FUSE Demonstrator Document

Low Emission PCB for weighing machines

AE No : 25853

Associated TTN : INTRACOM S.A.

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AE Abstract

LEON ENGINEERING is well established in the industrial weighing sector. The company designs, develops, manufactures and markets a rich line of products ranging from simple and advanced scales, weighbridge, batching, dosing, filling, loss-in-weight, weighing in motion, piece counting, check weighing, networking, weight data collection and barcode labeling, and other weighing system applications. The company also exports electronic weighing machines to OEMs. The electronic part of these products consists mainly of microprocessor based PCBs.

The objective of the AE was to help LEON ENGINEERING to derive experience in the design of low emission – high immunity PCBs so as to gain EMC approval for its products. A representative instrument was chosen for the experiment namely D2000BCU weighing batching controller.

D1000/D2000 family is part of Leon Engineering products, with very satisfactory weighing performance but it failed the EMC test when the company applied for obtaining the European Approval. The major target of this AE was to design a main board to conform to the directives 89/336, 90/384.

The new main board is an SMD technology design providing emissions with very satisfactory safety margins and immunity levels above requirements. Additionally speed and memory capability has been increased. Size has been decreased enabling redesign of the models in smaller enclosures (1/3 of the initial volume) reducing manufacturing costs in some cases. The knowledge and experience obtained from the AE enhances the company's engineers to redesign successfully existing and future products.

The duration of this AE was 11 months. The project started November 1st 1997 and ended at 30 September 1998. The actual budget was approximately 79 KECUs. Payback period is expected to be 11 months while the ROI on the FUSE investment is estimated to be 405%, three years after the introduction of the product into the market.

Keywords and signature

Keywords : Weighing machines, EMC approval, Low emission PCB, SMD technology.

Signature : 1-01225101204-0-3320-2-33-GR.

1. Company name and address

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2. Company size

LEON ENGINEERING S.A. has 65 employees divided in the following departments:

Management	2
Administration / Finance	6
Sales	9
Production / Service	27
R&D / Engineering / Quality control	17
Marketing	3

The average employee age is 33 years. 40% of the staff are higher education, graduates and 10% post-graduates. For the technical requirements of the project, a team of engineers was occupied from the Research and Development department comprising of one expert on system design and two electrical engineers expert on PCB design and system integration. Dissemination and exploitation activities were performed by the marketing department in co-operation with the engineers, while the management was conducted by senior manager. LEON ENGINEERING turnover is 6 MECU (1998).

3. Company business description

LEON ENGINEERING SA is a rapidly growing company that manufactures high technology products in the field of electronic weighing and industrial process automation.

It is the largest manufacturer of electronic scales and industrial systems in Greece, producing almost all types of electronic industrial weighing machines, such as weigh-bridges, platforms of various capacities (6-6,000 kg), automatic batching systems, slaughterhouse scales, crane scales, live animal scales, etc. It also specialises in the design and manufacturing of integrated weighing and data processing systems in industrial environments.

For the past two years the company has shown an impressive growth, producing a turnover of 2 billion drachmas for 1998, increasing the 1997 turnover by 28%.

The Company employs skilled and specialised mechanical and electronic engineers for hardware and software developments. In addition to the above, the company also works closely with external consultants on technical matters.

From the beginning of its formation, the company has aimed to provide high quality products and services to its clients. In this direction, it is constantly updating its products and continually seeking innovative and economical solutions to engineering problems, while the technical support it provides has been proved to be very successful by many customers both in Greece and abroad.

High standard engineering, high quality and performance of the company's products, responsible after sales service and the ability to take on and complete difficult projects is the base on which the company's future perspective is built on. All the above have placed the company in a leading position in the Greek market and open up great potentials for its export department.

Leon Engineering's product range consists of weighing indicators / controllers and systems that cover the majority of applications in the industrial weighing market.

- D500 family. Comprises of the models D500, D500B, D500N, D500NB, D500F, D500BC. They are versatile and economical digital weight indicators having all the basic scale functions and may be mains or internal rechargeable battery operated. The N series offer floor-scale and weigh-bridge functions. D500F offers digital and analogue interfacing to higher-level process control equipment. D500BC is an economical weighing controller for batching and blending applications.

- D1000 family. Comprises of D1000, D1000N, D1000N2, D1000AN2. They are suitable for weigh-bridge or scale applications offering numeric terminal, weighing memory, totalisers, data display, EDP port and additional alphanumeric keyboard.

- D2000 family. Comprises of D2000N2, which is a powerful numeric terminal suitable for high complexity weigh-bridge or scale projects and D2000BC, which is an advanced weighing controller for batching and blending applications.

- D1500/D2500/D3500 family. They are identical in weighing performance and functionality with D1000/D2000 family, but with extensive metal shielding in order to obtain EU type approval.
- _5 and MW1 are very simple and economic weighing indicators for non approved applications.
- PYRRHUS is a portable digital crane scale.
- ATHENA family: A series of price computing scales covering simple and advanced applications.
- WEIGHING KITS. The company offers mechanical kits for weigh-bridges and silo & tank weighing.
- BAG FILLING: High accuracy machines Gross (~ 180 B/h) or Net (~ 600 B/h)
- WEIGHING SYSTEMS (Software and hardware) :

- BASCON : Batching control system
- BETONICS : Ready mix controller system
- MANDOS : Manual dosing weighing formulation and control
- MAMMOTH : Weight labeling system
- SIMPLEX : Weight labeling scale
- LELAPS : Integrated software for factory weight data collection & barcode label printing.
- LEWIS : Weighing & data collection system for weigh-bridges.
- WEIGHMATIC : Unattended weigh-bridge system.

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

LEON ENGINEERING’S client portfolio, in the Greek market, consists mainly of end users and distributors, while its export market is mainly OEM’s and system integrators. The company’s long term experience and know how in the industrial weighing and automation industry, its dedication to manufacture products of high performance and quality and its never ending stride to offer services of the utmost quality, wherever needed, apply equally to both local and export markets. The company’s total turnover comes from the sales of weighing equipment, systems and installations.

The Greek weighing industry market is made up of 20 individual companies. Almost 80% of this market is shared between the 4 - 5 major competitive companies. LEON ENGINEERING has approximately 30% of this market and is by far the largest of its kind in Greece.

The Greek market for weighing equipment is approximately as follows:

DEVICE	TOTAL GREEK	APPROVED GREEK	NON-APPROVED	LEON SHARE APPROVED	LEON SHARE NON

	MARKET (pcs)	MARKET (pcs)	GREEK MARKET (pcs)	GREEK MARKET (pcs)	APPROVED GREEK MARKET (pcs)
Weigh-bridges	250	90	160	40	30
Industrial platforms	600	210	390	95	80
Shop scales	5000	1750	3250	700	200
Bench scales	1000	350	650	150	130
Batching plants	350	122	228	60	45
Various other applications	800	280	520	140	100
TOTAL	8000	2802	5198	1185	585

All of the 8,000 units mentioned must comply to the 89/336 and 90/384 directives (the same stands in the whole EU), but are divided in about 35% for the approved (legal for trade) and 65% for the non approved market. The Greek indicators/controller market is estimated at present at 2.4 MECU for the approved market and 3.1 MECU for the non approved. Before the AE the company's indicator/controller Greek market share was about 45% in the approved and 20% in the non-approved one.

The ElectroMagnetic Compatibility Directives 89/336 and 90/384 apply to all apparatus liable to cause or be affected by electromagnetic disturbance, that are placed on the market or taken into service. Since 1 January 1996, most electrical and electronic products sold in the EU must be constructed so that they do not cause excessive electromagnetic interference and are not duly affected by electromagnetic interference. They must carry the CE mark to show that they comply with these requirements and a manufacturer's declaration of conformity must be prepared for each product, and be made available to the authorities on request for up to 10 years after the last product of that type has been manufactured.

