FUSE APPLICATION EXPERIMENT AE 2013

DEMONSTRATOR DOCUMENT

BRAKE CONTROL SYSTEM:
HYBRID TECHNOLOGY (CHIP ON BOARD) REDUCES SIZE BY 85% AND MICROCONTROLLER IMPROVES BRAKE LIFE AND PERFORMANCE.

1 AE abstract

The company Dr. K. Michel from Kittlitz, Germany was founded in 1993 by Dr. Michel and has 4 employees. Main business field is the production of Brake Control Systems. It is a typical small company located in the Eastern part of Germany coming from the R&D department of the Technical University Dresden.

Rational for such an AE project was the opportunity to increase sales and market share by introducing an innovative brake control system. So the customer wanted to have an improved product in order to implement it to their brake systems for electromagnetic spring load brakes. Special demands were the size of the new product but also an increased functionality.

So the objective of this AE was to develop a system which gives the opportunity of a cost saving in manufacturing in combination with reduction in size and an increased functionality of the system in order to establish this system at the market.

The market world-wide for such a product is about 50,000. This is about 10% of the total market for brake control systems.

The existing product is a brake control system, which delivers state information of electromagnetic spring load brakes. It is realised in PCB technology with discrete components. The function is based on the use of a magnet-field sensor. But the size of this solution makes it impossible to implement it within the brake, so that it is mounted outside the brakes.

Due to the use of a new technology in this case a Chip on Board (COB) technology a replacement of the old system with the improved product will be possible. This system is much smaller, has an increased functionality and allows an implementation within the brakes, which is demanded by the customers. So the improved product is a combination of an increased functionality, realised due to the use of a microcontroller, and a reduction in size, realised due to the use of the MCM/COB technology.

The project started in September 1996 and was finished November 1997. This results in a duration of 15 month. The project was founded with 80 K€. There was an extension of the original planned 12 month because of company intern reasons.

The most benefit of the AE was the improvement of the system in order to reduce the size and to add additional functionality, which allows a wider application field in different industry sectors. Also the acquired knowledge at the company will be used in further project. The estimated sales figures for the next years show that the payback period will be about 2 years and the ROI will be about 439 % on the FUSE investment.

The most important lesson learned by the company was that the choice of the right subcontractor is essential for the success of such a complex project. So the due to the close co-operation of the FU and subcontractor resulted in the necessary step for an intermediate solution in order to guarantee the functionality of the final MCM/COB solution.

Keywords

Brake control, Chip on Board (COB), hybrid, COB, Reduced size, microcontroller, MCM.

1. Company name and address.

Dr. Michel-SENSORIK, owner Dr. Michel
Bahnhofstr. 24, D-02708 Kittlitz, Germany

2. Company size

The company is a typical SME that belongs to the category of new enterprises in East Germany founded after the end of the former GDR. The company was founded 1993.

The company is independent with 4 employees and a turnover of 180K€ in 1998.

3. Company business description

The business of Dr. Michel SENSORIK is the development and manufacturing of customer specific electronic devices in the following business fields:
- magnet field sensor
- switch control devices
- power supplies
- data telemetry
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The most important among them for the companies daily business are the switch control devices and the data telemetry devices. In the market for switch control devices the company is without competitors, and they hope to save this position also within the next years. One step to do this is the participation in the FUSE program with this AE. Most of this switch control units are combined with brakes and couplings were the control different states within such devices. In the market segment of data-telemetry systems our company especially manufacturers by orders from customers. This results in a low number of this high quality products which will be produces during one year. The following list gives an overview about our customers:

The following overview shows the products of our company:

Application field	Product-name	industry field	market introduction
Sensors	magnet-field sensor	industry	since 1997
Data-telemetry	FTSK	laboratory	since 1997
	DC	medicine	since 1996
Switch electronic	CC, Clutch Control	drive-technology	since 1995
	CC-NT	drive-technology	since 1998
	BC, Brake Control	drive-technology	since 1995
	BC-MIN	drive-technology	since 1998

The business activities of the company are often combined with the realisation of special projects for different customers. The results of this projects deliver the base for further activities in this application fields. Most of the products are manufactured by the company itself. Also the assembling of such systems within the products of the customers, especially the Brake Control Systems, is done by our company. This activities will be increased during the next years in order to guarantee a real service for our customers. Some components which can not be produced or assembled by ourselves are outsourced to different companies.

4. Company markets and competitive position at the start of the AE

The brake control system is an add on system for the use in electromagnetic spring load brakes. So it is necessary to give an overview about the market of spring load brakes in order to obtain a feeling how the brake control system can be rated within this market segment. The spring load brake system is sold 500 000 times world-wide in a wide variety of size and application such as lifts. A comprehensive market study and consultations with different brake manufacturer showed that it is possible to implement about 50 000 brake control systems within these spring load brakes. The market is primarily brake suppliers in Germany, UK and Japan. The main aspect was that this can be only realised with the new product because the brake manufacturer said that these figures are only realistic if the control system can be implemented within the brake.

