HELBAKO KOMPETENZ IN ELEKTRONIK / **SIEMENS** Automobiltechnik

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The present product specification shall be terminated as of today in spite of the missing final agreement of the development partner "SIEMENS". If the future agreement involves any necessity for alterations, this shall be agreed between the parties and become part of this product specification.

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1 Project Data

This project is a shared project in co-operation between the companies Helbako and Siemens.

2 Description of the System

2.1 General Product Data

The release of the passenger airbag must be prevented in case of the presence of a child seat on the passenger seat, because an airbag release might cause serious injuries of the child. Apart from this, a release of the passenger retract mechanism is not necessary if the passenger seat is not occupied, which would result in lower repair costs of the vehicle.
In this product specification, the interface electronics of the automatic child seat presence and seat occupancy detection (AKSE) shall be described.

As two different communication protocols are used for the data transfer from the AKSE to the airbag control unit, this shall be differed in the particular sections by the use of "a)" and "b)". In this case, the section mark "a)" shall be used for the "20 baud protocol" whereas the section mark "b)" shall be used for the "100 baud protocol".

2.2 General Test Conditions

The operation of the interface electronics is guaranteed with regard to the data and limiting values that are mentioned in this product specification. The values of the voltages, flows, performances, etc., which are mentioned hereinafter, refer to the connecting pins of the interface electronics.

2.3 Performance

2.3.1 General Description

The automatic child seat presence and seat occupancy detection system must fulfil the following tasks:

- Seat occupancy detection:
  The system is connected with a resistive foil printing sensor (FSR™) in the passenger seat. The condition of the sensor is periodically controlled and analysed. If there is a person on the passenger seat, his presence is detected from a defined seat weight and the status "passenger seat occupied" is set. This status is transferred to the airbag control unit in a protocol.
- Child seat detection:
  For the detection of a child seat on the passenger seat, an inductive coupling system is utilised. For this purpose, transmitting and receiving antennas are moulded on the foil printing sensor. The control unit inductively excites a resonator in the child seat by the transmitting antenna. This resonator gains its operating voltage from the exciting field and modulates a phase shift on the transmitting signal by the periodical change of its resonant frequency. The phase shift that is caused by the resonator is detected at the receiving antenna and will be regained by means of a demodulator (including the subcarrier frequency).

The system is able to detect the orientation of the child seat (in the forward and backward position). For this purpose, the system is constructed as follows: it is provided with a transmitting antenna and two receiving antennas that are positioned in the right and left half of the passenger seat. Furthermore, there are two resonators in the child seat.

2.3.2 Performance Characteristics

The interface electronics AKSE is characterised by the following performance:

- Utilisation of a combined sensor mat with transmitting and receiving antennas that are moulded on the foil printing sensor.
- Integration of all electronics on a board that is tightly connected with the sensor mat embedded in the passenger seat.
- Generation of a sinusoidal gating signal in the 130 kHz band for the contactless energy and information transfer.
- Adaptation of the transmitting signal to different environmental conditions by variation of the frequency and the amplitude.
- demodulation of the phase-modulated signal of the child seat resonators.
- Measuring of the resistance of the foil printing sensor to the seat occupancy detection
- Self-diagnosis of the performance part and the demodulation circuit
- Provision of an interface to the airbag control unit for the transfer of the AKSE status.
- Testing of the foil printing sensor and the transmitting/receiving antennas with regard to interruption and short circuit
- Analysis of the child seat resonators even in case of a failure of the reset function of the resonator.

These functions are realised by the operation of a micro controller which takes over the whole control. By means of a cyclic sequence of a test, the functional reliability of the system is guaranteed.

2.3.3 Seat Occupancy Detection

2.3.3.1 Operating Sequence

The measuring of the status of occupancy of the passenger seat is executed periodically with reference to the cycle time defined in chapter 2.4.2.2.2.4. For the differentiation of a line break and the non-occupied seat, the foil printing sensor is sequentially addressed by voltages with different polarisation. For the measuring of the resistance of the parallel-conducted SBE conductor lines, a series-connected diode is operated in conducting direction. Otherwise, in the case of measurement of the foil sensor resistance, this diode is operated in non-conducting direction and does not influence the measurement.

The resistance level for the transition of 'seat occupied' and 'seat non-occupied' is in the range of 48 kOhm R_{SBE} < 80 kOhm .

The request cycle for the seat occupancy detection depends on the latest status of the AKSE. The particular request cycles of the SBE are listed in chapter 2.4.2.2.2.4.

2.3.3.2 Self-controlling System

The self-controlling system of the SBE consists of measurements that are executed in cycles.

The cyclic tests that are executed on the basis of direct current measuring consist of the following examinations:

- Insulation resistance of the SBE to the transmitting antenna
- Insulation resistance of the SBE to the receiving antenna
- Insulation resistance of the SBE to earth
- Insulation resistance of the SBE to UBATT
- Short circuit in the SBE
- Interruption of the SBE
- Voltage drop of the switching transistors for the FSR analysis

Table 1 : Error thresholds SBE

Measurement		min	max
Insulation resistance of the SBE to the transmitting antenna	<	10 kOhm	980 kOhm
Insulation resistance of the SBE to the receiving antenna	<	12 kOhm	400 kOhm
Insulation resistance of the SBE to earth	<	10 kOhm	500 kOhm
Insulation resistance of the SBE to UBATT	<	100 kOhm	1 MOhm
Short circuit in the SBE	<	50 Ohm	150 Ohm
Interruption of the SBE	>	3 kOhm	8 kOhm
Voltage drop of the switching transistors for the FSR analysis	>	0.8 V	1.3 V

2.3.3.3 Error Qualification

a) For the 20 baud protocol the following applies

In the case of hardware failures, the tests are repeated according to the EEPROM parameter TD_QC. If the error occurs in a sequence of n times, the error message is transferred to the airbag SG with the next data protocol. The error qualification n can be set in the EEPROM parameter QUAL_ERR.

Once the error is qualified, the hardware is tested according to the cycle which is set in the EEPROM parameter TD_QC_ERR.

If no more hardware failure occurs, the tests are repeated according to the EEPROM parameter TD_QC. If no more error occurs in a sequence of n times, the new status is transferred to the airbag SG with the next data protocol. In case of an error dequalification, the EEPROM parameter QUAL_ERR is also applied.

During the qualification of an error, the status counters are not altered. Once the error is qualified, all status counters are reset.

b) For the 100 baud protocol the following applies

In the case of hardware failures, the tests are repeated according to the EEPROM parameter TD_QC. If the error occurs in a sequence of n times, the error message is transferred to the airbag SG with the next data protocol. The error qualification n can be set in the EEPROM parameter QUAL_ERR.

Once the error is qualified, the hardware is tested according to the cycle which is set in the EEPROM parameter TD_QC_ERR.

If no more hardware failure occurs, the tests are repeated according to the EEPROM parameter TD_QC. If no more error occurs in a sequence of n times, the new status is transferred to the airbag SG with the next data protocol. In case of an error dequalification, the EEPROM parameter QUAL_ERR is also applied.

During the qualification of an error, the status counters are not altered. Once the error is qualified, all status counters are reset.

2.3.4 Child Seat Detection

2.3.4.1 Operating Sequence

For the detection of the child seat, the transmitting antenna in the 130 KHz band is excited. With a variation of the frequency, the respective resonant frequency of both resonators in the child seat is determined. By means of the signal strength on both receiving antennas (after the execution of a phase modulation), the position of the child seat is determined. In addition, the type of child set is read out from the resonators.

The request cycle for the child seat detection depends on the latest status of the AKSE. The particular request cycles are listed in chapter 2.4.2.2.2.5.

After the evaluation of the subcarriers of the two demodulator channels and the IDs of the resonators, the latest status of the child seat detection is determined according to the decision matrix listed in chapter 2.3.4.4.

In case of a detected child seat and a sufficient subcarrier amplitude (EEPROM parameter : U_KSE_ID_MAX), a smaller transmission level is actuated with the next scan. If no child seat is detected or the subcarrier amplitude is lower than the value that is indicated in EEPROM (U_KSE_ID_IMIN) the maximum transmission level is used with the next scan.

If no subcarrier is determined, the cyclic demodulator test is executed which examines the receiving channels, demodulators as well as sample and hold filter structures.

2.3.4.2 Evaluation of Subcarriers

The demodulation of the receiving signal is effected by its combination with the frequency-synchronous transmitting signal; after the subsequent band-pass filtering, this results in a desired low-frequency signal (approx. 2.3 kHz in case of type B and approx. 3.3 kHz in case of type A). After this, the binary protocol of the resonator is determined by another frequency-synchronous demodulation. The reception frequency systematically results from the divisor factor 40 and 56 of the transmitting frequency. With the evaluation of the frequency rates for the right and left channel, it is determined whether a sufficient differentiation of the reception level is possible, and whether an allocation of the direction can be executed.

The limiting values for the decision on a sufficient differentiation are stored in the EEPROM and are to be specifically determined for each seat.

3 frequencies are examined with each frequency scan. If a scan executed the examination of the odd frequencies (1, 3, 5) , the even frequency levels (0, 2, 4) will be set for the next scan. With each frequency, the two receiving signals are subsequently demodulated by means of subcarrier A and subcarrier B. As the phase position between carrier and receiving signal is not known, the phase position of the created subcarrier is also shifted. The resulting output signals of the demodulator are scanned 64 times and the average value is calculated. The determined amplitudes are added for the 3 frequencies. The ratios of the 4 calculated subcarrier amplitudes determine the position of the child seat.

For a directional detection of the child seat position, which is independent of the mounting position, the right-left allocation of the receiving antennas can be exchanged by means of an EEPROM parameter(bit 5 in parameter ZAE_TYP). For the detection of the child seat direction, the following algorithm is applied:

1:

IF subcarrier A on the right demodulator channel is one factor X (EEPROM parameter K_KSE_HT_RAT) bigger than subcarrier A on the left channel,

AND subcarrier B on the left demodulator channel is one factor X (EEPROM parameter K_KSE_HT_RAT) bigger than the subcarrier B on the right channel,

AND subcarrier A on the right channel is bigger than the given minimum subcarrier (EEPROM parameter U_KSE_HT_MIN), AND subcarrier B on the left channel is bigger than the given minimum subcarrier (EEPROM parameter U_KSE_HT_MIN),

THEN there is a sufficient differentiation.

2:
IF subcarrier B on the right demodulator channel is one factor X (EEPROM parameter K_KSE_HT_RAT) bigger than the subcarrier B on the left channel,

AND subcarrier A on the left demodulator channel is one factor X (EEPROM parameter K_KSE_HT_RAT) bigger than the subcarrier A on the right channel,

AND subcarrier B on the right channel is bigger than the given minimum subcarrier (EEPROM parameter U_KSE_HT_MIN),

AND subcarrier A on the left channel is bigger than the given minimum subcarrier (EEPROM parameter U_KSE_HT_MIN),

THEN there is a sufficient differentiation.

3:
IF the aforementioned conditions are both not fulfilled,

AND subcarrier A on the right or left channel is bigger than the given minimum subcarrier (EEPROM parameter U_KSE_HT_MIN),

AND subcarrier B on the right or left channel is bigger than the given minimum subcarrier (EEPROM parameter U_KSE_HT_MIN),

THEN there is NO sufficient differentiation.

4:
IF all aforementioned conditions are not fulfilled,

AND subcarrier A on the right or left channel is bigger than the given minimum (EEPROM parameter U_KSE_HT_MIN)

OR

subcarrier B on the right or left channel is bigger than the given minimum subcarrier (EEPROM parameter U_KSE_HT_MIN),

THEN only one subcarrier has been detected.

