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A technology shift for a fireworks controller

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1. Introduction – In the past, wands with polder were used to fireworks ignition. But the proximity of the operator with the explosive tubes (or parts) was very dangerous and needed a new system more safety. Nowadays, ignition of each tube or explosive device is made from a firing case, located near the management place, using electrical igniter [1]. These igniters provide to convert electrical power in a flame which ignites mortar tube. Igniters are connected to the firing system by electrical wires called shooting wires. To provide easier network of shooting wires, which may be complex, it is possible to add electrical relays in this network to reduce the number of connexions rising management place. Then, the manager selects a wire and demands ignition of selected mortar tube. This kind of classical design needs a lot of time to installation and uninstallation (Image 1). More difficulties can be added like: presence of water, high installation... This kind of solution is also expensive with shooting wires (copper electrical wires). Once uninstalled, electrical wires cannot be reused. Recycling needs to be done. Image 2 shows a "classic" solution and the "new" solution to be found.



Image 1. Installation of a firework

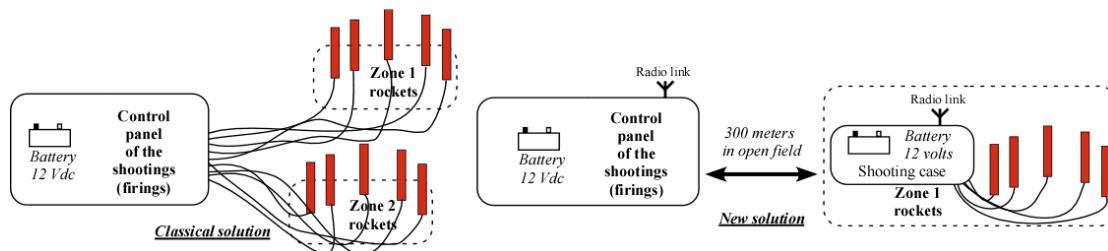


Image 2. Installation of a firework

1. Genesis of the project. How does this collaboration started with a manager who has Ruggieri certificate? – Projects conducted since 1996, are related with professional expectations of our training courses and are often carried out in partnership with local industrials [6]. Since then, we have an average of two to three industrial collaborations per year. Although we cannot guarantee optimal results for these collaborations, as the main actors of the project are training and these projects are often their first experience in relation to the working environment. We aim to guide our students toward a consistent set which includes a technical achievement based on a product, with document management, budget management... and, of course, writing of requirement specification to satisfy customer needs. Our strategy in project management, is identical with our DUT¹ and LP² students. The difference is on time

Fiche descriptive du projet : Commande de feu d'artifice
Département Génie Electrique & Informatique Industrielle
Année Universitaire 2014 - 2015

Responsables : Jean-François Millet & Pascal Vrignat

Client : Dominique PARADOT (Un particulier, électricien de métier habilité et enregistré à la préfecture pour animer les spectacles nocturnes) - 07 route de Limoges 36200 TENDU.

Description :

Remplacer un ensemble de liaisons électriques assurant la mise à feu des mortiers lors des soirées de feu d'artifice par une solution sans fil de type HF.

L'ensemble est composé de :

- 6 coffrets batteries pouvant relier jusqu'à 50 départs vers les mortiers,
 - 1 poste de commande à boutons poussoirs et voyants.
- Cette solution devra bien entendu être très fiable et sécurisée pour garantir les spectacles selon les différents scénarios choisis.

Volume de travail pour cette mission :

Ce travail concerne les heures allouées au projet pour la formation DUT GEIL.

Quantité d'étudiants pour ce projet : 3

Repères Internet :

http://www.indre.gouv.fr/content/download/1074/6881/file/Recueil_numero_8_du_14_septembre_2010.pdf



Valorisation de compétences :

- Fédérer un groupe de travail constitué de plusieurs acteurs très importants,
- Répondre aux enjeux techniques,
- Répondre aux enjeux économiques,
- Répondre aux enjeux juridiques.

