Convocatoria de ayudas de Proyectos de Investigación

MEMORIA TÉCNICA PARA PROYECTOS DE LA CONVOCATORIA DE I+D TIPO A ó B

1 RESUMEN DE LA PROPUESTA (Debe rellenarse también en inglés)

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PROJECT TITLE: Power quality. Measurement and analysis of electromagnetic disturbances. Filters and other corrective solutions.

SUMMARY:

Power quality is nowadays an interesting topic due to both the liberalization processes of electric power sector and an increasing concern of the final user for obtaining a product at a low cost and, if possible, with the higher quality standards. This coordinated research project approaches this problem from the quality of the voltage waveform point of view. The main objectives can be summarized as follows:

a) Power quality measurement. Two objectives can be pointed out within this research area:
   - Determination of the optimal number and location of power quality analyzers to obtain a given information level about the monitorized electric power system.
   - Power quality surveys at different geographical locations in order to prove the fulfilment of the actual normative.

b) Harmonic and voltage fluctuation effects. The interest is focused on obtaining results about the possible mechanical vibrations due to harmonics and the decrease of the expected life of the loads due to additional losses.

c) Voltage sag propagation in distribution power systems. The objective is to know the principles of voltage sag transmission in this special type of power systems in order to evaluate, once the problem has been generated, the affected geographical area. In addition, it should be required the formulation of a new algorithm providing the location where the voltage sag has been originated.

d) Harmonic mitigation in electric power systems. New contributions to the design of passive, active and hybrid filters will be proposed in order to obtain an economical and technical-competitive filtering method. These contributions affect to:
   - Topologies. New passive filter topologies will be proposed: wide band filter and third harmonic filter.
   - Design method. Optimization methods will be applied to design the filters (passive and hybrid types), using several design criteria throughout adequate objective functions. In addition, the variation of some parameters with time (supply conditions, linear and non-linear loads, etc.) will be taken into account.

2. INTRODUCTION

The end user of electricity, utilities and even local, regional and national governments is nowadays deeply concern about power quality. The Spanish normative about power quality can be found in the Royal Decree 1955/2000 [1]. This document classifies the power quality within three aspects that are clearly different each other:

a) Interruptions. Reliability criteria from the end user and utilities point of view as a function of the distribution network characteristic are established. The utilities are economically penalized in case over passing the imposed limits.
b) Power quality. In this case, the document cites the European Normative UNE-EN50160 [2], which defines the characteristics of the supply voltage of the public distribution networks. It is worth nothing that the utilities are not economically penalized in case of not complimenting this normative.
c) End user service. Basic and quantifiable aspects about the attention of the utilities to the end users are established.

This coordinated research project between the Universities of Vigo, Oviedo, Cantabria and Seville is within power quality area (characteristic of the voltage waveform). The main objectives of this research project are focused on four different aspects:

a) Power quality surveys.
b) Effects of harmonics and voltage fluctuations on industrial loads.
c) Voltage sags propagation in distribution networks.
d) Harmonic mitigation in industrial electric systems using passive, active and hybrid filters.

The main state of the art of the aforementioned topics is commented below in order to set the start point and the main objectives of this coordinated research project.

Power quality surveys

Power quality monitoring can be defined, within the power quality context, as the set of activities trying to evaluate the characteristic of the voltage waveform using the measurement and monitoring of the parameters defining this voltage waveform on different network points. The variations of these parameters are known as electromagnetic perturbations that can be registered using adequate measurement instrumentation.

The objective of this research project regarding with this topic is summarized as follows:

a) It is intended to evaluate the power quality indexes in the power distribution networks, industrial power systems and power stations based on renewable energy sources. These power quality surveys will be carried out within different Spanish geographical locations by each research project university partners. The objective is to establish the time evolution of the power quality seen by the electricity end user, as it has been done in similar power quality surveys performed in other countries [3-6].

b) On the other hand, the utilities will have to continuously measure the power quality levels in the future, especially if economic penalizations are included in the approved normative. In this sense, the number and optimal location of the power quality analyzers to obtain accurate information about the state of the distribution network at a low cost should be taken into account [7-8]. It is proposed to solve this problem to apply state estimation techniques [9, 10].

Effects of harmonics and voltage fluctuations

The harmonic content of the distribution network deeply affects the behavior of industrial loads. This part will analyze the study the effects of harmonics and interharmonics on several loads and component of the electrical power system. Those effects can be classified into two groups: the instantaneous effects (misoperation of devices) and long term effects. The study will be focused on the second group, particularly on the mechanical and electrical effects. The harmonic content considerably increases the losses in both the energy distribution and

electrical machines. As a consequence, a temperature increase can be produced being possible to affect the operating life of the electrical machine. In this sense, it is intended to focus the study on the impact that harmonic and interharmonic voltages have on some electrical machine parameters such as the efficiency, heating and reduction of operating life. On the other hand, it is also intended to analyze the effect of harmonics on the mechanical vibrations of the electrical machines, because their repercussion on the operating life. These studies will be carried out throughout experimental validation in the laboratory using for this purpose induction motors connected either directly to the mains or though an inverter application.

In the same way, the influence of the voltage fluctuation and the flicker on the aforementioned loads will be evaluated in order to asses the long term effects.

Propagation of voltage sags on distribution networks

Voltage sags are defined as a decrease between 0.1 and 0.9 p.u. the RMS value of the rated voltage during a time lapse ranging form 0.5 cycles to 1 minute [11]. They are one of the more common perturbations affecting power quality of electric power systems. The cause of the voltage sags in the electric power systems is generally a short-circuit fault and/or connection of huge loads. The voltage sags can be propagated to a far distance from the starting point they have been produced, affecting a high number of electricity end users. During the last years the research work within this area has been focused on protocol and measurement systems for this special type of perturbation. However, there is not enough work about the voltage sag starting point localization and propagation mechanisms. The utilities are more and more concern about how to asses the responsibilities related to a bad power quality due to the liberalization process of the electrical sector, being the voltage sags one of the most important problems. As a consequence, the research on the detection of the voltage sag propagation direction and the localization of the starting point has become an important task that nowadays is still unsolved.

Reference [12] is probably a pioneer research work on this area. It is used the perturbation energy in order to determine the direction of the propagation. The method is based on the intuitive comprehension of the physical phenomena describing the perturbation. The theoretical base is not available, thus to asses the reliability and limitations of the method is a difficult task.

Reference [13] develops a method based on the analysis of the slopes in the voltage-current diagrams because those slopes have opposite signs depending on the voltage sag starting point localization. Analyzing the slope sign, it is possible to determine whether the voltage sag becomes from the upper or lower voltage level. Once more, the proposed method is empirical and it is difficult to asses its application range.

It should be useful to analyze the complete knowledge applied in the research area of the electric power system protective relaying, because the voltage sags are mainly caused by short-circuit faults. The concept “incremental impedance” that is used in directional relaying can be found within this area. This concept can be used to the problem of detecting the starting point of the voltage sags [14]. The method is based on the analysis of the impedance obtained form the increments of voltage and currents of different locations corresponding to different quadrants of the impedance plot. One of the problems of this method is that the impedance is sensitive to the pre-fault and post-fault cycles [15], thus different selections of these scenarios affect the obtained result.

Taken into account these facts, it is intended to propose a theoretical method in order to detect the starting point and the propagation mechanism of voltage sags. The method is required to overpass the shortcomings previously reported. For this purpose it is propose to use artificial intelligence techniques such as neural network or fuzzy logic. A first stage devoted to simulate the proposed algorithms using adequate software will be carried out. Once these algorithms have been validated through simulation, they will be implemented using a digital signal processor (DSP). Finally, the proposed methodology will be proved in industrial electric power systems.

Harmonic mitigation on industrial power systems

The objective of this part is to analyze the different methods for mitigating the harmonic content of an electric power system with the lower economical cost. In this sense, two different filtering techniques exist:

a) Passive filtering. This type of filters are composed by passive elements that, as a function of their topology, in present a determined behavior in the frequency domain. The main advantage of this filtering solution is its extraordinary low cost. However, it can be pointed out that a high number of shortcomings appear, such as: resonance introduction in the electric power system [16], fixed operating point and effectiveness depending on the voltage supply conditions [17].

b) Active filtering. In this case the filter is composed by an inverter, usually a voltage source converter [18] or a current source converter [19]. The usual topology is the shunt active filter; however series active filters have also been developed usually associated with shunt passive filters [20]. The main problem of the active filters is its higher cost compared to the passive ones. However, the following advantages can be pointed out: tracking capability of the load changes, easy dimensioning and installation (shunt topologies) and, using adequate control techniques (reference current computation), the effectiveness of the filter is independent of the supply voltage conditions.

An alternative way, joining the advantages of both filtering techniques, is the hybrid filtering. This type of filters are composed by a passive and active parts that, as a whole, are required to have a lower cost given a mitigation conditions and tracking capability of load changes.

The research on passive, active and hybrid filtering techniques is well documented. The main contributions in each technique can be summarized as follows:

a) Passive filtering. The design criteria have advanced notably from the initial methods based on the designer's experience [21-22] to more sophisticated ones applying optimization criteria [16,17,23,24]. Recently, and in spite of the extraordinary research of the active filters, new publications on this area have appeared [3-4]. These papers point out some issues that never before have been taken into account, such as the multiple minima of the objective function due to resonance conditions.

b) Active filtering. The research on this are is focused in three different topics [18]: topology (introduction of multilevel structures [25-26]), modulation techniques [32] and computation of the reference current. It is worth noting that the methods for computing the reference current can be formulated into either frequency or time domains. The first ones are not usually applied due to their high computational cost; however the original idea can be applied again but using efficient harmonic computation techniques [27]. On the other hand, the computation methods based on the time domain formulation [28,20,29-30] carry out harmonic estimation errors due to either the voltage supply conditions (harmonic content) or the method formulation [31].

c) Hybrid filtering. Reference [33] provides a comprehensive view of this type of filters and the most common passive-active topologies. In spite of the different possible combinations, only a number of them have been really developed [34]. It is worth noting that these documents use only an operating point, invariable with respect the time, to establish the design characteristics of the active and passive filters.

The objective of this part is focused on the improvement of the filtering techniques previously explained. These improvements can be summarized as follows:

a) New passive filter topologies. Particularly, two new types of topologies are proposed: wide band filters and third harmonic filters.

a.1) Wide band filters are presented as a convenient solution for the improvement of the current harmonic distortion of the variable speed drives. The importance of this kind of loads in the modern industry is undeniable, being its growth in the last decade incredible. In fact, arc furnaces and this type of loads are the main cause of the harmonic penetration in the industrial electric power systems. These filters are three-phase three-wire, convenient for being used with any type of non-linear load with a controlled or uncontrolled rectifier as a front end. The characteristic topology of these filters and their frequency behaviour are shown in Figure 1. it can be seen that the main harmonics generated by this kind of loads (5th and 7th harmonics) have the higher attenuation levels, but also the high frequency harmonics are attenuated too.

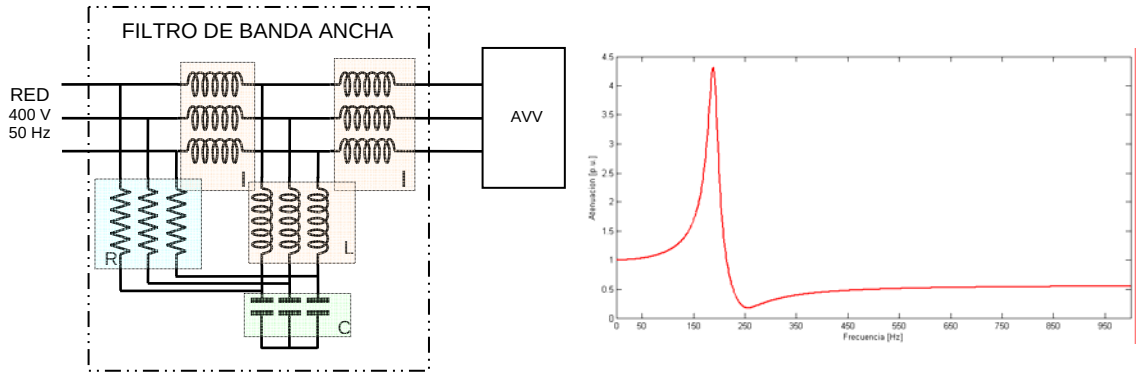

Figure 1. Wide band filter topology and frequency response.

a.2) Third harmonic filters are a convenient solution to prevent the third harmonic current flow in the low voltage networks. The 150 Hz currents are typically generated by single-phase non-linear loads such as discharge lamps and computers. The flow of these zero sequence currents (that are added in the neutral wire of the low voltage network) yields to overload conditions in the neutral wire that, in case of not being taken into account, can produce dangerous situations and undesirable power losses all over the low voltage network. Moreover, this zero sequence harmonic flow is responsible of additional current flows within the transformer high voltage delta windings. Commercial passive solutions to this problem exist, such as zig-zag reactances or delta-wye transformers. However, these solutions do not avoid the third harmonic flow, because they are intended to confine this harmonic content to a specific part f the low voltage network. This is an important fact in the case of the loads generating this type of harmonics, because they are low power loads widely dispersed all over the low voltage network. As a consequence the passive solutions previously described do not prevent the additional power losses due to Joule effect.

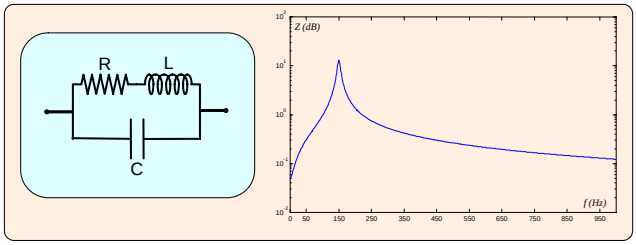

Figura 2. Third order harmonic filter topology and frequency response.

b) Improvements of passive filter design.

b.1) Modification of the passive filter optimization problem. These modifications affect both the objective function and the additional restrictions used in the design process.
b.2) Introduction of the operating point changes. It is intended to take into account the changes with time of the supply conditions, linear and non-linear loads in the design process of the passive filters.

c) Active filters. Two different research topics will be explored within this area. On one hand, the validation of the model in the frequency domain proposed in [36] using time domain simulation. On the other hand, improvements on the reference current computation techniques will be analyzed. Particularly, it is intended to analyze the behaviour of running average filters compared to the classical high pass filters used to extract the harmonics in the synchronous reference frame.

d) Hybrid filters. The objective is to calculate adequately as a function of the different topologies proposed in the specialized literature the passive and active components of the hybrid filter. For this purpose, the results obtained in the previously described objective will be used. Particularly, the optimization procedure will be carry out taken into account the changes of loads and supply conditions and using the frequency domain model of the active filter.

A high number of research groups from different universities are working on topics related to power quality:

a) Spanish research groups:

- Universidad Politécnica de Madrid. The research group directed by Dr. D. Julio García Mayordomo works on models and analysis methods in the frequency domain.
- Universidad Carlos III. The research group directed by Dr. D. Julio Usaola García works on several power quality issues, particularly non-linear load modelling, harmonic analysis methods and propagation of voltage fluctuations in electric power systems.
- Universidad Politécnica de Cataluña. The work of this research group directed by Dr. D. Joaquín Pedra Durán is focused on the effects of voltage sags on industrial loads.
- Universidad Politécnica de Valencia. The research group directed by Dr. D. Alfredo Quijano López develops research projects related to experimental measurement of power quality in electric power systems and its effect on industrial processes.
- Universidad de Huelva. The group directed by Dr. D. Patricio Salmerón Revuelta works on the power definitions in non-sinusoidal scenarios and active devices for harmonic mitigation.

b) International research groups:

- University of Chalmers (Sweden). This research group is devoted to the study of voltage sags, harmonic distortion and integration of renewable energies into electric power systems.
- University of Udine (Italy). This research group directed by Dr. Paolo Mattavelli is working on the design of electronic devices for the improvement of power quality (voltage sag mitigation and harmonic reduction).
- University of Boston (United States). The research group directed by Dr. Alex Stankovic is working on theoretical studies about new power definitions and simulation of dynamic phasors.
- University of Monash (Australia). The power electronic group directed by Dr. Graham Holmes works on active filtering for the harmonic reduction in electric power systems.
- University of Manchester (United Kingdom). A part of the researchers associated to this center (Dr. J. Milanovic and Dr. N. Jenkins) are working on the study of voltage sags, and power quality evaluation of distribution networks including dispersed generation.

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3. PROJECT OBJECTIVES

υ 3.1 Brief description of the reasons why it is important to promote this research Project.

This request is based on the following starting hypotheses:

- The design of compensation/correction devices for does not present an only methodology of calculation. This fact motivates the necessity to develop new strategies of design of harmonics filters, passive, active and hybrid. Another additional problem is the difficulty to establish useful comparisons between technologies, which could allow end users to make a suitable selection of the best solution for each problem. Considering as hypothesis that Broadband Filters(in its application to variable speed drives), and third harmonic filters (used in lighting systems and in typical office loads), are low cost solutions not very much studied, their careful design can satisfy in a suitable way the conditioning necessities in great part of the disturbing loads. The EPO commitment and the other companies interested in this project justify the interest that these products present in the market. In a national level these companies have a leadership position, wide penetration and deep knowledge.
- The current standard on power quality does not introduce clear criteria for the planning of the measurement surveys. The necessity of developing methods that allow the optimization of the number and location of the meters is established as the hypothesis.
- It seems clear that the economic effects of the lack of quality in the voltage wave are different depending on the type and level of the disturbance, and this is the reason why measurement and analysis is so important. Thus, the continuation of the measurement campaigns is proposed, allowing the improvement in the characterization of the existing quality indices for transport networks and distribution of electrical energy.

These hypotheses are shared by all the agents who take part in the network: distribution companies (Viesgo Distribution, S.L., Union Fenosa), producers (Temper) and clients (Robert Bosch Spain, - Treto, Cantabria-). The collaborators of the project will support by means of information and their knowledge of the network, devices and data.

