Journal of Embedded Systems, 2017, Vol. 4, No. 1, 1-6
Available online at http://pubs.sciepub.com/jes/4/1/1

DOI:10.12691/jes-4-1-1

Analysis and Design of a Wireless Remote Control for Circuit Breakers and Disconnecting Switches in Substations: Case of the Substations of National Railways Society of Congo

Kankolongo C. Kambaya[1], Katond JP. Mbay[2], Diambomba H. Tungadio[3,*]

[1]Department of Electronic, Institut Supérieur de Pédagogie Technique, ISPT/Likasi, DRC
[2]Department of Electro-mechanic, University of Lubumbashi, DRC
[3]Department of Electrical, Electronics and Computer Engineering, University of Pretoria, South Africa
*Corresponding author: tutudiambomba@yahoo.fr

Abstract This article presents the analysis and design of a wireless remote controller for performing the engagement manoeuvres and trip circuit breakers and disconnecting switches located in different substations of the National Society of Railway of Congo (SNCC). With the remote controller without son, SNCC avoid its expenses until then to send technicians in the different sub-stations for controlling circuit breakers and disconnecting switches on site. It will save time of execution of the manoeuvre of closing and tripping; and will quickly provide service in transport by rail for freight and travellers.

Keywords: *wireless remote control, switching, tripping, Cellphone*

Cite This Article: Kankolongo C. Kambaya, Katond JP. Mbay, and Diambomba H. Tungadio, "Analysis and Design of a Wireless Remote Control for Circuit Breakers and Disconnecting Switches in Substations: Case of the Substations of National Railways Society of Congo." *Journal of Embedded Systems*, vol. 4, no. 1 (2017): 1-6. doi: 10.12691/jes-4-1-1.

1. Introduction

The availability of electric power is important for the development of an economy and for a good quality of life. In the coming decade, studies show that the electric consumption will to increase. The most important condition for a reliable supply system is a good functioning transmission system. Scientific literature proposes several researches, problems and solutions using the wireless system in the management of equipment [1,2,3]. Habib and Khaled proposed a novel home energy management system using wireless communication technologies for carbon emission reduction within a smart grid [4]. Wireless powering and communication for implants, based on a Royer oscillator with radio and near-field links was proposed in [5]. Han at al. presented the remote-controllable and energy-saving room architecture based on ZigBee communication [6]. The authors in [7] proposed a wireless power outlet system for smart homes. Design and implementation of control mechanism for standby power reduction was presented in [8]. Sunghoi et al. presented the design and implementation of smart energy management system for reducing power consumption using ZigBee wireless communication module. Authors in [9] presented an optimal energy-balanced cooperative transmission based relay selection and power control in energy harvesting wireless sensor network.

In the context of scientific research as the result of this study is inscribed, the goal is to identify and analyse the different scientific issues and technological challenges related to the implementation of a system of remote control of mobile manipulators via a wireless network [10,11]. Electric locomotives SNCC are powered by the catenary line; it is supplied with electric current by the substations in which we find as main elements, the HV/MV transformers, circuit breakers and disconnecting switches. In order to ensure continuity of services in transport by rail for freight and passengers, SNCC had implanted within its facilities electromechanical remote controller for switching and remote tripping of circuit breakers and disconnecting switches located in its 11 substations. Copper conductors connected relays at control office (OC) of the electromechanical relay to remote Likasi located in 11 substations of SNCC; representing each relay circuit breakers and disconnecting switches located in the substations, a switching on operation or trigger an equipment located in any sub-stations was effected by operating a key on the relay that represents the OC.

A visual signalling OC allowed to see the actual state of the equipment in the various substations. But, following the theft and repeated destruction by the thunders of copper son that connect the relay located in the substations to those located in OC. Likasi, electromechanical remote is not currently in service.

This article aims not only restarting the remote control, but also to ensure that the problem with the repeated theft

of copper wires connecting the substations in OC no longer arises. Our main contribution is the use of mobile phones to send and receive remote control signals from the circuit breakers and disconnecting switches placed in different substations of SNCC. The rest of this paper is organized as follows: In section 2 the materials and methods used for this study system are explained. Section 3 gives a detailed results and an overview of a wireless remote control. Finally, the conclusion of the work is summarized in section 4.