In addition to the Greek market the company aims at a world wide market share and is presently active with sales in Europe, Middle East and the Far East, but with sales promotion all over the world. It started to make a significant contribution to total turnover in 1996 and it nearly doubled in 1998, while estimates for 1999-2000 are for an annual increase of more than 50%. The bulk of sales to Europe are for approved instruments, while the majority of exports to the Middle and Far East are of the non approved type with special requirements, but because of increased competition the standards are raised there as well. The export turnover has the following evolution:

Year	**Total turnover**	**Export turnover**	**Increase**	**% of total turnover**
1996	Euro 2,150,000	Euro 167,000		7,8%
1997	Euro 4,875,000	Euro 177,000	6%	3,6%
1998	Euro 5,940,000 ***Estimation***	Euro 250,000	41%	4,2%

1999	Euro 8,000,000	Euro 470,000	88%	5,8%
2000	Euro 9,200,000	Euro 800,000	70%	8,7%

The product selected to be improved by the AE was the D2000 BCU, a high accuracy and performance weighing controller that normally operates in severe industrial environments where EMC requirements are more stringent. Prior to FUSE AE this controller had been submitted for approval and failed.

It was evident that if the company wanted to stay at the first position in the Greek market and competitive for the international market, then it had to make the big step and provide only approved products as the market tends to these products. The company's already approved products have been achieved after a lot of PCB design-iterations and test measurements until achieving the EMC approval. These design iterations lead to extra company's effort and expenses, as well as to a long time to market of these products. It was evident that this was not the right way to achieve the EMC compliance for the products and a new strategy had to be followed, so as the PCB designs iterations to be reduced.

A table with our competitors in the Greek and international market and their products is given below. The table lists only competitive products to D2000BCU. It is difficult to match all the common points because every company follows its own design and feature philosophy. The common for all of the competitive products that are reported is that all satisfy the European EMC requirements. The new, improved Leon Engineering product named LESCON is also listed.

COMPANY/ MODEL	**PRICE (ECU)**	**ADC RATE int. Counts**	**SER.PORTS Nr / type**	**DIG. I/O**	**FEATURES / APPLICATIONS**
LEON ENG D 2000 BCU	773-1515	5-200 500.000	2 or 4 RS232 /RS485 20mA c.loop	16-64 IN 16-64 OUT (24 V)	* flexible system configuration & expansion *menu driven operation hopper scales, filling, bagging batching blending, loss-in-weight
GSE 650 SERIES	1362-1648	50 1000000	4 RS232 RS485 optional	136 I/O (24V IN, relay OUT)	*SCR feeder control*Fully programmable (250 macros) demanding applications
AD4325A/V	1113-1390	70 96.000	1 or 2 20mA c.loop RS232	16I/O 24VIN relayOUT	*fully automatic batching mode *gravity compensation / batching.
MINIPOND 25	1287-1802	50 1000000	-	-	*advanced filling function
SCHENK DISOMAT C	1184-1545	100 -	2 or3 RS485/ RS422 RS232 or 20mA cur.loop	OUT relay IN (24V) groups	*standard function block configuration *EDP/PLC connectivity/cargo, check, crane filling, discharge scales
PRECIA MOLEN MASCON 2	1800-2317	125 -	1,2,3,4 RS232 RS485 20mA cur.loop	16 I/O (24V)	*state-of-art controller *central planning / bagging & bulk scales

PFHISTER MSR2	1287-1545	100 -	1,2,3 RS232, /20mA c.loop	16 IN/ 16 OUT	*advanced design, communicatio functions, *reliabledosing regulatio batching, blending
AVERY BERKEL L225	772-1030	- -	-	-	*auto target weighing IFC /weighing, filling machines
LEON ENG LESCON (new product)	773-1515	5-200 500.000	2 or 4 RS232 /RS485 20mA c.loop	16-64 IN 16-64 OUT (24 V)	* flexible system configuration & expansion *menu driven operation hopper scales, filling, bagging batching blending, loss-in-weight

Strengths of the company in the local market are:
- Technical support & service / Flexible in software
- Long-term experience and know-how in industrial weighing
- Market share – leader in Greece
- Image of “a Reliable & Quality oriented” company (ISO 9001 certified)
- Increasing promotion plan budget (for brochures, exhibitions, mail, adv. insertions, etc.)
- Financial wellbeing / flexible structure
- Concentration on R & D / Technical edge / Effectiveness / Staff training
- Reorganization of LEON ENGINEERING in a five business units - model (shop scales, industrial weighing, weighing systems, turn key plants, weighing instrumentation)

Weakness of the company:
- Production: Low capacity, low human resources, no satisfactory ready-for-sale stock.
- Insufficient production cost monitoring.

5. Product to be improved and its industrial sectors

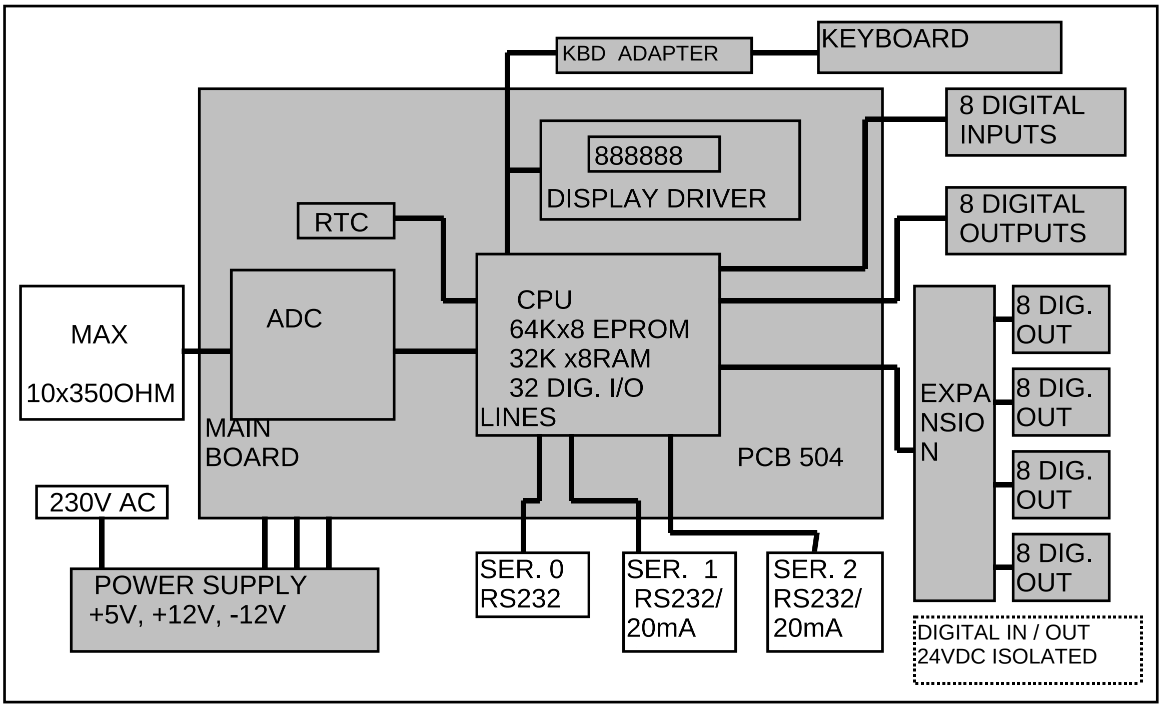
As it was mentioned earlier, the product selected for the improvement was the D2000 BCU, a high accuracy and performance weighing controller that normally operates in severe industrial environments where EMC requirements are more stringent. The unit consisted of a main PCB incorporating many functional modules with different levels of complexity and input output interfacing with motor starters, frequency inverters, solenoids, level switches, PLCs, printers, host computers e.t.c.