υ 3.2. Previous results

In relation to the specific topic of this project, it must be said that in fact it would not start from zero, but it is the next step of other projects already finished or that still last at the present time. In this way, almost all the team members have been involved in the period 2002-2005 in the development of a project of the National Plan "Quality of Wave and Energy Saving. Influence of the disturbances in the industrial facilities. Minimization of its effects". Within this framework numerous measurement campaigns have been carried out; harmonics, flicker and voltage sags in industrial facilities with different productive processes and in different spanish regions where the different teams perform their research activity were measured. This verified the most common types and levels of disturbances. The results of these measurements, properly treated, have provided us information on the fulfillment of standards and recommendations, and the existing disturbance levels. In wind farms; data as generated speeds by wind, active powers, short circuit powers in the point of common connection, type and level of global disturbances of the farm and type and level of particular disturbances of several generators, were registered, analyzing the different interdependences between the mentioned variables.

In addition, the participation of the members of the applicants research groups in other research projects of the R+D National Plan, in particular "Comparison, design and control of devices for balance and compensation of electrical charges" (DPI2001-2367), "Design and passive control of equipment for the mitigation of disturbances caused by electrical charges" (ENE2004-06117), "Nonconventional Systems for the improvement of the quality of wave in industrial surroundings" (ENE2006-07014/CON), "Modeling and simulation of electrical systems for the study of the transmission of voltage sags" (FC-03-PB-02-065) and "Design of an instrumentation for the measurement and evaluation of the quality characteristics of the connected wind turbines to the power system" (CIT-120000-2005-19), justifies the continuation of the research activity in this field.

With regard to activities carried out,

- Different laboratory tests have been developed.
- A disturbed network with different types of elements that interact directly has been modeled.
- A critical evaluation of the different mitigation methods of the injurious effects of the disturbances on the quality of wave in speed drives has been performed. Thus, it was possible to carry out a first evaluation of the nonconventional passive methods that contemplates the new project.
- With the purpose of verifying the possible variations in measurements suffered by the different metering instruments used, two Electromagnetic Compatibility tests were performed in the Laboratory. One to verify if two devices of the same model measure equally and other to verify the differences between the three models that is available.
- Publications in indexed international journals (see bibliography in the introduction section) and presentations in international meetings with peer review have been carried out.

• A scientific congress of international character on power quality and renewable energies (the International Conference on Renewable Energies and Power Quality - ICREPQ-) has been organized. This has the support of important national companies and organisms of recognized international prestige as the Institute of Electrical and Electronic Engineers (IEEE) of U.S.A.

3.3. Specific objectives of the research project

1. – The immediate goal is to continue with the study of the effects that cause the disturbances in the networks, receivers and industrial facilities (incorrect operation of regulation and protection equipment, additional losses in machines and capacitors batteries, interferences in the telecommunication systems, reduction of the capacity of cables by effects of overloads, heating of the induction motors caused by losses, increase of the losses in the power lines, life shortening of the receivers, generation of visual annoyance by the fluctuation in the intensity of illumination, incorrect performance of the protections, badly operation of measuring equipment, incorrect operation of motors, loss of synchronism of the synchronous machines, etc.)

1.1. - To improve the knowledge of the levels of existing disturbances (specially harmonics, fluctuations of voltage "flicker effect" and voltage sags) of the industrial facilities, corresponding to the provinces of Galicia (Team A), Asturias (Team B), Cantabria (Team C) and Andalucía (Team D) and to carry out, in a coordinated way, a comparative study.

1.2. - To improve the knowledge of the effects that cause disturbances in the devices more used (motors, converters and others). Among other effects, vibrations caused in motors and other equipment will be considered; for example, the turbines of the electrical power stations are put under strong vibrations, (mechanical resonances), which suppose a severe fatigue by effect of the frequency variations; therefore, it is important to analyze the effects of the vibrations (Teams A, B, C and D).

2. In the economic scope, to evaluate and to compare the cost of the existing mutual incompatibility between the quality of the electrical energy and the sensitivity of the different receivers and productive processes, with the cost that would provoke the increase of the compatibility between both parts, improving the design of the provision facilities and the industrial plants, or the immunity and characteristics of the receivers, allowing to establish methods of systematized economic evaluation of the different problems that appear and of its solutions. The primary target of the studies of economic impact of the bad quality of wave would be obtaining the curves of costs for different types of productive processes, under different disturbances and for different levels of these ones (Team A).

3 - To improve the knowledge of the levels of existing disturbances (specially harmonics, fluctuations of voltage "flicker effect" and voltage sags) of the wind farms, analyzing its effects and, also, to develop and to apply programs of analysis of contaminated networks (Team A and C).

4. - To find solutions for the reduction of the emission of the disturbances, to limit their propagation or to increase the levels of immunity. The optimized filtration of harmonics stands out specially (Team B and D). It is necessary to indicate that the filtration of harmonics in industrial loads can nowadays be approached by means of active or passive solutions. The active solutions present today a high cost, which actually makes them nonviable for most of the common applications. The passive solutions are more used but present problems, as the need of a study and design adapted to each installation (with the consequent increase of costs), or in other cases they do not manage to reduce the rates of distortion to acceptable levels.

5. - To develop methodologies that allow to optimize the selection of the number and location of quality metering devices, with the objective of getting an adapted knowledge of the levels and/or origin of the disturbances with the lower possible number of metering devices (Team C).

6. - The project will also try to transfer in a direct way its results to the companies interested in its development (EPOs). This will not be an obstacle to the presentation of the more general conclusions to the technical and scientific community, through publications in journals and congresses as much national as international, in the subjects relative to the quality of the electrical energy in which the project is fitted. Within the objectives relative to the diffusion of the results, it will be the presentation of these products to the end user, the comparative studies with respect to the rest of solutions which the market provides. These will be quite helpful at the time of deciding on the most suitable solution to their problem (Team A, B, C and D).

υ 3.4. In case of coordinated projects:

- General objectives of the coordinated project.
- Specific objectives of each individual project.
- Relationship between objectives, activities and individual projects.
- Coordination activities.

General objectives of the coordinated project.

The main objective of this research work is to improve the knowledge, measurement and analysis of the different disturbances that affect the quality of the voltage wave, taking always into account the effects (heating, vibrations, badly operation, etc) which have on the equipment, devices and systems. They affect the energy saving, the technical-economic actions which could be adopted and the different productive processes depending on the type of disturbance and the level of this one. For the attainment of these objectives, the following general activities are undertaken, which will be described in greater detail in section 4 of this document:

0. - Bibliographical review. It will be located and structured in those sections which are not available, information on the origins, the cause of each one of the disturbances to study, the measurement methods, existing standards until the moment, on measurement and emission, disturbing agents and methods of limitation.

1. – Power quality survey. Measurements of the disturbances to study should continue (harmonics, flicker and voltage sags, etc), in the point of common connection (PCC) of industrial plants, inner points, residential zones and specific points of the distribution networks.

2. - Relation cause-disturbance. It will be establish from the information relative to the disturbances that will study.

3. - Effects of the disturbances. With the information that will be obtained by measurement and tests of the equipment in the Laboratories of Electromagnetic Compatibility which the research group have, the quality level of the electrical energy and the effects that cause the disturbances in the facilities and equipment will be observed.

4. - Transmission of disturbances. It will try to establish considerations on the transmission of harmonics, flicker and voltage sags through the facilities and networks.

5. - Mitigation and immunization techniques. A plan of mitigation of the emission of harmonics and voltage sags, and another one of immunization and correction, will be carried out, evaluating its effectiveness and its cost.

6. - Integration of the information. The diversity of sources to use, specially in the field of measurements, but also in those of laboratory, as well as the volume of information to handle forces us to have to use a rational storage by means of computerized data bases.

7.- Final Report. The corresponding conclusions will be written and each team will elaborate a report that, jointly with necessary the partial information, will serve to make the final report of the project.

8.- Diffusion of the results of the project. The tasks related to the diffusion of the results of the project will be considered.

Specific objectives of each subproject

As it has been indicated, the general objectives and previous activities do not start from scratch but from other works and previous experiences. Although many tasks will be carried out for each one of the teams in their zone of influence (provinces), the collaboration between all the teams will be close in order to take advantage of personal and general experiences from the different groups. Thus, taking advantage of the experiences and the particular characteristics of the different groups, there are activities and tasks, either different or complementing the generals, which have been entrusted in a greater degree or intensity to a determined team, therefore:

Team A. Executor Center: University of Vigo

- Effects of the harmonics on rotating machines and other devices. Between these effects, the vibrations are included.
- Effect of the frequency fluctuations in natural vibration of generators, turbines and other devices.
- Effects of flicker on different devices and systems.

- Analysis in networks contaminated with harmonics (with nonlinear loads).
- Economic Analysis of poor power quality. Establishing a method of economic evaluation of the quality of the voltage wave. Although, this is a general activity in which each one of the groups has to contribute with their experiences, it is entrusted in greater degree to the Team of the University of Vigo.

Team B. Executor Center: University of Oviedo

- Deep study of the design parameters of a Wide Band Filter for its application to variable speed drives. Treatment of aspects as: detuning, working life, protections, effectiveness at medium load, behavior under imbalances and voltage distortion, adjustment to the reactive necessities of the load, etc.
- Design, construction and test of a Wide Band Filter of medium power (100 kW) in collaboration with the EPO, in order to be used as test platform.
- Study of the design parameters of Third Harmonic Filters. Treatment of aspects as: detuning, working life, protections, effectiveness at medium load.
- Construction and installation (under real operation conditions in industrial facilities) of a prototype of Third Harmonic Filter as tests platform, in collaboration with the EPO.
- Evaluation of the effect of homopolar voltages caused by Third Harmonic Filter on the low voltage system. Study of the effects of homopolar voltages on the most common loads that needs this kind of filter: lamps and typical office loads.
- To foment the use of harmonics filtration methods as a means to increase the wave quality in industrial systems improving the energy efficiency. To make public, between the possible users, comparative information relative to the different available solutions; and to spread between the technical and scientific community the advantages associated to the use of the nonconventional systems contemplated in this project.

Team C. Executor Center: University of Cantabria

- To identify procedures of measurement and design of optimal power quality surveys for the diagnosis of the individual and zonal quality in an area of distribution limited with precise measurements.
- To analyze the adjustment and suitability of the instrumentation of quality measurement based on its class (A or B) and on the requirements of norm UNE-EN 61000-4-30.
- To consider the necessities of measurement of a generic distribution network using estimation of states and observability of networks.
- To define a campaign of measurements to obtain a map with the distribution of the disturbances in the distribution network.
- Transient analysis of the propagation of disturbances through the devices of the distribution network, with special emphasis in the study of the propagation of voltage sags in transformers and the influence of the connections and the nonlinear behaviors.
- To study how it affects the possible saturation of transformers, after the recovery of the voltage, in the shape of the sag that propagates downstream (and upstream). To analyze the reach of this propagation by simulation and to validate it in real networks.
- To study the influence of the transformer connections in transients and the viability of applying these results to the limitation of the origin of faults in real networks.
- Development of a methodology for the determination of the parameters that define the nonlinear behavior of the transformer using a reduced number of manufacturer data on the connection current (inrush current).

Team D. Executor Center: University of Seville

- Modification of the presentation of the optimization problem for passive filters. These modifications deal with the objective function and with the additional restrictions used in the exposition.
- Introduction of the variations of the operation point of passive filters. The variations of the feeding conditions and of the linear and nonlinear loads are considered in the design of passive filters.
- Validation of the frequency model of the active filters by means of simulation in the time domain.
- Improvements in the techniques of calculation of the reference signal of the active filters: Analysis of the influence of the substitution of the high-pass filters calculated in the frequency domain by others of mobile average.
- To determine the size of the components (active and passive) of the hybrid filter, considering the different topologies proposed in the literature. For it, the results obtained in previous objectives will be used. Thus, the optimization will be carried out observing the variations of load and feeding conditions, and the frequency model of the active filter.

Interaction between the different objectives, activities and subprojects

The interaction between objectives and activities is reflected in the organization of activities of section 4. - Methodology and plan of work of this document, because all the general activities have been divided in tasks to be performed within the framework of each subproject.

Predicted mechanisms of coordination.

1. - The coordinator of each subproject will perform the pursuit and revision of his corresponding work plan. Each subproject will be documented every three months. The obtained objectives and the strong and weak points of the work will be presented to all the members that are part of the corresponding team.

2. - Four general meetings, with all the members of the different teams, will be organized throughout the execution of the project, in order to see the degree of attainment of the objectives, characteristics of the acquired metering equipment and the exposition of new strategies.

3. - The electronic mail, telephone, web, videoconference, etc, will be used for all those aspects relative to the project that is precise to solve in the short term.

4. - Specific meetings with the representation of the Promoting and Observant Companies (EPOs) and the different coordinators of the subprojects will be organized.

5. – In order to share the data, the use of a specific web server for recording the wave quality data is proposed. The University of Cantabria has a platform denominated BSCW that is specially indicated for the management and coordination of projects.

6. - The possibility of using the same simulation framework in the four teams is analyzed (it is not essential).

7. - The generation of publications extracted from the collaborations is expected.

Methodology and working plan.

The data collected by means of measurement, analysis and test of electrical machines, industrial equipment and facilities, (a part of which are available after the accomplishment of project DPI2002-04416), properly integrated, have to allow to relate the causes and the origin of the disturbances to the effects that cause. To reach this goal, we are going to follow the next working plan.

General task 0: Bibliographical review. In those sections in which there is no information on the origins, the causes, of each one of the disturbances to study, the measurement methods, existing regulations, until the moment, on measurement and emission, disturbing agents and methods of limitation, some bibliographical references will be located and structured. Since the study of these disturbances, in all its faces, it is being carried out at world-wide level by different investigators, and as they present their conclusions in papers published in specialized magazines, we will seek all the information related to the recent evolution of the investigations in this field.

Due to the previous tasks developed in the last years by the four research teams, in the development of other research projects and in the direction (and accomplishment) of Ph.D. thesis, an important bibliographical compilation on power quality are already available to the research teams, mainly, in their particular subjects of interest. But, in good logic, this compilation must be bring up to date, taking into account the last advances in this matter that, on the other hand, is in continuous evolution. This bibliographical update that will be developing by the different teams will be more intensive in the specific aspects of every subproject.

The task in this point "0", as previously indicated, will be carry out by all the members of the four teams in a coordinated way, during the whole evolution of the project, They will use the potentialities of the network in order to distribute the information among all the members of the teams.

Participant teams: Teams A, B, C and D in a coordinated form.

General task 1: Disturbances measurement. Every team will continued taking disturbances measurements to study (harmonics, flicker, voltage sags, and others), in the point of common coupling (PCC) of industrial plants, inner points, residential zones and specific points of the networks of distribution corresponding to the zone of influence, geographical region and bordering zones, of each one of the research teams.

Teams: This general activity will be developed, for two years, for all the teams in its own region: Team A in Galicia, Team B in Asturias, Team C in Cantabria and Team D in Andalucía, working in a coordinated way.

General task 2: Relation cause-disturbance. From the information relative to the causes of the disturbances that will be studied, supplied by the suppliers and from the technical people in charge of the industrial facilities (factories) and other kind of consumers, crossed with the measured and registered disturbances, some conclusions will be obtained on the concrete relations emitted cause-disturbance.

Teams: Teams A, B and C in a coordinated form.

General task 3: Effects of the disturbances. With the information that will be obtained, by measurement and tests of the equipment in the Laboratories of Electromagnetic Compatibility which it has the investigating group, it is tried to know so much in the quality level the electrical energy, like the effects that cause the disturbances in the own facilities and equipment (electrical machines, converters and other devices).

Teams: The work will be coordinated with the following distribution of teams:
- Effects of the harmonics on rotating machines. The vibrations are included (Team A)
- Effects of disturbances on converters and control systems (Team B)
- Effects of the voltage sags on the industrial facilities of L.V.(Team C)
- Effects of the harmonics on the industrial facilities of L.V. (Team C)
- Effects of flicker on different devices and systems (Team A)
- Effects of voltage sags (Team B)

General task 4: Transmission of disturbances. The researchers will try to have a deeper knowledge and to set rules on the transmission of harmonics, to flicker and voltage sags through the facilities and the network. To reach these goals:

4.1- The researchers will measure and register, in a simultaneous form, harmonics, voltage fluctuations "flicker" and voltage sags in different points from the facilities of a good number of industrial plants, in the distribution network and in other facilities.

4.2.- Models will be elaborated and programs of analysis of contaminated networks will be developed, to obtain computer simulation results.

4.3.- The obtained measures will allow to validate, establishing the corresponding error levels, the simulation results and the establishment of considerations about the initial hypotheses and the time of calculation.

4.4.- Once positively evaluated the models and results of simulation, analyses will be made to study a greater number of cases.

In order to develop point 4.1, as far as for measurement, the researchers will need to use, at least, two of four measuring equipment.

Teams: The work will be coordinated with the following distribution of teams:
- Transmission of the harmonics: Team C.
- Transmission of flicker: Team A.
- Transmission of the voltage sags: Team C

General task 5: Mitigation and immunization techniques. A plan for mitigation measures of emission of harmonics and voltage sags will be performed and another one for immunization techniques and correction, valuing its effectiveness and its cost. Special attention will be paid to the harmonic filters.

Teams: Teams B and D.

General task 6: Integration of the information. The diversity of sources to use, specially in the field measurements, but also in those of laboratory, as well as the volume of information to handle forces to the researchers to use a rational storage by means of computerized data bases. Also, since it is not technically possible to consider all the variables that take part, the treatment and correlation of data have to be made using statistical tools.

Teams: Teams A, B, C and D in a coordinated form.

General task 7: Economic analysis of poor power quality. It is advisable to establish a method of economic evaluation of the power quality to determine, systematically and in the most objective way, the costs dues to excessive levels of disturbances.