2.3.4.3 Type Analysis

Once a minimum subcarrier level, which is determined in the EEPROM, is exceeded (U_KSE_ID_MIN), the analysis of the type of seat is effected.

While reading the information sent by the resonators, a bit-synchronous scanning is executed. The received amplitude is measured 4 times in succession per bit while each measurement consists of 8 sampled values. The extraction of the particular bits is performed by means of the average value of the 4 amplitudes that have been determined per bit.

16+n bits (n = EEPROM parameter K_KSE_BITS) of the resonator protocol are read out and evaluated. These 16+n bits consist of a part of the header, the synchronisation part, the divisor factor bit, the parity bit, and the data bits. A maximum of 22 bits (K_KSE_BITS = 6) of the resonator protocol can be examined.

The protocol of the resonator is valid when the following conditions are fulfilled:

- two bits of the header have been received correctly
- the synchronisation part has been detected correctly

- data bits have been received without parity errors
- divisor factor bit of the resonator protocol complies with the subcarrier
- type of child seat is valid, i.e. type is not equal to 0
- two + n bits of the following header have been received correctly (n is determined by the parameter K_KSE_BITS)

If no ID can be read out in spite of a sufficient subcarrier level, all 24 bits of the resonator protocol will be read out and evaluated with the next type analysis. This result is independent of the case if the resonator executed a reset or not.

When a child seat has been detected correctly, an ID is still considered to be detected when a number of bits, which is indicated in EEPROM, does not comply (K_KSE_BITERR). But such a non-compliance with the ID is only permitted in case of reception sequences which succeed according to the number determined in the EEPROM. The tolerance of 'bit sweepers' shall minimise the danger of interrupting the detection of an existing child seat by an external jammer.

The extended analysis of the resonator protocol according to the procedure mentioned above, where all 24 bits are evaluated, is activated on the following conditions:

- subcarriers (HAT) are found directly after the power-on of the device
- two different IDs are detected
- only one ID is detected
- HTs are found, but no IDs

The 24 bits are all bits of the resonator protocol. In addition to the maximum of 22 bits that can be parameterised and that are to be evaluated, two other bits of the header are evaluated.

A deactivation of the extended analysis after a performed activation in the ZAE mode is not possible.

2.3.4.4 Decision Matrix

After the evaluation of the subcarriers of the two demodulator channels and the Ids of the resonators, the latest status of the child seat detection is determined according to the following decision matrix.

Table 2 : Decision Matrix KSE

	1 HT detected	**2 HT detected sufficient differentiation**	**2 HT detected no sufficient differentiation**
No ID	• interference signal • no orientation indicated • type 0	• interference signal • no orientation indicated • type 0	• interference signal • no orientation indicated • type 0
1 ID	• only 1 resonator detected • positioning of the child seat is not correct • type as read out	• only 1 resonator detected • positioning of the child seat is not correct • type as read out	• only 1 resonator detected • positioning of the child seat is not correct • type as read out
2 identical ID	• not possible	• child seat forward/backward • type as read out	• positioning of the child seat is not correct • type as read out
2 different ID	• not possible	• only 1 resonator detected • child seat forward/backward • type 0	• only 1 resonator detected • positioning of the child seat is not correct • type 0

In order to make sure that the AKSE complies with a Keyless Go System, which might be used in the vehicle, the error condition "interference signal" is displayed with a delay of 20 s. For this purpose, EEPROM cells are provided for the qualification and dequalification.

The qualification of a new condition is executed according to the following table:

Latest Condition / Counter	No Subcarrier	Child Seat QUAL_KSE	1 Resonator QUAL_KSE_1RESO	Subcarrier	Interference Signal QUAL_KSE_STOER	Latest Condition = ZAE Condition
No subcarrier	+1	0	0	X	X	0
Child Seat	X	+1	X	X	X	-1
1 Resonator	X	X	+1	X	X	-1
Subcarrier	-1	-1	-1	+1	X	-1
Interference Signal	0	0	0	0	+1	0

Explanatory note:
X Count is not altered
0 Counter is reset to 0
–1 Counter is decremented by 1
+1 Counter is incremented by 1

After the qualification of a new condition, the counters are pre-set with the following values :

Counter / New Condition	No Subcarrier	Child Seat QUAL_KSE	1 Resonator QUAL_KSE_1RESO	Subcarrier	Interference Signal QUAL_KSE_STOER
No Subcarrier	0	0	0	0	0
Child Seat	0	0	0	0	0
1 Resonator	0	X	0	0	0
Subcarrier	0	X	X	0	0
Interference Signal	0	X	X	X	0

Explanatory note:
X Count is not altered
0 Counter is reset to 0
–1 Counter is decremented by 1
+1 Counter is incremented by 1

If it is the case that there is another indication in the first line in addition to the qualification counter, this indication represents the limiting value of the appropriate qualification counter which can be EEPROM-parameterised.

2.3.4.5 Behaviour in Case of Changing Conditions

List of the consistent AKSE protocol combinations

These ones are based on the definitions mentioned in section "Status Information of the AKSE".

The listed values are decimals and represent the 3 bytes (addresses 0, 1, and 2) of the 100bd protocols. The messages in the 20bd protocols comply with those of the 2 first bytes of the whereas the 3rd byte must be ignored for the 20bd protocol. The listed values indicate the addresses of the respective bytes.

AKSE Condition	Appropriate Protocol (Addr. + Data, decimal)								
	SBE Condition								
	Occupied			Not Occupied			Defect		
	1st Byte	2nd Byte	3rd Byte	1st Byte	2nd Byte	3rd Byte	1st Byte	2nd Byte	3rd Byte
AKSE not occupied	0	80	147	0	64	145	0	96	145
Positioning of the child seat is not correct	16+X	80	147	16+X	64	145	16+X	96	145
Positioning of the child seat is not correct, only one resonator detected	16+X	81	147	16+X	65	145	16+X	97	145
Interference signal	32	80	147	32	64	145	32	96	145
AKSE hardware defect	0	82	147	0	66	145	0	98	145
Child seat backward detected	0+X	88	147	0+X	72	145	0+X	104	145
Child Seat forward detected	0+X	84	147	0+X	68	145	0+X	100	145
1 Reso KISI forward type 0	0	85	147	0	69	145	0	101	145
1 Reso KISI backward type 0	0	89	147	0	73	145	0	105	145
1 Reso pos. false type 0	16	81	147	16	65	145	16	97	145

Apart from these conditions, the default condition is possible with the values 0, 72, 147 (type of child seat 0, child seat backward detected, weight category 2). X is the type of child seat, 0<X<16 is applied.

Prevention of intermediate conditions

In case of a changing condition from a condition Z1 to a new condition Z", no intermediate condition is signalled which differs from Z1 or from Z2. In this case, Z1 and Z2 are any chosen conditions from the "List of the Consistent AKS Protocol Combinations" (Chapter 2.3.4.5 of the product specification).
Example: If „child seat forward detected“ is the latest displayed message (Z1 = „child seat forward detected“), and an AKSE hardware failure occurs and is qualified as such (Z2 = „AKSE hardware defect“), a protocol output must not be executed between the messages Z1 and Z2 which differs from "child seat forward detected" and “AKSE hardware defect”.

Direct output of changing conditions without any delay

By means of an allocation of the EEPROM parameter QUAL_KSE with the value 1, the qualification of the condition for the changing KSE conditions is parameterised in a manner that changing conditions are directly displayed within the scope of the specified request cycles.

Reaction times

The reaction times are indicated according to a simulation of the procedures in the software:

For this table, the following EEPROM parameters are applied for the respective ZAE mode:

	ZAE100	ZAE20
ZAE_TYP	0x81	0x80
TD_SBE	1	2
TD_SBE_OK	2	2
TD_SBE_KSE	4	4
TD_KSE	3	3
TD_KSE_FULL	56	67
TD_KSE_OK	6	6
TD_KSE_SBE	55	66
TD_QC	12	12
TD_QC_ERR	9	12
QUAL_SBE	3	3
QUAL_KSE	1	1
QUAL_KSE_BITERR	2	2
QUAL_KSE_STOER	8	10
QUAL_KSE_1RESO	8	10
DQUAL_SBE	56	3
DQUAL_KSE	2	2
DQUAL_KSE_NOTOK	2	2

The data in the matrix consist of MIN times in seconds (top) and MAX times in seconds (bottom).

The times were simulated with a resolution of 720 ms in the ZAE 100 operation mode, and with a resolution of 600 ms in the ZAE 20 operation mode. In this case, the initial condition covered a longer period of time (100 request cycles).

Matrix of the Reaction Times in the ZAE 100 Mode

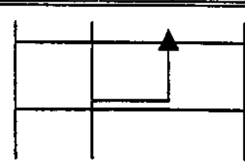
ZAE100

	SBE Not Occupied							SBE Occupied						
SBE: Not Occupied	No Reso	1 Reso without Protocol	1 Reso with Protocol	2 Reso equ. to IDs Direction of Travel	2 Reso equ. to IDs Wrong Pos.	2 Reso v. IDs Direction of Travel	2 Reso v. IDs Wrong Pos.	No Reso	1 Reso without Protocol	1 Reso with Protocol	2 Reso equ. to IDs Direction of Travel	2 Reso equ. to IDs Wrong Pos.	2 Reso v. IDs Direction of Travel	2 Reso v. IDs Wrong Pos.
No Reso		19,44 22,32	19,44 22,32	2,88 5,76	2,88 5,76	19,44 22,32	19,44 22,32	3,60 4,32	20,16 21,60	20,16 21,60	3,60 5,04	3,60 5,04	20,16 21,60	20,16 21,60
1 Reso without Protocol	3,60 10,80		18,72 60,48	2,88 8,64	1,44 43,20	18,72 24,48	18,72 60,48	3,60 7,92	3,60 7,20	18,72 60,48	3,60 8,64	3,60 43,20	18,72 23,76	18,72 60,48
1 Reso with Protocol	3,60 8,64	18,00 24,48		2,88 8,64	1,44 7,20	18,00 24,48	18,00 24,48	3,60 7,20	18,72 23,76	3,60 7,20	3,00 7,20	3,60 7,20	18,72 23,76	18,72 23,76
2 Reso equ. to IDs in Direction of Travel	4,32 9,36	19,44 24,48	18,72 24,48		2,88 9,36	18,72 60,48	18,72 24,48	3,60 7,92	20,16 23,76	18,72 23,76	3,60 7,20	3,60 7,20	18,72 60,48	18,72 23,76
2 Reso equ. to IDs Wrong Position	3,60 8,64	18,00 24,48	18,00 24,48	2,88 8,64		18,00 24,48	18,00 24,48	3,60 8,64	18,72 23,76	18,72 23,76	3,60 6,48	3,60 7,92	18,72 23,76	20,16 23,76
2 Reso with Different IDs in Direction of Travel	3,60 9,36	19,44 24,48	2,16 12,96	1,44 43,20	2,88 8,64		3,60 14,40	3,60 7,92	20,16 23,76	3,60 11,52	3,60 43,20	3,60 8,64	3,60 7,20	3,60 11,52
2 Reso Different IDs Position Wrong	3,60 8,64	18,00 24,48	18,00 24,48	2,88 8,64	1,44 7,20	19,44 25,92		3,60 7,20	18,72 23,76	18,72 23,76	3,60 7,20	3,60 7,20	20,16 23,76	3,60 7,20

min
max

ZAE Protocol	No Reso	1 Reso without Protocol	1 Reso with Protocol	2 Reso equ. to IDs Direction of Travel	2 Reso equ. to IDs Wrong Position	2 Reso v. IDs Direction of Travel	2 Reso v. IDs Wrong Position	No Reso	1 Reso without Protocol	1 Reso with Protocol	2 Reso equ. to IDs Direction of Travel	2 Reso equ. to IDs Wrong Position	2 Reso v. IDs Direction of Travel	2 Reso v. IDs Wrong Position
Byte 0	0x00	0x20	0x11	0x01	0x11	0x00	0x10	0x00	0x20	0x11	0x01	0x11	0x00	0x10
Byte 1	0x40	0x40	0x41	0x44	0x40	0x45	0x41	0x50	0x50	0x51	0x54	0x50	0x55	0x51
Byte 2	0x91	0x91	0x91	0x91	0x91	0x91	0x91	0x93	0x93	0x93	0x93	0x93	0x93	0x93

Timing:



The change of the SBE and the KSE condition always occured at the same time.