2. Material and Method

2.1. Material

To realize the model of the without wires remote controller, we used as components: a 220V/12V transformer, a diode rectifier, a filter capacitor, two cell phones, two photo-couplers, two relays, two incandescent lamps, a source AC voltage 220V and electronic measuring devices.

2.2. Method

To collect different information about the electromechanical remote, we made visits to OC electromechanical remote SNCC, a visit was organized to the Shituru substation and we the remote control was analysed by GSM. We interviewed staff OC., observed how agents SNCC proceed to engage them in case of break breakers. To design of the wireless remote control, we proceed by the experimental method. On the model of our experiment, we have two lights on and off in parallel from a cell phone. The scheme that was used is shown in Figure 1.

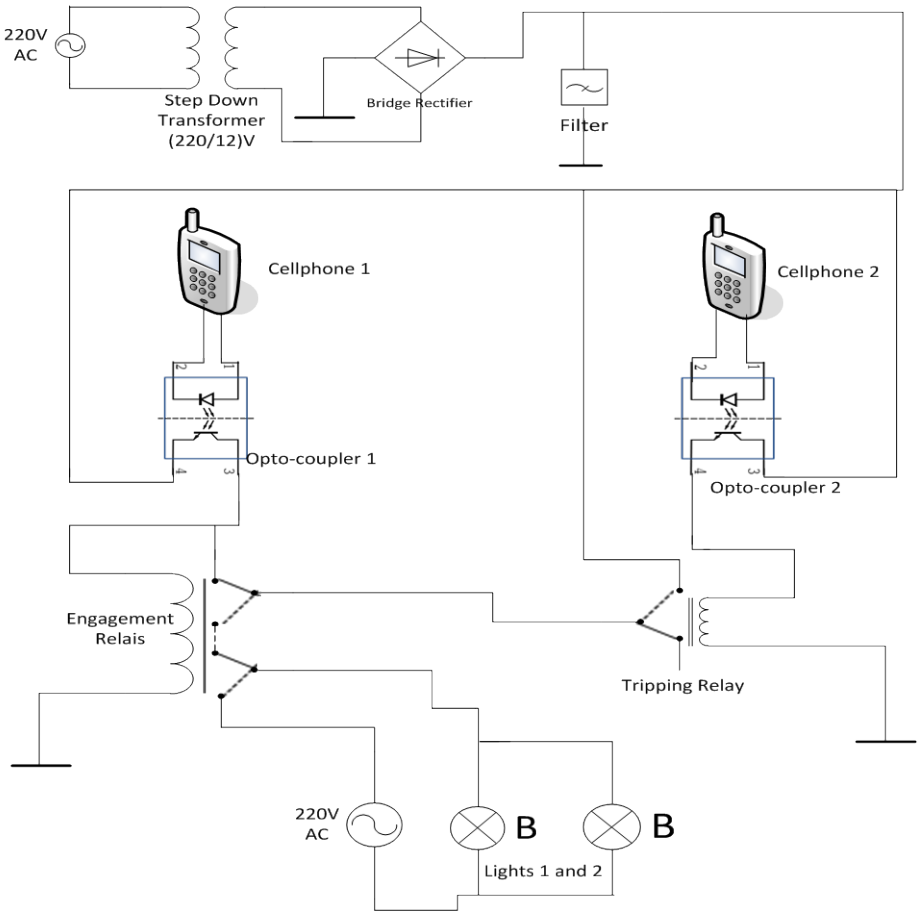

Figure 1. Design of Wireless Remote

Figure 2. Wireless Remote with lights off

Figure 3. Wireless Remote with lights on

In Figure 2, we can see the image of the driverless remote control when the lights are off. In Figure 3, we see the same pattern with the lights on. The black box on which the two phones are placed contain mounting the electronic diagram of Figure 1. One of the telephones contains the SIM (Subscriber Identification Module) card with the number that switch on lights, the other contains the telephone SIM card with the number that switch off the lights.

The manoeuvre of closing and tripping is performed as follows: when issuing a call to the cut number, and the recovery, the phone receiver receives the signal and sends it to the speaker. On mounting the signal goes the speaker is directed to the photo coupler; this, in turn, leads without galvanic contact and feeds the corresponding electromagnetic relay by 12V DC voltage. The switching relay opens or closes its contact to act on the coil of the double contact relay; both contacts of the trip relay commute together and oppose the engagement relay simple contact. To turn on the lights, it makes a call to the switching number; the contact of the engagement relay rises, both contacts of the trip relay by opposing the latching relay descended, both lamps in parallel light as their circuit is closed. To turn off the lights, we call the trigger number; both contacts of the trip relay go up, contact the engagement relay goes down, the lights of the circuit opens, the lights go out.

