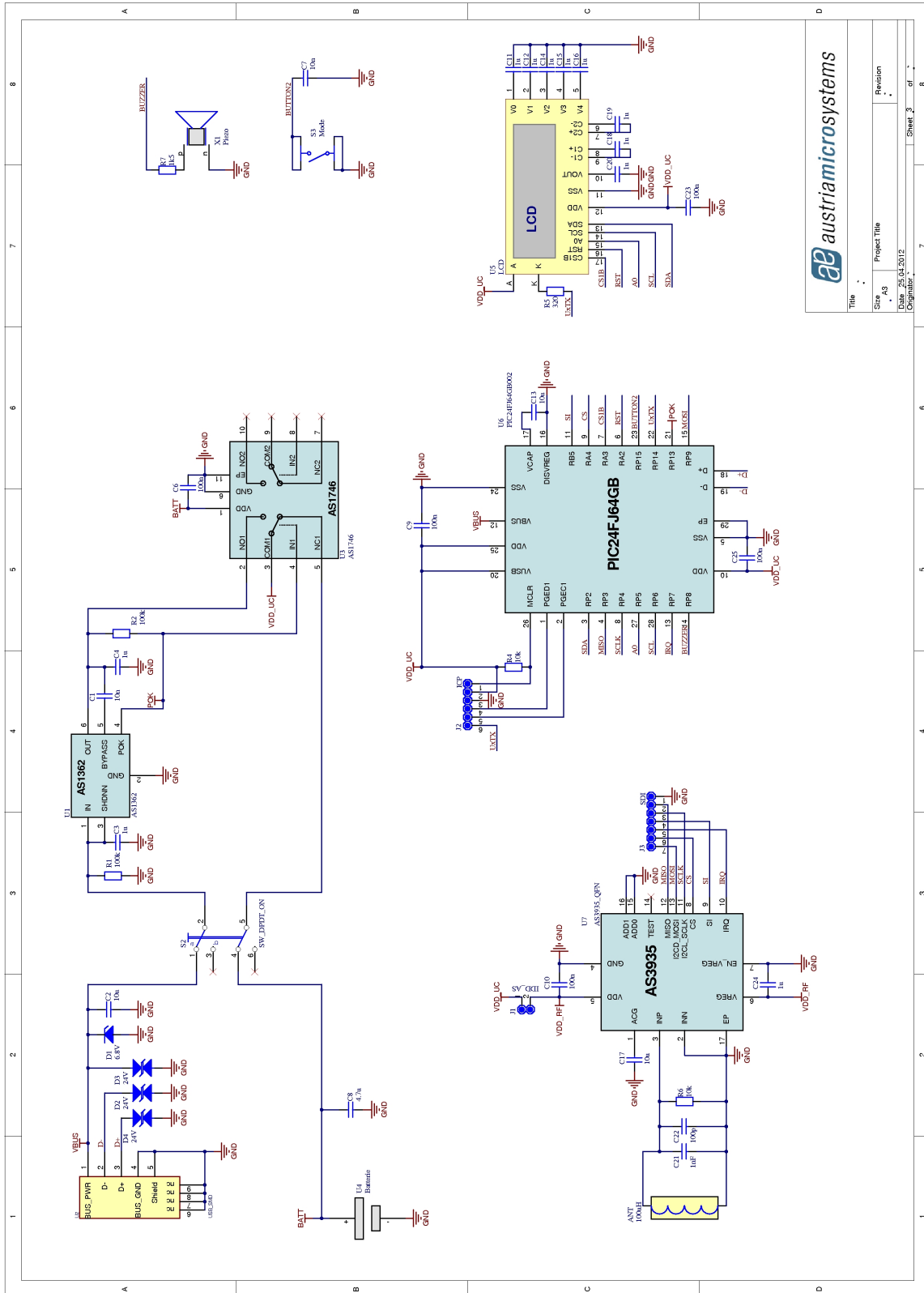
Layer Stack of Lightning Sensor
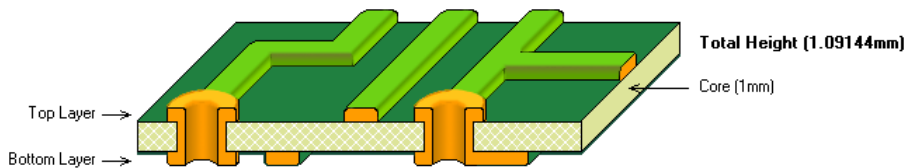
- ▪ PCB Material: FR4 1mm for Active Tag. FR4 1.6mm for Basestation
- ▪ 2 layer board
- ▪ Solder surface: chemical - tin
- ▪ Width of copper: 35µm
- ▪ Silk screen top/bottom: white