Matrix of the Reaction Times in the ZAE 100 Mode

	SBE Not Occupied							SBE Occupied						
SBE: Occupied	No Reso	1 Reso without Protocol	1 Reso with Protocol	2 Reso equ. to IDs Direction of Travel	2 Reso equ. to IDs Wrong Pos.	2 Reso v. IDs Direction of Travel	2 Reso v. IDs Wrong Pos.	No Reso	1 Reso without Protocol	1 Reso with Protocol	2 Reso equ. to IDs Direction of Travel	2 Reso equ. to IDs Wrong Pos.	2 Reso v. IDs Direction of Travel	2 Reso v. IDs Wrong Pos.
No Reso	41,76 43,20	20,88 43,20	20,88 43,20	4,32 43,20	4,32 44,64	20,88 43,20	20,88 43,20		19,44 59,76	19,44 59,76	2,88 42,48	2,88 42,48	19,44 59,76	19,44 59,76
1 Reso without Protocol	3,60 7,92	41,76 46,08	21,60 60,48	4,32 46,08	3,60 46,08	20,88 44,64	21,60 60,48	3,60 11,52		18,72 60,48	2,88 8,64	1,44 43,20	18,72 24,48	18,72 60,48
1 Reso with Protocol	3,60 7,92	19,44 44,64	41,76 46,08	4,32 46,08	4,32 46,08	19,44 44,64	19,44 44,64	3,60 9,36	18,00 24,48		2,88 8,64	1,44 7,20	18,00 24,48	18,00 24,48
2 Reso equ. to IDs in Direction of Travel	4,32 7,92	20,88 25,92	20,16 44,64	41,76 46,08	4,32 46,08	20,16 61,20	20,16 25,92	4,32 10,08	19,44 24,48	18,72 24,48		2,88 9,36	18,00 60,48	18,00 24,48
2 Reso equ. to IDs Wrong Position	3,60 7,92	19,44 25,92	19,44 25,92	4,32 44,64	41,76 46,08	19,44 25,92	19,44 25,92	3,60 9,36	18,00 24,48	18,00 24,48	2,88 8,64		18,00 24,48	18,00 60,48
2 Reso with Different IDs in Direction of Travel	3,60 7,92	20,88 44,64	5,76 46,08	3,60 46,08	4,32 46,08	41,76 46,08	5,76 46,08	3,60 10,08	19,44 24,48	2,16 12,96	1,44 43,20	2,88 8,64		3,60 14,40
2 Reso Different IDs Position Wrong	3,60 7,92	19,44 44,64	19,44 44,64	4,32 46,08	4,32 46,08	20,88 44,64	41,76 46,08	3,60 9,39	18,00 24,48	18,00 24,48	2,88 8,64	1,44 7,20	19,44 25,92	

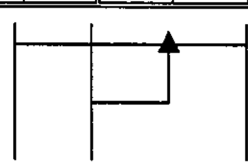
ZAE100

min

max

ZAE Protocol	No Reso	1 Reso without Protocol	1 Reso with Protocol	2 Reso equ. to IDs Direction of Travel	2 Reso equ. to IDs Wrong Position	2 Reso v. IDs Direction of Travel	2 Reso v. IDs Wrong Position	No Reso	1 Reso without Protocol	1 Reso with Protocol	2 Reso equ. to IDs Direction of Travel	2 Reso equ. to IDs Wrong Position	2 Reso v. IDs Direction of Travel	2 Reso v. IDs Wrong Position
Byte 0	0x00	0x20	0x11	0x01	0x11	0x00	0x10	0x00	0x20	0x11	0x01	0x11	0x00	0x10
Byte 1	0x40	0x40	0x41	0x44	0x40	0x45	0x41	0x50	0x50	0x51	0x54	0x50	0x55	0x51
Byte 2	0x91	0x91	0x91	0x91	0x91	0x91	0x91	0x93	0x93	0x93	0x93	0x93	0x93	0x93

Timing:



The change of the SBE and the KSE condition always occured at the same time.

Matrix of the Reaction Times in the ZAE 20 Mode

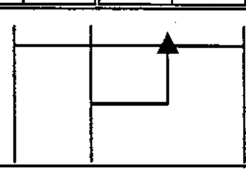
	SBE Not Occupied							SBE Occupied						
SBE: Not Occupied	No Reso	1 Reso without Protocol	1 Reso with Protocol	2 Reso equ. to IDs Direction of Travel	2 Reso equ. to IDs Wrong Pos.	2 Reso v. IDs Direction of Travel	2 Reso v. IDs Wrong Pos.	No Reso	1 Reso without Protocol	1 Reso with Protocol	2 Reso equ. to IDs Direction of Travel	2 Reso equ. to IDs Wrong Pos.	2 Reso v. IDs Direction of Travel	2 Reso v. IDs Wrong Pos.
No Reso	/	22,20 26,40	22,20 26,40	4,20 7,80	4,20 7,80	22,20 26,40	22,20 26,40	4,80 7,80	22,20 25,80	22,20 25,80	4,80 7,80	4,80 9,00	22,20 25,80	22,20 25,80
1 Reso without Protocol	5,40 13,20	/	21,00 64,80	4,20 10,80	3,00 46,80	21,00 28,20	21,00 64,80	4,80 10,20	4,80 9,00	21,00 64,20	4,80 10,80	4,80 46,20	21,00 27,00	21,00 64,20
1 Reso with Protocol	4,80 11,40	21,00 28,20	/	4,20 10,80	3,00 9,60	21,00 28,20	21,00 28,20	4,80 9,60	21,00 27,00	4,80 9,60	4,80 9,60	4,80 9,60	21,00 27,00	21,00 27,00
2 Reso equ. to IDs In Direction of Travel	4,80 12,00	22,20 28,20	21,00 28,20	/	4,20 11,40	21,00 64,20	21,00 28,20	4,80 9,60	22,20 27,00	21,00 27,00	4,80 9,00	4,80 10,20	21,00 64,20	21,00 27,00
2 Reso equ. to IDs Wrong Position	4,80 11,40	21,00 28,20	21,00 28,20	4,20 10,80	/	21,00 28,20	21,00 28,20	4,80 10,80	21,00 27,00	21,00 27,00	4,80 9,60	4,80 10,20	21,00 27,00	21,00 27,00
2 Reso with Different IDs in Direction of Travel	5,40 12,00	22,20 28,20	3,60 12,60	3,00 46,80	4,20 10,80	/	4,80 13,80	4,80 10,20	22,20 27,00	4,80 10,80	4,80 46,20	4,80 10,80	4,80 9,00	4,80 10,80
2 Reso Different IDs Position Wrong	4,80 11,40	21,00 28,20	21,00 28,20	4,20 10,80	3,00 9,60	22,20 29,40	/	4,80 9,60	21,00 27,00	21,00 27,00	4,80 9,60	4,80 9,60	22,20 27,00	4,80 9,60

ZAE100

min
max

ZAE Protocol	No Reso	1 Reso without Protocol	1 Reso with Protocol	2 Reso equ. to IDs Direction of Travel	2 Reso equ. to IDs Wrong Position	2 Reso v. IDs Direction of Travel	2 Reso v. IDs Wrong Position	No Reso	1 Reso without Protocol	1 Reso with Protocol	2 Reso equ. to IDs Direction of Travel	2 Reso equ. to IDs Wrong Position	2 Reso v. IDs Direction of Travel	2 Reso v. IDs Wrong Position
Byte 0	0x00	0x20	0x11	0x01	0x11	0x00	0x10	0x00	0x20	0x11	0x01	0x11	0x00	0x10
Byte 1	0x40	0x40	0x41	0x44	0x40	0x45	0x41	0x50	0x50	0x51	0x54	0x50	0x55	0x51
Byte 2	0x91	0x91	0x91	0x91	0x91	0x91	0x91	0x93	0x93	0x93	0x93	0x93	0x93	0x93

Timing:



The change of the SBE and the KSE condition always occured at the same time.

Matrix of the Reaction Times in the ZAE 20 Mode

	SBE Not Occupied							SBE Occupied						
SBE: Occupied	No Reso	1 Reso without Protocol	1 Reso with Protocol	2 Reso equ. to IDs Direction of Travel	2 Reso equ. to IDs Wrong Pos.	2 Reso v. IDs Direction of Travel	2 Reso v. IDs Wrong Pos.	No Reso	1 Reso without Protocol	1 Reso with Protocol	2 Reso equ. to IDs Direction of Travel	2 Reso equ. to IDs Wrong Pos.	2 Reso v. IDs Direction of Travel	2 Reso v. IDs Wrong Pos.
No Reso	4,80 7,80	22,20 25,80	22,20 25,80	4,80 8,40	4,80 9,00	22,20 25,80	22,20 25,80	/	22,20 63,60	22,20 63,6	4,20 45,60	4,20 45,60	22,20 63,60	22,20 63,60
1 Reso without Protocol	4,80 10,20	4,80 9,00	21,00 64,20	4,80 10,80	4,80 46,20	21,00 27,00	21,00 64,20	5,40 13,20	/	21,00 64,80	4,20 10,80	3,00 46,80	21,00 28,20	21,00 64,80
1 Reso with Protocol	4,80 9,60	21,00 27,00	4,80 9,60	4,80 9,60	4,80 9,60	21,00 27,00	21,00 27,00	4,80 11,40	21,00 28,20	/	4,20 10,80	3,00 9,60	21,00 28,20	21,00 28,20
2 Reso equ. to IDs in Direction of Travel	4,80 10,20	22,20 27,00	21,00 27,00	4,80 9,00	4,80 10,20	21,00 64,20	21,00 27,00	6,00 12,00	22,20 28,20	21,00 28,20	/	4,20 10,80	21,00 64,80	21,00 28,20
2 Reso equ. to IDs Wrong Position	4,80 10,80	21,00 27,00	21,00 27,00	4,80 9,00	4,80 10,20	21,00 27,00	21,00 27,00	4,80 11,40	21,00 28,20	21,00 28,20	4,20 10,80	/	21,00 28,20	21,00 28,20
2 Reso with Different IDs in Direction of Travel	4,80 10,20	22,20 27,00	4,80 10,80	4,80 46,20	4,80 10,80	4,80 9,00	4,80 10,80	5,40 12,00	22,20 28,20	3,60 12,60	3,00 46,80	4,20 10,80	/	4,80 13,80
2 Reso Different IDs Position Wrong	4,80 9,60	21,00 27,00	21,00 27,00	4,80 9,60	4,80 9,60	22,20 27,00	4,80 9,60	4,80 11,40	21,00 28,20	21,00 28,20	4,20 10,80	3,00 9,60	22,20 29,40	/

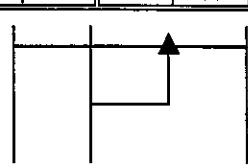
ZAE100

min

max

ZAE Protocol	No Reso	1 Reso without Protocol	1 Reso with Protocol	2 Reso equ. to IDs Direction of Travel	2 Reso equ. to IDs Wrong Position	2 Reso v. IDs Direction of Travel	2 Reso v. IDs Wrong Position	No Reso	1 Reso without Protocol	1 Reso with Protocol	2 Reso equ. to IDs Direction of Travel	2 Reso equ. to IDs Wrong Position	2 Reso v. IDs Direction of Travel	2 Reso v. IDs Wrong Position
Byte 0	0x00	0x20	0x11	0x01	0x11	0x00	0x10	0x00	0x20	0x11	0x01	0x11	0x00	0x10
Byte 1	0x40	0x40	0x41	0x44	0x40	0x45	0x41	0x50	0x50	0x51	0x54	0x50	0x55	0x51
Byte 2	0x91	0x91	0x91	0x91	0x91	0x91	0x91	0x93	0x93	0x93	0x93	0x93	0x93	0x93

Timing:



The change of the SBE and the KSE condition always occured at the same time.