So our system will be introduced to this market as a new solution. But there is also sometimes a replacement of existing mechanical switch based systems. Due to this replacement our company has had a turnover of 35 K€ in this special business field at the start of the AE.

The world-wide market for brakes is shared by Japan and European. The main companies operating in this field are SUMITOMO, WARNER, LENZE, BINDER, BRINKMANN, BAUER and other. The German market is covered by 10 companies. Three of them have a market share of about 80%. So the success of our company is to co-operate with the brake manufacturer and to convince them to use our brake control system in their brakes.

The main advantage at this time is that there is no competitor at the market who can offer such a brake control system. We are the only company who can deliver such a solution to the market, this results in a market share for this special application of 100%.

But it is very difficult to operate in this conventional market segment. Most of the brake manufactures see no necessity to introduce such a system in their products. It takes a lot of marketing activities to show them the advantages of such a brake control system. A result of this activities was a co-operation agreement with one of the most important brake manufacturer the company BRINKMANN.

Our sales in this market over the last four years have been:

	Year			
	1995	1996	1997	1998
Sales (K€)	35	10	5	50

In the field of data-telemetry operating many small high qualified companies. It is very difficult to estimate a market share within this business field, because this products are not produced in high volumes over the whole year. This data-telemetry devices are only produced at special orders from customers.

The main objective of our company is to achieve its turnover up to 50% with the new brake control system. Because of the not existing regulations for the implementation of such a control system within brakes, another objective is to establish such a regulation in close co-operation with the brake manufacturer. For this purpose a further development and improvement of this brake control system is an important point also after finishing the AE.

Concrete projects with 3 companies are planned during the next years.

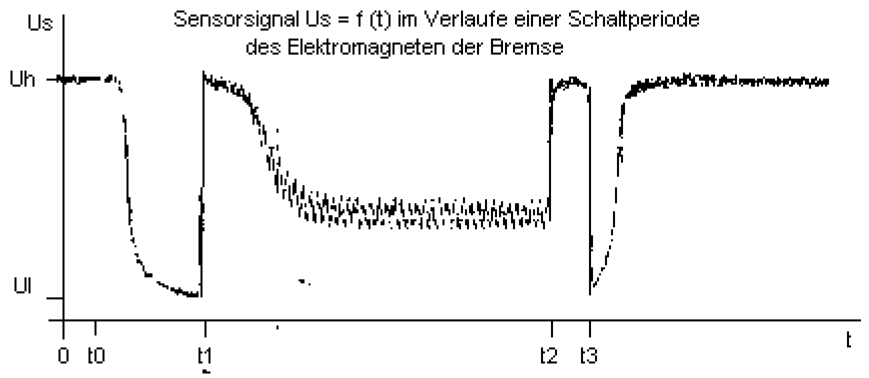
5. Product to be improved and its industrial sectors

The Brake-Control system was designed for the implementation in electromagnetic spring load brakes. The special developed magnetic-field sensor “esdec” allows to measure two main parameters of the brake :

- the abrasion of the friction clutch
- the ventilation state of a brake.

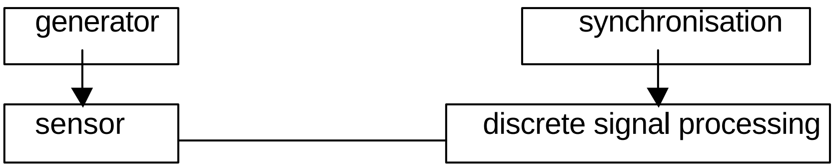
The system is realised in form of a PCB solution based on standard components. A software implementation is not possible. The use is restricted to one channel.

The magnetic-field sensor generates an electric signal which reflects the states mentioned above. This is done by a different amplitude and a different period of the signal. (Fig.1)