The D 2000 BCU is a family of batch control units, comprising of four models, the core of which is an advanced weighing controller for single scale feeding, batching and blending applications. Features of the product:

- Memory for 60 recipes of 16 ingredients each in mixed sequence
- Coarse - fine - tolerance – dosing time - settling time for each ingredient
- Two filling speeds, Fill and Discharge control with time monitor
- Ingredient change within recipe execution , % of recipe execution
- In flight compensation / Dynamic overweight control
- Silo selection (basic unit is upgradable via add on I/O PC boards and can handle 6, 16, 24, or 31 silos depending on the number of boards installed)

- Password protection on recipe and parameter memory
- 2 totalizers-Counters (for each ingredient & each formula)
- Weighing functions: Zero, Tare, Gross, Test, AZM, Motion Detection
- 28 key full numeric flat membrane keyboard inc. 12 direct function keys.
- LED red display (7 digits, 7 segments, 14mm high)
- Three communication ports (RS485,RS232C, 20mA C.L.)
- Continuous test & Error Indication / Reports (batch, recipe memory, error)
- Multiple D2000-BC can be connected via industrial network to a PC for multi-weigher batching and blending applications.

D2000BCU BLOCK DIAGRAM



These models are housed in various packages (aluminium, or stainless steel box) but all the packages are based on the same PCB. The PCB is mounted on the back of the front panel and contains all the electronic components plus the numeric and character displays. The PCB is a double sided plated through with overall dimensions 350mm X 110mm . On this PCB are mounted the CPU, 32K of RAM, 64K of ROM, the serial EEPROM the keyboard and display controller, the serial port peripherals, and the required logic to access the peripherals and the memory. There are 4X8 I/O buffered lines, a real time clock and a discrete component ratiometric ADC with high stability strain gauge amplifier (0.5_V per increment).

The PCB is assembled and soldered using conventional techniques and procedures. Since the designers of the PCB had not taken any care for EMC, the relevant products had been tested and did not conform to the 89/336 (Electromagnetic Compatibility) and 90/384 (Non Automatic Weighing Instruments) EEC directives, as it was found out when the instrument was submitted for type approval.(DELTA Electronics Testing, EU – Notified body No. 0199).

The shielding provided by the metal enclosure was insufficient because of the display and keyboard window, the fitting of the metal parts and input output cables and connectors. The immunity aspects were taken care in the installation of the unit with careful selection of EMC suppressers (suppress at the source principle), shielded cables and isolation of the instrument from the switch control cabinet so that normal operation was guaranteed but at extra cost. Emission levels could not be controlled. A different internal wiring arrangement would produce unpredictable results.

As EU directives came in to force and customers require products with approval, an immediate action was required in order to stay in the market. At the same time competitive instrumentation was getting smaller, with more features and more cost effective. It was evident that the company should be able to design the product with PCB level compliance.

6. Description of the technical product improvements

The outcome of this project was a general purpose main board that can be used in industrial weighing instruments/controllers, fully compliant to the applicable standards (Metrological aspects of weighing instruments EN45501 Annex B, OIML R76) and EEC directives(90/384, 89/336). These directives consider the following phenomena that can be regarded as electromagnetic disturbances:

1.Conducted low-frequency phenomena
•slow variations of supply voltages •harmonics, interharmonics •signalling voltages •voltage fluctuations •voltage unbalance •power-frequency variations •induced low-frequency voltages •DC in AC networks •DC ground circuits

2.Radiated low-frequency phenomena
•magnetic fields (continuous or transient) •electric fields

3.Conducted high-frequency phenomena
•induced continuous wave (CW) voltage or currents •unidirectional transients

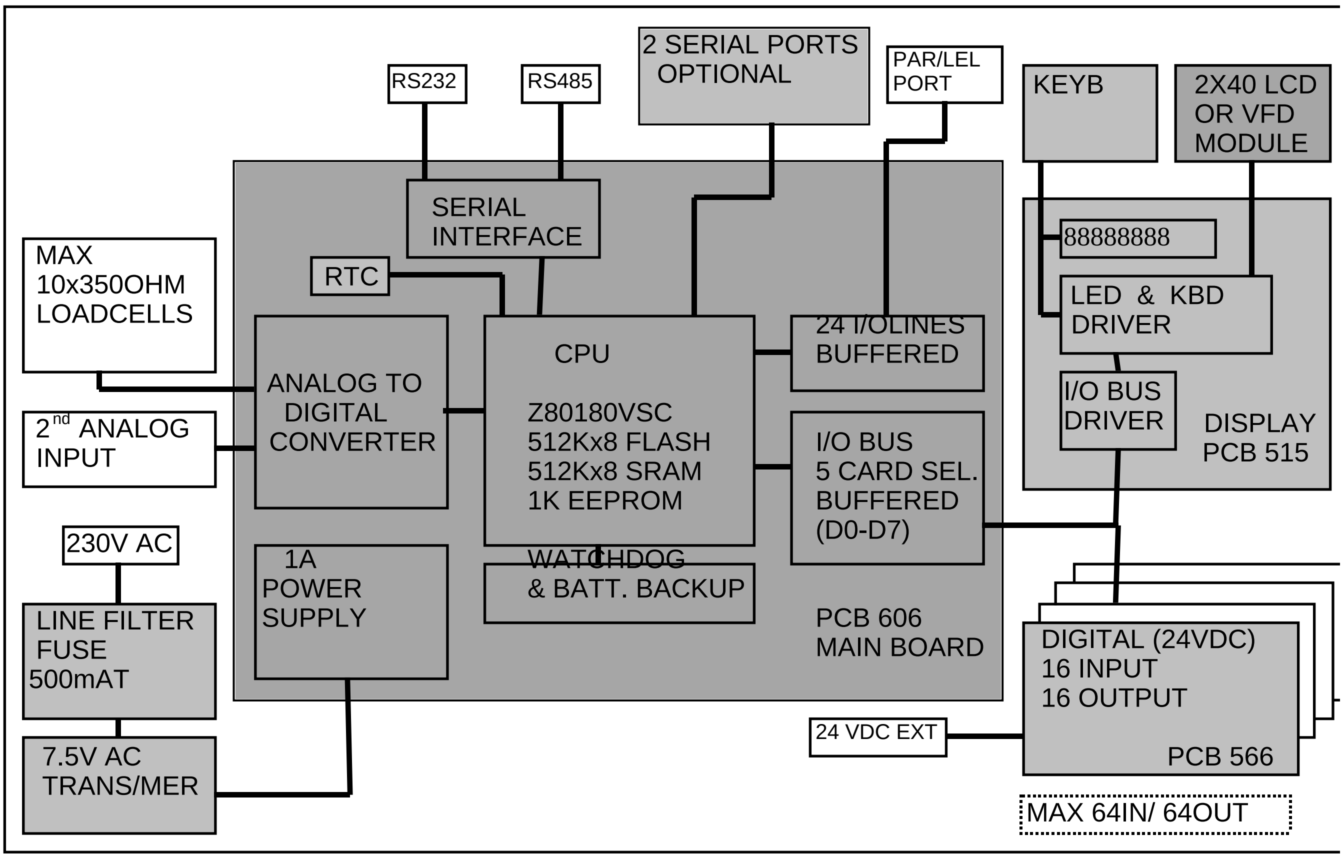
4.Radiated high-frequency phenomena
•magnetic fields •electric fields •electromagnetic fields •continuous waves •transients

5.Electrostatic discharge (ESD) phenomena

The developed board, a display and a keyboard board with a process input output board enabled LEON to build a new model, named “LESCON”, compatible with

D2000BCU, compliant with the EMC standard and with substantially added performance.

LESCON BLOCK DIAGRAM



The major changes and improvements of the new PCB come from the use of Surface Mount Technology, SMT, and the use of low power slew limited devices. Length of tracks especially address and data were kept as short as possible to minimize emissions. The small size of the new ADC enabled a better placement on the main board surrounded with a copper “frame” connected to ground. Signals enter the “frame” with EMI PCB filters (DSS 306).