The main target of the studies of economic impact of the power quality would be the obtaining of curves of costs for different types from customers, exposed to different disturbances and for different levels from the same ones.

The economic evaluation of poor power quality is based in three fundamental tools:
1.- Collection of information
2.- Integrated analysis of information
3.- Obtaining of the curves of costs.

Teams: Team A

General task 8: Report. The corresponding conclusions will settle down and each team will elaborate a closing report that, jointly with corresponding partial reports, they will serve to make the final project report.

Teams: Teams A, B, C and D in a coordinated form.

General task 9: Diffusion of the project results. The tasks related to the diffusion of the project results can be classified in:

- Books or book chapters' preparation on power quality, reporting general aspects of the research.

- Papers on power quality reporting specific aspects of the research, intended to be publish in technical reviews and magazines

➢ Presentation of the main research conclusions in national and international conferences or congresses. The elaboration of the corresponding communications and presentation in the event will be included.

- Use of the page Web to spread all that information that, properly sifted, could be of the general interest.
- Organization of courses, congresses, conferences, scientific workshops and meetings where the experiences of the different teams, national and international, related to power quality, could be presented and shared. In this sense, it will be continued with the organization of: "International Conference on Renewable Energies an Power Quality" (ICREPQ), "Meeting of Electrical Engineering Research Teams (RGIIE)" and the Spanish editions o the "Spanish Portuguese Conference on Electrical Engineering (SPCEE) ".
- Transference of the results to the companies that supported the project (EPOs).

It is considered that the proposed method and work planning of this coordinated project offers great possibilities for the study and awareness of the effect that exert many of the variables involved in the analysis of disturbances, and although is out of the scope of this project to include the analysis of all the variables that can influence or be influenced by each one of the disturbances, the main will be study.

Plans of work distributed by teams and reserchers

Once established a general work planning for the study of the different disturbances, as well as a good part of the methodology to follow, one appears, in the following sections, the work planning for each one of the teams, distributing the tasks between the different researchers.

TEAM A.

Research Centre: University of Vigo

Human Resources.- The Vigo's University has created a multidisciplinary team from different technical and economical departments for get the subproject goals. The members of the research team are:
Prof. Dr. Gustavo Pelaez Lourido. He is interested in the study of relationship between mechanical vibration in electrical equipment and the loss of power quality.
Prof. Dr. Juan Pardo Frojan who will study the economical impact of the electrical power system disturbances.
Prof José Manuel Rodriguez Iglesias will be the link between industrial and academic sectors. His is currently a partial time lecture of the Electrical Engineering Department (University of Vigo) and has been collaborator in the studied of several power quality issues in other research projects.
Prof. Debora Coll Mayor. She is an external participant from Baleares Island University where is currently a teacher. The Prof. Debora Coll received the PhD from a Germany University where she was researching in a power subjects.
Prof Filipe Tadeo Oliveira is another external participant from Department of Electrical Engineering of Leiria Polytechnic Institute (Portugal). His undergraduate report was done at University of Vigo (Erasmus program). He studied a power quality in wind generation system. Prof. Manuel Pérez Donsión was the supervised of this work.
Finally, Prof Manuel Perez Donsión will be the leader of University of Vigo research team and general coordinator of this project. He is a Professor of the Vigo University Electrical Engineering Department. He has supervised five PhD works. The power quality was the subject of three of those PhD report. The Prof. Manuel Pérez Donsión has been leader in several projects with public and private found support.

Reasons to support the necessity of a technician.- The technical worker could be a fundamental support to research team for the field working and experimental laboratory test.

Tasks. The different issues of this subproject are detailed in the following paragraph, and the members of the research team that will work in each activity are designated.

Task 0A: The documentation activity: look for technical information and distributions the information for the different research group.
Participan: All seconds
Members of the Research Group: Debora Coll Mayor, Filipe T. Oliveira and José Manuel Rodríguez Iglesias.

Task 1A: Measurements of disturbances in electrical power network This activity is including in a general activity "1" and will be done by every team in its area of influence. The A team will work at "Autonomous Region of Galicia".

The person in charge from team A (University of Vigo): Manuel Pérez Donsión, Filipe T. Oliveira, José Manuel Rodríguez Iglesias and the Technical worker.

Task 1APE: Measures of harmonic distortion, flicker and voltage sags in wind generation systems.
The team "A" will do measurements in the experimental wind generation park of Sotavento and will study the influence of this system in power quality. This installation has several generation technologies. The local government (Xunta of Galicia) is the owner of this installation. This study will try to extend the measures to other wind generation stations. The team "A" will study the different variables that can influence the impact of the wind generators in power quality.
The team "A" will analyze the relationship between basic data self-collected from sensors on each wind generator, the characteristics of the network (short-circuit power) and the different local and global network perturbations.
This task requires a campaign of measures that must be designed with care. The daily, weekly and even yearly variations must be collected so the periodic effects of this type of installations are considered.
Members of the Research Group: Manuel Pérez Donsión, Filipe T. Oliveira and the Technical worker.

Justification of a Technical worker required in this activity: The technical worker could be a fundamental support for the research team for the field work. Furthermore, the technician who works in this project will acquire a high skill in the field of electrical measurements.

Task 2A: Determination of relationship causes-emitted perturbation. This issue belongs to the general issue 2.
Members of the Research Group: Manuel Pérez Donsión

Task 3A: influence of perturbation in a electrical networks. This issue belongs to the general issue 3.

Task 3.1A.- Study of the effects of harmonic and inter-harmonic currents in induction motors performance

Task 3.1.1A Study of the increment of electrical losses. Measurements of electrical losses causes by harmonic and inter-harmonic currents in induction motors of different power, when they are fed from a programmable power source in several load conditions. Harmonic and inter-harmonic components will be added to the fundamental frequency taking into account the values recommended in standards and the mean values.
New necessities: A high sampler Data Acquisition PC Hardware is required for this issue (or commercial equivalent equipment). Also, a controlled brake is necessary for the implementation of the tests under variable load.
Members of the Research Group: Manuel Pérez Donsión, and the Technical worker.

Task 3.1.2A Study of lifetime decrease. A study of the evolution of the temperature in the motor when the machine is feed from a non-sinusoidal voltage source will be carried out. It will allow to determinate which are the harmonic effects on the lifetime of the electrical motor. This study can be developed using an infrared camera as thermocouples are not practical sensors for large scale measures.
Members of the Research Group: Manuel Pérez Donsión, Gerardo Pelaez Lourido and the Technical worker.

Task 3.1.3A Vibration analysis. A detailed analysis of shape vibration self mode and the influence of some harmonics in the mechanical vibration will be carried out. A scale model of generator will be done for the analysis of the performance of large machine with harmonic torques. It is necessary to purchase four channel data acquisition equipment and software. The cost of this equipment is included in the budget of the project.
Members of the Research Group: Gerardo Pelaez Lourido and the Technical worker.

Task 3.3A Influence of flicker on the performance of electrical equipment. The influence of voltage fluctuation on several electrical equipments (lamps, personal computers, machine drivers) will be studied. The voltage fluctuation will be generated by a programmable source that is part of our EMC laboratory. An electromagnetic compatibility study will be done. This activity is a continuation of the other one developed in a previous project.
Members of the Research Group: Manuel Pérez Donsión and the Technical worker.

Justification of a Technical worker required in this activity: The technical worker could be a fundamental support for the research team for the field work. Furthermore, the technician who works in this project will acquire a high skill in the field of electrical measurements.

Task 4AF: Voltage fluctuations and flicker transmission. This task belongs to the general activity 4 (study of flicker). Some considerations on the transmission of voltage fluctuations through installations and networks will be made.

Task 4.1.A Improvement of the flickermeter model. A flickermeter model has been developed by the research team. During this task the model will be improved. MATLAB and PSCAD are the software tools that have been used to develop the model. A comparative study of the results obtained with the different tools will be included. The analogical and digital coefficients to the filters of the model will be designed. By means of the measurement obtained with the flickermeter, a study about the

evolution of the disturbance in the frequency and time domain will be included. The results obtained during industrial measurements from steel companies will be analyzed. A study about the transmission mechanism of voltage disturbances will be developed. The measurements will be recorded in point of common coupling of the utility and in the transformer centre so the transmission mechanism will be analyzed.
Members of the Research Group: Manuel Pérez Donsión and Debora Coll Mayor

Task 4.2A. Power system modeling. The power system that is considered during the transmission of disturbances will be modelled using real data of transformers, transmission lines and consumption rates. The power system will be modeled using Thevenin equivalents using real values of short-circuit powers. Models will include converter type loads integrated in software tools to simulate polluted networks.
Members of the Research Group: Manuel Pérez Donsión and Debora Coll Mayor

Task 4.3A: Validation of the models. The results obtained with the models are compared with the measurements that have been obtained in real systems. To determine the dependences of the different electric parameters involved, different cases will be analyzed.
Members of the Research Group: Manuel Pérez Donsión and Debora Coll Mayor

Task 4.4A: Parametrical dependence. The relationship between the characteristics of the flicker and the components and parameters of the power system will be analyzed.
Members of the Research Group: Manuel Pérez Donsión and Debora Coll Mayor

Task 4.5.A: Influence of the short-circuit parameters. A practical situation with a constant load fed by two different electric systems with different short-circuit powers will be studied. This difference will be variable so as the relative position of the load. This implementation will need load flow studies in order to achieve the optimum model of the network in the different situations.
Members of the Research Group: Manuel Pérez Donsión and Debora Coll Mayor

Task 5A: Mitigation and reinforcing of compatibility. A study about the real conditions that could avoid the effects of the flicker and improve its transmission conditions will be carried out. Efficiency and costs will be taken into account.
Members of the Research Group: Manuel Pérez Donsión, José Manuel Rodríguez Iglesias y Juan Pardo Frojan.

Task 5APE: Flicker analysis in wind farms. The measurements that have been obtained during the study at the Sotavento wind farm and other real wind systems will be used to develop several electric models to simulate its real performance. These models will allow the simulation of the influence of the speed of the wind. The models will allow the study of the wind generator behavior and the wind farm behavior as a whole too. Then an equivalent generator representing the whole wind farm will be obtained.
Members of the Research Group: Manuel Pérez Donsión, Filipe T. Oliveira y Debora Coll Mayor.

Task 6A: Integration of information. This task corresponds to the General Activity 6 that will be face up by all the Research Groups in a coordinated manner.
Members of the Research Group: Manuel Pérez Donsión, Gustavo Pelaez Lourido y Juan Pardo Frojan.

Task 7A: Economical analysis of power quality disturbances. Economical analysis about the effects of power quality events will be included in this study. The next items will be considered:

- *Economical analysis using the relationship between the disturbance and its effects on the equipments and industrial systems. Cost of the solutions.*
- *Study of the relationship between the type of disturbance and the cost of its effects.*
- *Study of the relationship between the level of disturbance and the cost of its effects.*
- *Relationship between the cost of the solutions and the cost of the disturbance effects.*

It should be taken into account that the evaluation of production losses, especially important in the case of industrial installations, can be of different magnitudes depending on the type of productive process.
Members of the Research Group: Juan Pardo Frojan.

Task 8A: Conclusions and final report. The respective conclusions will be stated, and each group will write a final report that together with other partial documents will be useful for the elaboration of the Final Report of the Coordinated Project.
Members of the Research Group: Manuel Pérez Donsión, Debora Coll Mayor, Gustavo Pelaez Lourido y Juan Pardo Frojan.

Task 9A: Spreading of the results obtained in the project

- Two papers about the project results will be sent to indexed magazines.
- Four papers about conclusions obtained in the project will be sent to national congress and four papers will be sent to international congress. This will comprise not only the elaboration of the corresponding communications but also its defense during the event.
- Organization of the international congress: “International Conference on Renewable Energies and Power Quality (ICREPQ)”, in which the different groups (both national and international) will exchange their experiences in the field of renewable energies and power quality.
- Organization of the traditional “Reunión de Grupos de Investigación de Ingeniería Eléctrica (RGIIE)”. An adequate forum for the exchange of experiences between the different Spanish groups interested in this field.
- Organization of the biennial “Spanish-Portuguese Conference on Electrical Engineering (SPCEE)”. An adequate forum for the exchange of experiences between groups from different nationalities especially oriented to the Spanish and Portuguese communities.
- Transfer of the results to the companies involved in this application as EPO’s of the project.

Members of the Research Group: Manuel Pérez Donsión, Debora Coll Mayor, Filipe T. Oliveira, Gustavo Pelaez Lourido y Juan Pardo Frojan.

TEAM B.

Research Centre: University of Oviedo.

Human Resources.- The training and qualification of the staff from the University of Oviedo is detailed in the cv. attached to the application.

Reasons to support the necessity of a technician.- A technician will be put under contract between the 13th and 30th months in order to collaborate with the members of the research team in the tasks described in this document during this period. His specific activities will be described in detail in every task in which he has been included. As a general view, the aim of his work is to allow the researchers to focus in the most technical and scientific aspects of the project, assuming part of the most routine tasks (measurements, starting of equipment, programming, etc). One of his main responsibilities will be the implementation of a software tool for the design of Broad Band Filters. In order to perform this job adequately, he will first collaborate with the rest of the research team in two previous tasks, getting then involved deeply in the development stage of the product. It should be remarked, that the participation of this person in the project will lead to a great development of his capacities, due to the nature of the activities in which he will be involved. In this particular instance, once the 18 months of length of the contract had been finished, he will be able to deal with highly specialized measurement equipment, and will have an important experience in the field of Power Quality. All these aspects will make him a valuable personal for companies in the electric market.

Tasks. The methodology that will be carried out during the length of this I+D+I project, will consist on the execution of the tasks that are described in the following. These tasks have been codified in order to a subsequent identification of them in the Time Diagram. The letter 'B' stands for the team from the University of Oviedo. Taken the General Activity number 5 into account, which is by far the one that requires the most intensive dedication from this Research Group, the letter 'a' identify those tasks related with Broad Band Filters, while the letter 'b' identify those related with Third Harmonic Filters.

Task 0B: *Search, organization and spread of information*.

It corresponds to the General Activity number 0, which is carried out intensively by all the members of the four groups in a coordinated manner (nevertheless we remark here the researchers that will gather the main responsibilities in this subproject) during near the whole length of the project. In this way, the great potentiality of the information nets will be exploited, in order to guarantee the spread of the information between all the members of the group. Considering the research group of the University of Oviedo (Team B), the continuous knowledge actualization will be especially focused in the specific aspects affecting their subproject.

Research Centre: Team from the University of Oviedo.

Members of the Research Group: José Manuel Cano Rodríguez, Gonzalo Alonso Orcajo, Carlos Hirám Rojas García.

Task 1B: *Measurement of perturbations under study*.

The measurement of perturbations campaign will take place during the first two years of the project, and it is in fact the continuation of the one started under the preceding Coordinated Project with reference DPI2002-04416-C04. Team B (University of Oviedo) will spread the campaign along the Princedom of Asturias and neighbouring areas.

The measurement campaign will be focused specially on industrial installations with high percentages of non-linear loads, as they are the most susceptible items when speaking of Power Quality. A particular attention will be paid to the effect of voltage sags and the injection of harmonic currents.

Reasons to support the necessity of a technician: The presence of a technician under contract from the beginning of the second year of the project will allow him to collaborate with the research team during the most part of the measurement campaign (to be exact during 12 of the 19 months that it will last). After a quick training process by the part of the Research Group, this person will be responsible of certain tasks such as the placing the measurement equipment, collecting the data cards, making a pre-treatment of data, etc. This is an aspect of high interest for the technician, as he will be trained in the operation of sophisticated equipment, and at the same time he will release the rest of the research group fro certain repetitive activities (as the unavoidable displacements), allowing them to focus on the most scientific aspects of the project.

Research Centre: Team from the University of Oviedo (in coordination with the rest of the teams).

Members of the Research Group: Carlos Hirám Rojas García, Francisco Pedrayes González, Técnico Contratado.

Task 2B: *Conclusions on cause-emitted perturbation relationships*.

It corresponds to the General Activity number 2 that will be developed by all the teams involved in the project in a coordinated manner.

Research Centre: Team from the University of Oviedo (in coordination with the rest of the teams).

Members of the Research Group: Gonzalo Alonso Orcajo, José Manuel Cano Rodríguez, Carlos Hirám Rojas García.

Task 3B: *Effect of voltage sags on Adjustable Speed Drives*.

The General Activity number 3 studies the effect of electromagnetic perturbations on different equipment. The Group from the University of Oviedo will continue its previous research activities on the effect of voltage sags on Adjustable Speed Drives. This problem is one of the main Power Quality concerns as is the origin of a great amount of economic losses in the whole world. As one can see in the cv. of the members of the Research Group of this subproject, their contributions on this field are extensive.

Research Centre: Team from the University of Oviedo.

Members of the Research Group: José Manuel Cano Rodríguez, Gonzalo Alonso Orcajo, F. Pedrayes González.

Task 5B - 1a: *Modelling of a Broad Band Filter*.

A model of a Broad Band Filter will be built using the software Simulink from MatLab. This mathematical model will be the base for subsequent studies that will be taken into account in other activities of the project. It is important to consider that the modelling of filter components will not be an easy task, as it must represent with accuracy all the stray effects that influence it efficiency. As an example the chokes should take into account the variation of the inductive values due to the operating point, and power losses. The Research Group has a demonstrable experience in this field as can be checked (See publications on section 6).

Research Centre: Team from the University of Oviedo.

Members of the Research Group: José Manuel Cano Rodríguez, Gonzalo Alonso Orcajo, Carlos Hirám Rojas García.

Task 5B – 2a: *Theoretical studies on the design and performance of a Broad Band Filter*.