Layout Recommendations

- ▪ Do not cross the SPI lines with the sensitive inputs of the antenna.
- ▪ Below the 500 kHz LF antenna there should not be a GND plane.
- ▪ Make sure that the GND plane is routed carefully.
- ▪ Do not run SPI or any other interface on 500 kHz clock speed, in order to avoid cross-coupling.

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Layout of Lightning Sensor
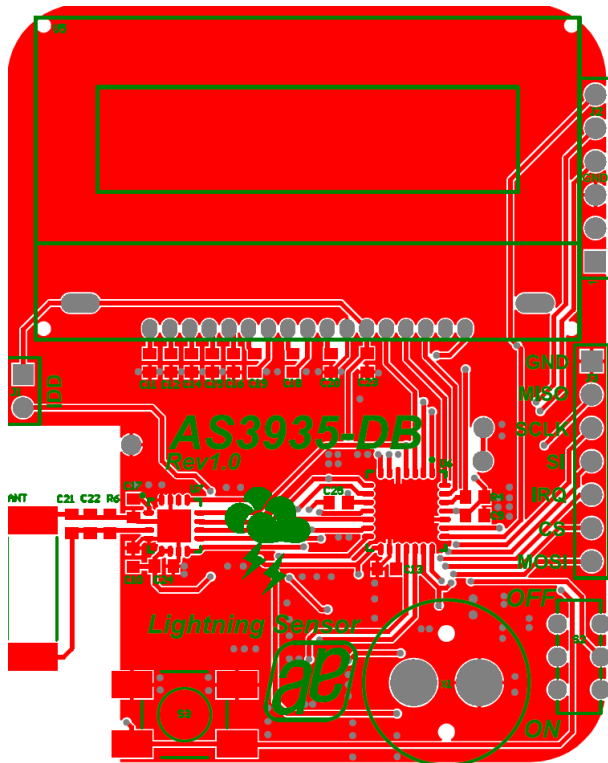
Board schematics

Board Layout

Figure 7: Top Layer
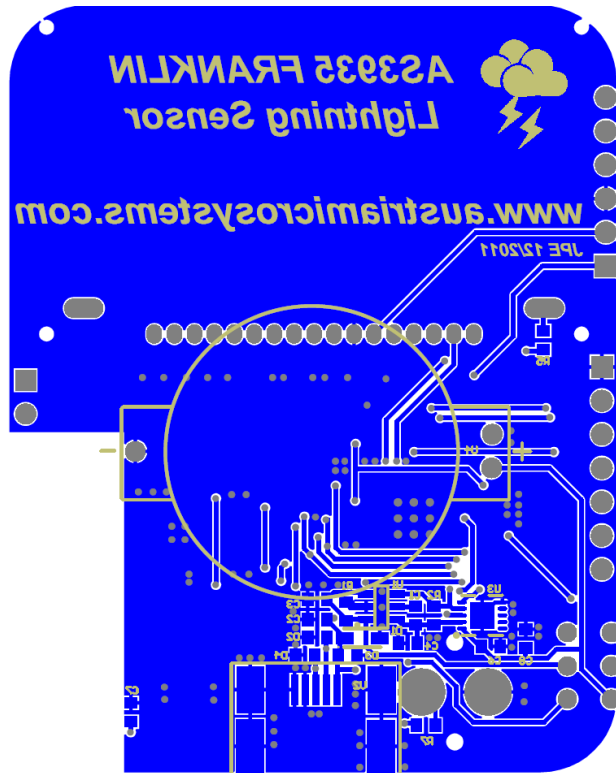
Figure 8: Bottom Layer