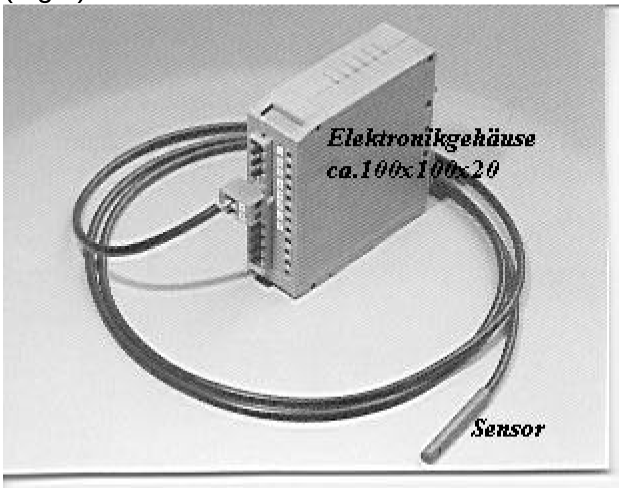
The signal stays at Uh level as long as the brake is without current. When the current is switched on some milliseconds later the signal decreases to Ul level. As a result, a connection of the tie plate and magnet part is realised at time t1. That means the air gap is zero. In the time between t1 and t2 the electromagnet remains closed. The drive is free. The current is switched off at t2. As a result the magnetic flux density is increased and the sensor signal increases to Uh level. At time t3 the electromagnet is switched off by the spring return. The sensor signal decreases to Ul level for a short time and increases to Uh level again based on the reduced remanence. The states “opened” and “closed” can be detected by evaluation off the signal changes at t1 and t3. The time difference t1-t0 defines the abrasion of the friction clutch. The detailed analysis of the resulting parameters requires a deep system know-how which is available at the company.

The signal processing was realised with discrete technology after the following schematic. (Fig.2)



The existing PCB-solution with standard components is successful placed at market. It is sold as a one channel solution for the implementation in switch cabinets.

(Fig.3)



This system was presented at the Hannover industry fair in 1995. During this event it was seen that the market for such devices only can be reached, if we can realise the following features:

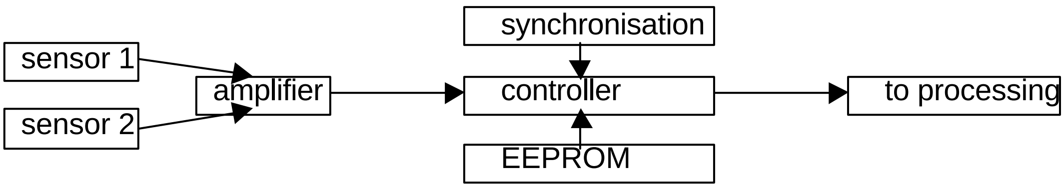
- two channel implementation (two-circle brakes, double-brake systems)
- reduction in size for implementation within the brake
- exclusion of manipulations from the customer
- function control
- storage of data for assessment of accidents
- higher functional adaptation
-

These demands and parameters are not achievable with the existing system. The main advantage of such a system is that there are no longer mechanical manipulations within the system are necessary.

However the technical realisation with the existing product did not allow its full implementation in the brake.

6. Description of the product improvements

The demands described above can be realised with a microcontroller in combination with new construction technologies. The following schematic was to realise
(Fig.4)



The main advantage of this realisation is the possibility to control processes within the brake.

This realisation is completely new at the market, but the producers of brakes must define which information must be provided for the user. The machine building industry, especially the brake manufacturer, allow no constructional variation in their product. That’s why we have to implement the product and the sensor in their existing products.

The microcontroller functionality allows processing of the sensor information so that improved braking, increased brake life and preventative maintenance are achieved. this results ultimately in lower life cycle cost and safer systems.

With the old solution only a mechanical diagnosis of a brake was possible. Only two status were displayed.

Through the new diagnostic possibilities an improvement in:

- reliability
- higher functionality
- higher flexibility
- reduction in size

are possible.

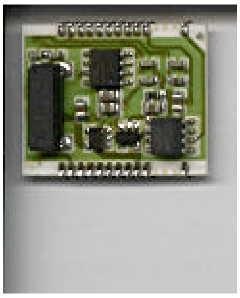
The first step within the AE was the development of a schematic of the system, because the schematic of the existing solution was not usable. This was followed by the implementation of a microcontroller and the introduction of a new construction technology.

As an important fact the ratio of purchase and sale prize should be higher than 3.

The following table gives an overview about the main improvement comparing old and new product:

	old	new
size	100*100 mm	20*25 mm
number of electronic components	30	10
number of PCB	3	2
functionality	2 (plate position, abrasion)	10(plate position, abrasion plate movement, break power, failure detection,...)
test, calibration	manual	automatic

A picture of the new MCM/COB assembly is shown (almost actual size):



There is no competitive product at the market. And to compare our product with the mechanical switches which were sometimes used in special brakes is impossible because the work at a complete different base.

7. Choice and rational for the selected technologies and methodologies

The main point for the improvement of the product, was the reduction in size without a significant cost increase and the implementation of electronic data processing and control. The existing solution has had a dimension of 100 x 40 mm. That's why it was impossible to implement this solution in the brake. There were two basic possibilities for the product-improvement:

- coupling of the existing system with a combination of microcontroller/EEPROM
- new development of the system with an implementation of signal generation by a microcontroller.

The first solution with a combination of microcontroller and EEPROM with the existing product would result in an even higher size. That's why we decided to design a complete new system based on a MCM/COB-technology. With this technology a control of the size is possible by use of a suitable current schematic. The company itself will not become a deliverer of MCM/COB-technology, but will acquire profound know-how in use of MCM/COB-technology.