Proper parts placement, effective grouping in combination with well designed ground planes raised the immunity level by 4-5 times compared to the old design and 2-3 times compared to the required standards.

Immunity to radiated EM fields of 7-10 V/m without degradation of performance was tested, compared to 3V/m required by the standards, without metal shields on the sensitive analog part.

Immunity to Fast Transients Bursts was raised to level 3, (3KV to mains power supply and 1,5 kV to signal and I/O lines), compared to level 1, (1KV mains, 0,5 kV lines), required by the standards.

Immunity to Static Discharge was tested to 8 kV contact and 12kV air, compared to 6KV contact, 8KV air required by the standard.

The average emission level was reduced to 20 dbuV/m, with a safety margin of at least 6 db (from highest peak in the spectrum) compared to limits for class B products.

The CPU’s clock frequency was raised without effect on emission requirements. The CPU crystal is now 18.432 MHz compared to the previous 6.144 MHz. Increased clock speed was possible without threatening EMC limits because of the excellent layout, as SMD allow very short interconnecting wires.

The memory capacity was increased to 512Kx8 RAM and 512Kx8 EPROM. The feature of a Flash memory was added to enable the development of low-level software to support the reprogramming trough a serial port.

The parts that remain as through hole are connectors, inductors, high value capacitors and EMI filters, as these parts were either unavailable or unreliable because of their limited mechanical strength.

The size of the main board was reduced to 50% length or to 25% area. The size of the new main board is 180 x 110mm with the power supply components included, instead of 350 x 110mm of the previous model. The size reduction enables the use of smaller volume enclosures with costs reduced from 20% to 40% depending on type.

The assembly cost of the new board is about the same with the old one (10 ECU), but the man-hours for the assembly of the complete new instrument are 50% less than the previous one. Human error is expected to decrease due to fewer interconnections.

Reliability of the instrument mistakes during assembling a PCB of this level of complexity reach to an amount of 10% of fault boards. The time for repairing and detecting them is considerable. The advantage of SMD technology to give eliminated amount of fault PCB’s, makes use more profitable.

The communication of the main board with peripheral boards is based on a low speed latched I/O bus (designed to accept up to 5 cards). Peripheral boards are connected with the main board with a single 26 way flat cable reducing internal wiring in comparison with the previous model. One of them is the necessary to operator display and keyboard. The other 4 cards are designed as 24V dc optoisolated process inputs and outputs. Each card has 16 inputs and 16 outputs raising the total available capability of the unit to 64 inputs and 64 outputs. This design is more flexible in the configuration of the controller. From EMC scope the latched I/O bus is significantly more quiet compared to the address / data section, reducing emissions from interconnecting cables. A disadvantage of I/O bus is the requirement of a driver circuit for each board, that led to the design of 32 I/O digital input output PCBs, compared to the 8 I/O of the old model .

The ADC performance was raised in terms of speed and long term accuracy as the new SIGMA/DELTA converter used includes a self calibration circuitry. The sampling rate was increased to 220/sec compared to 20/sec of the previous design.

Finally, concerning the power consumption it should be noted that the new unit was powered by a 9V/500mA ac mains adapter and single 5Vdc, compared to the 230Vac input and 5Vdc, +/-12Vdc of the previous model. Compliance with the Low Voltage Directive, is easier to achieve and maintain in the new model.

7. Choices and rationale for the selected technologies, tools and methodologies

Device technology

PCB technology. Although the project was initially targeted at reducing EMI emission due to the PCB it was quickly understood that cable emissions were also dependent on PCB topology. Furthermore it was realised that the susceptibility issue was of equal or even more importance in the design of the PCB.

Surface mount technology (SMT) offers smaller component sizes and should therefore give reduced interference coupling, since the circuit loop area can be made smaller. To take full advantage of SMT a multilayer board construction with ground plane is normally necessary in order to reduce track coupling. A significant advantage of SMT is that due to smaller component sizes more room is made available on the board for additional functions or for quiet areas to fit EMI suppression devices for peripheral connections if needed.

A double-sided PCB was decided to be experimented with instead of a 4-layer design on the grounds of reduced cost and investigation of the design techniques and tools. Partial ground planes were used in critical sections of the board. If the 2-layer board worked that would cost half the price of a four-layer board and would be available by many more vendors which enhances delivery times.

As the requirements of the digital section of the board are not very high (e.g. clock frequency of 18MHz) a carefully laid out PCB to minimise board area and track size could have a good chance of success. In any case SMT and 4-layer PCB would be attempted if the double-sided board failed.

- Components. Through hole or SMD. Through hole are the most available in market and they can be used for production of small quantities but reducing of the board size and keeping tracks as short as possible is achieved with SMD components. Production cost is lower in large quantities and SMT machine assembling reduces faulty boards. Additionally given the size reduction of SMT components more room is made available for quiet areas and suppression components for I/O.

Design methodology.

The procedure chosen for the design of the PCB was based on the maximum knowledge to be acquired by LEON engineers. For this reason the design was performed with continuous interaction and work with the Subcontractor. As there was no interface from QUIET to ORCAD, and LEON wanted to retain its PCB file formats, the design was performed with close interaction and continuous step by step feedback. At short intervals of time the PCB file was e-mailed to Subcontractor, simulated with the QUIET tool, and remarks for emission results and suggestions for optimizing was returned to Leon. The final design had the optimum performance and the maximum experience was derived.

In general for reduced emission care should be taken for:

- Selection of the clock frequency. Raise of the CPU crystal raises the emissions.

- Selecting the slowest logic family to handle the job.

- Proper decoupling by choice and placement of decoupling capacitors adjacent to chips and di/dt limiting by series resistance where reduction of the track is not possible.

- Shielding. RF metal shield was designed for the sensitive (0.4_V per increment) analog part, but it was not finally needed because the RF immunity of the part was a good margin better than required.

- The PCB must be designed such that it meets the requirement, even when placed inside a plastic enclosure.

- Grouping parts effectively. Because of the presence of analogue, digital, communications and power supply components present on the source board the design method was based on a partitioned system to account for the varied EMC aspects.

- A star ground system optimised to include partial ground planes in the critical section was executed, with a clean ground arrangement for the input-output connections.

- A linear power supply was chosen because of its low emission and because the ripple output is suitable for sensor excitation. Separate tracks were used for the sensitive analog part.

- Intermittent operation of the internal I/O signal lines was chosen and a proprietary I/O bus was designed to fulfill the task.

Testing methodology.

-Prior to the EMC measurement, simulation of the board was made from the Subcontractor. He used the QUIET (Quad Integrated Emi Tool which is a package developed by Quad Design for the simulation of Printed Circuit Boards radiated Electromagnetic Interference EMI). It is a tool intended to help designers localize, quantify and correct radiation problems on PCB’s. QUIET runs on Unix systems and although it is an individual product, it is delivered as an add-on for the Mentor Graphics Board Station. Leon Engineering used the ORCAD tool for the design.

-Emission limits. Conformance to the 89/336/EEC directive was the major criteria. The emission control requirements for industrial and domestic areas are shown in Table 1 and 2 respectively. The LESCON unit (frequency range 150 kHz-1GHz) is used in industrial areas and conformance to the EN55011 class A limits is required.

Finally, the unit was able to satisfy the EN55011 class B limits that are 10dB lower (considering the same measuring distance).