Bill of Material of Lightning Sensor

Bill of Materials

AS3935 Lightning Detector Demoboard

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Business Unit:	SBU Communications	
Originator:	Josef Pertl	
PCB Name:		
PCB Version:	V1.0	
BOM Revision:	1	
Report Date:	30.11.2011	

#	Designator	Comment	Footprint	Details	Component_Description	Supplier 1	Supplier Part Number 1	Quantity
1	ANT	100uH		Premo	beigestellt für die erste Bestellung			1
2	C1, C7	10n	C0603-ss	6.3V/X5R				2
3	C2, C13, C17	10u	C0603-ss	6.3V/X5R	TDK - C1608X5R0J106M - CAPACITOR	Farnell	1844199	3
4	C3, C4, C11, C12, C14, C15, C16, C18, C19, C20, C24	1u	C0603-ss	6.3V/X5R	KEMET - C0603C105K9RACTU -	Farnell	1865556	11
5	C6, C9, C10, C23, C25	100n	C0603-ss	6.3V/X5R				5
6	C8	4.7u	C0603-ss	6.3V/X5R	CAP CER 4.7UF 6.3V X5R 0603	Digi-Key	587-1255-1-ND	1
7	C21	680pF	C0603-ss	25V/COG 1% Tolerance	COG			1
8	C22	270pF	C0603-ss	25V/COG 1% Tolerance	COG			1
9	D1	6.8V	SOD323F (SC-90)		ON SEMICONDUCTOR - MM3Z6V8T1G -	Farnell	1431206	1
10	D2, D3, D4	24V	D0603_SUPRESSOR-ss		COOPER BUSSMANN - 0603ESDA-TR1 -	Farnell	1470613	3
11	D9	ON	D0603		MULTICOMP - OVS-0608 - LED 0603 SUPER	Farnell	1716774	1
12	J1	IDD_AS	PLUG_THMD_STRIP2					1
13	J2	ICP	PLUG_THMD_STRIP6	(not assembled)				1
14	J3	SDI	PLUG_THMD_STRIP7	(not assembled)				1
15	R1, R2	100k	R0603-ss	0.1W				2
16	R4, R6	10k	R0603-ss	0.1W				2
17	R5	320	R0603-ss	0.1W				1
18	R7	1k5	R0603-ss	0.1W				1
19	R8	3k9	R0603-ss	0.1W				1
20	S2	SW_DPDT_ON	JS202011AQN		SW SLIDE DPDT 6VDC 0.3A PCMNT	Digi-Key	401-2000-ND	1
21	S3	Mode	SWITCH_SMD_MINITAST		TE CONNECTIVITY / ALCOSWITCH -	Farnell	3801287	1
22	U1	AS1362	SOT23_6	beigestellt				1
23	U2	USB_SMD	SOCKET_SMD_USB_MINI_AB_M		CONN RECEPT USB 5POS RT ANG SMD	Digi-Key	WM17122DKR-ND	1
24	U3	AS1746	TDFN-10 3x3	beigestellt				1
25	U4	Batterie	THT_BAT_CR2032_HU2032LF		RENATA - HU2032-LF - THT BATTERIE-	Farnell	1319749	1
26	U5	LCD	NHD-C12832A1Z-FSR-FBW-3V3	128x32 pix display blue backlight	beigestellt für die erste Bestellung	Digi-Key	NHD-C12832A1Z-FSB-FBW-3V3-ND	1
27	U6	PIC24FJ64GB002	QFN28_6x6		MICROCHIP - PIC24FJ64GB002-I/ML - MCU	Farnell	1778483	1
28	U7	AS3935_QFN	QFN16_4X4_0.65mmPitch	beigestellt	Lightning Detector			1
29	X1	Piezo	PKM13EPYH4002-B0	Piezo		RS Components	516-8268	1
Approved			Notes					50