At the beginning of choice of technology also an ASIC-solution was taken in consideration. But this solution was not suitable because the parameter which should be controlled were not specified by the customers of the product. The MCM/COB-solution with the flexibility of a microcontroller could be a good basic for an introduction of the ASIC-technology during the lifetime of the product.

The first choice for a microcontroller was the PIC-line because they :

- are RISC-controller (fast)
- have Agreeable prizes
- are approved in many products.
-

In our company we developed an interim solution in SMD-technology, which could not achieve the necessary reduction in size of the product. In detail the SMD-solution was more than 2 times bigger than the MCM/COB-solution. But some experiences from this development could be used during the implementation of MCM/COB-technology.

The total cost of the Brake-Control system should not increase a value of 10% of the costs for the whole brake. This can only be realised with the MCM/COB-solution. The real costs are depending on the used electronic devices, the layout and the number of elements.

The CAD tools used for the development were Mentor Board Station for the PCB design of the SMD solution (intermediate step for functional test) and Mentor Hybrid Station for MCM/COB design
(offers additional features necessary for hybrid/MCM/COB solutions, e.g. calculation of resistor dimensions which are printed on the ceramic

The necessary development tools were bought outside the AE.

8. Expertise and experience in microelectronics of the company and the staff allocated to the project

Within the company the PCB technology is used for the manufacturing of their products. So there is experience in design, test and manufacturing by using this technology. The technical manager has special experience in the application field of magnetic sensors due to his former profession in the R&D department. He has also basic knowledge in project management as well as experience in co-operating with other companies.

All of the staff were involved in the AE with the experience above.

Missing technical experience

- MCM/COB technology (design and manufacturing)
- SMD technology (design and manufacturing)
- Selection of high integrated standard components
- Debugging and test methods
- Microprocessor selection, integration and microprogramming.

During this AE knowledge in the fields of SMD- and MCM/COB-technologies was acquired. Special competence in the field of programming microcontroller is now available in our company.

9. Workplan and rational

The workplan for this project resulted from consultations with the TTN and the subcontractor (both parts were performed by GEMAC). Within the project the FU had the responsibility for nearly every step on the way to the final product. Only the manufacturing of the MCM/COB was a task for the subcontractor. The following table shows the effort for each work-package separated for the FU and the subcontractor. The value and signs within the columns are the original planned numbers. Because this project was based on a know-how transfer, the main activities of the FU were to take part on special organised meetings and conferences in order to get an overview about the technology and the handling of such projects. During the whole AE the FU take the leadership when caring out the special tasks. They did the main work especially in the specification of the MCM/COB system. This resulted also in an increased effort for the FU. They did more as originally planned in this tasks (53 pd instead of 40 pd).

Task	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1. Management	░	░	░	░	░	░	░	░	░	░	░	░			
	█	█	█	█	█	█	█	█	█				█	█	█
2. Specification			░	░	░	░	░								
	█	█	█	█	█	█	█	█							
3. Training	░				░			░	░	░					
	█				█	█		█	█				█		
4. Design							░	░	░						
							█	█	█						
5. Evaluation					░			░		░	░	░			
					█	█	█	█					█	█	█

Planned	░
Actual	█

The work done in the single tasks can be described shortly as follows:

Workpackage 1 (Monthly reports, TTN contacts, Internal management, Final report, Presentation, Publication) : The FU sets up experiment management schedules, managed the project in technical questions and delivers reports, the subcontractor assisted with in technical management planning; effort: FU 40 pd

Workpackage 2(Functional specification, Hardware planning, Software planning, MCM/COB planning) : The FU was responsible for making the system specification especially in functional related tasks, the subcontractor assisted in close co-operation for the specification in technology and design related tasks; effort FU 53 pd, SC 2 pd

Workpackage 3(Technical management, Specification training, CAD training, Evaluation training.) : The FU was took part in several training activities in order to acquire theoretical and practical knowledge in technology related and management related problems, the subcontractor organised or carried out this activities itself; effort FU 30 pd, SC 8 pd

Workpackage 4(Design circuitry for MCM/COB, µC/E2PROM integration, Layout for MCM/COB) : The FU developed the circuitry and the integrated µC/EPROM, made the layout for the MCM/COB and delivered the design for manufacturing, the subcontractor assisted especially in the MCM/COB design and the layout process of the MCM/COB; effort FU 90 pd, SC 8 pd

Workpackage 5(Test specification, Subsystem test, Prototype test, Brake Control test) : The FU tested the system including the software while the subcontractor manufactured the MCM/COB; effort FU 65 pd

The main event during the AE was the introduction of an intermediate step. A SMD solution was proposed from the subcontractor in order to guarantee an error free function of the MCM/COB. This step was discussed with the TTN and the FU. The FU also saw the necessity of this step and agreed to make this step an the way to the final MCM/COB solution. The effort for this solution was packed into the specification tasks. This SMD solution was realised only for functional test it can not be used as a replacement of the final MCM/COB solution, because it can not deliver the necessary functionality and the required reduction in size for an implementation within the brake. Within the project there was a break of 3 month, because the company had other no FUSE related business in this period.