By using the model developed in task number 5B – 1a, the phenomenon of detuning of the filter will be studied in detail, focusing in the consequence of this aspect in the filtering performance. This should lead to the determination of feasible design criteria on the selection of components. With an especial interest, the performance of the filter far from full load will be studied, considering that in actual applications this apparatus should operate in a wide range of power values. An especial care will be taken into account so as the loss of filtering performance will be acceptable in all the range. Laboratory test will now be carried out using an 11kW prototype that has been manufactured by the Research Group in previous work.

This activity will be made in coordination with the Research Group from the University of Sevilla. The determination of the most suitable parameters for the filter constitutes a complex optimization problem which involves multiple variables (minimization of Total Harmonic Distortion, minimization of amplification at the anti-resonance frequency, minimization of power losses, etc.). This Research Group has a demonstrable experience in this field (see publications on optimization of shunt filters), so its contribution to this task will be remarkable.

The model will be used too, to analyze the performance of the filter under voltage unbalance. This is an important aspect, as some of the passive filtering solutions that are nowadays present in the market, loss a great part of its filtering efficiency when unbalance is present, which is very usual in real installations. In the same way the influence of distortion levels on input voltage will also be analyzed.

Finally, the most suitable protection system for the installation of the filter will be determined. In order to do this in the correct way, the transient behaviour of the apparatus will be considered. This will be quite simple as the model developed in task 5B – 1a is still valid for this application. The protection of filter components will be taken into account, as well as the protection of the installation and load that is being supplied through the filter. The possibility of an emergency by-pass will also be considered in order to guarantee the continuity of the supply.

Research Centre: Team from the University of Oviedo (in coordination with the team from the University of Sevilla).

Members of the Research Group: Gonzalo Alonso Orcajo, José Manuel Cano Rodríguez, Carlos Hirám Rojas García.

Task 5B – 3a: *Design of a prototype of Broad Band Filter*.

The Research Group will now proceed to the design of a Broad Band Filter of medium-high power (close to 100 kW). In this design the conclusions obtained in the previous tasks will be taken into account. The design process will chase an optimal

power factor, trying to achieve the reactive power compensation of the load, and not only to reduce the harmonic content of the supply currents. In this design, the demonstrative and test character of the installation will be considered so as to permit an easy access to the collection of measures.

Research Centre: Team from the University of Oviedo.

Members of the Research Group: José Manuel Cano Rodríguez, Gonzalo Alonso Orcajo, Carlos Hirám Rojas García.

Task 5B – 4a: *Manufacturing and starting of the prototype of Broad Band Filter*.

From the design obtained in the previous activity, and following the direction of the members of the Research Group, the staff from the EPO will proceed to the manufacturing of the apparatus. In this way, the staffs from TEMPER S.A.U. has a wide experience in the commercial field in the electric sector of our country, so this will facilitate the access to the best components (that must be manufactured ad-hoc for the filter in some cases). In relation with the manufacturing and assembly of components the company is also leader in the manufacturing of some electric equipment, so this wide experience is expected to be a strong guaranty of success.

Research Centre: Temper S.A.U. under the direction of the team from the University of Oviedo.

Members of the Research Group: Carlos Hirám Rojas García, Miguel Fernández (TEMPER).

Task 5B – 5a: *Study of the performance of the Broad Band Filter under real conditions. Study of aging and estimation of MTBF.*

The evolution of filter parameters during the aging process will be studied. The presence of transient over-voltages in the electric grid causes the perforation of the dielectric of capacitors; this phenomenon leads to excursions of their capacitive values. As a consequence, the system gets progressively detuned, and so the filter losses its filtering efficiency. This process will be investigated in detail.

The prototype will permit the verification of the validity of the theoretical conclusions reached in the task 5B – 2a, in relation with the performance of the filter under real conditions, such as the presence of voltage unbalance and voltage distortion.

Different components will be test in order to optimize the design of the filter. As an example, different types of capacitors (with different types of dielectric materials) will be test, so the harmful effects of the aging process will be minimized as far as it is possible.

The preceding studies will allow the members of the Research Group to make an estimation of Mean Time Before Failures for the equipment. In this time range an adequate level of filtering efficiency should be guaranteed.

On facing up this activity, the experience of the Research Group from the University of Sevilla will be exploited. This team has made in the past several studies on the aging process of components used in shunt filters. The coordination between both groups in the undertaken of the activity will avoid the duplication of tasks.

Reasons to support the necessity of a technician: The function that will face up the technician under contract in this activity will be clarified in the next task for a better comprehension.

Research Centre: Team from the University of Oviedo (in coordination with the team from the University of Sevilla).

Members of the Research Group: Carlos Hirám Rojas García, Francisco Pedrayes González, Técnico Contratado.

Task 5B – 6a: *Implementation of software tool for the optimal design of Broad Band Filters.*

In this section of the project, the Research Group will develop a software tool which will be intended to offer an immediate design solution (including protections) for a specific necessity of a Broad Band Filter.

One must consider that the design process of this type of filters is complex. As a topology that is partially connected in series with the load, every design power required level should be studied ad-hoc, as every case leads to different values in filter components. Two other factors cause the multiplication of design options. On one side the necessity (or not) for reactive power compensation leads to a modification on the optimal design values. On the other side, filters oriented to high power levels should take into account, as a design parameter, the short-circuit power at the point of common coupling, as in those cases, the network impedance can have a significant influence in filter performance.

The collaboration with the Research Group from the University of Sevilla will be also of great interest in this task. The determination of the most adequate object function in order to optimize the design will be treated here as a general case in order to systematize the calculation process in the software tool.

Reasons to support the necessity of a technician: Tasks 5B - 5a and 5B – 6a need a technician in order to guarantee their correct development, which take place between the 16th and 30th months of the life of the project (nevertheless the technician will join the group previously because of his participation in other activities). The main function of this person will consist on allowing the rest of the members from the Research Group to focus in the more scientific and technical aspects of the project, assuming a great part of the most mechanical assignments. One of his main responsibilities will be the implementation of a software tool for the assisted design of Broad Band Filters. In order to perform this work in the adequate manner, he will previously collaborate with the members of the team in the task 5B – 5a, getting then deeply involved in the stage of development of the product. In this previous activity he will be responsible of the continuous process of measurements and collection of data that will take place during the aging process of the prototype.

Research Centre: Team from the University of Oviedo (in coordination with the team from the University of Sevilla).

Members of the Research Group: José Manuel Cano Rodríguez, Gonzalo Alonso Orcajo, Técnico Contratado.

Task 5B – 1b: *Modelling of a Third Harmonic Filter.*

This task presents a very close methodology to task 5B – 1a, so their planning are superimposed in the Time Diagram. In this task the Research Group will model a Third Harmonic Filter by using the software Simulink from MatLab. The model will then be used in the rest of activities of this section. The main difficulties that determine the modelling works are very similar to those faced up with the Broad Band Filter. As an example the models for the reactive components used by both filters will be essentially the same. As it was stated in task 5B – 1a, the Research Group has a demonstrable experience in this kind of activities (see publications in section 6 of this document).

Research Centre: Team from the University of Oviedo.

Members of the Research Group: José Manuel Cano Rodríguez, Gonzalo Alonso Orcajo, Francisco Pedrayes González.

Task 5B – 2b: *Theoretical studies on the design and performance of a Third Harmonic Filter*.

The methodology used to face up this task is very similar to the one used in 5B – 2a. As a consequence both of them will take place at the same time (see the Time Diagram). Using the model developed in the previous task, a detailed study of the phenomenon of detuning will be carried out, and its influence on the reduction of filtering efficiency will be considered. This will lead to the determination of feasible design criteria for the selection of components. Again at this stage, a close collaboration with the team from the University of Seville will take place, in order to find the most adequate technique for the optimization of the design. An especial attention will be paid to the study of the operation of the filter far from full load, considering that in actual applications this apparatus use to work in a wide range of power levels. A quite care will be taken in guaranteeing an acceptable level of filtering in the whole range.

As these apparatus are single phase, there are not sensible to the presence of unbalance in the supply network; and as they do not include shunt connected elements the influence of reasonable levels of distortion in the supply voltage is negligible. These two aspects make some difference with the comparable activity for the case of Broad Band Filters (5B – 2a).

The most suitable protection system for the installation of the device will be determined. For this task, the transient behaviour will be of especial interest. The model developed in the task 5B – 1b will be used with this aim. This study will take into account not only the protection of the internal components of the filter, but also the installation and the load fed through it. The possibility of installing a by-pass will be considered in order to guarantee the continuity of the voltage supply in case of breakdown of the filter.

Finally, and this is an specific aspect of this type of filter, the impact on the Low Voltage installations of the presence of zero-sequence voltages induced by these devices will be investigated. Previous studies carried out by this Research Group, point out that this voltages are mitigated in a great percentage in real operating conditions (due to the interaction established between the existing linear loads of the installation and those fed through this type of filters). The real voltage distortion levels at the output of these apparatus will then be determined, and we hope that this aspect will reduce the reserves that some times the market shows when considering this type of solution (because of the possibility of a lack of compatibility between the final load and the output voltage of the filter). This last aspect (that is expected to lead soon to publications) will make this activity of longer duration than the comparable one in the section of Broad Band Filters (5B – 2a).

Research Centre: Team from the University of Oviedo (in coordination with the team from the University of Sevilla).

Members of the Research Group: Gonzalo Alonso Orcajo, José Manuel Cano Rodríguez, Francisco Pedrayes González.

Task 5B – 3b: *Design of a prototype of Third Harmonic Filter.*

A Third Harmonic Filter for a circuit of 16 A will be designed. In this design all the conclusions reached in the previous activities will be considered. The demonstrative and test prototype character of the equipment will be taken into account, in

order to permit an easy access to the measurement points. This task can be faced up even before that certain aspects of task 5B – 2b are completely finished, so in the Time diagram they share a couple of moths with the object of not delaying the field tests.

Research Centre: Team from the University of Oviedo.

Members of the Research Group: José Manuel Cano Rodríguez, Gonzalo Alonso Orcajo, Francisco Pedrayes González.

Task 5B – 4b: *Manufacturing and starting of the prototype of Third Harmonic Filter.*

From the design developed in the previous task, and following the direction of the members of the Research Group, the staff from the EPO will proceed to the manufacturing and starting of the device. This filter will be installed in an illumination board placed in a manufacturing plant from TEMPER S.A.U. (Crady's plant), EPO from this subproject. This will be done, in such a form that a shunt comparable illumination circuit exists (with the same type and number of lamps) in order to make a comparative study of both systems.

Research Centre: Temper S.A.U. under the direction of the team from the University of Oviedo.

Members of the Research Group: Carlos Hirám Rojas García, Miguel Fernández (TEMPER).

Task 5B – 5b: *Study of the performance of the Third Harmonic Filter under real conditions. Study of aging and estimation of MTBF.*

It is the comparable task to 5B – 5a, now for the case of Third Harmonic Filters. A deep investigation of the two illumination systems cited in the previous activity (with and without filter) will be carried out, not only to determine the efficiency of the filter, but also to consider the variation of luminous intensity and power consumption.

Furthermore, a tracking of the different parameters of the filter in time will be done. Just like in the case of the Broad Band Filters, the presence of transient over-voltages in capacitors causes perforations in the dielectric materials that lead to variations on capacities. A detuning of the filter arises then, with the subsequent loss of filtering efficiency. The behavior of this phenomenon in the time will be investigated in detail (and the experience on the field of the Research Group from Seville will be exploited through a close collaboration). In this type of filter the operation at medium loads is also a matter of interest, and the measurements in real conditions will be used to check the conclusions achieve in the task 5B – 2b.

Also in this case, different types of components selected to optimize the design will be tested. For example different types of capacitor with different dielectric materials will be tried, to assure the best solution, in attention to the aging process. Then an estimation of the Mean Time Between Failures (MTBF) will be stated. In this period of time we could guarantee a certain filtering efficiency of the filter.

Research Centre: Team from the University of Oviedo (in coordination with the team from the University of Sevilla).

Members of the Research Group: Carlos Hirám Rojas García, Francisco Pedrayes González.

Task 6B: *Integration of information*.

This task corresponds to the General Activity 6 that will be face up by all the Research Groups in a coordinated manner.

Research Centre: Team from the University of Oviedo (in coordination with the rest of the teams).

Members of the Research Group: Gonzalo Alonso Orcajo, José Manuel Cano Rodríguez, F. Pedrayes González.

Task 8B: *Conclusions and final report*.

The respective conclusions will be stated, and each group will write a final report that together with other partial documents, will be useful for the elaboration of the Final Report of the Coordinated Project.

Research Centre: Team from the University of Oviedo (in coordination with the rest of the teams).

Members of the Research Group: José Manuel Cano Rodríguez, Gonzalo Alonso Orcajo.

Task 9B – 1: *Divulgation of results in relation with Broad Band Filters.*

As it was remarked in the previous sections, one of the most directs ways of making a transfer of the results of the project to the industry, would be the cession, under contract between the parts, of the right to use the protected software tool implemented in task 5B – 6a, and that will condensate a great part of the results obtained in this subproject.

Furthermore, the results of general character (see section 5 of this document) will be presented in the most reputable publications on the field, not only at the scientific level but also in spreading reviews. In this last case, an especial attention will be focused in those aspects in which the proposed solutions developed in this subproject beat the most spread solutions present in the market.

At the moment of starting of this activity, it is expected that the companies involved in the project (in especial the EPO of this subproject) will be in the position of manufacturing a final product to offer to the market. The staff from TEMPER S.A.U. will include in their usual conferences oriented to electric professionals, the most practical information in relation with the developed solutions. This should contribute to a quick introduction of these devices in the industrial environment.

Research Centre: Team from the University of Oviedo (in coordination with TEMPER S.A.U.).

Members of the Research Group: Gonzalo Alonso Orcajo, José Manuel Cano Rodríguez, Nacho Lora (TEMPER), Pedro Cabello (TEMPER).

Task 9B – 2: *Divulgation of results in relation with Third Harmonic Filters.*

Most of the considerations exposed in the activity 9B – 1 are of application in this point too. The results with a more general character, in especial those related to the presence of zero-sequence voltages in installations using Third Harmonic Filters, are expected to be published in one of the most prestigious scientific reviews related to Power Quality issues (see section 5). In a more technical area we will try to show our results in publications oriented to professionals in this field, trying to focus in the advantages of this solution in relation to other methods of mitigation of *tripplens*.

Just like for the case of Broad Band Filters, we hope that at the moment of the beginning of this task, the companies involved in this subproject will now be capable of starting with the launching of a final product. The staff from TEMPER S.A.U. will include in their usual conferences oriented to electric professionals, the most practical information in relation with this improved solution.

Research Centre: Team from the University of Oviedo (in coordination with TEMPER S.A.U.).

Members of the Research Group: Gonzalo Alonso Orcajo, José Manuel Cano Rodríguez, Nacho Lora (TEMPER), Pedro Cabello (TEMPER).

TEAM C.

Center.- University ofCantabria

Human resources. - It is reflected in detail in the cv enclosed with the request the academic formation and qualification of the own personnel of the University of Cantabria.

Reasons to support the necessity of a technician
The hiring of a technician for 18 months is a necessity. When the technician acquires the necessary knowledge inherent to a part of the different phases of the project will be a great aid. In addition, he will acquire knowledge about the elaboration of models, industrial networks of distribution and industrial installations, the operation of the measuring instruments, the techniques and conditions of measurement, analysis of measurement, right location of the instruments (zones of low electromagnetic influence), connection forms, types of usable bores and, specially, about the assemblies that will be carried out in the Laboratory of Electromagnetic Compatibility.

Tasks. Next the different tasks that team C will carry out are indicated. The person or people who work directly in each one is (are) indicated

Task 0C: Search, structuring and diffusion of the information.

It belongs to general activity "0". All the members of the four groups will carry out this task. This task will be carried out in an intensive way during the whole project. The coordination of the groups will be carried out by means of the net. The information among the members of the groups will be distributed using the net. The team at the University of Cantabria (Team C) will take an intensive search of the specific aspects of the subproject that must develop.

Researchers: Responsible people will be: Mario Mañana Canteli, Alfredo Ortiz Fernández and the hired person. All the members of the team will collaborate in this work that doesn't have really finalization.

Justification of hired personnel's necessity: The hiring of a person that collaborates during the duration of the activity of the project is necessary for the acquisition and organization of the whole necessary bibliographical information for the development of the project. In addition, this task is formative. The hired person will acquire knowledge about the required bibliography, sources where to obtain the information and, also, about the handling and classification of written or computerized documents.

Task 1C: Measurement of the perturbations to study.

It belongs to general task "1". This task will be developed during two years by all the groups in its assigned zone. The zone of Cantabria and bordering belongs to the team C.

The Power Quality survey will be intensified especially in the following aspects:

a) Measures of the parameters that characterize the quality of the electric supply, specially, harmonic, fluctuations of voltage, "flicker effect" and voltage sags in industrial facilities of the region that possess a significant number of electrical drives.

b) Measures in distribution networks located in points of electric power distribution to industrial areas of the region.

New necessities: Instrumentation of measure of the quality of the supply according to the norm UNE-EN 61000-4-30.

Researchers: Maria de los A. Cavia Soto, Mario Mañana Canteli, Paulino Sanchez Barrios, Alfredo Ortiz Fernández and hired person.

Justification of hired personnel's necessity: The hiring of a person that collaborates during two years in the activities 1C of the project supposes a help when he acquires the necessary technique. In addition, this task is formative. The hired person will acquire knowledge about the operation of the measuring instruments, the techniques and conditions of measurement, MV and LV networks, industrial installations, right location of the instruments (zones of low electromagnetic influence), connection forms, types of usable bores, etc. Without a doubt, this person will be the most suitable to collaborate with the investigators in the realization of this task.

Task 1.1C: Development of techniques and methodologies of measurement.

The objective of this task is to develop techniques and methodologies of measurement that allow to optimize the number and location of measuring equipment of the quality of the electric supply. The use of techniques of state estimation and nonlinear optimization is proposed.