¹ DUT : second year of Bachelor Degree

² LP : Professional Bachelor Degree

Image 3. Description form for the project

passed on these projects: 96 hours by DUT student, 150 hours by LP student. At the beginning of the academic year, we provide a lot of information to students: calendar organization (with milestones), evaluation process (work, activity report, presentation), one sheet description of projects (Image 3). Then, students can select an ordered list of projects. According to this list, the project "A technology shift for a controller fireworks" could begin with students.

2. Cost, time, performance - This work needs a coherent organization over several months. Three students have worked on the project during the period from September to March. Two teachers supervised students. A final internship study for a student was planned to finalize works that remained to be done (Photo 1). The delivery of the solution to the customer took place in the last day of May. The overall cost for this version amounts to € 1,700.

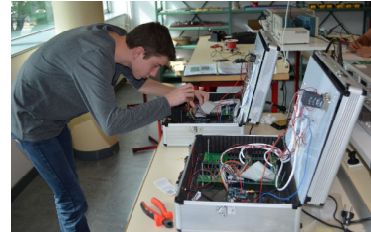
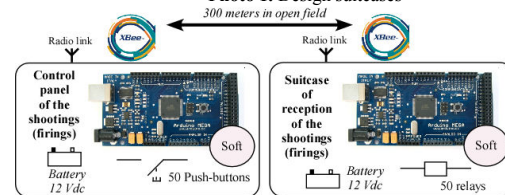


Photo 1. Design suitcases



2. Experimental and results – Proposed solution, which was validated by the customer, is shown in the Image 4. This solution uses radio frequency technology (Xbee-Pro) based on Arduino Single-Board Computer (SBC Arduino [2]). An important work of CAD had to be conducted to create all the interfaces compatible with Arduino adopted solution.

Image 4. Validated solution

These works require to develop PCB (Printed Circuit Board) prototypes for the Arduino SBC. This PCB is the result of an important work of design to provide connexions for all the inputs and outputs of the installation (Image 5). The files for the production were created using the Cadence software. PCBs were manufactured by Eurocircuits company under our specific recommendations [4].

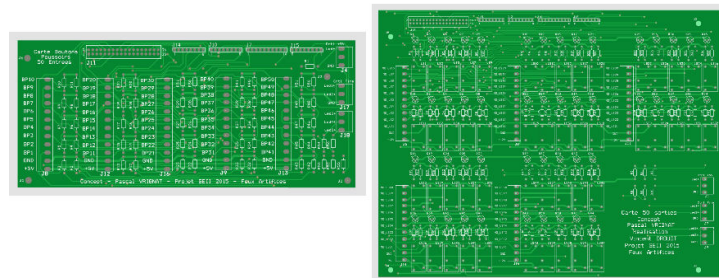


Image 5. PCB creation for inputs and outputs

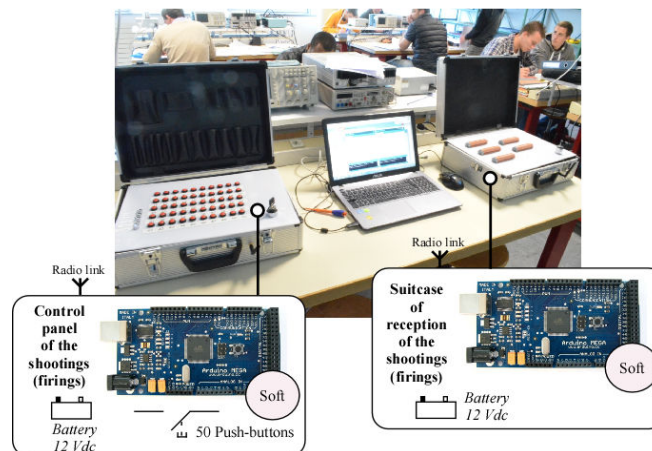


Image 6. Results

Image 6 shows the construction of the two suitcases that will be devoted to shooting fireworks. These little bulky suitcases, respect constraints that had been expressed in the requirement specification. Programming of the solution was split in two parts. The first part consists in programming each radio XBee-Pro module. This programming was performed with the X-CTU software [5]. This program was designed to declare the logical addresses of the two XBee-Pro modules. The second part consists in programming in C language and individually, each Arduino board with the builder programming environment. The flow chart (Image 7) shows operating principle for suitcases.