3. Results

As in the substations SNCC there is a 48V DC supply from storage batteries, there are relay interlocking and tripping. The assembly of the experiment is simplified for substations suitable for SNCC. There is shown in Figure 4.

3.1 Discussion

a. The Cellphone

To perform remote control driverless, mobile phone is a major asset. Because it allows remote communication without physical supports; in this communication there is a transport of low power and at the reception, the signal received by the antenna undergoes a first band filtering and amplification undergoes controlled amplification to arrive at the correct level to extract the audio signal [12-18]. The signal that should control the speaker is sent to the photo coupler, via the latter, the relays are energized and can close or open contacts, thus controlling breakers and disconnecting switches.

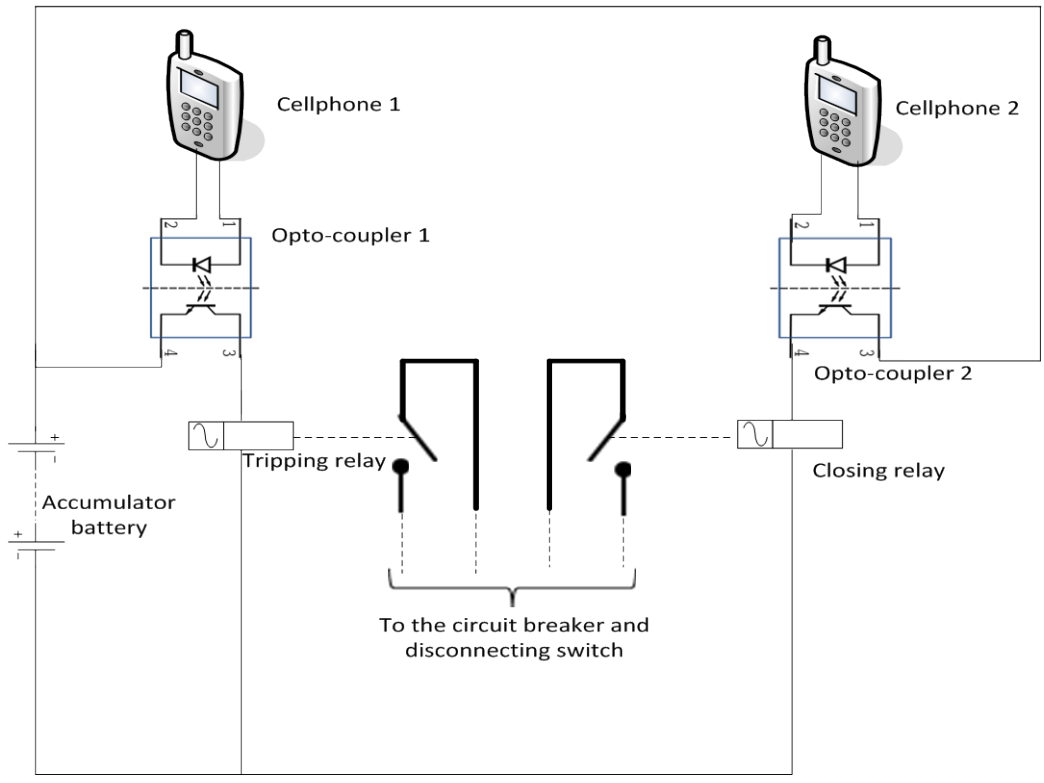

Figure 4. Wireless Remote for sous-station de la SNCC

b. Photo-coupler

The photo-couplers or opto-couplers are components integrated in the same housing an infrared emitting diode and a photo detector (photo transistor, for example). These two elements are optically coupled, but are electrically isolated [19,20]. A photo-coupler (or opto-coupler) is an electronic component capable of transmitting a signal of an electric circuit to another, without galvanic contact between them [21,22]. The photo-coupler is called opto-coupler or opto-isolator.

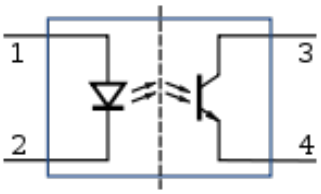

Figure 5. Symbol of an opto-coupler

where: 1-2: A light emitting diode (LED) [13]; 3-4: Phototransistor. The phototransistor behaves as a switch (between the collector and the emitter) controlled by the LED.