Layout of Lightning Emulator

Board schematics
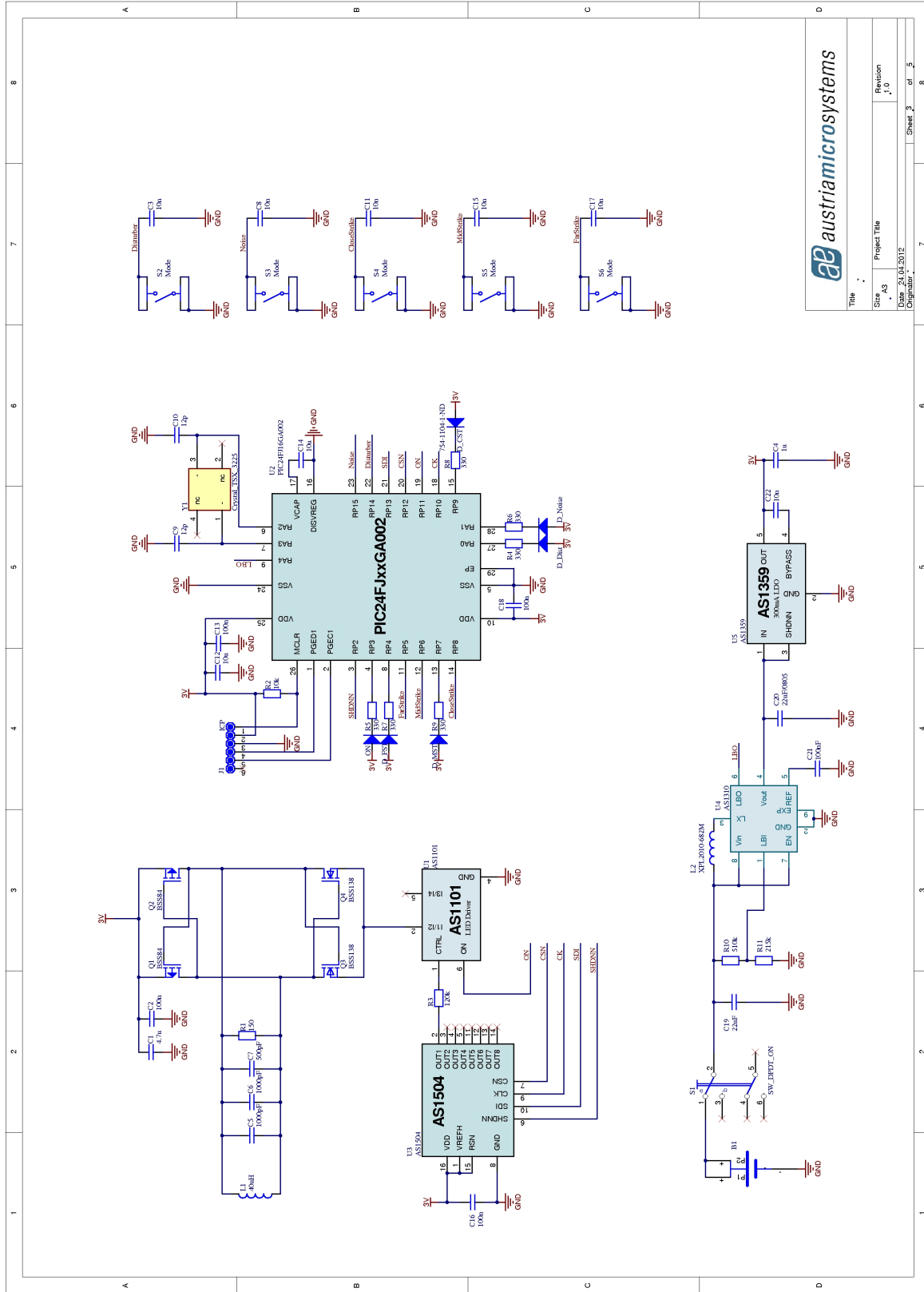
Board Layout
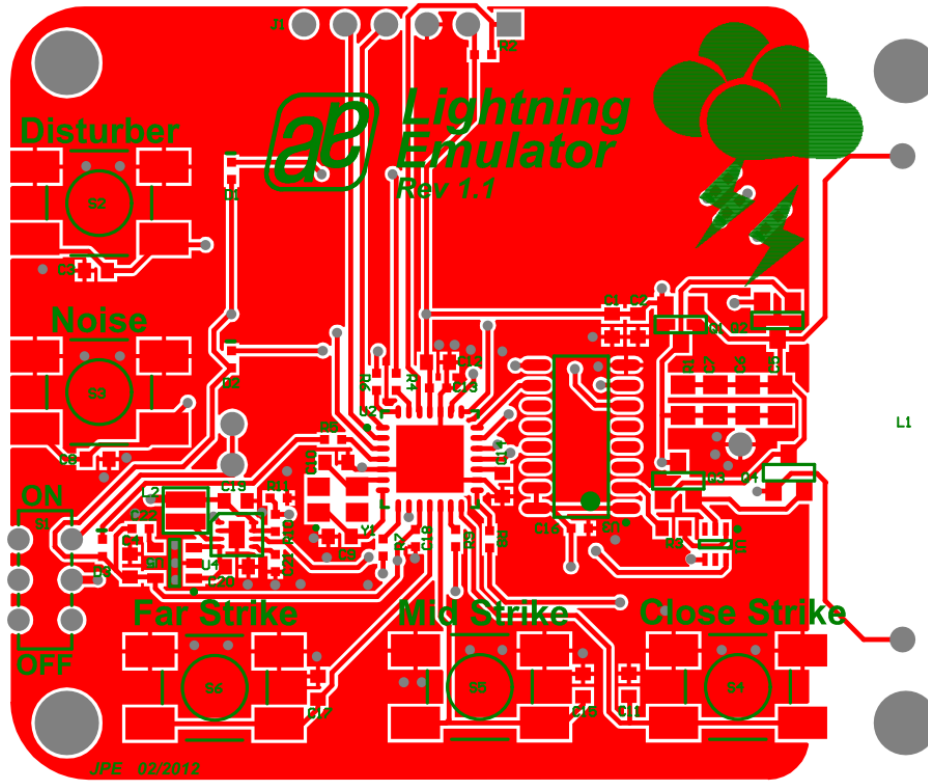