Summary of effort and costs

	First User				Subcontractor		Total	
	Effort (pd)		Costs (K€)		Costs (K€)		Costs (K€)	
	Plan	Act	Plan	Act	Plan	Act	Plan	Act
1. Management	30	40	10,00	9,54			10,00	9,54
2. Specification	15	20	3,55	3,52	2,60	2,60	6,15	6.12
3. Training	20	30	6,30	6,90	6,90	6,90	13,20	13,80
4. Design	80	100	21,25	19,12	10,00	10,00	31,25	29,12
5. Evaluation	50	88	14,25	15,65	5,00	5,00	19,25	20.65
Total	**195**	**278**	**55,35**	**54,73**	**24,50**	**24,50**	**79,85**	**79,23**

10. Subcontractor information

Our objective within the preparation phase of the AE was to find a subcontractor for a wide range of activities. Of course an excellent know-how in the whole area of MCM/COB technology and microcontroller application was absolutely necessary. On the other side it was our objective to learn as much as possible within the Application Experiment in order to be able to solve such problems in the next time ourselves. That resulted in an additional requirement: A possible subcontractor had to be experienced also in the co-operation between two partners, especially in training and know-how transfer activities, and this not in an academic, but in a very industry-oriented way. This limited the possible choices in our region. Of course there are a lot of companies in the Dresden region that can be partners for MCM/COB developments. But most of them are not experienced in know-how transfer. On the other side academic institutes offer training courses at a very academic level, and a continuous assistance in the design task would have been complicated.

In order to avoid information lacks and to guarantee best practice in all tasks we preferred one qualified subcontractor for all know-how transfer activities.

Last not least there was an additional condition: Dr. Michel SENSORIK has no manufacturing department for the designed MCM/COB. Also in this area we need a supplier. The best way to avoid problems is to do development and production with one partner. As a result of the design, he will be familiar with all technical details. This prevents difficulties and guarantees a high flexibility in the case of necessary modifications.

Last not least the geographical distance should be as small as possible in order to have direct access without high effort.

Altogether formed the basis for the selection of our subcontractor. The following issues had to be realised by the subcontractor:

- Training activities for the Technical Management of microelectronics projects (selection of technologies, components and tools, definition of a workplan, costs, interfaces to subcontractors (what is effective to do ourselves),

- Know-how transfer in the field of MCM/COB technology and microcontroller application (inclusive the use of corresponding tools) in form of training courses followed by “Learning-by-Doing” activities
- Complex and “online” design assistance
- Ideally manufacturer of the prototypes and later on for manufacture.

We selected GEMAC Chemnitz as such a subcontractor. The company is experienced in training activities as well as practical designs in the microcontroller and MCM/COB area. Being a company itself, GEMAC is experienced in all “practical” aspects of the application of microelectronics technologies. The company isn’t a distributor of special tools or components and can give independent advise based on their own experiences.

Within different projects the effective know-how transfer to customers was demonstrated. Additionally, GEMAC has an own manufacturing department.

Last not least, the distance between Kittlitz and Chemnitz is relatively small.

The subcontractor was responsible for the training activities. These activities were immediately followed by a “Learning-by-Doing” Step – the programming of microcontroller and the design of first MCM/COB modules of the Brake-Control system.

This enabled the involved staff of our company to execute the next design steps themselves, based on a decreasing assistance from the subcontractor. In any case it was important to have direct access to the specialists of the subcontractor at any time by phone and -if necessary- by direct visits in Kittlitz or Chemnitz.

The basis was a contract between the partners in which all topics mentioned above were defined. Basis for the successful completion of the contract was the working prototype. Bonus or penalty clauses were not contained (except the common terms of business). Of course both parties declared to keep confidential all detailed technical or business information they got during the execution of the project. Dr. Michel SENSORIK owns all results.

11. Barriers perceived by the company

The origin of the staff including the manager are the former R&D landscape of the GDR. That’s why the basic principles of MCM/COB technology were known from 10 years ago. But the development of such technology was not followed up.

There were existing barriers in all fields of the AE. If the company will be able to introduce the Brake-Control system successful at the market the following question had to be solved:

management barriers:
How to start such a project
Without knowledge it is difficult to define a realistic workplan and to estimate the costs of such a project. First estimations of the cost deliver a value of 100 K€, which is going beyond our possibilities.