Class A Limits for Industrial Areas									
Frequency Range, __z 0.15 _ 0.5_ 5 _ 30_ 230_ 1,000									
Specifications	DB_V		DB_V		dB_V		DB_ V/m	dB_ V/m	NOTES
	QP	AVG	QP	AVG	QP	AVG	QP	QP	Quasi-Peak, Average
EN 50081-2, "A"	79	66	73	60	73	60	30	37	@ 30m, A Limit
EN 55011, "A"	79	66	73	60	73	60	30	37	@ 30m, A Limit
EN 55022, "A"	79	66	79	66	73	60	30	37	@ 30m
Vfg 251, Group "1A"	79	66	73	60	73	60	30	37	@ 30m
FCC Part 15, "A"	-	-	73	60	83	70	40	46	@ 30m

(all columns are relevant to this AE)

Table 1 – Class A limits of radiation that may apply to PCBs

Class B Limits for Domestic Areas									
Frequency Range, __z 0.15 _ 0.5_ 5 _ 30_ 230_ 1,000									
Specifications	DB_V		dB_V		DB_V		dB_ V/m	dB_ V/m	NOTES
	QP	AVG	QP	AVG	QP	AVG	QP	QP	Quasi-Peak, Average
EN 50081-1, "B"	66-56	56-46	56	46	60	50	30	37	@ 10m, B Limit
EN 55011, "B"	66-56	56-46	56	46	60	50	30	37	@ 10m, B Limit
EN 55022, "B"	66-56	56-46	56	46	60	50	30	37	@ 10m

For 0.15 to 0.5 MHz range, limit is decreasing linearly with the logarithm of frequency.

(all columns are relevant to this AE)

Table 2 – Class B limits of radiation that may apply to PCBs

- Simulation tools. For an efficient PCB design compliant to the EMI requirements, an advanced tool for the PCB simulation and testing should be used. In our case the Subcontractor used the QUIET simulation tool running under Mentor Graphics Board Station. Comparing the emission levels from the compliance test report with those from the QUIET tool (graph representing the total emissions of the PCB) it is observed that results agree. This tool in conjunction with the rules laid down by standards specifications lead to a design with reduced EMI emission of the digital part of the PCB, while keeping the cost as low as possible. Import of the physical characteristics (outline, number and use of layers), routing information (tracks topology, segment widths, fill areas) in combination with software simulation parameters (net clock frequencies) give an initial emission result. Modification in one of the above PCB characteristics gives instantly the effect on the total emission level. Care should be taken to ensure the interface of the company's PCB design tool with the EMI simulation tool so as to perform the tests without need of changing the PCB tool. Throughout the whole process of testing and verification should be performed with close collaboration with the Subcontractor. If it is found necessary, further improvements should be made through back-annotation. Leon Engineering used the ORCAD tool for the design.

- Pre-compliance EMC measurements. The basic measurements regarding the strength of the EMI emissions were carried in our facilities making use of equipment that were purchased during the FUSE experiment. EMC tests were performed 'in house' at a good level except of the emissions test. The noise floor of a spectrum analyser is not sufficient and interference from radio and TV stations exceeds the emission limits so results within that frequency range can not be defined. Radiated E.M. fields test give a rough result but it can be estimated if the emissions of the EUT are excessive. Static and burst tests could be considered as very reliable. RF immunity and conducted emissions tests give acceptable limits of uncertainty. Moreover, the final product should be verified for the level of the EMI emissions using external facilities. (Anechoic chamber RF measurements)

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

LEON ENG. has a very good experience in the area of PCB design. The designers of the company have used successfully the well-known ORCAD tool for the design of the electronic schematic diagram and the PCB. However, they had never tried to reduce the EMI emission, since this requirement was never demanded in the past. The goal of the PCB designer was to design a PCB in the proper size and with the proper placement of the electronic components. The additional rules that required by the 89/336/EEC directive were used for the first time in this experiment. The persons involved with the project were:

- **Mr Dimitrios Ploumakis:** R&D manager and technical manager of the project. He is an expert on system design and integration. He engages in the development (hardware and low-level software) of microprocessor based units of the company and has a wide experience of the structure and technical requirements of industrial installations.

- **Mr Apostolos Sarimichailidis:** Electronic engineer specialised in hardware design. He uses the ORCAD package for the design of the electronic schematic diagrams and the PCB's and has a good experience in component technology. Also he has developed the low-level software for some of the company's microcontroller based indicators.

- **Mr Nikos Iglezos :** Electronic engineer specialised in advanced low-level software development and system integration. He engages in the development of assembly language the software for the batching controllers belt scales and weighbridge indicators, as well as C and Basic high level language, PC based support software for DOS and windows environment.

- **Mr Vyron Loukidis :** He is the marketing manager in the Marketing and Export department. His main responsibilities at the company include business and marketing plans, promotion and action plans (advertising schedule, printed material, commercial exhibitions etc) export sales plans & targets, exports customer handling.

- **Mr Nikos Leon :** Expert in the field of electronic weighing instrumentation, general manager of the company and the contact person for the European and Asian market.

9. Workplan and rationale

Task 1. Requirements and Specifications.

The subcontractor in collaboration with LEON ENG. studied the old PCB and underlined the weak points of the design. Knowledge on the PCB design techniques were transferred from the Subcontractor to LEON ENG. Training in PCB design with emphasis in EMC design methodologies was performed in this phase. The weak points of the old design were brought out and an example of designing PCB with low EMI emission was given based on a demo electronic diagram on QUIET simulation tool. The requirements imposed by the 89/336 directive were analysed and the specifications were extracted. The circuits were also redesigned to increase the operational capacity of the instrument, but with software compatibility in mind. The redesign was planned from the beginning of the AE, making use of presently available integrated circuits.

Duration:	2 months (m1-m2)
Effort:	4 person months
Deliverables:	D1.1 Report on PCB Design Techniques
	D1.2 Report on requirements
	D1.3 Report on Specifications
Milestone:	The study of the PCB design techniques.

Task 2. Implementation of the PCB design techniques (as modified).

In this Task the subcontractor (Applied Electronics Lab.) transferred the electronic schematic diagram of the new design in the Mentor PCB tool. Based on the deliverables of Task 1 and the directive 89/336 the improved PCB design was worked out. There was strong collaboration and interaction with LEON ENGINEERING to transfer the footprints of new SMD devices that were used in the new design. The fundamental proposal referred to simulation on the old PCB but this was not performed since selection of SMD technology and redesign was decided.

Duration: 6 months (m3-m8) (extended from 3 months)
Effort: 9 person months (extended from 7 months)
Deliverables: D2.1 Report the new PCB design
Milestones: The PCB design

- During execution of the this task (task 2) a technical decision was taken for the cooperation of the two participants. It was decided that LEON's Eng. engineers would develop the PCB layout using the OrCAD EDA, since the MENTOR board station and the QUITE EMI simulation tools were too expensive to be purchased by LEON Eng. This decision introduced three months extension of the Task 2 and 2 personmonths more on effort of the company. Thus Task 3 run simultaneously with Task 2, since the implementation of the PCB by LEON was depended on the simulation of the PCB by University of Patras and via-versa. This modification enabled the engineers of LEON Eng. to derive the maximum of experience on PCB design techniques, since there was a continuous feedback during the design.

Task 3. Testing of the PCB.

The Subcontractor developed software in order to import in MENTOR board station tracks and pads from the OrCAD EDA tool. Simulations were performed during intervals of 1-2 weeks and the required modifications were incorporated through back-annotation and rebuilding of the PCB. Eventually a trial PCB was developed and fully tested both for its functionality and the EMI emissions using the facilities of LEON ENG. A small non-scheduled extra effort of 0.5 p.m. from LEON ENG. was made for placement corrections on the PCB with an extension on the duration of this task.

Duration: 4 months (m6-m9) (extended from 3 months)
Effort: 5.5 person months (extended from 5 months)
Deliverables: D3.1 Report on the final PCB design and testing.
Milestones: Testing the PCB

Task 4. Integration of the final prototype and verification

The PCB developed and tested in the previous tasks was finalised and incorporated in a full-assembled working prototype with an aluminium table-top enclosure. This prototype was verified as a complete system, both for functionality and EMI emission, using external facilities. The results were successful. Extension of this task would be useful for integration of a better prototype and more representative to the final product.