New necessities: Software of simulation of networks that allows to carry out load flows and to obtain operating conditions.

Researchers: María de los A. Cavia Soto, Mario Mañana Canteli y Alfredo Ortiz Fernández.

Task 2C: Conclusions on the concrete relationships cause-generated perturbation.

It belongs to general activity "2".

Researchers: Members of the team C that work in this activity: Paulino Sánchez Barrios, Alfredo Ortiz Fernández, Severiano Pérez Remesal y Mario Mañana Canteli.

Task 3C: Effects that cause the perturbations.

Task 3.1C: Analysis of the effects of the voltage sags on industrial installation of L.V. The team C will carry out a meticulous analysis of the effect that have the voltage sags and the brief interruptions on the Low Voltage industrial installations (L.V.)

Researchers: Paulino Sánchez Barrios, María de los A. Cavia Soto, Alfredo Ortiz Fernández y hired person.

Justification of hired personnel's necessity: This hired person will collaborate in the field measures that will be carried out as well as in the development of the specific software of analysis.

Task 3.2C: Analysis of the effects of the harmonics on the Low Voltage industrial installations.

The team C will carry out a meticulous analysis of the effects that the harmonics have on the Low Voltage industrial installations (L.V.).

Researchers: Alfredo Ortiz Fernández, Severiano Perez Remesal and hired person.

Justification of hired personnel's necessity: the hired person will collaborate in the field measures that will be carried out as well as in the development of the specific software of analysis.

Task 4C: Transmission of perturbations.

The purpose of this task is to obtain a number of considerations about the transmission of harmonics and voltage sags through the networks (HV, MV and LV) and installations:

Task 4.1C: Transmission of harmonics.

Task 4.1.1C: Simultaneous measurement of harmonics.

The harmonics will be monitored, measured and registered simultaneously in the electric networks of HV, MV and LV, the common point of connection and in different points of the interior installations of the industrial facilities.

New necessities: System of programmable data acquisition.

Researchers: Mario Mañana Canteli, and hired person.

Justification of hired personnel's necessity: The hired person will collaborate in the field measures that will be carried out as well as the development of the software of analysis of the measures.

Task 4.1.2C: Elaboration of transmission models of harmonics.

Models will be elaborated and analysis programs will be carried out that allow to obtain results of the simulation by means of computer for the transmission of harmonics.

New necessities: Software of simulation of networks that allows to carry out of load flows and to obtain operating conditions.

Researchers: Mario Mañana Canteli and hired person.

Justification of hired personnel's necessity: The hired person will participate in the elaboration of the transmission models of harmonics.

Task 4.1.3C: Validation of the transmission models of harmonics.

The measures obtained in the task 4.1.1C will allow to validate the simulation results and to establish considerations about the departure hypotheses and the time of calculation.

Researchers: Mario Mañana Canteli and hired person.

Justification of hired personnel's necessity: the hired person will collaborate in the validation of the models.

Task 4.2.C: Transmission of voltage sags.

Task 4.2.1C: Simultaneous measurement of voltage sags.

The voltage sags will be monitored, measured and registered simultaneously in the electric networks of HV, MV and LV, the common point of connection and in different points of the interior installations of the industrial facilities.

New necessities: System of programmable data acquisition.

Researchers: Alfredo Ortiz Fernández, Severiano Perez Remesal, Fernando Delgado and hired person.

Justification of hired personnel's necessity: The hired person will collaborate in the field measures that will be carried out.

Task 4.2.2C: Elaboration of transmission models of voltage sags.

Models will be elaborated and analysis programs will be carried out that allow to obtain results of the simulation by means of computer for the transmission of voltage sags.

New necessities: Software of simulation of networks that allows to carry out of load flows and to obtain operating conditions.

Researchers: Alfredo Ortiz Fernández, Severiano Perez Remesal, Fernando Delgado and hired person.

Task 4.2.3C: Validation of the transmission models of voltage sags.

The measures obtained in the task 4.2.1C will allow to validate the simulation results and to establish considerations about the initial hypotheses and the time of calculation.

Researchers: Alfredo Ortiz Fernández, Severiano Perez Remesal, Fernando Delgado and hired person.

The investigations framed in the general Activity 5 of the general working plan won't be carried out by the team C.

Task 6C: Integration of the information.

It belongs to general activity “6”. This task will be carried out in a coordinated way among all the groups.

Researchers: All the nominal members of the team and hired person.

Justification of hired personnel's necessity: the hired person will collaborate in the coordination of the groups and in the management of the web server of information based in BSCW.

The investigations framed in the general Activity 7 of the general working plan won't be carried out by the team C.

Task 8C: Conclusions and final report.

Each team will edit the corresponding conclusions elaborating with them a final report. The final memory of the project will be edited serving like base the final report and others partial reports.

Researchers: All the nominal members of the team and hired person.

Task 9C: Diffusion of the results of the project.

Two tasks related with the diffusion of the results of the project will be carried out affecting at two of the members of the Group of Investigation:

- Presentation of the conclusions by means of four reports in national congresses and four reports in international meeting. This presentation will include the elaboration of the corresponding report as well as its defense in the congress.

-To facilitate the tool of prediction of the effects of the perturbations in electrical drives through the Web page of the Group of Investigation of the University of Cantabria. With this purpose a page associated to the project will be elaborated that will allow to download the tool. The most interesting conclusions obtained about the mitigation of the effects of the perturbations will also be available.

-Preparation and publication in magazines of some papers about power quality. Specific aspects of the investigation will be analyzed in these articles.

-Transference of the results to the companies that endorsed the request of the project.

Researchers: Mario Mañana Canteli, Alfredo Ortiz Fernández, Maria de los A. Cavia Soto and hired person.

Justification of hired personnel's necessity: The hired personnel will carry out the design of the Web page dedicated to the project as well as of its technical and contents management.

TEAM D.

Center.- University of Seville

Human resources.- The formation and qualification of the researchers of the University of Seville are reflected in the respective curricula attached to the request.

Justification of the necessity to contract a technician.
The contract of a technician for aid to the development of the project has been considered. His activity will be centered mainly in three activities:

- Programming, set up, survey and overturned of information of the power quality measurement devices to be installed in industrial facilities and distribution networks.
- Laboratory work in assemblies of power and signal.
- Programming and maintenance of a Web page of the power quality research team.

It is understood that, although these tasks can be developed by anyone of the researchers of the group, the presence of a technician would allow to the researchers the opportunity to focus in those aspects important of the activities to develop. In addition, it is understood that the work to develop is educative because the contracted person would acquire useful knowledge about power quality. Given to the particularity of the mentioned activities and the anticipated service load, the contract will have duration of two years, part job.

Tasks. Following, the different general tasks that will be performed by the University of Seville team are going to be related, indicating the researchers directly tied to the ones.

Task 0D: Search, organization and diffusion of the information.

This task corresponds with the general task "0" and they will be carry out, in a intensive form, by all the members of the four groups in a coordinated form for the whole project extension and, using the network potentialities, they will spread the information among all the members of the team. With regard to the University of Seville research team (Team D), they will intensify the search in the specific aspects of the subproject that they are going to develop: mitigation of harmonics by means of passive, active and hybrids filters.

Researchers: J.Mª Maza, M. Burgos and P. Cruz.

Task 1D: Measurement of the disturbances

It corresponds with the general task “1”. This task will be developed for two years, by all the teams, each in its zone. Andalusia and the bordering zone, corresponds to the Team D. The researchers intended to make measures of power quality in different points of the distribution network. As can be seen from the support letters to this project of I+D+I, the participant companies as EPO are very much interested. Not only industrial facilities with problems of power quality (PERSAN and TRH), but the main supplier of Andalusia (ENDESA DISTRIBUTION S.L.U.), promoters of electrical power stations based on renewable energies (SOLAR SERIES and NEON ENERGY) and the regional administration (AGENCY ANDALUSIAN OF THE ENERGY) are supporting the accomplishment of these campaigns.
It should be noted that there are six organizations that have shown their support this project of investigation whose letters are attached to the project documentation. Nevertheless, the software application limits the number of organizations to four.

New needs: Power quality measurement instrumentation in agreement with UNE-EN 61000-4-30.

Researchers: M. Burgos, M. Casal and contracted technician.

Task 5D: Harmonic mitigation

Within this activity the University of Seville research team divides its activity in tasks related to passive, active and hybrid filters. Each one of these tasks is divided as well in more specific others as follows. Additionally to the developed theoretical work a experimental validation will be made in the laboratory.

Task 5D.1. Passive filters

Task 5D.1.1. Improvements in the optimization problem formulation.

The new formulations will consider aspects that have not been had in consideration to date and that can be summarized as follows:

- Objective function. References [16-17] respectively use as objective function the intensity reactivates and a linear combination of tension and intensity. Other functions can be used as objective to design the filters, such as the filter cost.
- Restrictions. The restrictions that usually are considered to solve this problem can be divided in two fundamental blocks: restrictions of determined resonance to harmonic and technical restrictions. The first are necessary to find the minimum global of the optimization problem. The second introduce some technical limitation to the solution, as the required global reactive compensation (voltage distortion and current below a limit) and other related to the dimension of passive elements of the filter [35].

Researchers: J.Mª Maza, M. Burgos and J.C. del Pino

Task 5D.1.2. Incorporation of new filter topologies in the optimization methods.

This task is coordinated between the Universities of Seville and Oviedo, especially the Tasks 5B-2a, 5B-5a, 5B-6a, 5B-2B and 5B-6b. The objective is to introduce in the methods of optimization proposed in the Task 5D.1.1 the topologies of filters that the research team of the University of Oviedo will study: filter of broadband and filter of third harmonic. The final purpose of this task is to design an efficient sizing algorithm, so that it could be implemented in the Tasks 5B-4a and 5B-4b of the University of Oviedo. This algorithm must take into account not only the different criteria of optimization previously shown, but also the resolution of practical problems such as the influence of the variation of parameters in the filters resonance frequencies and the parameters of operation of the passive components that conform the filter.

Researchers: J.Mª Maza, P. Cruz and J.C. del Pino

Task 5D.1.3. Introduction of the temporary variations of load.

In the previously existing publications about passive filters shows that the dimension of the filter are chosen considering a given fixed point of operation. This procedure does not take into account that, in any industrial facility there are variations throughout the time of all the parameters that take part in the filter size (the impedances of load and network, voltage harmonics and current, among others). Therefore it is tried to introduce all these variations in the process of optimization of the passive filters, in order to find the optimal filter for a given profile of load. These profiles of load can easily be obtained for each specific application through campaigns of harmonic measurement in points of each specific industrial installation.

Researchers: P. Cruz, M. Burgos and J.C. del Pino.

Task 5D.2. Active filters.

Task 5D.2.1. Simulation of active filters.

The objective of this simulation task is twofold. On the one hand, is desired to validate by means of the simulation in the dominion of the time domain the frequency model of active filter proposed by this research team [36]. In these simulations it is tried to characterize both the influence of the modulation stage and the frequency of commutation. On the other hand, it is tried to make contributions to the stage of calculation of the reference signal. One of the more advanced methods to calculate the reference signal is the proposed in [29]. In this method the calculation of the harmonics is used using a synchronous reference (axis) and applying to a low pass filter formulated under frequency domain. The problem of this formulation is in the delay introduced by this type of filter. In this sense, it is tried to improve the performance of the active filter by means of the substitution of this type of filter by another one of average moving, stetted in the time domain.

Researchers: P. Cruz, J. Mª Maza y C. Montalvo

Task 5D.3. Hybrid filters.

Task 5D.3.1. Optimization of different hybrid filters topologies.

It is tried to study the design stage of the hybrid filters taking into account both the previously existing topologies as some new ones. In any case, the design strategies that will be used are going to be based on optimization methods that use some tools developed in previous stages of the project, specifically:

- Active filter frequency model. In this sense, the active filter could be introduced in the developed methods of optimization as a nonlinear load (voltage controlled source current model).
- Methods of optimization that consider the operation point variation. The objective will be to obtain a filter of minimum cost with a previously specified performance (maximum distortions of tension and intensity). This way, the passive part of the hybrid filter would be in charge to absorb the "base" part of the requirements, whereas the active one would be used to follow the load variations.

Researchers: J.Mª Maza, C. Montalvo y M. Burgos

Task 5D.4. Experimental laboratory validation.

The objective of this activity is to set up in the laboratory a system of validation reference and test of hybrid filters. The objective is to characterize the real behavior of this type of devices exposed to real conditions of operation, taking into account:

- Presence of the network impedances.
- Voltage harmonic in the supply.
- Time variable loads and conditions of the supply voltage.

Within this activity, the following different tasks are considered:

Researchers: M. Casal, M. Burgos and J.C. del Pino

New needs: Hand instrumentation for power quality measurement (harmonic).

Task 5D.4.1. Determination of the functional characteristics

It is tried to evaluate which must be the characteristics of the reference system that is desired to mount in the laboratory. These characteristics are conditioned by the previous equipment available in the laboratories of the Department of Electrical Engineering of the University of Seville.

Researchers: M. Casal, M. Burgos and J.C. del Pino

Task 5D.4.2. Assembly of the components of power and signal

It is desired to install a scale distribution network which parameters, such as the network impedance, the level of harmonic distortion of the voltage supply and the point of operation of the linear and nonlinear loads could easily be modified. This distribution network could be additionally instrumented with voltage and current transducers. The data acquired by means of data acquisition cards will be analyzed by means of a specific Virtual Instrument designed for that purpose.

Researchers: F. González, P. Cruz y Contracted technician

Task 5D.4.3. Introduction of the active filter in the reference system

Once installed the network of distribution of reference, a three-phase three levels inverter (developed DPI2001-2367 and ENE2004-06117 projects) will be connected. This inverter will be used as active filter to develop the tasks of power reactive compensation and harmonics mitigation. The operation of the active filter in steady state, and with variations in the load, network impedance and voltage supply, will evaluated.

Researchers: P. Cruz, J.Mª Maza and C. Montalvo

Task 5D.4.4. Assembly of the hybrid filter

The use of the design algorithms proposed in the previous tasks will be applied to a specific time evolution of the conditions of the supply network and the loads, reproduced in the laboratory. The result will be the optimal design of the hybrid filter for this pattern of operation. The assembly of the passive elements of the hybrid filter will be made.

Researchers: J.Mª Maza, P. Cruz and F. González

Task 5D.4.5. Comparison among passive, active and hybrid filter for a given load profile.

In this task it is tried to evaluate from a technical and economical point of view the performance of different filter options available for a given profile of load.

Researchers: M. Burgos, J.Mª Maza and P.Cruz

Task 6D: information integration

This task corresponds with the General task 6 that must be performed by all the teams in a coordinated form.

Researchers: J.C. del Pino, C. Montalvo y Contracted technician

Task 8D: Conclusions and closing report

Every team will elaborate a closing report including the corresponding partial conclusions. The final report of the project will be will be based on all those partial reports .

Researchers: J.Mª Maza, P. Cruz and M. Casal

Task 9D: Diffusion of the project results

The tasks relative to the diffusion of results are collected in section 5 of the memory with detail. The objective of this task is to show for different audiences (industry, local administrations, regional and or nationals, educational at university, second and third cycle levels, research, etc.) the main conclusions related to the power quality. To reach that goal, a few diffusion media will be used (attendance from congresses, power quality Web page, scientific meetings, creation of seminaries, publication of papers in technical reviews and magazines, etc.).

Researchers: J.Mª Maza, M. Burgos and F. González

4.1 SCHEDULE

TEAM A
Research Centre: UNIVERSITY OF VIGO

Activities/Tasks	Centre	Responsible person and others involved	First year (*)	Second year (*)	Third year (*)
General Activity 0 Task 0A *Search, organization and spread of information*	Univ of Vigo	D. Coll Mayor F. T. Oliveira J. M. Rodríguez	X|X|X|X|X|X|X|X|X|X|X|X|	X|X|X|X|X|X|X|X|X|X|X|X|	|X|X|X|X| | | | | | | |
General Activity 1 Task 1A *Measurement of perturbations under study*	Univ of Vigo	M. Pérez Donsión Filipe T. Oliveira José M. Rodríguez Personal Contratado	| | | | |X|X|X|X|X|X|X|	X|X|X|X|X|X|X|X|X|X|X|X|	| | | | | | | | | | | | |
General Activity 1 Task 1AP *Measurement of harmonics, flicker and sags in Wind Farms*	Univ of Vigo	M. Pérez Donsión Filipe T. Oliveira Personal contratado	| | | | |X|X|X|X|X|X|X|	X|X|X|X|X|X|X|X|X| | | | |	| | | | | | | | | | | | |
General Activity 2 Task 2A *Conclusions on the relations cause-disturbance emitted*	Univ of Vigo	M. Pérez Donsión	| | | | | | | | | | | | |	| | | | | | | | | | | | |	|X|X| | | | | | | | | |
General Activity 3 Task 3.1.1A *Study of the effects of the armónicos on motors. Study of the increment of losses*	Univ of Vigo	M.Pérez Donsión Personal contratado	| | | | | | | |X|X|X|X|	|X|X|X|X|X|X|X|X|X| | | |	| | | | | | | | | | | | |
General Activity 3 Task 3.1.2A *Study on the loss of working life*	Univ of Vigo	G. Pelaez Lourido M. Pérez Donsión Personal contratado	| | | | | | | | | | | | |	| | | | | | | | |X|X|X|X|	|X|X| | | | | | | | | |

General Activity 3 Task 3.1.3A *Vibrations*	Univ of Vigo	G. Pelaez Lourido			
General Activity 3 Task 3.3A *Effect of flicker on different devices*	Univ of Vigo	M.Pérez Donsión Personal contratado			
General Activity 4 Task 4.1A *Improvement of the model of flicker meter*	Univ of Vigo	M.Pérez Donsión D. Coll Mayor			
General Activity 4 Task 4.2A *Electric power system modelled*	Univ of Vigo	M.Pérez Donsión D. Coll Mayor			
General Activity 4 Task 4.3A *Validation of the models*	Univ of Vigo	M.Pérez Donsión D. Coll Mayor			
General Activity 4 Task 4.4A *Influence of the parameters*	Univ of Vigo	M.Pérez Donsión D. Coll Mayor			
General Activity 4 Task 4.5A *Analysis of the influence of the short circuit powers*	Univ of Vigo	M.Pérez Donsión D. Coll Mayor			
General Activity 5 Task 5.A *Mitigation and immunization measures*	Univ of Vigo	M.Pérez Donsión J.M. Rodríguez J. Pardo Frojan			
General Activity 5 Task 5APE *Analysis of flicker in Wind Farms*	Univ of Vigo	M. Pérez Donsión F.T. Oliveira D. Coll Mayor			
General Activity 6	Univ of Vigo	M. Pérez Donsión			

Task 6A *Integration of the information*		G. Pelaez Lourido J. Pardo Frojan			
General Activity 7 Task 7A *Economic analysis of power quality*	Univ of Vigo	J. Pardo Frojan			
General Activity 8 Task 8A *Conclusions and closing report*	Univ of Vigo	M. Pérez Donsión D. Coll Mayor G. Pelaez Lourido J. Pardo Frojan			
General Activity 9 Task 9A *Diffusion of the results of the project*	Univ of Vigo	M. Pérez Donsión D. Coll Mayor G. Pelaez Lourido J. Pardo Frojan			

TEAM B
Research Centre: UNIVERSITY OF OVIEDO

[ ] The workers that TEMPER S.A.U. (EPO) put in the service of the project appear in the section 'Person in charge and other people involved' enclosed in square brackets.
[ ] Other groups with which a high coordination degree will be necessary appear in the section 'Research Team' enclosed in square brackets.