The evidence of these values is detected by simulated and comparison with real measured values.
The reaction times of the device in case of state transitions are, among others, also determined by the parameterisation according to the EEPROM configuartioin under 2.3.4.5. In connection with the values, the respective time basis for the 20 and 100 Baud protocol is indicated. Thus, the reaction times can be determined for fixed configurations, e.g. in case of a special EEPROM parameterisation of the state qualification.

2.3.4.6 Self-controlling System

The self-controlling system of the AKSE consists of measurements that are executed in cycles.

The cyclical measurements consist of :

- Measurement with test signal (test of the receiving function including demodulator circle if no subcarrier is detected)
- Offset voltage demodulator
- Short circuit of the receiving antenna
- Interruption of the receiving antenna
- Insulation resistance of the receiving antenna to earth
- Insulation resistance of the receiving antenna to UBATT
- Short circuit of transmitting antenna
- interruption of the transmitting antenna
- Insulation resistance of the transmitting with regard to earth
- Insulation resistance of the transmitting with regard to UBATT
- Insulation resistance between transmitting and receiving antenna

In the test of the demodulator with the test signal, the complete signalling distance from the sender to the AD converter of the µC is tested. In this case, the carrier of the first demodulation is modulated with an internally produced subcarrier and the resulting signal is measured with the appropriate channel of the AD converter.

With the demodulator test, the following points are checked:

- Amplification factor
- Amplification ratio between the two demodulator channels
- A/B subcarrier separation

The evaluation is limited to the measurement of the channel where the subcarrier amplitude is below the AKSE parameter U_KSE_DEMSTOER that can be set in EEPROM. If the subcarrier amplitude on both channels is higher than the pre-set value, the demodulator test shall not be executed.

The measurement of the resistance of the transmitting antenna is sequentially executed in two different current directions. Apart from the measurements of the antenna circuits mentioned herein, the coupling measurements for the seat occupancy are executed as described in chapter 2.3.3.2.

Table 3 : Error Thresholds KSE

Measurement	Error at:	min	max
Short circuit of the receiving antenna	<	3 Ohm	30 Ohm
Interruption of receiving antenna	>	220 Ohm	300 Ohm
Insulation resistance of the receiving antenna to earth	<	30 kOhm	110 kOhm
Insulation resistance of the receiving antenna to UBATT	<	20 kOhm	650 kOhm
Short circuit of the transmitting antenna	<	1.5 Ohm	5 Ohm
Interruption of the transmitting antenna	>	15 Ohm	20 Ohm
Insulation resistance of the transmitting antenna with regard to UBATT	<	80 Ohm	1 kOhm
Insulation resistance of the transmitting antenna with regard to earth	<	40 Ohm	10 kOhm
Insulation resistance between transmitting and receiving antenna	<	5 kOhm	360 kOhm

2.3.4.7 Error Qualification

a) For the 20 baud protocol the following applies

In the case of hardware failures, the tests are repeated according to the EEPROM parameter TD_QC. If the error occurs in a sequence of n times, the error message is transferred to the airbag SG with the next data protocol. The error qualification n can be set in the EEPROM parameter QUAL_ERR.

Once the error is qualified, the hardware is tested according to the cycle which is set in the EEPROM parameter TD_QC_ERR.

If no more hardware failure occurs, the tests are repeated according to the EEPROM parameter TD_QC. If no more error occurs in a sequence of n times, the new status is transferred to the airbag SG with the next data protocol. In case of an error dequalification, the EEPROM parameter QUAL_ERR is also applied.

During the qualification of an error, the status counters are not altered. Once the error is qualified, all status counters are reset.

b) For the 100 baud protocol the following applies

In the case of hardware failures, the tests are repeated according to the EEPROM parameter TD_QC. If the error occurs in a sequence of n times, the error message is transferred to the airbag SG with the next data protocol. The error qualification n can be set in the EEPROM parameter QUAL_ERR.

Once the error is qualified, the hardware is tested according to the cycle which is set in the EEPROM parameter TD_QC_ERR.

If no more hardware failure occurs, the tests are repeated according to the EEPROM parameter TD_QC. If no more error occurs in a sequence of n times, the new status is transferred to the airbag SG with the next data protocol. In case of an error dequalification, the EEPROM parameter QUAL_ERR is also applied.

During the qualification of an error, the status counters are not altered. Once the error is qualified, all status counters are reset.

2.3.5 Error Handling

Apart from the self-diagnosis functions of the seat occupancy detection and the child seat detection function that are mentioned in the chapters 2.3.3.2 and 2.3.4.6, the general operating conditions of the AKSE are periodically controlled.

With each switch-on, the whole ROM and the relevant EEPROM parameters (AKSE parameters, QC parameters) are checked by means of the check sum.

For testing the communication path with regard to error messages of the ASIC to the µC, an error is produced from the µC in order to test if this error is messaged back to the µC.

If the supply voltage drops under 7.8 V ... 9 V, an undervoltage is detected by the ASIC and messages to the µC. An overvoltage is detected by the ASIC and also messaged to the µC, if the supply voltage is higher than 16 V ...18.5 V.

In case of a permanently interrupted communication between µC and ASIC, the window watch dog is not triggered any more and the ASIC executes a hardware reset.

Serious errors that result in a switch-off of the AKSE are the following:

- Insulation TX against GND
  If the measurement of the insulation resistance of the transmitting loop sends back a value against GND which is below the permitted minimum value (EEPROM parameter), an qualification counter is incremented. If the qualification counter also reaches the limiting value QUAL_XERR, which is set as EEPROM parameter, the AKSE shall be permanently switched off.

- Exceedance of a non-permitted high transmitting power
  If the voltage drop, which is measured by the transmitting resistance, exceeds the limiting value ITX_MAX while the transmitting level is switched on, the transmitting power level is switched off and the serious error is registered. In addition, the ISO_TX_VBAT error is indicated.

If there is no more serious error, the error memory must be deleted before the operation of the AKSE in the ZAE mode can be started again.

Table 4 : System Responses in Case of Hardware Failures

Failure	Description of the Failure	Error Handling
µC-ROM	ROM failure (check sum)	• Reset
µC-SFR	Register failure (check sum)	• Registration of the appropriate error code in the error memory of the EEPROM • Reset
EEPROM	Error parameter (check sum)	• Registration of the appropriate error code in the error memory of the EEPROM • Reset
OT	Overtemperature	• Registration of the appropriate error code in the error memory of the EEPROM • Reset
OV	Overvoltage	• Registration of the appropriate error code in the error memory of the EEPROM • Reset
UV	Undervoltage	• Reset
SIF	Communication error ASIC	• Registration of the appropriate error code in the error memory of the EEPROM

EXEQ	Transmission path for error messages by ASIC is defect	• Reset or error bits SBE / KSE are set in the ZAE protocol • Registration of the appropriate error code in the error memory of the EEPROM
SBE defect	Error seat occupancy detection	• Error bit SBE is set in the ZAE protocol • Registration of the appropriate error code in the error memory of the EEPROM
KSE defect	error child seat detection	• Error bit KSE is set in the ZAE protocol • Registration of the appropriate error code in the error memory of the EEPROM

2.4 Architecture

2.4.1 Component Structure

2.4.1.1 Power Supply

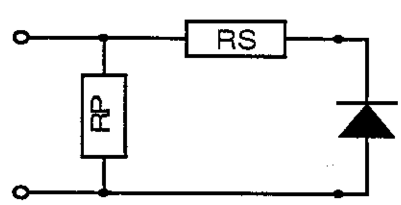
The power supply consists of a voltage regulator for the provision of a stabilised operation voltage of 5V for the power supply of the microcontroller and other system components. In case of a defined operation voltage as a result of failure of the input voltage (KL15R) as well as in case of a failure of a SW-controlled trigger impulse for the addressing of a watch dog, a signal is generated for the defined reset of the microcontroller.

2.4.1.2 Logic of SBE Analysis

For the analysis of the occupancy status of the passenger seat, the resistance of the is analysed. The measurement of the resistance is executed by an AD conversion of the voltage drop at the foil resistance. As for the detection of any line break, the resistance of the parallel SBE conductor paths is measured.

Equivalent circuit diagram:

Ersatzschaltbild



Occupancy detection of the SBE on the basis of the 80 kΩ - upper resistance limit of the seat occupancy detection:

	R_P	> 80 kOhm	=	seat not occupied
48 kOhm<	R_P	≤ 80 kOhm	=	tolerance area
	R_P	≤ 48 kOhm	=	seat occupied

In the tolerance area of the insulation measurement of the SBE connections with regard to UBATT (= 16 V), an extension of the tolerance area of the SBE measurement may amount to 30 kOhm< R_P ≤ 80 kOhm.

If any other leaks of the SBE connections occur below the detection limit, this will result to a shift of the upper resistance limit of the occupancy measurement of 50 kOhm towards the maximum occupancy threshold of 80 kOhm which leads to the output of the certain condition "seat occupied".

The mark space ratio between a "powered" and "dead" seat mat is smaller than 1:50.

2.4.1.3 Transmitting Frequency Generation

For the addressing to the transmitting antennas, a frequency within the scope of 123 up to 133 KHz is provided. By means of a microcontroller, the frequency can be set in the following six steps123 KHz, 125 KHz, 127 KHz, 129 KHz, 131 KHz and 133 KHz which guarantees a separated optimum adaptation to the resonant frequency in the child seat.

Design measures make sure that the limiting value of 135 KHz is not exceeded when the maximum frequency is set..

2.4.1.4 Power Amplifiers

The addressing signal for the balanced power amplifier is gained by regulation of the measured transmitting power level. After this, a sinusoidal signal with a low deterioration factor is generated in the ASCI. With this signal, the power transistors are addressed.

The setting of the transmitting power is executed in the pre-selection mode in three levels that can be selected in dependence of the supply voltage of the AKSE (UBATT) and in dependence of the child seat detection. This pre-selection mode is of big advantage for the detected child seat in order to reduce the human-biological stress.

Table 5 : Transmission Levels in the Pre-selection Mode

Power Level	UBATT [V]	Transmitting Power Amplitude [mA]		
		Min	Type	Max
1	≥9	175	230	315
2	≥11	280	375	470
3	≥12	380	450	520
3	≥9 and <12	280		520

The deterioration factor of the transmitting signal typically amounts to 3 %. The maximum value of the deterioration factor amounts to 7 %.

In the case of a wrong detection of a child seat, the power level that can provide the maximum transmitting power is always utilised. This is a guarantee that in the case of a wrong detection of a child seat and a supply voltage of ≥9 V and a transmitting antenna resistance of ≤15 Ohm the minimum transmitting power amplitudes amounts to 280 mA. For the reset of the resonator, the transmitting power of the AKSE electronics is switched off according to the so-called Vogt specification that is enclosed in the appendix document list for system components. The observance of conditions for the reset that are mentioned in this Vogt specification of the resonator are guaranteed for the operation of the electronics in the generally specified area. Under the observance of the generally specified operating range, this also refers to the operating voltage range between undervoltage switch-off and overvoltage switch-off.