Duration: 3 months (m9-m11)
Effort: 2 person months
Deliverables: D4.1 Report on the final results
Milestones: Intergration and Final Verification

Task 5. Marketing/ Exploitation

The dissemination and exploitation of the results of this application experiment was the goal of this task. There was a continuous process, covering mostly the second half of the project duration and included: internal dissemination of the design experiences to the company's engineering team to enhance its PCB design know-how, external dissemination and exploitation marketing activities like preparation of the information material (brochures and leaflets) for advertising companies and access to possible consumers. An extra man-month was required for this task.

Duration:	6 months (m6-m11)
Effort:	2 person month (extended from 1 person month)
Deliverables:	D5.1: Report on dissemination/exploitaion activities
Milestones:	Wide awareness of the product to the target market.

Task 6. Management

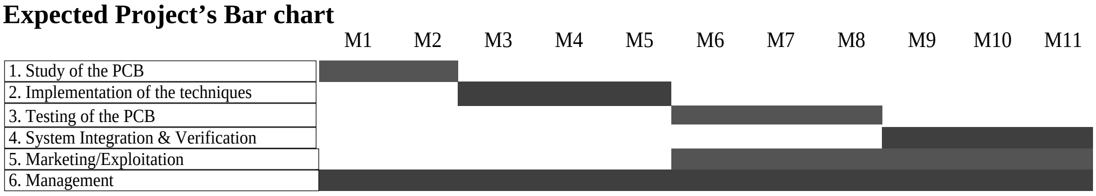
The purpose of this task was to ensure the smooth and successful execution of the project by co-ordinating the project’s tasks and the associated work of the involved partners, by monitoring the correct and on-time achievement of goals and milestones and the preparation of deliverables and reports and by controlling the consumption of resources as well. The modifications performed during Task 2 and 3 enabled the engineers of LEON Eng. to derive the maximum of experience on PCB design techniques and to retain the final PCB files in OrCAD EDA tool. The project’s duration was within the estimated timeline (11 months) but an extension on Task 4 would be useful for integration of a better prototype and more representative to the final product.

Duration:	It covered the whole project duration
Effort:	1 person month
Deliverables:	D6.1: Control and Management 1st report
	D6.2: Control and Management 2nd report
Milestones:	Project on time and in budget

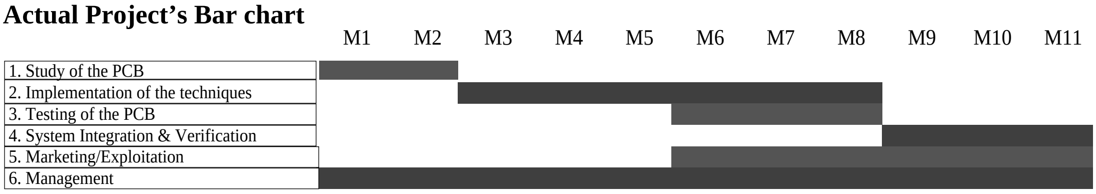
Risk Analysis

The development of the new PCB was based on a working product made with a different components package technology. This product was well understood and had been working in a large number of devices sold to satisfied customers. Technological risk was also low due to subcontractor’s expertise in EMC design techniques and PCB design tools and LEON’S knowledge on PCB design.

Expected Project’s Bar chart



Actual Project’s Bar chart



The person months allocation per task and organisation is shown in the following table, as well as subcontractor costs:

Task	*Leon Engineering person-months*	*Leon Engineering costs*	Applied Electronics Lab. person-months	Applied Electronics Lab. costs
1	2 pms	5.4 KECU	2 pms	6.75 KECU
2	5 pms	13.5 KECU	4 pms	13.5 KECU
3	3.5 pms	9.45 KECU	2 pms	6.75 KECU
4	2 pms	5.4 KECU	-	
5	2 pms	5.4 KECU	-	
6	1 pms	2.7 KECU	-	
Total	**15.5 pms**	**41.85 KECU**	**8 pms**	**27 KECU**

10. Subcontractor information

Name: Applied Electronics Laboratory of University of Patras, Greece

Size: The personnel of the Applied Electronics Lab. of Patras University consists of 5 Faculty members (most of them have PhD degrees from U.S. universities), 20 graduate students, 5 permanent research engineers, two secretaries and two technicians.

Business: Research and Academic Institution

Relevant Expertise & Experience: The Applied Electronics Lab. has long proven research capability in the area of Electronics and Microelectronics. It is well equipped with the most popular EDA tools such as ORCAD, PROTEL, EAGLE and the state-of-the-art on EDA MENTOR BOARD STATION 5 enhanced with the QUITE EMC tool. The laboratory has rich experience on PCB design compliant with the EMC rules. For the development of this project it was used the Mentor Board Station 5 and the Quite EMC tool.

The rich experience of the subcontractor on PCB design methodologies as well as its appropriate equipment for this work were the basic selection criteria. The interface between the company and the subcontractor was performed with continuous meetings of the persons that were involved. Electronic mail was widely used for the interchange of data.

Leon Engineering signed a contract with the subcontractor. The basic contractual issues that agreed were:

- No IPR-related issues granted to the subcontractor.

· The subcontractor kept the right of any scientific publication with the prior approval of LEON Engineering.

Services provided: Consulting/design/training in PCB design with emphasis in EMC design methodologies.

Personnel involved: A Full Professor, a research associate engineer and a highly qualified graduate student were involved in the project.

11. Barriers

Leon Engineering had attempted in the past to design and produce PCB level compliant products but failed to do so. Only with extensive metal shielding it was made possible to produce CE compatible range of products.

- Knowledge barriers

EMC directives are relatively recent and most electronic engineers do not have satisfactory knowledge of the requirements. Restrictions on the emission limits of a microprocessor based PCB, were unknown to be considered. Small and medium companies usually do not occupy their engineers, for research of directives and PCB design techniques to face the new requirements. An additional problem is that the emission levels of a PCB could not be estimated, till the moment the prototype is subjected to the verification laboratory. Also if they don't have the appropriate guidance the research may be time spending and the data collected would be confusing and difficult to be applied.

- Financial barriers

Financial barriers originate from the change in production needed if a new PCB technology was adopted. The indicators that failed the EMC tests (D1000/D2000 series) were redesigned with handy solutions, by separating the initial card and covering them with metal boxes. Redesigning them was not attempted because of time pressure and the risk of re-testing to notified verification laboratories. Furthermore it takes a long time for a new design to prove itself and be released into the market. Due to volume required in SMT, manufacturing costs of PCB's were estimated higher.

Additionally 'rework' and 'service' station would have to be created with special view and handle apparatus due to small size of SMT components. This is not only applicable to the manufacturer but to the customers also (OEM).

The building up of an in house EMC testing facility cost could not be estimated because of the difference in price / performance of systems from different vendors.

- Technology barriers

PCB production flexibility offered by the company's 'through hole' component and solder machines would be difficult to replace on the grounds that an 'in house' SMT manufacturing facility would take a long time to install and run reliably.

Tools to enable proper EMC behaviour prediction with realistic results were not available.

The effect of interconnecting wires was unknown and could invalidate any results obtained theoretically.

It was doubtful whether the analogue part could be placed on the same PCB adjacent to digital circuits without suffering from noise and RF coupling.

12. Steps taken to overcome the barriers and arrive at an improved product

Knowledge barriers

The prospect of non-compliance with EMC requirements was seriously threatening for the company to be persuaded to invest in low EMI PCB designs. The subcontractor had a long and proven experience in high density, low EMI, PCB design. Contacts with the University of Patras encouraged the company to make the step for the training of the engineering personnel in state-of-the-art PCB design. There, it was clear that the under-development circuit layouts could be effectively simulated prior to production and the major barrier was overcome. From the new design a number of products would be able to be constructed with increased EMC performance. The experience gained from the collaboration would enhance engineer's knowledge to face future designs.