Figure 9: Top Layer of Lightning Emulator
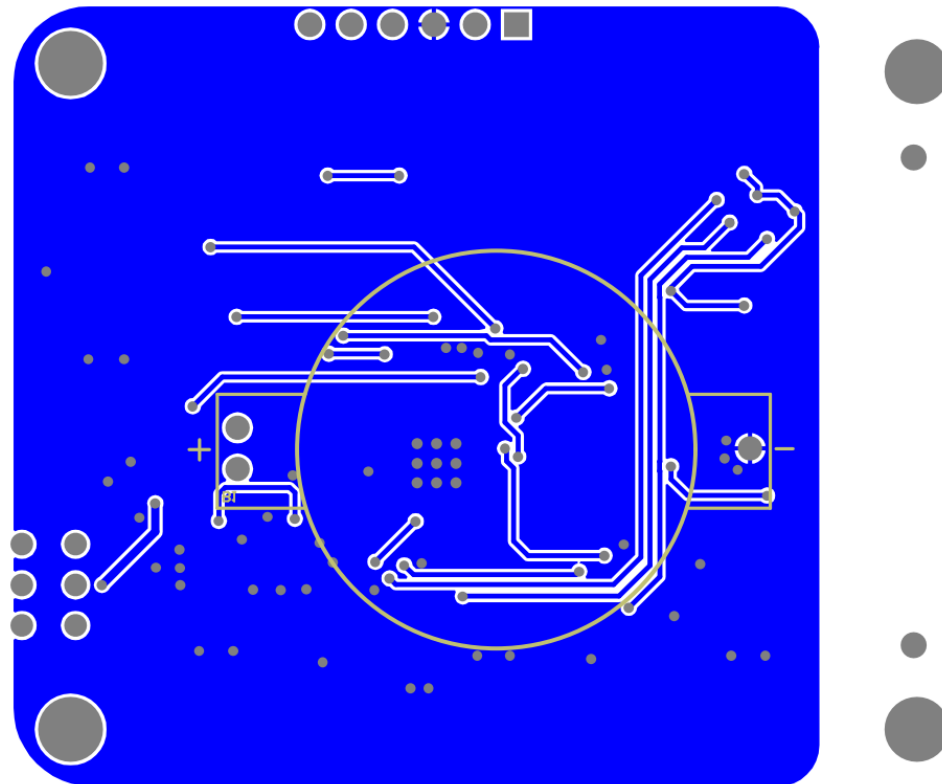
Figure 10: Bottom Layer of Lightning Emulator