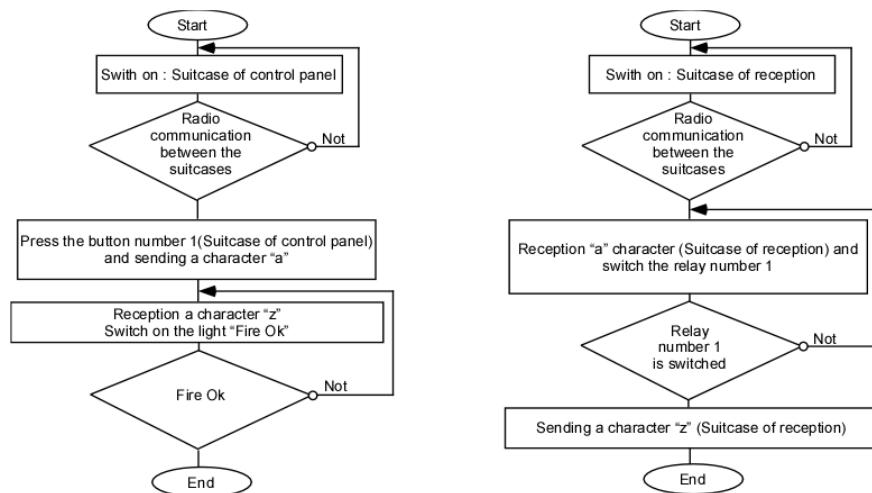


Image 7. Flowchart principle

4. Conclusion – These works need a lot of hours spent to search the optimal solution considering limited financial cost (nearly 2.000 euros) and various technical constraints. All constraints of the project were defined with drafting the technical specifications [6]. The first fireworks has be shot ten months after the study.

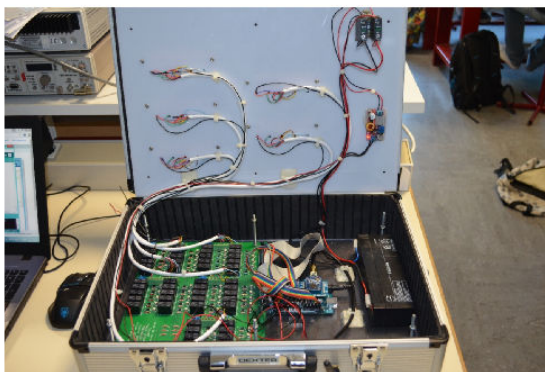


Photo 2. Wiring and tests

The customer is very satisfied with the work done and wishes to continue the research for a complementary solution. This next solution will be able to control two new reception suitcases. Under these conditions, the manager can control 150 rockets departures.



Photo 3. 20 June: fireworks

5. References

- [1] Decree No. 90-897 of October 1, 1990 on the regulation of fireworks
- [2] <http://www.arduino.cc/>
- [4] <http://www.eurocircuits.com/>
- [5] <http://www.digi.com/support/productdetail?pid=4549&type=drivers>
- [6] P. Vrignat, J.F. Millet, F. Duculty, S. Begot, M. Avila, “*Rédaction d’un cahier des charges fonctionnel dans le cadre d’une organisation au sein d’un projet : retour sur expérience avec des étudiants Bac+2*”, AIPU, Association Internationale de Pédagogie Universitaire, 28ème Edition, Mons, Belgique, 2014.