Financial barriers

The proposal for knowledge transfer concerning the process of EMC testing and verification was also attractive. This was the motive for the purchase of testing equipment and creating in the company an EMC pre-compliance TESTstation.

To limit the disadvantages of volume manufacturing, new designs will be based on multi purpose PCB's that can be used in similar capacity instrumentation. EC funding was also a strong motive to start a project like this and helped our company to overcome the financial barriers.

Technology barriers

From the design point of view it was soon realized that the board should be designed with EMC in mind, by partitioning the board, component selection, PCB layout including cable terminations.

External SMT production facilities were chosen for the current production as it would be premature to consider in-house SMT manufacturing at this stage. For the maintenance and development of SMT boards two rework SMD soldering station were purchased, not covered by the AE. Finally, it should be noted that LEON technicians were trained in SMD handling and repairing by the suppliers.

13. Knowledge and experience acquired

The increase in the First User capabilities after the execution of the experiment is manifold.

At first, the experience derived from this application experiment, in the state-of-the-art design of PCBs, is considered by LEON ENG. as crucial for the viability of its products. This was achieved by the active participation of LEON’s involved personnel at the whole design procedure. Furthermore, the new techniques will be extended to new designs thus maintaining and enhancing its position in the local market and its export potential.

From the beginning of the experiment it was decided that Leon Engineering personnel would carry out the design of the board so that internal replication of the results would be possible. The Subcontractor teached Leon’s designers on how to do it and how to verify each step of the design. The result of the AE, a working PCB that is compliant with the EMI directives verified the knowledge acquired during this project and make our engineers to feel confident for their skills in PCB design techniques.

However the final simulation still has to be performed by the subcontractor. Since the simulation software is much more expensive (QUIET tool price is approximately 65000 USD) than the cost (13500 KECU) of the simulation task performed by the subcontractor.

This effected long communication and interaction with the Subcontractor. A lot of work was carried out to transfer knowledge from Subcontractor to the company.

Additionally conversion of ORCAD files to QUIET format was a tedious task. But it gave the opportunity to our engineers to involve with a different tool for PCB design and increase their knowledge field.

The company believes that after this AE its engineers are able to design PCBs with good EMC performance and with minimal simulation before actual testing. Still the simulation tool is being under consideration for purchase whenever it becomes available in low cost PC platform.

14. Lessons learned

Several lessons were learned because of the new technologies and the planning of the project.

The company tried to design PCB level compliance before the AE but failed to do so. During this project the company gained valuable experience covering not only technical subjects but also project management and cooperation with external facilities. At the start of this project it was stated that the subcontractor would design and simulate the existing PCB on Mentor Graphics Board Station. That not only had the disadvantage of the reduced collaboration of the company's engineers with Subcontractor's but also minor modifications were time consuming. It is good practice to check in advance interfacing of PCB design tools with the Subcontractor's simulation and verification tool. Creation of new library parts and routing of high complexity and density PCB's is more difficult and time consuming. Meetings with SMD manufacturers are necessary to define design considerations, requirements and minimum quantities for a mass production. The availability of SMD components and delivery times should also be carefully considered.

Normally component placement / PCB topology for packing reason produce aesthetically pleasing designs.

An efficient PCB design (from EMC scope) on the other hand should concentrate in controlling current flows / loops, by strategic component placement, track size and properly positioned ground planes. The first designers approach to place component on the board and then interconnect them according to the schematic usually produces poor EMC performance PCBs.

Although SMT is normally used in conjunction with multilayer PCBs a more economical double-sided board may equally be EMC effective if designed carefully with controlled di/dt.

Tools to test and verify EMC behavior during the design stage proved an invaluable aid as it reduced end-of-line testing.

15. Results: product industrialisation and internal replication

The outcome of this AE as already mentioned before, was a main board used in a weighing indicator/controllers with very good EMC characteristics and small size. This board introduces SMT to LEON products and the need for subcontracted SMT facilities.

Arrangements were made with SMT manufacturers and a lot of technical details have been defined for an initial production, such as the design and order of the stencil, component packaging and assembling procedure of the through hole parts of the board. A trial production quantity of 100 pieces has been planned for the second quarter of 1999.

Suppliers were found for the SMD components and quotations were received. For components packaged in reels such as resistors, capacitors and diodes it was found more advisable to accept the order of the minimum quantity of 5000 pieces.

The cost of the new main board including assembling costs is about 79 ECU. Cost of a display board (including the 2x40 LCD module) is about 48 ECU and of a digital I/O board (32 I/O capability) is about 30 ECU. Total cost of electronics is 157 ECU.

The cost of electronics of the previous model with equal characteristics, is analyzed below:

Main board with included display circuitry 82 ECU, power supply board 12 ECU, communication board 8.5 ECU, four I/O boards (32 I/O capability) 34 ECU and the 2x40 LCD module 19.5 ECU. Total cost of electronics is 156 ECU.

It was decided that the new instrument will be offered at the same price as the old one but increased capabilities, functionality and reliability. Furthermore the instrument should be used in new fields such as belt scales, loss-in-weight feeders etc.

Reduction of cost is made from the reduced size of the enclosure. The aluminum tabletop enclosure of the previous model was about 33 ECU and the new with reduced volume is about 21 ECU. The man-hours for assembling are also reduced because of the less complexity of the new design.

The new main board is suitable for all of the rest models of D1000/D2000 family with the appropriate software and small variations of the composition of hardware.

A new enclosure has been designed and constructed and a new keyboard foil has been introduced bearing a scale automation silhouette that minimizes integration costs to mimic panel requirements.

Although most of the control software are proven as the predecessor had been operating for 10 years, the new design will go through an internal verification stage for 3 months (January 99 to March 99) for the 10 prototypes built. Faults would be 'debugged' and improvements if any will be made. Next units will be installed in selected customers – installations and closely watched for the period April 99 – June 99. Normal sales should be released July 99. The first step of this product to the industrial market was an interest of a few samples from 'The Scale Company b.v'.

The old product model name was replaced with a new one in order to reflect the added performance. The proposed name was "LESCON".

The total industrialization cost, following the AE, is estimated not to exceed 55KECU, excluding type approval and certification costs that are close to 35KECU for both Non-Automatic and Automatic weighing instrument type approval.

The company's personnel that was involved in each stage of the new PCB development acquired a lot of knowledge and experience on EMC PCB techniques and methodologies. These skills will be useful for the future PCB developments for our products as the non approved market will not exist in a few years in Greece. Besides, the main objective of the AE was that: To help LEON ENGINEERING to derive experience in the design of low emission – high immunity PCBs so as to gain EMC approval for its products. In addition the use of the SMD technology for the first time in our PCB developments and the collaboration with the SMD suppliers open the way in our company to use a new PCB technology with many advantages in its products.

16. Economic impact and improvement in competitive position

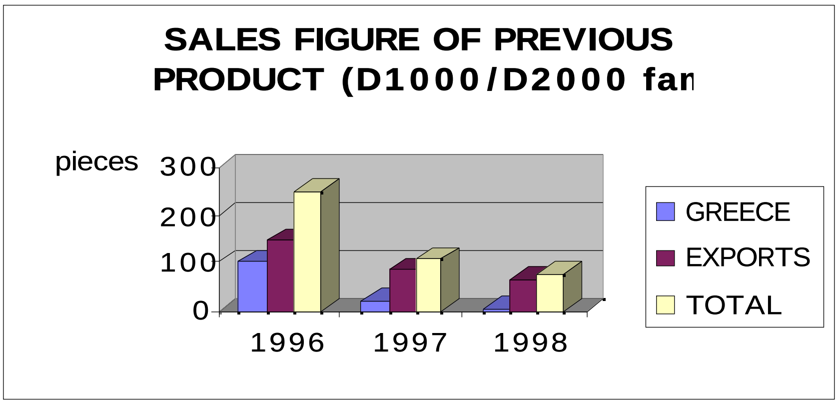
As a medium size company with around 65 employees and a turnover of 4.8 MECU for 1997 and 6 MECU for 1998) with an increase of 30% per year, which has constantly taken place over the last few years, Leon Engineering is looking forward to expanding its share in domestic and foreign markets.