Activities/Tasks	Research Team	Person in charge and other people involved	First year (*)	Second year (*)	Third year (*)
General Activity 0 Task 0B *Search, organization and spread of information*	Uni. Oviedo	J. M. Cano G. A. Orcajo C.H. Rojas			
General Activity 1 Task 1B *Measurement of perturbations under study*	Uni. Oviedo [Rest of Equi.]	C. H. Rojas F. Pedrayes Contratado			
General Activity 2 Task 2B	Uni. Oviedo	G. A. Orcajo J. M. Cano			

Conclusions on cause-emitted perturbation relationships	[Rest of Equi.]	C.H. Rojas			
General Activity 3 Task 3B *Effect of voltage sags on Adjustable Speed Drives*	Uni. Oviedo	J. M. Cano G. A. Orcajo F. Pedrayes		X X X X X X X X X X X X	
General Activity 5 Task 5B-1a *Modelling of a Broad Band Filter (b.b.f.)*	Uni. Oviedo	J. M. Cano G. A. Orcajo C.H. Rojas	X X X		
General Activity 5 Task 5B-2a *Theoretical studies on the design and performance of a b.b.f.*	Uni. Oviedo [Uni. Sevilla]	G. A. Orcajo J. M. Cano C.H. Rojas	X X X X		
General Activity 5 Task 5B-3a *Design of a prototype of Broad Band Filter*	Uni. Oviedo	J. M. Cano G. A. Orcajo C.H. Rojas	X X		
General Activity 5 Task 5B-4a *Manufacturing and starting of the prototype of b.b.f.*	Uni. Oviedo [Temper S.A.U.]	C. H. Rojas [Miguel Fernández]	X X X	X X X	
General Activity 5 Task 5B-5a *Study of the performance of the b.b.f. under real conditions.* *Study of aging and estimation of MTBF of b.b.f.'s*	Uni. Oviedo [Uni. Sevilla]	C. H. Rojas F. Pedrayes Contratado		X X X X X X X X X	X X X
General Activity 5 Task 5B-6a *Implementation of software tool for the optimal design of b.b.f.'s*	Uni. Oviedo [Uni. Sevilla]	J. M. Cano G. A. Orcajo Contratado		X X X	X X X X X X
General Activity 5 Task 5B-1b *Modelling of a Third Harmonic Filter (t.h.f)*	Uni. Oviedo	J. M. Cano G. A. Orcajo F. Pedrayes	X X X		
General Activity 5 Task 5B-2b *Theoretical studies on the design and performance of a t.h.f.*	Uni. Oviedo [Uni. Sevilla]	G. A. Orcajo J. M. Cano F. Pedrayes	X X X X X X X		
General Activity 5 Task 5B-3b *Design of a prototype of Third Harmonic Filter*	Uni. Oviedo	J. M. Cano G. A. Orcajo F. Pedrayes	X X		
General Activity 5 Task 5B-4b	Uni. Oviedo [Temper S.A.U.]	C. H. Rojas [Miguel Fernández]	X X X	X X X	

Manufacturing and starting of the prototype of t.h.f.					
General Activity 5 Task 5B-5b *Study of the performance of the t.h.f. under real conditions.* *Study of aging and estimation of MTBF of t.h.f.'s*	Uni. Oviedo [Uni. Sevilla]	C. H. Rojas F. Pedrayes			
General Activity 6 Task 6B *Integration of information*	Uni. Oviedo [Rest of Equi.]	G. A. Orcajo J. M. Cano F. Pedrayes			
General Activity 8 Task 8B *Conclusions and final report*	Uni. Oviedo [Rest of Equi.]	J. M. Cano G. A. Orcajo			
General Activity 9 Task 9B-1 *Divulgation of results in relation with b.b.f.'s*	Uni. Oviedo [Temper S.A.U.]	G. A. Orcajo J. M. Cano [Ignacio Lora] [Pedro Cabello]			
General Activity 9 Task 9B-2 *Divulgation of results in relation with t.h.f.'s*	Uni. Oviedo [Temper S.A.U.]	G. A. Orcajo J. M. Cano [Ignacio Lora] [Pedro Cabello]			

(*) Shade the appropriated number of cells (months)

TEAM C
Research Centre: UNIVERSITY OF CANTABRIA

[ ] Other groups with which a high coordination degree will be necessary appear in the section 'Research Team' enclosed in square brackets.

Activities/Tasks	Centre	Responsible person and others involved	First year (*)	Second year (*)	Third year (*)
General Activity 0 Task 0C *Search, organization and spread of information*	Univ de Cantabria	M. Mañana Canteli A. Ortiz Fernández Hired technician	|X|X|X|X|X|X|X|X|X|X|X|X	X|X|X|X|X|X|X|X|X|X|X|	|X|X|X|X| | | | | | | |
General Activity 1 Task 1C Measurement of the disturbances	Univ Cantabria [Viesgo Distribución] [Robert Bosch]	M. Mañana Canteli María A. Cavia Soto P. Sánchez Barrios A. Ortiz Fernández Hired technician	| | | | |X|X|X|X|X|X|X|X|	X|X|X|X|X|X|X|X|X|X|X|	| | | | | | | | | | | |
General Activity 1 Task 1.1C *Development of techniques and methodologies of measurement*	Univ de Cantabria	M. Mañana Canteli A. Ortiz Fernández María A. Cavia Soto	| | |X|X|X|X|X|X|X|X|X|X	X|X|X|X|X|X|X|X|X|X| | | |	
General Activity 2 Task 2C *Conclusions on the relations cause-disturbance emitted*	Univ de Cantabria	P. Sáchez Barrios M. Mañana Canteli A. Ortiz Fernández S. Pérez Remesal	| | | | | | | | | | | | |	| | | | | | | | | | | | |	|X|X| | | | | | | | | | |
General Activity 3 Task 3.1C *Analysis of the effects of sags on low voltage grid.*	Univ de Cantabria	P. Sánchez Barrios María A. Cavia Soto Hired technician	| | | | | | | | | | | | |	X|X|X|X|X|X|X|X|X|X|X|	|X|X|X| | | | | | | | |
General Activity 3 Task 3.2C *Analysis of the effects of the harmonics on low voltage grid.*	Univ.De Cantabria	A. Ortiz Fernández S. Pérez Remesal Hired technician	| | | | | | |X|X|X|X|X|	X|X|X|X|X|X|X|X|X|X|X|X	|X|X|X| | | | | | | | |
General Activity 4 Task 4.1.1C *Simultaneous measurement of harmonics*	Univ de Cantabria [Viesgo Distribución]	M. Mañana Canteli Hired technician	| | | |X|X|X|X|X|X|X|X|X	X|X|X|X|X|X|X|X|X|X|X|X	| | | | | | | | | | | | |
General Activity 4	Univ de Cantabria	M. Mañana Canteli			

Task 4.1.2C *Elaboration of models of harmonics transmission*		F. Delgado S. Román Hired technician			
General Activity 4 Task 4.1.3C *Validation of the models of harmonics transmission*	Univ de Cantabria	M. Mañana Canteli F. Delgado S. Román Hired technician			
General Activity 4 Task 4.2.1C *Simultaneous measurement of voltage sags*	Univ de Cantabria [Viesgo Distribución]	A. Ortiz Fernández S. Pérez Remesal F. Delgado S. Román Hired technician			
General Activity 4 Task 4.2.2C *Elaboration of models of sags transmission*	Uuniv de Cantabria	A. Ortiz Fernández S. Pérez Remesal F. Delgado S. Román Hired technician			
General Activity 4 Task 4.2.3C *Validation of the models of sags transmission*	Univ de Cantabria	A. Ortiz Fernández S. Pérez Remesal F. Delgado S. Román Hired technician			
General Activity 6 Task 6C *Integration of the information*	Univ de Cantabria	P. Sánchez Barrios María A. Cavia Soto M. Mañana Canteli A. Ortiz Fernández F. Delgado S. Román S. Pérez Remesal Hired technician			
General Activity 8 Task 8C *Conclusions and final report*	Univ de Cantabria	P. Sánchez Barrios María A. Cavia Soto M. Mañana Canteli A. Ortiz Fernández F. Delgado S. Román S. Pérez Remesal Hired technician			
General Activity 9 Task 9C *Diffusion of the results of the project*	Univ de Cantabria	A. Ortiz Fernández María A. Cavia Soto M. Mañana Canteli Hired technician			

TEAM D
Centre: UNIVERSITY OF SEVILLE

[ ] Other groups with which a high coordination degree will be necessary appear in the section 'Research Team' enclosed in square brackets.

Activities/Tasks	Centre	Responsible person and others involved	First year (*)	Second year (*)	Third year (*)
General Activity 0		J.Mª Maza			
Task 0D	Uni. Sevilla	M. Burgos	X X X X X X X X X X X X	X X X X X X X X X X X X	X X X X
Search, organization and spreading of information		Contratado			
General Activity 1		M. Burgos			
Task 1D	Uni. Sevilla	M. Casal	X X X X X X X X X X X X	X X X X X X X X X X X X	X X X X
Measurement of disturbances to be analysed		Contratado			
General Activity 5		J.Mª Maza			
Task 5D.1. Passive filters	Uni. Sevilla	M. Burgos	X X X X X X X X X X		
Task 5D.1.1. Improvements in the optimization problem		J.C. del Pino			
General Activity 5		J.Mª Maza			
Task 5D.1. Passive filters	Uni. Sevilla	P. Cruz	X X	X X X	
Task 5D.1.2. Incorporation of novel topologies		J.C. del Pino			
General Activity 5		P. Cruz			
Task 5D.1. Passive filters	Uni. Sevilla	M. Burgos		X X X X	
Task 5D.1.3. Introduction of load variations		J.C. del Pino			
General Activity 5		P. Cruz			
Task 5D.2. Active filters	Uni. Sevilla	J. Mª Maza	X X	X X X	
Task 5D.2.1. Simulation of active filters		C. Montalvo			
General Activity 5		J.Mª Maza			
Task 5D.3. Hybrid filters	Uni. Sevilla	C. Montalvo		X X X X X X X X X X	
Task 5D.3.1. Optimization of different topologies		M. Burgos			
General Activity 5		M. Casal			

Task 5D.4. Experimental validation		M. Burgos	X X		
Task 5D.4.1. Functional characteristics	Uni. Sevilla	J.C. del Pino			
General Activity 5		F. González			
Activity 5D.4. Experimental validation	Uni. Sevilla	P. Cruz	X X X X		
Task 5D.4.2. Arrangement of signal and power components		Contratado			
General Activity 5		P. Cruz			
Activity 5D.4 Experimental validation	Uni. Sevilla	J.Mª Maza	X X X X X X X X X X X X X X X X X X X X		
Task 5D.4.3. Incorporation of active filter		C. Montalvo			
General Activity 5		J.Mª Maza			
Activity 5D.4. Experimental validation	Uni. Sevilla	P. Cruz			X X X
Task 5D.4.4. Assembly of hybrid filter		F. González			
General Activity 5		M. Burgos			
Activity 5D.4 Experimental validation	Uni. Sevilla	J.Mª Maza			X X X X X X
Task 5D.4.5. Comparison of different filters		P.Cruz			
General Activity 6		J.C. del Pino			
Task 6D	Uni. Sevilla	C. Montalvo		X X X X X X X X	X X X X X X
Integration of information		Contratado			
General Activity 8		J.Mª Maza			
Task 8D	Uni. Sevilla	P. Cruz			X X X
Conclusions and final report		M. Casal			
General Activity 9		J.Mª Maza			
Task 9D	Uni. Sevilla	M. Burgos	X X X	X X X	X X X
Exploitation of results		F. González			

(*) Shade the appropriated number of cells (months)

5. BENEFITS OF THE RESEARCH PROJECT

5.1 SCIENTIFIC-TECHNICAL CONTRIBUTIONS AND PREDICTABLE BENEFICTS

If the objectives of the project are considered, the main scientific contributions are shown in the next table. Each contribution is linked with the research group that will have the major responsibility. The code for the different groups is: A: University of Vigo; B: University of Oviedo; C: University of Cantabria; D: University of Seville.

Group	Scientific and technical contributions	Benefits
A	Development of the method for the evaluation of the costs linked to the absence of power quality	Economical impact of power quality and power reliability problems on productivity and downtime depending of the kind of user
A	Measurement of the power quality 'events' in critical coupling points	Conclusions about the behavior of the Spanish power system during PQ-events
A	Effect of the harmonic and interharmonic currents on induction motors	Conclusions about the impact of the current distortion on the induction motor: ageing, losses and vibrations
A	The flicker measure model developed by the research group will be improved	It will be improve the measure of this PQ-event
B	No conventional passive solutions for the reduction of harmonic distortion will be analysed	Low cost solutions that improve the efficiency of the utility will be improved.
B	Broad band filter prototype will be designed and built	Useful equipment for the reduction of harmonic distortion will be developed.
B	Software tools for the design of broad band filters will be designed	It will make easier the practical use of this solutions
B	Third harmonic filters will be built and analysed under real conditions	Development of a useful product for the reduction of harmonic distortion in single-phase circuits
B	Effects of the zero-sequence voltages on the low voltage systems using third harmonic filters will be analysed	Analysis of the convenience of using this kind of filters under different types of loads
C	Analysis of the waveforms under PQ-events attending the origin, the propagation and power system conditions	To obtain the minimal time of diagnosis: location of the origin and used switchgears by waveform analysis
C	A methodology to obtain the optimal number of measurement points for an adequate image of the experimented PQ events will be designed.	Reducing the cost of the utility monitoring
C	A guide to compare the results obtained during the use of A and B class equipments for the measurement of power quality events will be developed	It is important to select the equipment under the better quality/cost relationship and monitoring conditions
C	Dynamical models of power transformers considering the technical data of the manufacturer for the study of short duration PQ-events propagation will be developed	Improvement of power systems models. It will help during the diagnosis and location of the origin.
C	A general model of lamp to adjust the UNE-EN 61000-4 to different and new technologies will be developed	The relationship between the flicker and the impact on the power system will be improved
D	The design of passive filter equipments considering objective functions and restrictions will be improved	The design of passive filters will be improved
D	The type of load will be Included as restriction in the design process of passive filters	The behaviour of the power system is considered during the design of harmonic filters in order to optimize it.
D	Non-conventional topologies of harmonic filters will be developed using the same procedure of conventional shunt filters. The group of the University of Oviedo will cooperate in this item.	Non-conventional filtering solutions will be analysed and developed.

D	The reference signal that is used in the control system of active filters will be analyzed and improved	Major contribution to the development of active filter systems
D	Topologies of Hybrid harmonic filters will be improved	Major contribution to the development of hybrid harmonic filters

5.2 ADAPTATION OF THE PROJECT TO THE PRIORITIES OF THE RESEARCH PROGRAM BASIS

This project is included into the Energy Research Program. The first of the two priorities that this program includes is "*The study of types and uses of the energy when the efficiency and the environment are considered*". This priority is included in the follow two items:

1.5 The efficiency during the use of the energy could be improved considering and analyzing new generation process, new transformers and auxiliaries' equipments.

1.6 Power systems: Supply systems, distribution conditions, new equipments. The working conditions of the power system, new semiconductor devices, etc.

The final objectives of this project are included in the above items. As an example, the hybrid and passive filter solutions are developed to improve the efficiency of the power system (losses are reduced) and the power quality. The cost of this kind of solutions will be reduced and its use is extended. The monitoring of PQ events allows evaluating the correct status of the system.

5.3 SPREADING PLAN AND INDUSTRIAL USE OF THE RESULTS

Spreading plan include the papers published in magazines and congress, doctoral theses, developed research projects, developed industrial projects, industrial spreading projects and training about the items included in 5.1.