2.4.1.5 Amplifier with Demodulation

The voltages that are induced on the receiving antennas are decoupled and pre-amplified. After this, the two receiving signals are led to multipliers and synchronously demodulated with the original transmitting signal. By means of a subsequent low-pass filtering, all high-frequency signal parts are filtered. Then, the low-frequency signal of the resonators is pre-processed with SC filters while the further process is executed by means of AD conversion in the µC.

For the analysis of the data signal of the resonators, see boundary conditions in the section "Sensor Mats with Antennas".

2.4.1.6 Range

Apart from the performance parameters of the device, the range of the child seat detection is also determined by the structure of the system. The most important influence factors are the following:

- Characteristics of the mounted resonators
- Characteristics of the sensor foil and assembly in the seat (connection to the resonator, attenuation by the seat periphery)

All behaviour patterns for the range that are mentioned in this product specification refer to the reference structure according to the resonator specification of the company Vogt after chapter 3 "Document List for System Components".
The electronic system is built in a way that resonator pairs, which consist of resonators according to the enclosed Vogt specification in the appendix "Document List for System Components", are correctly detected in the ranges that are indicated in the Vogt specification under phase-shift keying measurements and in case of a utilisation of the measuring apparatus that is described in the Vogt specification.

2.4.1.7 Phase-Shift Keying

With the selection of the transmission levels and the selection of the amplification levels of the demodulator, it is guaranteed that resonators, which correspond with the enclosed Vogt specification in the appendix "Document List for System Components" and which generate a minimum phase-shift keying of 0.25° in case of at least one of the possible combinations from the three transmission levels and the two reception amplifiers at the entrance of the electronic system, are safely detected.

2.4.1.8 Microcontroller

For the control of the whole process a microcontroller is utilised. This microcontroller internally includes an AD converter for the evaluation of the demodulated signals and for the analysis of the seat occupancy. The system parameters are saved in an EEPROM.

The correct function of the µC is secured with a window watch dog. The timing of the watch dog is independent of the timing of the µC. A triggering of the watch dog is possible in a time window between 50 .. 100 % of the watch dog time. The watch dog time is between 750 .. 1170 ms.

If the supply voltage (U_{BAT}) drops under the supply voltage that is determined for the µC, the µC receives a reset.

2.4.1.9 EEPROM

The EEPROM includes the parameters that are used for the function of the AKS. There are two blocks of parameters:

- AKSE parameters
- QC parameters

The AKSE parameters contain the setting for the function of the AKSE.

The QC parameters contain the limiting values for the self-controlling systems.

Table 6: AKSE Parameters

Area	Name	Description	Format	min	max
Header	SUPPLIER	supplier 72 : HELBAKO 83 : SIEMENS	1	72 / 83	
	DEVICE	AKSE Identification 1 : AKSE I Helbako 2 : AKSE II Helbako 3: AKSE II Siemens	1	3	
	HW_VERSION	hardware version	1	1	255
	SN_3 .. SN_0	serial number	1	1	16777215
IEE	IEE_QC	free for IEE	1	0	255
	IEE_0 .. IEE_9	free for IEE	1	0	255
Hardware	ZAE_TYP	ZAE telegram type bit 0 : ZAE telegram 0 : 20 Baud 1 : 100 Baud bit 1..4: bits not used bit 5 : seat foil built-in direction 0 : forward 1 : backward bit 6 : ZAE type 0 : Open Collector 1 : Push-Pull bit 7 : AKSE enable 0 : no normal function 1 : ZAE protocol			
	ZAE_00 .. ZAE_02	default values of the ZAE data bytes 0 .. 2		0	63
Timing	TD_SBE	request cycle SBE	600 ms 720 ms	600 ms 720 ms	153.0 s 183.6 s
	TD_SBE_OK	request cycle SBE when seat is occupied	600 ms 720 ms	600 ms 720 ms	153.0 s 183.6 s
	TD_SBE_KSE	request cycle SBE when child seat is detected	600 ms 720 ms	600 ms 720 ms	153.0 s 183.6 s
	TD_KSE	request cycle KSE, 3 frequencies in the possible sequences 0, 2, 4 or 1, 3, 5	600 ms 720 ms	600 ms 720 ms	153.0 s 183.6 s
	TD_KSE_FULL	request cycle KSE with complete scan, 6 freq. while maintaining the sequence of the frequencies	600 ms 720 ms	600 ms 720 ms	153.0 s 183.6 s
	TD_KSE_OK	request cycle KSE when child seat is detected, only 3 freq.	600 ms 720 ms	600 ms 720 ms	153.0 s 183.6 s
	TD_KSE_SBE	request cycle KSE when seat is occupied, only 3 freq.	600 ms 720 ms	600 ms 720 ms	153.0 s 183.6 s
	TD_QC	request cycle QC	600 ms 720 ms	600 ms 720 ms	153.0 s 183.6 s
	TD_QC_ERR	request cycle QC in case of error	600 ms 720 ms	600 ms 720 ms	153.0 s 183.6 s
SBE	QUAL_SBE	status qualification "seat occupied", qualification counter	1	3	254
	DQUAL_SBE	status dequalification "seat not occupied", qualification counter	1	3	254

	U_SBE_THR	limiting value for detection „seat occupied"	20 mV	20 mV	5 V
KSE	QUAL_KSE	status qualification KSE, qualification counter	1	1	254
	DQUAL_KSE	status dequalification KSE, qualification counter	1	1	254
	QUAL_KSE_BITERR	status qualification bit sweeper, qualification counter	1	1	254
	QUAL_KSE_STOER	status qualification KSE interference signal, qualification counter	1	1	254
	QUAL_KSE_1RESO	status qualification KSE only 1 resonator, qualification counter	1	1	254
	DQUAL_KSE_NOTOK	status dequalification interference signal, 1 resonator, qualification counter	1	1	254
	U_KSE_HT_MIN	min. subcarrier amplitude for subcarriers ok, comparison of the subcarrier amplitude at 0° and 90° phase position divided by two	1	0	255
	U_KSE_ID_MIN	min. subcarrier amplitude for evaluation of ID, comparison of the square of the signal at 0° or 90° phase position	1	0	255
	U_KSE_ID_IMIN	min. amplitude data signal with setting I_TX (setting of higher transmission power amplitude), multiplication by 8 and then comparison with the sum of the squares of the voltages at 0° and 90° phase position	8	0	2040
	U_KSE_ID_XMAX	max. amplitude data signal (override demodulator), multiplication by 256 and then comparison with the sum of the squares of the voltages at 0° and 90° phase position	256	0	65280
	U_KSE_ID_IMAX	max. amplitude data signal with setting I_TX (setting of lower transmission power amplitude), multiplication by 16 and then comparison with the sum of the squares of the voltages at 0° and 90° phase position	16	0	4080
	U_KSE_STOER	amplitude for bit interference signal, multiplication by 128 and comparison with the sum of the squares of the voltages at 0° and 90° phase position	128	0	32640
	K_KSE_HT_RAT	min. amplitude ratio between both channels, increment is 1/32 per digit	3.125 %	0 %	796 %
	U_KSE_ITX450	min. voltage for transmission level 450mA, measurement is executed by voltage dividers with 120mV per digit referring to VDD1	120 mV	0 V	30 V
	K_KSE_BITS	number of bits (16 + K_KSE_BITS) that are to be analysed; the parameter must be increased by 4 per bit unit ¼); only integral multiples of 4 are permitted.	0.25	0	24
	K_KSE_BITERR	max. number of bit errors when child seat is detected	1	0	254
	U_KSE_DEMSTOER	subcarrier amplitude where no more demodulator test is possible; comparison with the sum of the squares of the voltages at 0° and 90° phase position	1	0	255
QC	QUAL_ERR	qualification error; qualification counter	1	1	254
	QUAL_XERR	qualification of serious errors that result in switch-off; qualification counter. Errors are ITXGND_ERR and overvoltage switch-off	1	1	254

In the column 'Format' listed above, the upper value is applied for the ZAE 20 mode, if two values are indicated, while the lower value applies for the ZAE 100 mode.

2.4.2 Interfaces and Operating Conditions

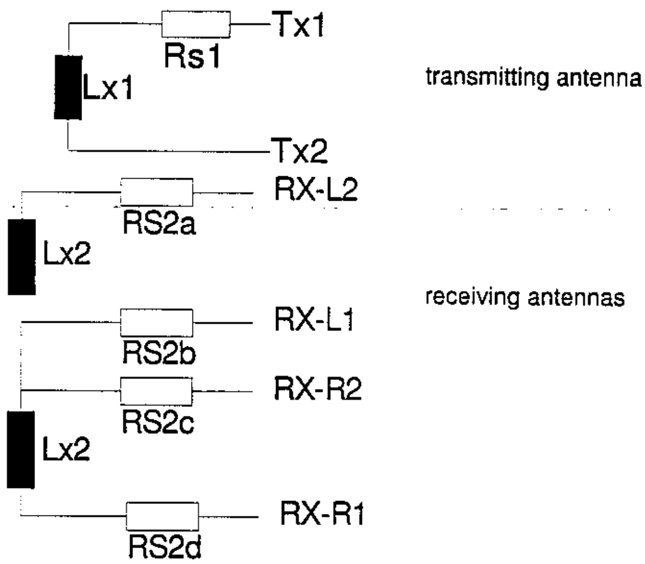
2.4.2.1 Operating Conditions of the Sensor Mat with Antennas

The connection between the AKSE interface electronics and the sensor mat is determined for a connection that cannot be removed.

The total connection includes 10 lines:

- 2 lines transmitting antenna (with 4 connector pins)
- 4 lines receiving antennas
- 2 lines foil printing sensor
- 2 lines diode for interruption and FSR-short circuit measurement

The operating conditions of the SBE / AKSE are defined by the following simplified equivalent circuit diagram:



transmitting antenna

$5\ \text{Ohm} \le Rs1 \le 15\ \text{Ohm}$

$0\ \mu H \le Lx1 \le 2\ \mu H$

receiving antennas

$30\ \text{Ohm} \le RS2x+RSy \le 220\ \text{Ohm}$ with $x,y \in \{a,b,c,d\}$ and $x \neq y$

$0\ \mu H \le Lx2 \le 2\ \mu H$

In order to be able to analyse the resonator signal, the phase-shift keying of a resonator frequency must be within the scope of 123 kHz up to 133 kHz >= 0,25°.

Range of the static phase-shifting of the receiving signal to the transmitting signal: 90° ± 30°.

The processing of the receiving signal is crossed, i.e. the left side is analysed between RX-L2 and RX-R2 whereas the right side is analysed between RX-R1 and RX-L1.

If there is no different indication, the following data shall apply to the operating range.