The manpower that has to be spent for training activities and project work is very high. We were not able to make a realistic forecast, because also the daily business of our company had to be solved.

Another problem was the division between activities to be done ourselves and to be outsourced to subcontractor during and after the AE.

Selection of partners
For the management issues as well as the know-how-transfer activities in all tasks we needed an experienced partner that had not only the intention to execute a paid project alone, but also to

organise an effective training. Because this know-how transfer prevents next orders to such a partner (we are able to do next projects ourselves), at least concerning the design tasks, it is not easy to find somebody who combines its technical expertise with the know-how transfer.

Additionally, it is risky to go to a design house or distributor who is connected only with one MCM/COB or µC manufacturer.

Technological barriers:
Specification of product features
In order to take advantage from the use of microcontroller and MCM/COB technology it is necessary to know all technical features of them. On the other side, there were some illusions what could be implemented in the system. The lacking know-how in this field was a real barrier to specify the new improved Brake-Control system.

Financial barriers
All the point resulted in a high financial barrier for our company. There was a risk to spend much money for training activities, wrong design tools, high manpower for a development that did not guarantee a successful and competitive product at the end.

Cultural barriers
This barrier was relatively low. The manager of the company has a very good understanding of what advantages the introduction of a new technology can bring to the products of the company. He already uses electronic technology like PCB and discrete components in his company before the start of the AE, so that the psychological step to another microelectronic technology was not so difficult as if there were no experience in the use of microelectronic. Sure there is a new quality between the use of discrete components and the use of MCM/COB.

All these barriers made it impossible to start a new development for our Brake-Control system before, even if we knew about features to be improved and the lack in flexibility that prevented additional market shares for our company.

12. Steps to overcome the barriers

The overcome of all these barriers which were explained in the last section was closely related to the execution of this Application Experiment. There were several ways for doing this. This process started already in the preparation phase of the submission.

management barriers
In several discussions with the TTN we got an overview about the complexity of a MCM/COB project. So the necessary manpower could be estimated. A first workplan was prepared. Later on during the project we realised what can be done ourselves and what processes must be outsourced. So we executed the most work ourselves and only outsourced the MCM/COB production itself.

technological barriers
During the specification phase of the project, we learned due to several training activities and learning by doing what can be realised with the new technology. Especially the possibilities of the implemented microprocessor were analysed. We chose the microcontroller with assistance of the subcontractor according our requirements.

financial barriers
Due to the good preparation of this AE and the funding of the project by the FUSE program the financial risk was minimised. So it was possible to concentrate our limited manpower beside the daily business on activities like training, co-operation with the subcontractor and learning by doing. Also the buying of the suitable development tools was now possible due to the consulting by the subcontractor.

cultural barriers
As mentioned above this barrier played not such an important role like the other. The management and the development staff realised within a short time the possibilities for the company due to the use of the new MCM/COB technology. After the feasibility study made in close co-operation with the subcontractor and the TTN all problems concerning this new quality of technology for the company could be solved.

13. Knowledge and experience acquired

Within the AE the company Dr. Michel SENSERIK acquired knowledge in many fields.

The modality and the contents of the knowledge transfer were done in a very effective way. The aim of all activities was to enable the FU to realise future MCM/COB projects himself.

Knowledge was acquired in the following fields:
- choice of technology e.g. availability, costs, required knowledge and equipment
- planning and managing MCM/COB projects e.g. define workpackages, estimate costs
- choosing subcontractors e.g. access, interact, interface, communicate
- development MCM/COB e.g. design, specification, manufacturing

The main advantages of this transfer process was that it was not only done theoretically. The learning by doing started with a practical training at the subcontractors facilities and was realised in this way during the whole AE. As a result an increasing of the know-how level at the FU could be estimated, so that the guiding activities by the GEMAC were decreased step by step. During this transfer process the FU regularly contacted the subcontractor in order to discuss problems or to present some achievements. Also the possibility to contact the specialist at GEMAC in case of problems was used frequently. Very important were their hints by the design of the MCM/COB layout and the right use of an in-circuit programmer for microcontroller. The FU is now able to set up and manage his own second project with MCM/COB technology as well as a project with a new technology. One important thing during this AE was the decision to make an intermediate step for the realisation of the final MCM/COB solution. This step required several meetings and discussions about the necessity with the subcontractor and the TTN but finally also the FU saw the necessity for such a step. The knowledge transfer for a MCM/COB project must be realised with as many information exchange as possible between the FU and the subcontractor, because it is one of the most difficult technology steps within microelectronic technologies.

What knowledge we gained was very much as we expected and we are now able to do the things we wanted to do before the experiment..