- Indexed magazines: IEEE Transactions on Power Systems, IEEE Transactions on Power Delivery, IEEE Transactions on Energy Conversion, IEE Proceedings on Electric Power Applications, IEE Proceedings on Generation, Transmission and Distribution, etc.
- Congress: International Conference on Harmonics and Quality of Power (ICHQP), International Conference on Renewable Energies and Power Quality (ICREPQ), International Symposium on Diagnostics for Electrical Machines, Power Electronics and Drives (SDEMPED), Power Quality Conference (PQC), etc.
- Training: As a conclusion of the DPI2002-04416-C04 project a summer course about the power quality has began in the university of cantabria. In the future a doctoral program with participation of the different research group will be put into action.
- Thematical group: It is proposed to make a thematical group about power quality in Spain and collaborate with another PQ international research (NoE) and training groups (Leonardo).
- Doctoral thesis: (Section 7).
- National magazines: Energía, Automática e Instrumentación, etc.
- Industrial collaboration: Some industrial companies are interested in collaborating during the project. One of them is ENEL Viesgo S.A. from the UC.
- Use of the results by Companies that market Electrical Components: The interest of the collaborating companies is very high so the spreading of the results is guaranteed..
- Spreading of the results for the maintenance department training: One of the most important objectives of this project is to use the main information about the benefits of the developed filtering equipments to train engineers and electricians. Some studies have been included to compare the final solutions obtained during the project with the commercial solutions that exist now. TEMPER S.A.U. is a electrical company that may be very interesting in this subject. This company has trained about power quality to technical personal and electricians during the last ten years. The results of this project could be included in their conferences

6. HISTORIAL OF THE RESEARCH CENTER

RECORD OF THE APPLICANT TEAM IN THE PROPOSED TOPIC (in case of Coordinated Project, the sections 6. and 6.1. will have to fill up for each one of the participant teams)

• To indicate the previous activities of the team and the achievements reached in the proposed topic:

- the objectives already obtained and the reached results must be indicated with clarity if the project is the continuation of other previously financed.
- the antecedents and previous contributions of the team must be indicated with the purpose of justifying their capacity to carry out a new project.

Team A. Centre: University of Vigo

- Measures of harmonic, flicker and voltage sags in wind farms. Initially, the Experimental Wind farm of Sotavento (property of the Xunta of Galicia) was used to develop this investigation activity outlined as objective. Later on, different measures and analysis of results in different points (Restaurante "Casa Pablo", Bar "Torre", Aserradero "Maderas López y Reyes, S.L.", Vivienda unifamiliar de Jesús Soto) have been carried out. These measure points are located electrically next to the wind farm "O Carrio.". This last activity has been made with the purpose of deepening in the study of the incidence of the operation of the wind farms in the quality of wave of the network. The different interdependences of the variables (these variables are mentioned next) have been related using measured data: speeds of wind and generated active powers that they register in the own wind farm, short-circuit powers in the point of common connection, type and level of global perturbations of the wind farm, type and level of particular perturbations of several wind generators.

- Analysis of flicker in wind farms: A series of electrical models that try to reproduce the real conditions of operation of the park has made using the real data that have been collected from the measurements of flicker. Models in detail have been carried out of a wind generator and of the system.

- Measures of harmonic, flicker and voltage sags in diverse industries: diverse monitored campaigns of measures of harmonics and interharmonics, flicker and voltage sags, with a minimum duration for campaign of one week, have been carried out in the following industries: Siderurgia Nacional de Productos Longos, PSA Peugueot Citroën, Lancott, Industrias González, Frujorge, Inasus, Granitos Montefaro, Public2000, Talleres Fidel, Productos de Poliestireno. Equipments have been used that are adapted to the changes in the norm of measure of harmonics CEI 6100-4-7. Later on, the results of the measures have been treated. These data have provided us information on the fulfillment of norms and recommendations and the existent perturbations levels.

- Analysis of the errors made in the measures registered by the different measure equipments.
Two tests were made in the Laboratory of Electromagnetic Compatibility of the ETSII with the purpose of checking the possible variations in the taking of measures of the different used measure instruments: one to check if two equipments of the same model measured exactly the same and the other one to check the differences among three different models used in the mensurations.

- Diffusion of the results of the project. A book about wave quality has been finished and it has been sent McGraw Hill for its publication. An article in the journal "IEEE Transaction Power Delivery" and presentation of 8 reports in international congresses.

- Five international events have been organized "International Conference on Renewable Energies and Power Quality (ICREPQ)", editions of 2003, 2004, 2005 and 2006 (Vigo, Barcelona, Zaragoza and the last one in Palm of Majorca) and the "9th Spanish Portuguese Congress on Electrical Engineering" (Marbella 2005) and four national events of Engineering Electric "Meetings of Investigation Groups of Electric Engineering", editions of 2003, 2004, 2005 and 2006, where the different investigation groups have been able to exchange experiences among them.

Team B. Research Centre: University of Oviedo

The research group from the University of Oviedo has taken part in different projects about power quality during the last ten years. In the PQ subject different projects, publications (see curricula of the research group) and industrial courses have been carried out. Bellow the most recent projects and publications can be seen.

Projects:

[A] TITLE: Modelling and simulation of electric power systems for the study of voltage sags transmission.
FINANCIAL ENTITY: FICYT –Regional research plan
Main researcher: Gonzalo Alonso Orcajo
Researchers: José Manuel Cano Rodríguez, Carlos H. Rojas García, Manuel García Melero, Manés F. Cabanas

[B] TITLE: Power Quality and energetic efficiency. Influence of perturbations on industrial installations. Minimization of harmful effects.
FINANCIAL ENTITY: CICYT – NATIONAL RESEARCH PLAN.
DURATION OF THE PROJECT from 2002 to 2005. Economical support (group U. Oviedo): 24.000 €
COLABORATING ENTITIES: Univ. de Vigo (coordinador) – Univ. de Cantabria - Univ. Oviedo – Univ. de Sevilla
Main researcher: José Manuel Cano Rodríguez
Researchers: Gonzalo Alonso Orcajo, Carlos H. Rojas García, Manuel García Melero, Manés Fernández Cabanas

[C] TITLE: Non-Conventional passive devices for the improvement of power quality in industrial sceneries.
FINANCIAL ENTITY: National Research Plan. (Bridge project)
DURATION OF THE PROYECT, since 2006 to 2007. Economical support: 6.000 €
COLABORATING ENTITIES: Univ. Oviedo, TEMPER S.A.U.
Main researcher: José Manuel Cano Rodríguez
Researchers: Gonzalo Alonso Orcajo, Carlos H. Rojas García, Joaquín Francisco Pedrayes González, Tania Vázquez Sánchez.

Publications:

[1] Authors (p.o. de firma): J. M. Cano, G. A. Orcajo, M. F. Cabanas, M. G. Melero, J. G. Mayordomo, R. Asensi
Title: New transfer functions for an accurate estimation of harmonic distortion in AC/DC converters working under unbalanced conditions.
Ref. magazine: IEEE Transactions on Industry Applications, Vol: 37 Nº 2, date: March/April 2001

[2] Authors: J. M. Cano, G. A. Orcajo, C. H. Rojas, M. G. Melero, M. F. Cabanas.
Title: Technical and economical assessment of the effect of voltage sags on adjustable speed drives.
Congress: International Conference on renewable energies and power quality – 2004

[3] Authors: G. Alonso Orcajo, J. M. Cano R., C. H. Rojas G., M. G. Melero, M. F. Cabanas, F. Pedrayes.
Title: Voltage sags in industrial systems.
Congress: International Conference on renewable energies and power quality-2005

[4] Authors (p.o. de firma): J. M. Cano, G. A. Orcajo, C.H. Rojas, M.G. Melero, M. F. Cabanas, F. Pedrayes G.
Title: Analysis of the effects caused by structural asymmetries in the performance of three-limb core three-phase inductive filters.
Ref. magazine: IEEE Transactions on Energy Conversion.
Vol: Nº , date: 2006, Date of acceptation: 22-07-2006. (The acceptation letter is included in the enclosed documents)

In the power quality subject, this subproject is dedicated to find design solutions to avoid the effects of disturbances on the power system. The task of study and analyze PQ solutions to reduce the effects of the disturbances has started during the project of the national research plan titled 'Power Quality and energetic efficiency. Influence of perturbations on industrial installations. Minimization of harmful effects.' This project has finished recently. (November 2005). During this project TEMPER SAU company has collaborated with interest because this company wants to enter into the market of power quality products. The group of the university of Oviedo has trained the technical department of the company during the course shown below:

- *'Disturbances in power systems. Causes and effects.*
  Reference: *FUO-EM-102-04*
  March 2004. Duration: 20 h.

New equipments have been designed to improve the power quality in particular utilities and avoiding the negative effects of the disturbances. Initial prototypes of broad band filters and third harmonic filters have been designed and built. These tasks have been carried out during a project developed by the University of Oviedo and TEMPER SAU. The reference is indicated below:

- *'Commercial solutions to improve the power quality of the electrical system'*.

  Reference: *FUO-EM-103-04*
  Contract: Art 11
  Financial entities: TEMPER SAU
  Collaborating entities: TEMPER SAU, Universidad de Oviedo y Fundación Universidad de Oviedo
  Duration, since: 2004 to 2006
  Main researchers: José Manuel Cano Rodríguez y Gonzalo Alonso Orcajo
  Number of researchers: 5
  Economical support: 31.034 €

The group from the University of Oviedo has presented to the last proposal of National Research Plan an individual solicitude with similar topics that the one being presented in this solicitude. The proposal was entitled 'Non-conventional devices for the improvement of power quality in industrial sceneries´, and was considered like a `bridge project´ with a duration of one year. This kind of `bridge projects´ allows obtaining a partial economical subvention for the research group while a review of the proposal is made. So while the new proposal of projects appears the research activities of the group are not cancelled. In this solicitude all the comments and recommendations that were made by the reviewers have been considered and the minor and major revisions have been included. The main topic of the `bridge project´ and the activities have been included in a general proposal where four universities have joined their efforts.

TEMPER SAU has shown its interest by means of a letter attached to this solicitude. The company agrees to work in the project while it is carried out. This support is very important and is a good sign when the ability of the research group to develop the project is evaluated.

Other companies have shown their interest about the results that could be obtained by the research group. KLK and Trefilería Moreda, have shown this interest by means of letters attached to the solicitude.

Team C. Centre: University of Cantabria

The experience of the UC team is based in a trajectory of more than a decade dedicated to the study of the problem of the quality of the electric supply. As a summary, the last three more important projects related with this thematic are detailed.

- *CIT-120000-2005-19 (2005).* D*esign of an instrumentation for the measure and evaluation of the characteristics of quality of the turbines that are connected to the electric network.*

This project can be considered a previous step to the current application. Basically, it consists on the study of the problem of monitoring the flicker generated by the connection of wind farms**.** The relationship of the obtained results with the objectives of the new proposal is outstanding.

Previous results	New proposal
Generation of a bibliographical information base on the flicker measure.	The acquired knowledge allows to locate easily the necessary extensions to approach the new work. In a similar way, the study of the sources of knowledge can be used to determine the groups that are located in the vanguard of the knowledge in this field.
Knowledge of the existent perturbations levels (especially, flicker, harmonics and voltage sags), in the different levels of the network (MV and LV) in Cantabria.	The knowledge of the partial levels of distortion in concrete points of the distribution network can be used as starting point of the estimate of the state of the network. Also, the realization of the project would allow continuing studying the evolution of the levels of contamination of the previously studied points.
Development of a model of standard measurer of flicker according to the norms UNITE-IN 61400-20 and UNITE-IN 61000-4-15	Development of new models of measurer of flicker that consider the use of lamps of technologies no incandescent.

- *DPI2002-04416-C04-01 (2002-05).* Quality of the wave and energy saving. Influences of the perturbations in the industrial electric installations. Minimization of the effects.

This project can be considered a previous step to the current application. Basically, it consists on the study of the problem of the perturbations in the industrial installations. The effects of the perturbed loads on different types of electric loads have been studied. The relationship of the obtained results with the objectives of the new proposal is outstanding.

Previous results	New proposal
Generation of a bibliographical information base on the perturbations, origin, causes, effects and way to minimize them.	The acquired knowledge allows locating easily the necessary extensions to approach the new work. In a similar way, the study of the sources of knowledge can be used to determine the groups that are located in the vanguard of the knowledge in this field.
Knowledge of the existent perturbations levels (especially, flicker, fluctuations of voltage, harmonics and voltage sags), in the	The knowledge of the partial levels of distortion in concrete points of the distribution network can be used as starting point of the

different levels of the network (MV and LV) in Cantabria.	estimate of the state of the network. Also, the realization of the project would allow continuing studying the evolution of the levels of contamination of the previously studied points.
Knowledge of the effects that cause the perturbations in the electric loads (motors, converters and other devices) as well as the necessary solutions to diminish the emission of perturbations, to limit its propagation or to increase the levels of immunity. The optimized filtrate of harmonics is outstanding.	The knowledge acquired in the study of the effects of the perturbations and its possible solutions can be used during the modeled phase.
Knowledge of the techniques of measure of perturbations as well as of the appropriate methodology for the structuring of the data collected by measure, analysis and test. Development of test protocols for the valuation of instrumentation that is oriented to the measure of perturbations, being based on the existing norms.	it is basic for a correct selection of the instrumentation the knowledge of the equipments and techniques of measure

- *Report on the state of the electrical distribution network of Robert Bosh Spain factory of Treto (RBET), Cantabria*

In this project, a study of the electrical distribution network of a company of the region was carried out. With respect to the size and characteristics of its productive process, it could be considered sufficiently significant with regard to the nature of its loads. When being a company with a high level of automatization, it presents a great sensitivity to the appearance of disturbances, specially sags and surges. The relation of the results obtained with the objectives of the new proposal is remarked:

Previous results	New proposal
Study of the voltage quality of in a low voltage distribution network with reduced geographic scope	The proposal considers the study generalization to high voltage distribution networks with extensive scope.
Study of the surges propagation mechanisms in the low voltage distribution network with reduced scope.	Extension of the study of the propagation mechanisms of disturbances, as a previous step to the establishment of a systematic methodology of location of metering equipment.

Publications

Books

Authors: L.I. Eguíluz Morán, P.M. Lara Santillán, J.C. Lavandero González, M. Mañana Canteli, J.C. Montaño Asquerino, A.A. Pérez Miguel, P. Salmerón Revuelta,
Title: Potencia en régimen no-sinusoidal
ISBN 84-8102-321-3. D.L. SA-97-2003
Publishing house :University of Cantabria
Place:Santander 2004.

Authors: L.I. Eguíluz Morán, M. Pinilla Rodríguez, J.M Romero Gordón, J.Lomba Diego, R. Vega Madrid, M. Pérez Donsión, B. Novo Ramos, J.L. Falagán Cavero, J.C. Lavandero González,
Title: Calidad del suministro eléctrico
ISBN 84-688-3406-8. D.L. SA-1139-2003
Publishing house: University of León
Place:Laredo, Santander 2003.

Authors: L.I. Eguíluz, J.C. Lavandero, M. Mañana, P. Sánchez,
Title: Eficiencia energética y calidad de suministro.
Energía. ISSN 0210-2056 D.L. M-22290-1975
Publishing house:Alción
Place:Madrid 2001.

Authors: L.I. Eguíluz, M. Mañana, J.C. Lavandero
Title: La calidad del suministro eléctrico.
ISBN 84-600-9629-7. D.L. SA-8-2001.
Publishing house: University of Cantabria. Electrical Engineering Department
Place:Santander 2001.

Journals

Authors: M. Mañana, A. Ortiz, L.I. Eguíluz, C. Renedo, S. Pérez
Title: Time-domain Classification of Power Quality Disturbances Based on Signal Phase-Space (Enviado para revisión)
EURASIP JOURNAL ON ASP. SPECIAL ISSUE ON EMERGING SIGNAL PROCESSING TECHNIQUES FOR PQA
Publishing house: ISSN: 1110-8657
Place: Sylvania, USA

Authors (p.o. de firma): M. Mañana, A. Ortiz, L.I. Eguíluz, C. Renedo,
Title: Three-phase adaptive frequency measurement based on Clarke's transformation.
IEEE Transactions on Power Delivery. ISSN 0885-8977
Key: A Volume: 21, No. 3 Pages, 1101:1105 Fecha: 2006-07-01
Publishing house:Institute of Electrical and Electronic Engineers (IEEE)
Place:New York, USA

Authors (p.o. de firma): A. Ortiz, C. Gherasim, M. Mañana, C. Renedo, L.I. Eguíluz, R. Belmans,
Title: Total harmonic distortion decomposition depending on distortion origin
IEEE Transactions on Power Delivery. ISSN 0885-8977
Key: A Volume: 20. No 4 Pages, 2651: 2656 Fecha: 2005-10-01
Publishing house:Institute of Electrical and Electronic Engineers (IEEE)
Place:New York, USA

In addition, communications in several international meetings related to power quality have been presented: ICREPQ, SPCEE, ICHPQ and IPST.

Team D. Centre: University of Seville

The requested research Project can be considered as a continuation of the coordinated project entitled *Power quality and energy saving. Influence of disturbances on industrial installations. Minimization of their effects* with reference DPI2002-04416-C04-04 funded by the Ministry of Science and Technology in the 2002 Call for proposals. In this research project the problem of power quality was considered from a general viewpoint, tackling the University of Seville Team, among others, the following activities:

- power quality measurements in distribution and industrial networks. With this aim several power quality measurements equipments were purchased. Novel procedures of parameter estimation in harmonic disturbing consumers [41-43].
- Analysis of harmonic filtering. The aim of this activity was the optimization of equipments needed to filter harmonics. Procedures of design of passive filters have been developed [16,37-39], as well as analysis of the behavior of calculation methods of reference current [31,40] and frequency models of active filters [36]. With these models it will be possible to tackle the problem of optimization of design of hybrid filters, being one of the main objectives of the new research project.

As well as the work previously described, framed into the former coordinated project, during last years the research group behind this proposal has developed other activities related with power quality funded by public institutions, 2 research projects (DPI2001-2367 and ENE2004-06117) and 2 grants for infrastructure, and private (6 applied research projects), as can be seen in the next section of this proposal.