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Bill of Material of Lightning Emulator

Bill of Materials

Bill of Materials For Schematic Document [LightningEmulator_Sheet1.SchDoc]

Business Unit:	SBU Communications
Originator:	Josef Pertl
PCB Name:	Lightning Emulator
PCB Version:	V1.1
BOM Revision:	1
Report Date:	22.02.2012

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#	Designator	Comment	Footprint	Details	Description	Supplier 1	Supplier Part Number 1	Supplier Unit Price 1	Quantity
1	B1	Battery_Holder_3pin_THMD	THT_BAT_CR2450_HU2450N-LF			Mouser	614-HU2450N-LF	1,19	1
2	C1	10u	C0603-ss						1
3	C2, C21	100n	C0402-ss						1
4	C3, C8, C11, C15, C17	10n	C0603-ss						5
5	C12, C14	10u	C0603-ss			Digi-Key	587-1255-1-ND	0,24	3
6	C5, C6	1000pF	C0805-ss	100V/COG/5%		Farnell	1612203	0,132	2
7	C7	500pF	C0805-ss	100V/COG/5%		Farnell	1740648		1
8	C9, C10	12p	C0603-ss	not assembled					2
9	C13, C16, C18	100n	C0402-ss						3
10	C19, C20	22u	C0603-ss	6.3V/0603					
11	C22	10n	C0402-ss	6.3V/0402					
12	D1	D_Dist	D0402-ss	red		Digi-Key	754-1104-1-ND	0,29	1
13	D2	D_Noise	D0402-ss	red		Digi-Key	754-1104-1-ND	0,29	1
14	D3	ON	D0402-ss	blue		Digi-Key	754-1102-1-ND		1
15	D4	D_FST	D0402-ss	yellow		Digi-Key	754-1105-1-ND	0,26	1
16	D5	D_MST	D0402-ss	orange		Digi-Key	754-1103-1-ND	0,29	1
17	D6	D_CST	D0402-ss	red		Digi-Key	754-1104-1-ND	0,29	1
18	J1	ICP	PLUG_THMD_STRIP6	not assembled					
19	L1	40uH	B82111E	500kHz Antenna		Farnell	9753354	1,22	1
20	C4	1u	C0603-ss	6.3V/0603					
21	L2	6.8uH	XPL2010-682M			Coilcraft			
22	Q1, Q2	BSS84	SOT23			Farnell	1094997RL		2
23	Q3, Q4	BSS138	SOT23			Farnell	1467960	0,118	2
24	R1	150	R0805-ss						1
25	R2	10k	R0402-ss						1
26	R3	120k	R0603-ss						1
27	R4, R5, R6, R7, R8, R9	330	R0402-ss			Farnell	2059219		6
28	R10	510k	R0402-ss						1
29	R11	215k	R0402-ss						1
30	S1	SW_DPDT_ON	JS202011AQN			Digi-Key	401-2000-ND	0,51	1
31	S2, S3, S4, S5, S6	Mode	SWITCH_SMD_MINITAST			Farnell	3801287		5
32	U1	AS1101	AS1101-SC70-6			austriamicrosystems			1
33	U2	PIC24FJ16GA002	QFN28_6x6			Digi-Key	PIC24FJ16GA002-I/ML-ND	2,53	1
34	U3	AS1504	SOIC127P600X172-16N			austriamicrosystems			
35	U4	AS1310-3.3V				austriamicrosystems			
36	U5	AS1359-3.1V				austriamicrosystems			
37	Y1	Crystal_TSX_3225	TSX-3225_Crystal	not assembled		Farnell	1712841	2,52	1
Approved			Notes						50

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