14. Lessons learned

The AE was a development project. An existing product was completely new designed. Starting with the electrical schematic and finishing with the prototype. A new construction technology has to be used. For this a personal base and the necessary equipment had to be realised in our company. This resulted in a very strong functional extension. It had to be estimated that such a process deliver valuable experiences for product improvements.
- The owner of the company realises that the investment in new equipment is not the objective of this AE. It is even better to generate to possibilities for design and implementation of a MCM/COB device.
- The implementation of new technologies leads to product improvements. This improvements are no guarantee for a higher prize accepted by the customer.
- The procurement of small amounts of IC’s was underestimated. The costs and the time were much higher than expected.
- Small companies which want’s to introduce new technologies in their products need a deliverer and partner for this.

- Training on the project is one of the best ways instead of theoretical training courses. An experienced subcontractor is the base for effective training and design assistance.
- The workplan should have a time reserve, because the planned time is only to be seen as a optimum. Time delays can arise in form of redesign, procurement of devices but also unhealthy and vacations of the staff.
- Especially for small companies the daily business of the company can influence the AE. If there are special orders from customers for other companies it is clear that the FU must interrupt the work for the AE, in order to keep his company alive by selling his products.

15 Resulting product, its industrialisation and internal replication

As a result of the AE the product is realised in two applications. These application will be implemented in the electromagnetic spring load brake.

Fig.5 Intermediate step (SMD) controller at the back plane M 1 : 1, size 25x30

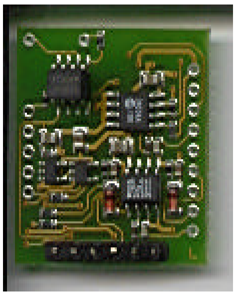
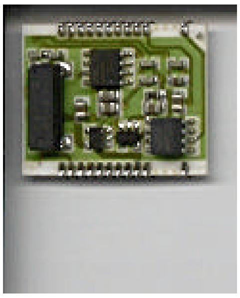


Fig.6 MCM/COB-construction, controller as bare chip at the back plane M 1 : 1 size 20x25



To realise the technical improvements have a look at Fig.7, which shows the system before the development by this AE.

Fig.7 PCB-construction, PCB for WEB case M 1 : 1 size 85x95

The objective of the AE was the increase of the market share and the establishment of the Brake Control System at the market due to the improvement of the existing solution. During the proposal phase of this AE there were several discussions, meetings and market analysis carried out in close co-operation of the FU and the TTN. Within this activities a list of important features of the system to be improved was generated. The most important points are:

- very small system in order to integrate it within different brakes
- very high functionality due to the necessity to carry out special diagnostics within the brake
- very high reliability, because the system should be implemented in systems (i.e. elevators) which could be hazardous for people and goods.
- Very high demands concerning the electromagnetic susceptibility, mechanical stress and heat

As the result of this demands on the system the only possible solutions were an ASIC or a MCM/COB realisation of the system. Within several discussions the MCM/COB solution was chosen because of the following reason:

- compared with the ASIC lower NRE cost taking into consideration the number of pieces to be produced
- different electronic components can be implemented, especially active and passive components for the connection with the sensor elements
- higher flexibility for special application within different brake types due to the implementation of a microcontroller

The possibility for a realisation of the system with a SMD solution mentioned by the reviewer in order to achieve the technical objectives of the AE was impossible due to the following reason:

- smallest size, a MCM/COB delivers always a smaller size as a SMD solution
- lowest electromagnetic susceptibility and highest reliability concerning heat, only a ceramic carrier as used for MCM/COB solutions can guarantee this due to his low dielectric constant and very good heating conductivity
- very high reliability concerning mechanical stress, the number of connection points within a MCM/COB is lower compared to a SMD because many connections are realised within the carrier

During the AE there was a development of a SMD **only** for the functional test of the system and as the base for a successful MCM/COB design. This SMD intermediate step can realise the basic functions of the brake control system but never fulfil the requirements concerning size, and reliability. So the SMD is not a solution with the same functionality like the MCM/COB solution as the reviewer mentioned.

Only the MCM/COB solution can fulfil the requirements concerning the size which was demanded by the potential customers for such a system. Please find enclosed the picture which shows the space in which the system should be implemented. So the customer will pay the higher price for the MCM/COB because the size and the reliability are their main objectives for the realisation of the brake control not the higher price of the MCM/COB solution.

For the future it is necessary to use the experiences acquired by this development process. The customers must be convinced of the high quality of the product. Based on the first class production the increase of the turnover has to focused on. For a future development of an ASIC the current schematic and software has to be inspected. In case of feasibility, such a development will be deliver a further reduction of size of about 50%. With this technology the use of masses of such brake-control systems could be realised.

The internal replication of the AE is the basic for our partnership with a brake manufacturer. For an implementation of our brake-control system within his product-line a repetition of the design and development process is necessary. Another point is the use of the new technologies in our products too. The MCM/COB are manufactured outside by a third party, but the implementation in the brakes is done ourselves.