Due to the work developed in the last years, and in the scope of power quality, several activities related with exploitation of results have been performed: 1 invited communication in an international congress [43], 5 communications to international congresses [36-38,40,44], 1 paper in an out-of-JCR international journal [45] and 4 papers in JCR-included international journals [16,31,41,42].

6.1 RESEARCH PROJECTS

TEAM A
Research Centre: UNIVERSITY OF VIGO

Title of the project or contract	Relationship with the present application (1)	Chief Researcher	Quantity of the financial support EURO	Supporting Organization and Project Reference	Length of the project (2)
1. Wave quality and energy saving. Influences of the perturbations in the industrial installations. Minimization of its effects.	1	Manuel Pérez Donsión	55.000,00	Ministry of Education and Science DPI2002-04416-C02	2003-2005
2. Wave quality and energy saving. Influences of the perturbations in the industrial installations. Minimization of its effects.	1	Manuel Pérez Donsión	23.800,00	Xunta de Galicia. PGIDIT03PXIC30308PN.	2003-2005
3. applicable methodology for the energy saving in domestic and industrial installations	2	Manuel Pérez Donsión	6.960,00	Unión Fenosa	1º semestre 2005 1º semester 2005
4. Measure and analysis of the power quality in the industrial areas LALÍN 2000 e Polígono de Botos	1	Manuel Pérez Donsión	4.988,00	Asociación de Empresarios de Deza (AED)	2º semestre 2005 2º semester 2005
5. Analysis of the Thermal Behavior of the Pavilion Nº 2. Study and Analysis of the Heating System by Radiant Conduits and Technical advice in the Selection and Installation of the Mentioned System.	3	Manuel Pérez Donsión	4.000,00	Fundación Semana Verde de Galicia	1º semestre 2004 1º semester 2004

(1) 0, 1, 2 or 3 according to the key:
0 = is the same proyect; 1 = is very much related; 2 = is partially related; 3 = without relation

(2) C= concession, S= request

TEAM B
Research Centre: UNIVERSITY OF OVIEDO

Title of the project or contract	Relationship with the present application (1)	Chief Researcher	Quantity of the financial support EURO	Supporting Organization and Project Reference	Length of the project (2)
1. Analysis using the Finite Element Method of the axial stray flux and the mechanical efforts at the coils of induction motors of low and medium voltage: application to the detection of incipient failures and estimation of Mean Time Before Failures.	(2)	Manés Fernández Cabanas	31.799,55€	FICYT – Asturias Reg.P. of I+D (FC-98-PB-TDI98-03)	(C) 1998/2000
2. Treatment of partial discharges for the detection of failures in the insulation of medium voltage motors and analysis of the aging of mica-epoxy insulations using Finite Element models, electric, thermal and environmental tests.	(2)	Manés Fernández Cabanas	206.627,96€	FEDER Funds- Spanish National Plan of I+D - ABB Service. FEDER 1FD97-0567	(C) 1999/2001
3. Support from the Regional Research Plan from Asturias for the acquisition of scientific-technique equipment for the performance of electric tests.	(1)	Manés Fernández Cabanas	57.096,14€	FICYT – Asturias Reg. P. of I+D	(C)
4. Theoretical and experimental study for the development of new criteria and diagnostic parameters in the tests of dielectric absorption, delta tangent, over-voltage and shock waves for electric machines.	(2)	Manuel García Melero	52.143,81€	FICYT – Asturias Regional Plan of I+D FC-99-PA-TDI99-07	(C) 1999/2001
5. Study of non-theoretical current harmonics produced by DC and AC motor on different working conditions.	(1)	Gonzalo Alonso Orcajo	17.116,84€	FICYT – Asturias Regional Plan of I+D FC-99-PA-TDI99-04	(C) 1999/2001
6. Development of new tests for the improvement of the diagnosis of rotor asymmetries in working squirrel cage induction motors.	(2)	Manés Fernández Cabanas	49.643,59€	CICYT – Spanish National Plan of Research MCT-00-DPI-0609	(C) 2001/2003
7. Failure and ageing mechanism of electric insulation materials and its relationship with partial discharges.	(2)	Manés Fernández Cabanas Proyecto Coordinado – 7 centros participantes	180.303,63€	CICYT – Spanish National Plan of Research MCT-00-MAT-0134-P407	(C) 2001/2003

8. Development of new low cost methods for the early detection of incipient failures in power transformers.	(2)	Manés Fernández Cabanas	31.853,64€	FICYT – Asturias Regional Plan of I+D FC-01-PB-TBI-11	(C) 2001/2003
9. Theoretical and experimental study of the influence of main voltage unbalance in the generation of non-characteristic current harmonics by adjustable speed drives of PWM type.	(1)	José M. Cano Rodríguez	19.232,38€	FICYT – Asturias Reg.P. of I+D FC-01-PB-TBI-13	(C) 2001/2003
10. Modeling and simulation of electric power systems for the study of voltage sags transmission.	(1)	Gonzalo Alonso Orcajo	20.048 €	FICYT – Asturias Reg.P. of I+D FC-03-PB-02-065	(C) 2003/2005
11. Detection of inter-turn short-circuits in the stator of working low voltage and medium voltage motors fed by converters.	(2)	Manuel García Melero	20.000€	CICYT – Spanish National Plan of Research MCT-02-DPI-03628	(C) 2002/2005
12. Power Quality and energetic efficiency. Influence of perturbations on industrial installations. Minimization of harmful effects.	(1)	José M. Cano Rodríguez Proyecto Coordinado – 4 centros participanes.	24.000€	CICYT – Spanish National Plan of Research MCT-02-DPI04416-C0403	(C) 2002/2005
13. Technical advice for the research on commercial solutions for the improvement of electric power quality.	(1)	José M. Cano Rodríguez Gonzalo Alonso Orcajo	31.034 €	Contract – Article 11	(C) 2004/2006
14. Non-Conventional passive devices for the improvement of power quality in industrial sceneries.	(0) Bridge Project	José M. Cano Rodríguez	6.000 €	CICYT – Spanish National Plan of Research ENE2006-07014/CON	(C) 2006/2007

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(2) C= concession, S= request

TEAM C
Research Centre: UNIVERSITY OF CANTABRIA

Title of the project or contract	Relationship with the present application (1)	Chief Researcher	Quantity of the financial support EURO	Supporting Organization and Project Reference	Length of the project (2)
1. Design of an instrumentation for the measurement and evaluation of the characteristics of the quality of the connected wind turbines to the power system.	0	Mario Mañana Canteli	35.768	Ministry of Education and Science CIT-120000-2005-19	2005-marzo 06
2. Design and development of an electrical direction for chain vehicles	2	Mario Mañana Canteli	80.751	Ministry of Education and Science CIT-020400-2005-73	2005-marzo 06
3. Design of systems of electrical propulsion for heavy vehicles	2	Mario Mañana Canteli	80.751	Ministry of Education and Science CIT-020400-2005-72	2005-marzo 06
4. Report on the state of the distribution power system of RBET (factory of Treto, Cantabria)	0	Mario Mañana Canteli	6.000	Robert Bosch España (factory of Treto, Cantabria)	2003
5. Wave quality and energy saving. Influence of the disturbances in the industrial electrical systems. Minimization of its effects	0	Luis Ignacio Eguíluz	42.000	Ministry of Education and Science DPI2002-04416-C04-01	2003-05
6. Integral system for data acquisition in integral plants	2	Mario Mañana Canteli	24.000	IPS Norte	2002-03
7. Situation of the energy in Cantabria	1	Luis Ignacio Eguíluz	60.000	Government of Cantabria	2002-03

(1) 0, 1, 2 or 3 according to the key:
0 = is the same proyect; 1 = is very much related; 2 = is partially related; 3 = without relation

(2) C= concession, S= request

GROUP D
Research center: UNIVERSITY OF SEVILLE

Title of the project or contract	Relationship with the present application (1)	Chief Researcher	Quantity of the financial support EURO	Supporting Organization and Project Reference	Length of the project (2)
Mechanism of failure and deterioration of the electrical insulating materials and its relation with the partial unloadings. MAT2000-0134-P4-07	3	(Aitor Kortajarena,Director) M. Burgos Payán	13.462,68	National plan for Scientific research, development and technological innovation 2000-2003	2000/2003 C
Power quality and Power Savings. Influence of the disturbances in the industrial facilities. Minimization of their effects. DPI2002-04416-C04-04	1	(M. Pérez Donsión, Coordinador) M. Burgos Payán	84.450	National plan for Scientific research, development and technological innovation 2002-2005	2002/2005 C
Comparison, design and control of devices for balance and compensation of electrical loads. DPI2001-2367	2	A. Gómez Expósito	82.428	National plan for Scientific research, development and technological innovation 2002-2004	2002/2004 C
Design and control of equipment for the mitigation of disturbances caused by electrical loads. ENE2004-06117	2	J.A. Rosendo Macías	35.305	National plan for Scientific research, development and technological innovation 2004-2007	2004/2007 C
Scaled Electric network for the analysis of disturbances in a power laboratory	1	A. Gómez Expósito	95.000	Technological Scientific Infrastructure call. Ministry of Science and Technology	2003/2004 C
Laboratory of voltage sags immunization	1	M. Burgos Payán	21.500	Technological Scientific Infrastructure call. Ministry of Science and Technology	2003/2004 C
Experimental validation of active loop supply equipment	3	P. Cruz Romero	3.000	Council of Education and Science of the Meeting of Andalusia	2004 C

Study of electromagnetic compatibility in the substation Cosario (Almeria)	1	J.M. Maza Ortega	10.000	Endesa - Sevillana	2003/2004 C
Experimental study of domestic air conditioning equipment consumption	2	J.M. Maza Ortega	5.300	Endesa - Sevillana	2004 C
Power quality in electrical energy distribution public networks	1	J.M. Maza Ortega	39.000	Endesa – Sevillana Junta de Andalucía	2004/2007 C
Reliability in the public low voltage distribution networks	1	M. Burgos Payán	3.300	Endesa – Sevillana Junta de Andalucía	2004/2007 C
Power saving measures in electrical motors	2	J.M. Maza Ortega	3.300	Society for the Power Development of Andalusia (SODEAN)	2004 C
Behavior of the aerogenerator A-300 against voltage sags	2	M. Burgos Payán	5.800	Desarrollos Eólicos S.A.	2005 C

(1) 0, 1, 2 or 3 according to the key:
0 = is the same proyect; 1 = is very much related; 2 = is partially related; 3 = without relation

(2) C= concession, S= request

7. PROJECT AND APPLICANT GROUP TRAINING CAPACITY (In case of Coordinated Project it will have to fill up for each one of the participant equipment)

This section only must be fill up if it has been responded affirmatively to the corresponding question in the request questionnaire.
It must be justified that the applicant group can receive scholarship holders (of the Program of Formation of Investigators) associated to this project and must argue the training capacity of the group. In case of Coordinated Project, it must be fill up by each subproject that asks for FPI scholarship holders.

Team A
Research Center: UNIVERSITY OF VIGO

Training capacity of the present research project can be seated in the following significant aspects:

1.- It allows to acquire knowledge of the operation of the measuring instruments, techniques and conditions of measurement in distribution networks as in industrial facilities and also in wind parks.

2.- It makes possible to acquire the necessary experience to pay attention the suitable points for the location of the measuring instruments (low electromagnetic influence zones), connection form, types of probes to use, etc.

3.- It facilitates acquisition of programming knowledge, in terms of measuring equipment programming software, programs elaborated for the treatment of lines, transformers and loads in adverse conditions of disturbance, in addition, taking into account that this personnel is taking care of the design of the web pages dedicated to the project, it makes possible to them to acquire knowledge on this subject.

4.- In addition to the declared previous points, this is a training project because it aims to spread culture of the quality through training courses that have been designed in this matter.

5.- It also makes possible, the doctoral thesis accomplishment in the thematic one of the quality of the tension wave, in this sense the main investigator already has directed three doctoral theses that include different particular aspects from the same one.

6.- It is also possibly to participate in work meetings with discussions on the procedures to follow, in congresses where the profits will be exposed to develop in this field, etc.

Due to all previously indicated, we considered that the training possibilities of the present coordinated subproject are excellent.

Team B
Research Centre: UNIVERSITY OF OVIEDO

The training ability of the research group has been demonstrated during the last years by means of several aspects:

- Grant holders of the national research plan and foreign students have been included and trained in the last projects that the group has carried out.
- Doctoral theses about power quality and electrical machines have been developed. Three of them have received the doctoral award that gives the University of Oviedo each year.
- The researchers are teaching in the doctoral program of the Electrical department from the University of Oviedo since 1999.

During the last course (2005-2006) three of the members of the research group (including the main researcher) teaching a doctoral course that can see below:

- Doctoral Program: *Control of process, industrial electronic and electrical engineering*
- Course: *Solutions and commercial equipments to improve the power quality of the industrial systems*
- Teachers: *G. A. Orcajo, J. M. Cano, C. H. Rojas.*

This course is about the main subject of the present project.

During this course (2006-2007) the three researchers of the group are teaching in the same doctoral program. This doctoral program has obtained an award to the quality of its contents and teachers. The award was given by the ANECA (National Evaluation Agency) and is a warranty of the training ability for the group.

The research group has a specific electrical laboratory to develop the project. This laboratories have the necessary measurement equipments and test benches to carry out the project. The doctoral theses about power quality have been carried out in this laboratory.

As a conclusion a correct training labor could be carried out and doctoral thesis could be developed by the new researchers that would be included into the group.

Team C
Research Center: UNIVERSITY OF CANTABRIA

The research group who constitutes the central nucleus of the applicant team should receive contracted personal, since:

- Bachelor formative effect. From the academic point of view, the team is form by PhD associate professors who develop their educational work in the Superior Technical School of Industrial and Telecommunication Engineers of the University of Cantabria, teaching in different disciplines related to electronics, electrical engineering and the thermal machines and motors, so that they can collaborate in the integral formation of the contracted investigators. •
- Complementary formative effect. During the past few years, the applicant research group has coordinated and developed several summer courses, as much in the University of Cantabria as in the University Menéndez Pelayo, in relation to the topic of the project. •
- Doctorate formative effect. Also from an academic point of view, more oriented towards the research, the PhD associate professors coordinate and distribute teaching in doctorate courses related to the topic of the proposal. The doctorate program, which is interdepartmental, counts on the quality mention of the Ministry of Education and Science. •
- Four doctoral theses, related to the topic of the project have been defended in the last years:

    - Title: Contributions to the definitions of power in multiphase systems in nonsinusoidal regime.
      Doctor: Pedro Mª Lara Santillán
      University of Cantabria.
      Faculty: E.T.S.I.I and T. Date: 01-September •1999
    - Title: Contributions to the representation, detection and classification of disturbances lead in electrical systems of power.
      Doctor: Mario Mañana Canteli
      University of Cantabria.
      Faculty: E.T.S.I.I and T. Date: 14-Julio-2000 •
    - Title: Development and implementation of techniques for estimation of failures in power systems.
      Doctor: Jose Luis Falagán Cavero
      University of Cantabria.
      Faculty: E.T.S.I.I and T. Date: 20-November •2000
    - Title: Contributions measurement of power and energy in non-sinusoidal regime.
      Doctorando: Alfredo Ortiz Fernandez
      University of Cantabria.
      Faculty: E.T.S.I.I and T. Date: 14-March-2005

PhD Thesis in course related to the subproject: •

- Title: Contributions to the study of flicker.
  Student: Gerardo Díez Cagigal
  Director: Mario Tomorrow Canteli
  Predicted conclusion date: June 2007 •
- Title: Contributions to the modelización of fuel cells and their application in distributed generation.
  Student: Emilio Andrea Blanco
  Director: Mario Tomorrow Canteli
  Predicted conclusion date: June 2007 •

- Title: Contributions to the modelización of power transformers in high frequency and its application to the data transmission.
  Student: Cándido Capellán Villacián
  Director: Mario Tomorrow Canteli
  Predicted conclusion date: June 2007 •

- Collection and management of research resources. From the point of view of the research, the professors of the team have large experience in coordination, management and development of research activities, with public and private financing.

Team D
Research Center: UNIVERSITY OF SEVILLE

The training capacity of this group of investigation is based in these arguments:

- Scholarship holders FPI and FPU of the national and autonomic programs of formation have been taken.
- It have been addressed and finished in the last years three doctoral theses within the investigation applicant group. At the present time two doctoral theses in the scope of the quality of electrical provisioning are being addressed related to new control techniques using active filters (Student doctorate D. Sergio Ceballos Manozzi) and new models in the time domain for alternates/continuous rectifiers (Student doctorate D. Jose Miguel Herrera Rosell).
- Members of the research group of the University of Seville give teaching in the doctorate program "Economic and Technical Management of Generation, Transport and Distribution of Electrical Energy Systems". This program has the Quality Mention granted by the ANECA from its first call in course 2004-2005. Fruit of this mention, at the moment it participates in the teaching of the first Official Masters of the University of Seville (MOUS) in "Electrical Energy Systems", the only one in Andalucía. Both the mentioned program of doctorate and in the Masters, issues related to the quality of provision are treated; in particular: "Quality and management of the electrical energy " and "Application of FACTS devices in transport and energy distribution networks".
- In the last years and due to the Mention of Quality granted by the ANECA to the doctorate program it has been possible to have economic aids that have made possible the presence in these courses of more than a ten visitor professors of international recognized prestige, such as Dr. Göran Anderson, Dr. Ali Abur, Dr. Francisco Galiana, Dr. Arimdam Ghosh and Dr. Victor Quintana among others.
- The international contacts of the components of this research group, have made possible the accomplishment of stays in foreign centers of investigation of recognized international prestige. In particular, student doctorate D. Sergio Ceballos Manozzi has enjoyed a stay granted scholarship in Boston, in charge of professor Dr. Alex Stankovic.

On the other hand, both the experience of the components of the group of investigation in the thematic proposal, and the logical structure of the programmed tasks makes the attainment viable of a doctoral thesis within the scope of this subproject of investigation.