Table 7: Operating Range of the SBE

Column / Line	1	2	3	4	5
1	Measurement	Error at	Min	Max	Operating Range
2	insulation resistance of the SBE to the transmitting antenna	<	10 kOhm	980 kOhm	> 250 kOhm, (s. 2.4.1.2) function acc. to product specification
3	insulation resistance of the SBE to the receiving antenna	<	12 kOhm	400 kOhm	> 100 kOhm (s. 2.4.1.2) function acc. to product specification
4	insulation resistance of the SBE to earth	<	10 kOhm	500 kOhm	> 10 kOhm upper limiting value „SBE occupied" is shifted into safe area, lower limiting value „SBE occupied" acc. to product specification (s. 2.4.1.2)
5	insulation resistance of the SBE to UBATT	<	100 kOhm	1Mohm	> 250 kOhm; function acc. to product specification, the detection limit for the status SBE occupied can be shifted to the range of 30 kOhm up to 80 kOhm before the detection of an error (s. 2.4.1.2)
6	short circuit in the SBE	<	50 Ohm	150 Ohm	> 50 Ohm device is permanently in the condition "SBE occupied" up to > 80 kOhm
7	interruption of the SBE	>	3 kOhm	8 kOhm	< 8 kOhm function acc. to product specification
8	voltage drop of the switching transistors for the FSR analysis	>	0.8 V	1.3 V	no operating range defined because of internal parameter function acc. to product specification

Table 8: Operating Range of the KSE

Column / Line	1	2	3	4	5
1	Measurement	Error at	Min	Max	Operating Range
1	short circuit of the receiving antenna	<	3 Ohm	30 Ohm	> 30 Ohm; for the range of 3 Ohm up to 30 Ohm the following applies: Without any child seat and in case of prior functional restriction, the more sensitive demodulator test leads to the "KSE defect". In the case of a detected child seat, this can result in a total failure of a channel as a resonator is detected and the demodulator test is not executed for this reason. Without a second error, however, a resonator is safely detected in the second reception channel where are no errors.
2	interruption of the receiving antenna	>	220 Ohm	300 Ohm	< 300 Ohm function acc. to product specification
3	insulation resistance of the receiving antenna to earth	<	30 kOhm	hm	> 110 kOhm: function acc. to product specification (For the range of 30 kOhm up to 110kOhm the following applies: if no child seat is detected by shifting of the input level, other tests might lead to the message KSE- defect even earlier)

4	insulation resistance of the receiving antenna to UBATT	<	20 kOhm	650 kOhm	> 650 kOhm: function acc. to product specification (For the range of 20 kOhm up to 650kOhm the following applies: if no child seat is detected by shifting of the input level, other tests might lead to the message KSE- defect even earlier)
5	short circuit of the transmitting antenna	<	1.5 Ohm	5 Ohm	> 5 Ohm In case of other conditions acc. to the product specification, the transmitting power is provided acc. to the specification. For the range of 1.5 Ohm to 5 Ohm, the following applies: Depending on the error at the transmission loop, a power reduction in the mat is possible to 15 / 50 of the minimum transmitting power of 280 mA @ 9V Vbatt.
6	interruption of the transmitting antenna	>	15 Ohm	20 Ohm (1)	<=15 Ohm: transmitting power acc. to 2.4.1.4, >15 Ohm and <= 20 Ohm: Reduction of the transmitting power to 280 mA @ 9V * 15/20 = 210 mA, >20 Ohm and <= 28 Ohm: Reduction of the transmitting power to 280 mA @ 9V * 15/28 = 140 mA.
7	insulation resistance of the transmitting antenna to UBATT	<	80 Ohm	1 kOhm	> 1 kOhm function acc. to product specification
8	insulation resistance of the transmitting antenna to earth	<	40 Ohm	10 kOhm	> 10 kOhm function acc. to product specification, but within the range of 40 Ohm up to 10 kOhm, a raising of the transmitting power amplitude is possible up to (15 / 40) % depending on the other operating conditions (>12V)
9	insulation resistance between transmitting and receiving antenna	<	5 kOhm	650 kOhm	> 650 kOhm (applies to receiving function) function acc. to product specification (For the range of 5 kOhm up to 650kOhm the following applies: if no child seat is detected by shifting of the input level, other tests might lead to the message KSE- defect even earlier) error detection and influence of analogous insulation errors against Vbat, as the potential transmitting antenna is equivalent to ≈ UBATT – 1 V.

(1): The maximum error detection threshold of the interruption of the transmission loop of 20 Ohm is reached by calibration in the line production.

2.4.2.2 Serial Interface

a) For the 20 baud protocol the following applies

The interface for the airbag control unit is unidirectional. The interface electronics therefore provides a current-limited "push-pull power amplifier.

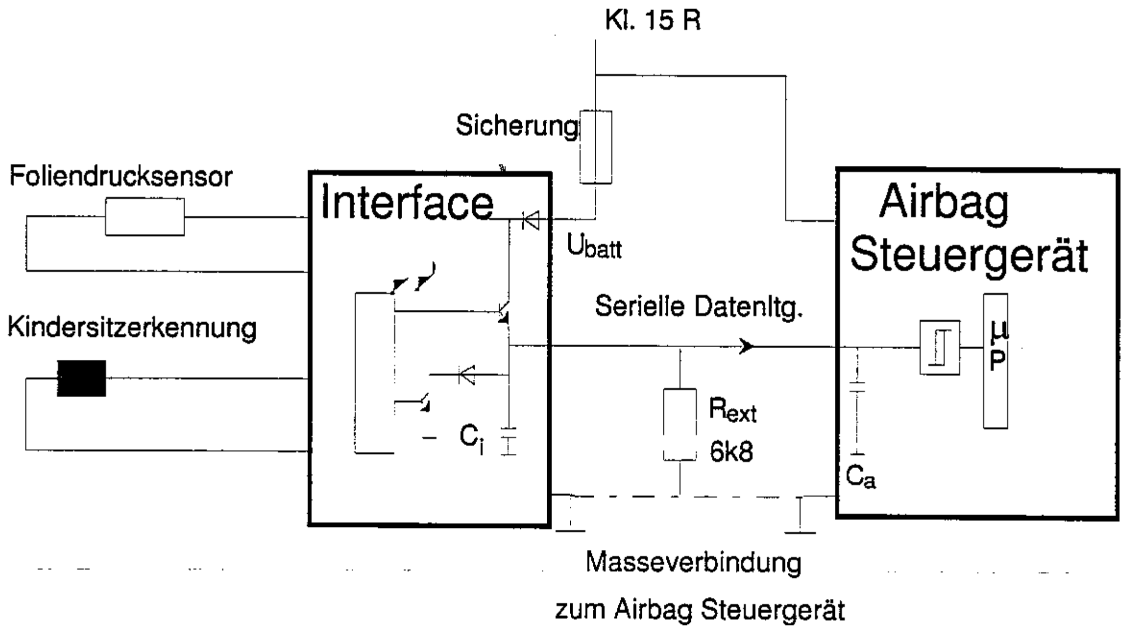
The protocol is based on a transmission rate of 20 baud.

b) For the 100 baud protocol the following applies

The interface for the airbag control unit is unidirectional. The interface electronics therefore provides a current-limited "push-pull power amplifier.

The protocol is based on a transmission rate of 100 baud.

2.4.2.2.1 Elementary Circuit Diagram



Airbag Steuergerät = airbag control unit
Foliendrucksensor = foil printing sensor
Kindersitzerkennung = child seat detection
Masseverbindung zum Airbag Steuergerät = earth connection to airbag control unit
Serielle Datenltg. = serial data line
Sicherung = fuse

2.4.2.2.2 Protocol for Airbag Control Unit

2.4.2.2.2.1 Status Messages of the AKSE

a) For the 20 baud protocol the following applies

The following information is transferred to the airbag control unit:

I. SBE – passenger status:	passenger seat occupied
	SBE error
II. KSE status:	child seat backward detected
	child seat forward detected
	only one resonator detected
	positioning of the child seat is not correct
	AKSE hardware defect
interference signal	
III. Type of child seat:	4 bits provided

b) For the 100 baud protocol the following applies

The following information is transferred to the airbag control unit:

I. SBE – passenger status: passenger seat occupied

	SBE error
II. KSE status:	child seat backward detected
	child seat forward detected
	only one resonator detected
	positioning of the child seat is not correct
	AKSE hardware defect
	interference signal
III. Type of child seat:	4 bits provided
IV. Seat bits:	3 bits provided
V. Weight category bits:	2 bits provided

2.4.2.2.2.2 Coding of the Status Messages

a) For the 20 baud protocol the following applies

The information is transferred in 2 blocks with 11 bits each.

Start Bt	Address Bit		Data Bit						Parity Bit (even)	Stop Bit
0	A1	A0	D5	D4	D3	D2	D1	D0	P	1

The parity bit is produced in a way that the sum of the "1" conditions is even.

The data transmission rate amounts to 20 baud and is executed by MSB first.

The address bits allow the transmission of four different protocols while only 2 codes are utilised at the beginning:

Coding: A1=0 A0=0

Denotation	Interference Signal	Wrong Positioning of the Child Seat	Type of Child Seat			
			T3	T2	T1	T0
default	0	0	0	0	0	0
data bit	D5	D4	D3	D2	D1	D0

Note: In the drawing 581 03 012 00 from the company VOGT electronic, 3 types out of 15 possible types of child seats are defined at present.

Table 9 : Types of Child Seats according to Company VOGT

Type	T3	T2	T1	T0	Type of Child Seat
1	0	0	0	1	child seat against direction of travel
2	0	0	1	0	child seat in direction of travel
3	0	0	1	1	child seat permitted in both directions

Coding: A1=0 A0=1

Denotation	SBE defect	SBE occupied	child seat backward	child seat forward	KSE defect	Only one resonator
default	0	0	1	0	0	0
data bit	D5	D4	D3	D2	D1	D0

b) For the 100 baud protocol the following applies

The information is transferred in 3 blocks with 11 bits each.

Start Bit	Address Bit		Data Bit						Parity Bit (even)	Stop Bit
0	A1	A0	D5	D4	D3	D2	D1	D0	P	1

The parity bit is produced in a way that the sum of the "1" conditions is even.

The data transmission rate amounts to 100 baud and is executed by MSB first.

The address bits (= select bits) allow the transmission of four different protocols while only 3 codes are utilised at the beginning:

Coding : A1=0 A0=0

Denotation	Interference Signal	Wrong Positioning of the Child Seat	Type of Child Seat			
			T3	T2	T1	T0
default	0	0	0	0	0	0
data bit	D5	D4	D3	D2	D1	D0

Note: In the drawing 581 03 012 00 from the company VOGT electronic, 3 types out of 15 possible types of child seats are defined at present.

Table 10 : Types of Child Seats according to Company VOGT

Type	T3	T2	T1	T0	Type of Child Seat
1	0	0	0	1	child seat against direction of travel
2	0	0	1	0	child seat in direction of travel
3	0	0	1	1	child seat permitted in both directions

Coding : A1=0 A0=1

Denotation	SBE defect	SBE occupied	child seat backward	child seat forward	KSE defect	Only one resonator
default	0	0	1	0	0	0
data bit	D5	D4	D3	D2	D1	D0

Coding : A1=1 A0=0

Denotation	Seat Bit 2	Seat Bit 1	Seat Bit 0	Weight Category Bit 1	Weight Category Bit 0	Seat mounted yes/no *
default	0	1	0	0	1	1
data bit	D5	D4	D3	D2	D1	D0

1 The bit D0 (seat mounted yes/no) is always transmitted with logical "1".

Table 10 : Determination of the seat bits in the 100 baud protocol

Seat Bit 0	Seat Bit 1	Seat Bit 2	Comment
0	1	0	default **
0	0	1	driver seat ***
0	1	0	passenger seat
0	1	1	left back seat ***
1	0	0	central back seat ***
1	0	1	right back seat ***
1	1	0	***
1	1	1	***

** "seat passenger is also transmitted in the default condition
*** code for AKSE not relevant

Table 11 : Determination of the weight bits in the 100 baud protocol

Weight Category Bit 0	Weight Category Bit 1	Comment
0	0	not occupied
0	1	class 1 – light
1	0	class 2 – heavy
1	1	class 3 – (free)

In case of an occupied seat, the AKSE always indicates class 2 (exception: default coding).