The overall Greek weighing market is estimated at about 20 MECU, of which LEON holds today almost 30%. The Indicator/Controller is an important component in any weighing system. The price of indicators/controllers for legal for trade applications (weighbridges, scales etc.) is between 450 and 2500 ECUs depending on the features, while the ones for non legal for trade applications cost from 300 to 1000 ECUs. The direct cost on the other hand is in the region of 150 to 550 ECUs for the first ones and from 90 to 360 ECUs for the latter.

This market is divided into the approved market, (legal for trade), according to directive 90/384/EEC, (non automatic weighing instruments) and the non approved market.

The 90/384/EEC directive valid since January 1, 1993 allows equipment that have national approvals prior to that date to be legally operating up to 31.12.2002 (transition period).

The new product is an upgrade of the representative controller D2000-BC from the D1000/D2000 family. The sale figures of the last 3 years are shown below:

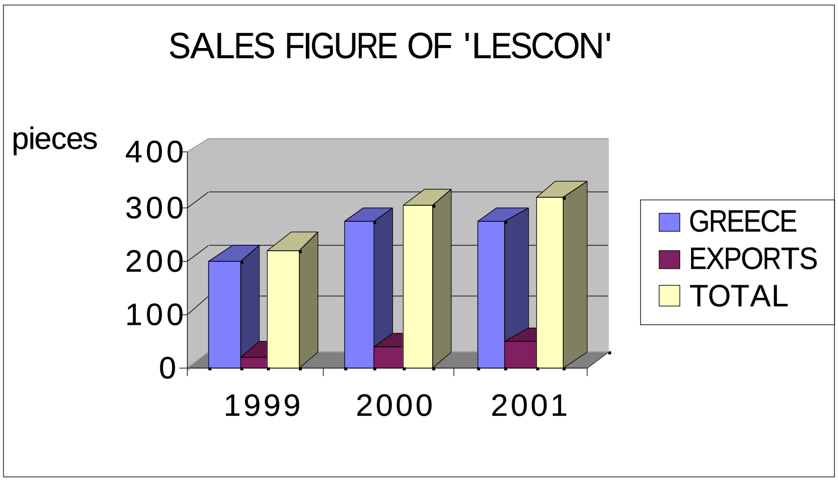


As it can be observed the sales of these units were falling during the last years. The need of approved solutions in the Greek market guided to a rapid decrease of domestic sales. The rest of units sold, are exports into countries that do not require approvals (i.e. Pakistan, Egypt, Lebanon, Iran, etc.). ***If the product had not been improved so as to comply with the Directives, then the product would be out of the Greek market after the next three years and the number would be limited only to exports at the countries mentioned before (middle bar of groups). A number of 50-70 units per year can be estimated.***

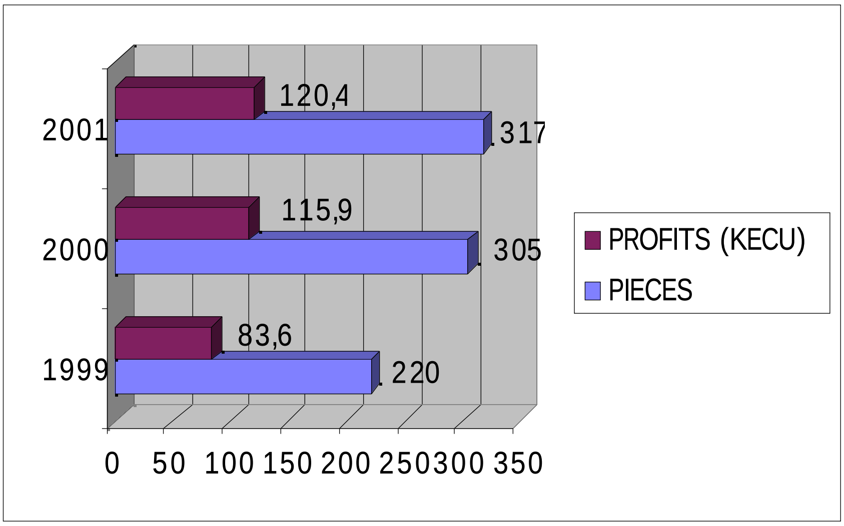
The areas into which the new 'LESCON' weighing controller can be incorporated is batching plants (350 pcs per year) and at about a 40 % of the various applications such as loss-in-weight feeders, belt scales, high speed bagging scales etc. (320 pcs per year). The Greek market has the need of about 670 pcs per year concerning the target group that 'LESCON' could cover. LEON ENGINEERING has a market share of 50% for the batching applications and the 30% of various ones. Taking the safe approach that this market will remain stable, it can be estimated that sales would reach a value of 270 pieces per year.

The new product due to its increased functionality, optimised performance and appearance, and of course the EMC compliance, would attract more foreign customers. We can estimate that about a 10% would be added to the number of pieces in Greek market. This amount would increase at least 30% per year according to the company's export market plan. Thus, the add-on to the total sales from exports is expected to be 10% for 1999, 13% for 2000 and 17.5% for 2001.

The 270 pieces that were estimated previously would actually be decreased by _ due to the industrialisation phase required (3 first months of 1999) thus a value of 200 plus 10% from exports equals to 220 pieces for the first year. Following the scenario that Greek market's share remains stable and the increase is provided from exports the sales for the next year should be:



The average production cost of a 'LESCON' unit (depends on version) is about 393 ECU, including materials, man-hours and indirect costs. Average selling price is about 773 ECU. An average profit for each unit is calculated to 380 ECU. Even if the Greek market remains stable and considering a moderate raise in exports, it may be estimated that profits from the sales of the three next years (842 units) will bring us a value added of about 319.9KECU.



Considering the above diagram it can be estimated that the **Pay-back period** is about 11 months. Considering the estimated profits of the three next years (319.9

KECU) and the total cost of the AE covered by FUSE (79 KECU), then the **FUSE Return on Investment (ROI)** is 405% over a period of 3 years.

The above calculation is focused only on the 'LESCON' controller. As the same electronics will be used for variants of the unit, additional benefits may be expected.

Moreover, this experiment will improve the quality of the future products since the state-of-the-art design of a PCB will be applied there, as well. The products with the new PCBs will conform to the directives. Thus, the competitiveness of these products in the European market will be secured and export prospects will be higher.

The Greek weighing is divided in about 35% for the approved market and 65% for the non-approved. Given the fact that till 2002 all weighing instruments for legal for trade applications should bear the European approval, we forecast an increase in the legal for trade market all over Europe.

17. Added value to the portfolio and target audience

The subject of this AE concerns every company that is involved with products based on PCBs or microprocessors / microcontrollers. Old design methodologies need to be upgraded to face the requirements of the EMC directives. The viability of a product is directly related to its EMC performance. Especially the industrial products in some cases require immunity higher than that required by the relevant standards.

Medium size companies that develop industrial application specific products such as measuring, control and monitoring equipment are the possible target audience. Companies that have a small R&D team and design a large variety of products need the support of an experienced Subcontractor to make a technological boost to overcome the requirements. This is necessary to secure the viability of their products in the market.

Finally, the dissemination of the experience derived from this experiment through seminars organised by the local TTN and the subcontractor and articles in the local press will help Greek companies to use this know-how for their products, as well.

In terms of PRODCOM codes the following sectors seem to fit the subject of this AE:

instruments and appliances for measuring/checking (3320)

office machinery (3001)

computers and other information processing equipment (3002)

electric equipment and apparatus (31)

electronic components and TV, audio, video (32)

medical equipment and surgical appliances (3310)