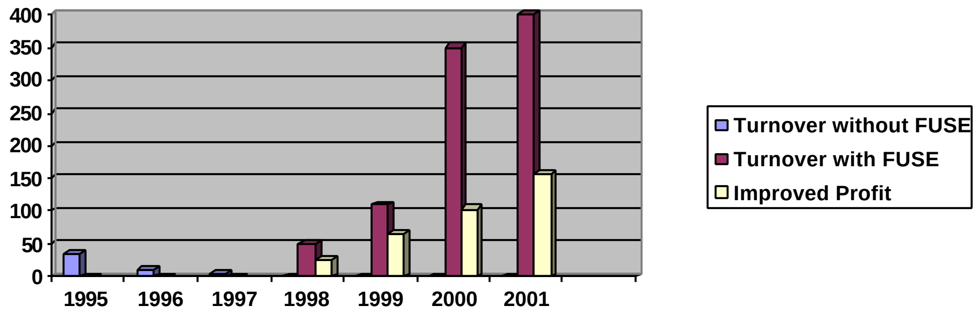
Industrialisation costs for the manufacture of the MCM are included in the product cost since this is outsourced and so about 5K€ was required to ensure that the system was reproducible in quantity. This was concerned with final test of manufacturing prototypes and lasted about 2 months.

16. Economic impact and improvement in competitive position

The company Dr. Michel SENSORIK had a turnover of 35 K€ in 1995 with the Brake-Control systems. In the market segment of systems for detection of abrasion and tie plate orientation the company is the only manufacturer and has no competitors. The whole brake-control system is an add on for brakes. That's why the forecast of future sales figures is not easy. We had to contact the manufacturer of brakes in order to co-operate with them, but this means also that our turnover has a strong relation to the number of sold brakes of this manufacturer. The following table shows the turnover which will be achieved in the different application fields of this brake control system. Without an improvement of the system it would be impossible to sell this system further to the brake manufacturers. The turnover of realised with the old system would be going to zero. Only with the new system is a co-operation with the brake manufacturer possible.

	annual turnover (K€)						
System-type	1995	1996	1997	1998	1999	2000	2001
BC-DB-100				50	50	150	150
BC-ZK-12					50	150	150
BC-LB-380					10	50	100
BC-EB-st	35	10					35

DB ... double brake; ZK ... two circle brake; LB ... lamella brake; EB ... one circle brake



The costs of the product so far has to be calculated by the price of the components used, the amount of assembling the system, the marketing activities. We are also restricted by the demands of the brake manufacturers i. g. the costs of the brake control system has to be within a range of 5-10% of the whole brake. This results in a selling price of about 50 ECU per system. Taking into consideration that the prices of brakes are nearly constant the selling price of our new system has to be in the same region like the old ones. That means if we want to increase our turnover we have to reduce the production costs or we have to sell more systems.

The estimated figures are shown in the following table.

	annual turnover by pieces			
System-type	1998	1999	2000	2001
BC-DB-100	1000	1000	1500	1500
BC-ZK-12		1000	1500	1500
BC-LB-380		500	1000	1000
BC-EB				2000

DB ... double brake; ZK ... two circle brake; LB ... lamella brake; EB ... one circle brake

The number of pieces sold as a result of this AE will increase because of the penetration of new market segments. Based at this figures the return on investment and the payback period can be estimated as follows.

The costs for the estimation of the return on investment (ROI) taken into consideration are the manufacturing costs, the costs for establishing a series production, the costs for the parts of the system which will be bought from the subcontractor, the costs for necessary marketing activities and a life time of the product of about 4 years. A sum up is shown in the following table.

Manufacturing costs (assembling)	12 ECU
Series production establishment	is established before AE
Parts from the subcontractor	12 ECU
Marketing activities	done by customers
Sales price of the system	50 ECU

This results in a profit per system of about 26 ECU. Combined with the estimated number of sold pieces over 4 years, that means an ROI of 439 % and a payback period of about 2 year on the FUSE investment.

17. Target audience for dissemination throughout Europe

Best practice lessons learnt in this experiment are concerned with:

- Product specification
- Selection of technologies to match product needs
- Selection of subcontractor
- Economic modelling
- Product requirements from marketing.
- Project planning and management.

The most important points which were typical for this AE and the company are listed as followed, and should be the base for the search of a potential replicant :

- Dr. Michel is typical SME in East Germany, which has established successful at the European market with own products since 1991. They have experiences in standard technologies and special applications. The introduction of new technologies like MCM/COB was completely new for them from both side, technical and economical.
- One of the main experiences is that the choice of the right subcontractor is the base for a successful introduction of new technologies in the companies products. The knowledge transfer delivers the base for own activities in this field.

The main target audience are small companies which are able to acquire knowledge and carry out the most activities themselves.