The AKSE always sends all three pieces of information. (The pieces of information that do not belong to the AKSE are ignored by the airbag release unit)

The bit "SBE occupied" is related to the weight category bits as redundancy, i.e. "weight category bits 0 and 1 = 0" complies with "SBE occupied = 0" and "weight category bit 0 = 1 and weight category bit 1 = 0" complies with "SBE occupied = 1".

During the qualification of a new condition, the protocol still transfers the previous condition to the airbag control unit. When the qualification of the SBE, KSE or of an error is terminated, new conditions are also qualified during the running qualification, i.e. at latest after 2 request cycles and with the exception of the conditions "interference signal" and "1Resonator", and the new condition is transmitted to the airbag control unit.

The exceptions mentioned above, i.e. "interference signal" and "1Resonator", are only transmitted after the complete termination of their qualification, provided that they occur during a running qualification. Until this moment, the previously qualified condition is transmitted.

2.4.2.2.2.3 Timing

a) For the 20 baud protocol the following applies

The transmission of a bit amounts to 50 ms ± 2 %. Consequently, the transmission of a block is executed in 550 ms ± 2 %. The sending period of the particular blocks amounts to 1.2 seconds. Thus, a complete protocol consisting of two blocks is provided every 2.4 seconds.

2 s after the "Power On" at latest, the AKSE sends the first protocol (default protocol) to the central unit. If it is the case that no error, no subcarrier and no seat has been detected within the first measurement cycle, only the first

transmission includes the default protocol. Otherwise, the default protocol is sent until a secured message can be displayed according to the respective qualification count.

After this, a new protocol is transmitted every 2.4 seconds.

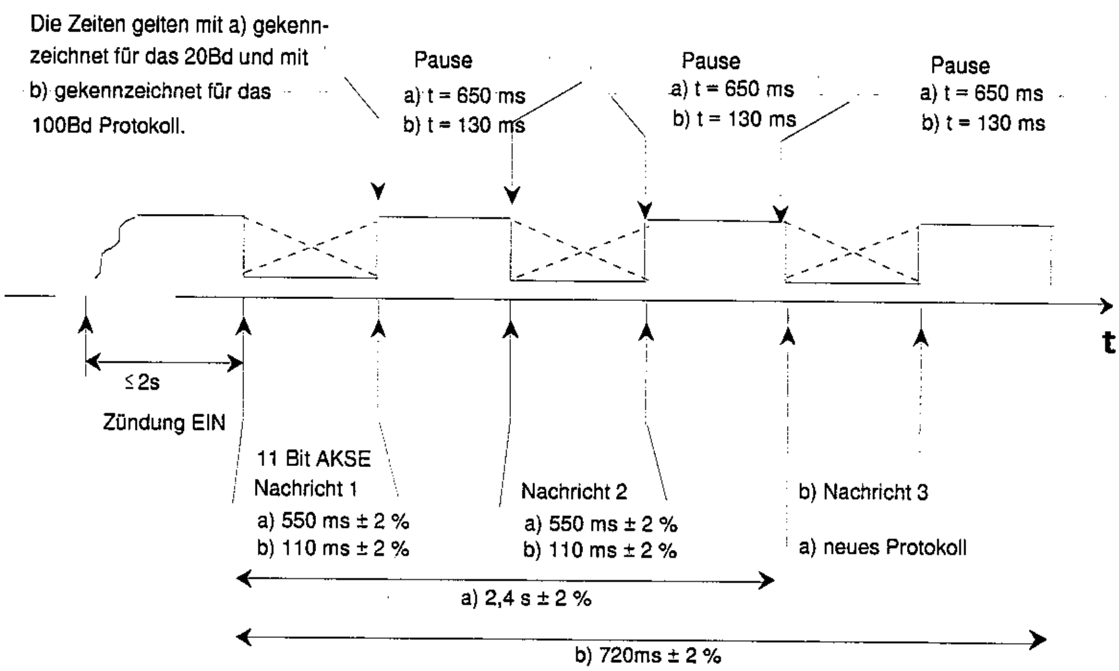
b) For the 100 baud protocol the following applies

The transmission of a bit amounts to 10 ms ± 2 %. Consequently, the transmission of a block is executed in 110 ms ± 2 %. The sending period of the particular blocks amounts to 240 ms. Thus, a complete protocol consisting of three blocks is provided every 720 ms.

2 s after the "Power On" at latest, the AKSE sends the first protocol (default protocol) to the central unit. If it is the case that no error, no subcarrier and no seat has been detected within the first measurement cycle, only the first transmission includes the default protocol. Otherwise, the default protocol is sent until a secured message can be displayed according to the respective qualification count.

After this, a new protocol is transmitted every 720 ms.

Figure 1 : Timing for the 20 baud and 100 baud protocol



The times marked under a) refer to the 20 Bd protocol whereas the times marked under b) refer to the 100 Bd protocol.

Nachricht = Message
neues Protokoll = new protocol
Pause = Break
Zündung EIN = Power ON

2.4.2.2.2.4 Request Cycle of the Seat Occupancy Detection

The request cycle of the seat occupancy detection can be set in the EEPROM.

a) For the 20 baud protocol the following applies

Table 12 : Request cycle SBE in the 20 baud protocol

Condition	EEPROM Parameter	EEPROM Value	Value
seat not occupied	TD_SBE	2	1.20 s
seat occupied	TD_SBE_OK	2	1.20 s
child seat detected	TD_SBE_KSE	4	2.40 s

b) For the 100 baud protocol the following applies

Table 13 : Request cycle SBE in the 100 baud protocol

Condition	EEPROM Parameter	EEPROM Value	Value
seat not occupied	TD_SBE	1	0.72 s
seat occupied	TD_SBE_OK	2	1.44 s
child seat detected	TD_SBE_KSE	4	2.88 s

The aforementioned request cycles for the seat occupancy detection in the 20 baud protocol and in the 100 baud protocol are only applied in case of static conditions.

2.4.2.2.2.5 Request Cycle of the Child Seat Detection

a) For the 20 baud protocol the following applies

Table 14 : Request cycle KSE in the 20 baud protocol

Condition	EEPROM Parameter	EEPROM Value	Value
no child seat + seat not occupied	TD_KSE	3	1.80 s
child seat detected (SBE not relevant)	TD_KSE_OK	6	3.60 s
seat occupied + no child seat	TD_KSE_SBE	66	39.60 s
independent of the condition	TD_KSE_FULL	67	40.20 s

b) For the 100 baud protocol the following applies

Table 15 : Request cycle KSE in the 100 baud protocol

Condition	EEPROM Parameter	EEPROM Value	Value
no child seat + seat not occupied	TD_KSE	3	2.16 s
child seat detected (SBE not relevant)	TD_KSE_OK	6	4.32 s
seat occupied + no child seat	TD_KSE_SBE	55	39.60 s
independent of the condition	TD_KSE_FULL	56	40.32 s

The aforementioned request cycles for the seat occupancy detection in the 20 baud protocol and in the 100 baud protocol are only applied in case of static conditions.
If the SBE hold time takes effect, the timing follows according to the data mentioned under "no child seat + seat not occupied".

2.4.2.2.3 Diagnostic Operation

For the execution of measurements during the manufacturing, a bi-directional communication can be executed to a test unit. In the mode of diagnosis, the hardware interface only works as open collector power amplifier.

The mode of diagnosis in the QC mode is compatible with the existing diagnostic operation of the AKSE I from HELBAKO. Additional diagnostic functions have been transmitted in extended QC functions.

A description of the mode of diagnosis follows in chapter 2.5.

2.4.2.2.4 Constant-Current Mode

For the execution of measurements during the manufacturing, the device can be set in a mode of constant power consumption.

In order to bring the AKSE into this status, the K line (of the serial interface) must be pulled on a low level. After 500 ms at latest, this is detected by the AKSE and switched over to constant power consumption.

Every 2 ms ± 2 %, the K line is each time interrogated for approx. 25 µs. If no low level has been detected 4 times in a row, the constant-current mode is quit. Then, the operating sequence restarts with "Power-On".

During the low –impulse time (at the K line), the AKSE electronics are in the mode of constant power consumption. During this time, the electronic system does not execute any measurements or control of the electronics or the periphery (apart from the permanent interrogation of the K line). As no data can be transmitted to the interface during this period of time (K line = low), the airbag electronics should state this in case of unintended activation.

As another condition, it also has to be noted that a minimum waiting time of 1 s must be observed between the switch-on of the battery voltage and the creation of the low-signal.

Low – Impulse with :	$U_{low} \leq 0.25 \times UBATT$
Drive ability of the low –pulser :	$I_{low} > 100$ mA
Current limiting of the high-drive :	$I_{HIGH} < 100$ mA

2.4.2.2.5 Hardware Interface

The hardware interface is realised as a current-limited push-pull power amplifier and complies with the following design:

Input protection capacity Ci: 470 pF ≤ Ci ≤ 1 nF (dependant on EMC demands)

Output circuit condition:	low status:	$Uo \leq 0{,}2 \cdot U_{Batt}$ at $R_{ext} = 2k2$ to U_{Batt}	
		$Uo \leq 1{,}1$ V	at $I_{in} \leq 1$ mA
		$Uo \leq 1{,}4$ V	at $I_{in} \leq 10$ mA
	high status:	$Uo >= 0{,}7 \cdot U_{Batt}$	at $R_{ext} = 2k2$ to GND
		$Uo >= U_{Batt} - 2{,}0$ V	at $I_{out} \leq 10$ mA
		$Uo >= U_{Batt} - 2{,}5$ V	at 10 mA $\leq I_{out} \leq 30$ mA

2.4.3 Signals

The following signals are utilised and generated:

- For the seat occupancy detection, the resistance of the sensor mat is evaluated (also compare 2.4.1.2).
- For the child seat detection, transmitting antenna signals are generated and received at the receiving antenna in a modulated manner. (also compare 2.3.4).
- For the communication with the airbag control unit a serial interface is used. (also compare 2.4.2.2).

2.4.4 Connecting Components

The connection between the AKSE electronics and the sensor mat as well as the AKSE electronics and the transmitting/receiving antennas is effected by solder or press contacts. The connection between the AKSE electronics is effected by a cable connection with a plug that is connected with the AKSE electronics by solder or press contacts.

2.5 Mode of Diagnosis

2.5.1 Login

Table 16 : Setting of the serial interface

baud rate	9600
data bits	8
stop bits	1
parity	None

A login in the QC mode is only possible after a hardware reset. After the switch-on of the supply voltage, there is the possibility to set the AKSE into the QC mode within a given time window. Within this time window, the tester must send the QC demand ('IEE-qc') to the AKSE. A reception of the QC demand without any errors is confirmed by the AKSE with the symbol 't' (0x74). After this, the AKSE is in the QC mode.

In case of a faulty transmission, the AKSE waits for the QC demand until the time window is terminated.

2.5.2 Structure of QC Protocols

2.5.2.1 Protocol Tester -> AKSE

Table 17 : QC protocols without parameters

Byte	Contents
1	protocol-ID
2	protocol-ID inverted

Table 18 : QC protocols with transfer parameters

Byte	Contents
1	protocol-ID
2	protocol-ID inverted
3	length byte (n-2)
4..n	transfer parameters
n+1	check sum (Σ 3..n)

2.5.2.2 Protocol AKSE -> Tester

Table 19 : Response in case of faulty QC protocol request (error report 1)

Byte	Contents
1	0x3F ('?')

The protocol response is sent in case of the following errors:

- protocol-ID + protocol-ID inverted != $FF
- maximum number of the possible parameters has been exceeded
- Check sum is not correct

Table 20 : Response in case of invalid QC protocol request (error report 2)

Byte	Contents
1	protocol-ID
2	0x3F ('?')

The protocol response is sent in case of the following errors:

- unknown protocol-ID
- no permission for the execution of the protocol

Table 21 : Response of QC protocol

Byte	Contents	Explanation
1	protocol-ID	ID of the required test protocol
2	length byte (n-1)	number of the test result bytes + check sum bytes
3..n	data of the test protocol	data of the required test protocol
n+1	check sum (Σ2..n)	Σ (length byte, data of the test protocol)

2.5.3 Logout

When no new protocol request occurs within 10 s ± 10 % after the last byte sent by the AKSE, the QC mode shall be terminated.

2.5.4 Timing

Table 22 : Timing of QC protocols

	Min	Type	Max
Start window QC login after Power On			450 ms
End window QC login	750 ms		850 ms
Delay between 2 bytes at login	3 ms		
Delay last byte AKSE -> Tester and new protocol request	5 ms		10 s
Delay between 2 bytes at protocol request	3 ms		50 ms
Delay last byte protocol request and first byte AKSE -> Tester	3 ms		1 s
Delay between 2 bytes at protocol response	3 ms		1 s

2.5.5 QC protocols

Table 23 : List of QC protocols

Name	ID	Description	Authorisation
QC_PWD	0xAA	password for access by QC protocols	QC_NORMAL
QC_PARA_RD_OLD	0x05	read out parameter (format as AKSE I)	QC_NORMAL
QC_PARA_RD	0x07	read out parameter	QC_NORMAL
QC_PARA_AKSE_WR	0x06	write parameter	QC_EE_WR
QC_SCAN	0x01	small frequency scan	QC_NORMAL
QC_TEST_OLD	0x04	QC test mode (format as AKSE I)	QC_NORMAL
QC_TEST	0x08	QC test mode	QC_NORMAL
QC_DEVICE	0x10	read device ID	QC_NORMAL
QC_ERRLIST	0x11	read and delete error codes	QC_NORMAL
QC_DUMMY	0xFF	no action	QC_NORMAL

2.6 Electrical Characteristics

2.6.1 Power Supply

2.6.1.1 Voltages

The +12V supply is executed by the connected terminal 15 R.
Range of supply voltage : full functioning: 9.0 V up to 16 V.

2.6.1.2 Flows

After the decay of the switch-on peak current caused by the charging of the input capacities, the maximum current consumption of the device amounts to Ieff = 600 mA and the minimum current 1 mA, for UBATT = 12 V.

2.6.1.3 Electrical Power

10 seconds after the connection of the power supply, a maximum power of 7.2 Watt occurs with a supply voltage of 12 V.

2.6.2 Electrical Stability

2.6.2.1 Inverse-Polarity Protection

The device is protected against inverse polarity of the supply voltage.

2.6.2.2 Overvoltage Stability

Test voltage	:	27 V
Testing time	:	2 min

After this stress, the device is still fully functioning. Measurements and protocol outputs must not be executed during this influence.

2.6.2.3 Short Circuit Stability

External lines to the airbag control unit have a short circuit protection against earth or a supply voltage potential.

2.6.2.4 Voltage Regulation

The AKSE electronics depends on an existing voltage regulation when the provided supply voltage is limited.
For the data exchange by the serial interface it must be noted that the levels described under 2.4.2.2.4 and 2.4.2.2.5 are shifted according to the voltage regulation.

2.6.3 Electromagnetic Compatibility

2.6.3.1 Conducted Disturbance Variables

2.6.3.1.1 Immunity

2.6.3.1.1.1 Conducted Disturbance Variables on Feeders

Please find a more detailed description in the Mercedes Benz specification „AV EMC 000 000 71 99 as of 1st January 1997". For the pulses 1 and 2 the focus IV applies as well as the functional status C. For the pulses 3a and 3b the focus IV applies as well as the functional status A. For the pulse 4 the focus IV applies as well as the functional status C.

2.6.3.1.1.2 Coupled Disturbance Variables on Sender and Sensor Lines

Please find a more detailed description in the Mercedes Benz specification „AV EMC 000 000 71 99 as of 1st January 1997". For the pulses 1 and 2 the focus IV applies as well as the functional status C. For the pulses 3a and 3b the focus IV applies as well as the functional status A.

2.6.3.1.1.3 Ripple of the Supply System

Please find a more detailed description in the Mercedes Benz specification „AV EMC 000 000 71 99 as of 1st January 1997".

2.6.3.1.2 Jamming

Please find a more detailed description in the Mercedes Benz specification „AV EMC 000 000 71 99 as of 1st January 1997".

2.6.3.2 Insolated Disturbance Variables

Please find a more detailed description in the Mercedes Benz specification „AV EMC 000 000 71 99 as of 1st January 1997".

2.6.3.3 Interference Suppression

The observance of the postal regulations referring to the interference suppression in conformity with DIN VDE 0879 is guaranteed. The necessary application for the postal permission is executed by the system supplier.

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AKSE ASIC2
FCC ID: NSZ-AKSE

This device complies with Part 15 of the FCC rules operation is subject to the following two conditions:
1) This device may not cause harmful interference, and,
2) This device must accept any interference received including interference that may cause undesired operation.

Warning: Changes or modifications not expressly approved by party responsible for compliance could void the user's authority to operate the equipment.

2.6.3.4 ESD

For the ESD stability, the AV- EMC 000 000 71 99 as of 1st January 1997 is applied.

2.6.3.5 EMC Design

2.6.3.5.1 Types and Conduction of Lines

The connection between the interface and airbag electronics is executed by unshrouded lines that are connected to the airbag control unit by a common reference point.

2.6.3.5.2 Signalling Process in the Supply System of the Vehicle

The AKSE electronics is protected against interference in the supply system of the vehicle as described in the Mercedes Benz specification „AV EMC 000 000 71 99 as of 1st January 1997.

2.6.3.5.3 Earth Conception

The earth conception is designed over a large area on the board. In order to meet the EMC demands, a multilayer might be utilised. For the design of the layout, a layer is presently designed as earth space. The earth is connected to the vehicle by a connection pin.

2.6.3.5.4 Vehicle Antennas

For the detection of the child seat, one transmitting antenna and two receiving antennas are mounted in the passenger seat.

2.6.3.5.5 EMC Hardware Measures

Apart from the earth conception, EMC filters are mounted at the entrances/exits of the interface electronics as well as at different internal circuit points.

2.6.3.5.6 EMC Software Measures

With the sweep area of the transmitting frequency, frequency-stable jammers are suppressed in the transmitting /reception frequency area.

2.7 Environmental Characteristics

2.7.1 Mechanical Characteristics

The interface electronics is intended for the mounting in the passenger compartment of the vehicle, the protection class is IP54. The mechanical tests are described in document "Qualification Regulations SBE(SBE / AKSE (Siemens document, drawing No.: 659393.40.21)".

2.7.2 Climatic Characteristics

Storage temperature range T(U) = -40°C....+90°C
Operating temperature range T(U) = -40°C....+85°C

2.7.3 Human-biological Compatibility

For the proof of human-biological compatibility, a scientific evidence was delivered by the Institute for Mobile and Satellite Communication Technique. The result of the report was sent separately. With regard to the report, the turn-on time of the sender was reduced to a minimum.

The simulation of the software procedures leads to the following worst-case turn-on times of the sender:

The applied EEPROM parameters are listed in 2.3.4.5.

Turn-on Times of the Sender

Protocol Status SBE	ZAE100 not occupied	occupied	ZAE20 not occupied	occupied
No Reso	10,0 %	2,0 %	11,5 %	2,0 %
1 Reso without protocol	5,5 %	5,5 %	6,5 %	6,5 %
1 Reso with protocol	6,0 %	6,0 %	7,0 %	7,0 %
2 Reso, equ. IDs in direction of travel	6,0 %	6,0 %	7,0 %	7,0 %
2 Reso, equ. IDs pos. wrong	6,0 %	6,0 %	7,0 %	7,0 %
2 Reso, unequ. IDs in direction of travel	6,0 %	6,0 %	7,0 %	7,0 %
2 Reso, unequ. IDs pos. wrong	6,0 %	6,0 %	7,0 %	7,0 %

Referring to the second decimal of the results, the aforementioned figures are rounded to full half percent.
The aforementioned values refer to the worst-case conditions (extended analysis) and in comparison with a request cycle, they are calculated over a long period of time (several minutes).
The proof of these values is given by simulation and comparison with real measured values.

2.7.4 Fail-safety in Comparison with Transponder Systems

In order to reach a high safety distance in comparison with other transponder systems, which work with a similar transmission principle, the type analysis was introduced as described in chapter 2.3.4.3 . In order to reach a considerable safety distance in comparison with SmartCards, the limiting value of the level for the interference signal output must be accordingly set with a high value. The decision about the height of the limiting value must be made by all project partners.

2.7.5 Chemical Characteristics

The chemical resistance is described in the document "Qualification Regulation SBE/AKSE (Drawing No.: 659393.40.21)"(Point 9).

3 List of Documents for System Components

The system consists of the following components

- interface electronics

  according to this product specification

  Drawing with measurements of the board, document No. 65 93 91.40.02 (company Siemens)

- seat mat and antennas

- resonators

  resonator specification of the company Vogt, document No. 581 03 012 52

4 Appendix

5 Glossary

100baud protocol	variant of the ZAE protocol which communicates with the airbag control unit on the basis of a data rate of 100 baud
20baud protocol	variant of the ZAE protocol which communicates with the airbag control unit on the basis of a data rate of 20 baud
Airbag-SG	airbag control unit
AKSE	automatic child seat detection
AKSE parameter	EEPROM parameter of the electronics which determine the performance and timing of the child seat and seat occupancy detection
EXEQ	transmission path – ASIC-Pin – between ASIC and µC for the transmission of ASIC errors
FSR	force sensitive resistor
HT	subcarriers
ID	resonator protocol information
KISI	child seat
K line	communication line
KSE	child seat detection
OT	overtemperature
OV	overvoltage
protocol ID	identification – functional code – of the QC telegrams
QC mode	operation mode which does not comply with the mode in the vehicle, but it permits the selective execution of self-controlling system measurements. For the entrance in the QC mode, a login condition must be fulfilled in a certain time window after the Power-On. After this, one can communicate with the electronics in a bi-directional serial manner by means of special telegrams.
QC parameter	EEPROM parameter of the electronics which determine the performance of the self-controlling system measurements. In principle, these are limiting values.
QC telegrams	telegrams that cause the execution of certain tests or the output of certain information by the module in the QC mode
RESO	resonator
RX	is always given when the reference to the reception loops must be made. Example: ISO_RX_GND means isolation reception loops against GND.
SBE	seat occupancy detection
SC filter	switched capacitor filter
serious error	The occurrence of a serious error leads to the switch-off of the electronics in

	the ZAE mode. Serious errors are ITXGND_ERR and the overvoltage switch-off
SIF	serial interface – this means the serial interface between the ASIC and the µC
SRA	anode connection of the FSR
SRK	cathode connection of the FSR
SW	software
TX	is always given when the reference to the transmission loop must be made. Example: ISO_TX_GND means isolation transmission loop against GND.
type A/type B	refers to the resonator of the company Vogt and the sucarriers it generates: type A means division of the transmitting frequency by 40 and type B means division of the transmitting frequency by 56
UBATT/UBAT	supply voltage of the electronics from the vehicle
UV	undervoltage
ZAE	central airbag unit – airbag control unit
ZAE mode	operation mode which is used for the operation of the vehicle and the communication with the airbag control unit
ZAE protocol	protocol that uses the electronics for the information transfer to the airbag control unit