-Transistor Blocked (switch open): The transistor is blocked if the current I_F is zero if: $I_C = 0A$ therefore $V_F < 0.6V$. The phototransistor is equivalent to:

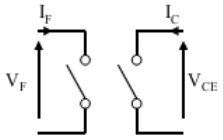

Figure 6. Switch open

-Transistor saturated (switch closed): the transistor is saturated if:

$$I_F \geq \frac{I_{C\max}}{CTR_{\min}}, then\ V_{CEsat} \approx 0.4V. \qquad (1)$$

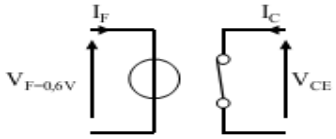

Figure 7. Switch closed

To ensure saturation of the phototransistor, taking into account the inaccuracy of the components (real and not theoretical values), we calculate the saturation current with a coefficient of supersaturation. Therefore:

$$I_F \geq K\frac{I_{C\max}}{CTR_{\min}} \qquad (2)$$

where: K is the oversaturation coefficient, generally chosen equal to 2 (as a minimum value).

c. Overview of the Wireless Remote Control

The system proposed in this article works with any phone, that has a speaker; this is why we can put up with less than 20,000 Fc (≈22$). In the remote wireless control using the mobile phone, the coverage of GSM network operator's replace the copper conductors; the signals of the receiver's phones and photo couplers located in the sub-stations replace OC. of the electromechanical remote control relay. Photo couplers play exactly the same role as the relays located at OC, the electrical signal that feeds the speaker phone is sent to the photo couplers, they will control the relay interlocking and relay tripping circuit breakers and disconnectors located in the substations.

GSM communications require a subscription contract with an operator. The operator provided a SIM card which contains information on the chosen subscription and whose depends the billing and a PIN (Personal Identification Number) code to unlock [23]. The area of use of the phone must be covered by the network of GSM operators, in the opposite case the wireless remote control is no longer possible [24,25]. The number of subscribers is supported by an antenna of a cellular phone operator is limited, beyond this number there is congestion, no calls cannot go through and the wireless remote will no longer works; this is why the phones used must have three SIM cards because it is rare that three operators are out services simultaneously, otherwise the wireless remote control will not be operational.

Since a speaker of a cell phone receives an electrical signal when it receives any call or message, the risk of switching on/off can occurs. This system allows the caller is actually in the right to activate or deactivate. Only people who knows the numbers to call and have recorded their own phone numbers, can activate or deactivate the system. The configuration of phones receptors in terms of call screening, also gives great security by letting the numbers of persons to perform the engagement maneuver and tripping, and blocking other issues whatever their natures. In a substation, the maximum number of equipment to be controlled is 20.

The number of tripping is growing as illustrated in the graph of release statistics from January to June 2015 below:

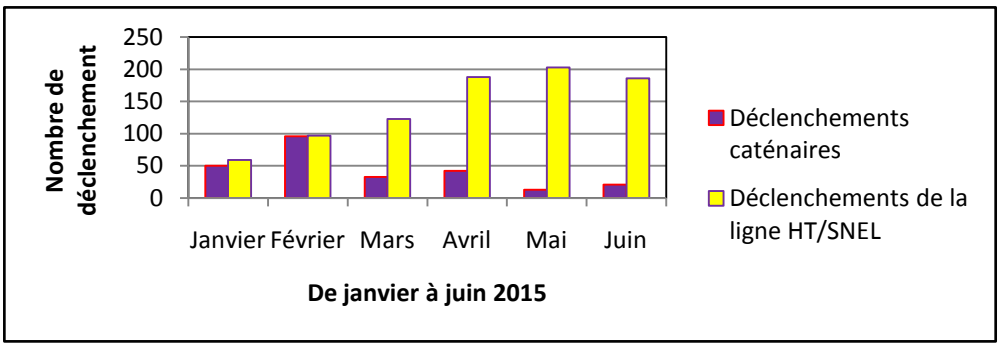

Figure 8. Statistics of tripping operations in all substations SNCC from January to June 2015

As shown in Figure 8 of OC. SNCC pulled specifications triggers statistics, the number of tripping SNEL is upward because the power demand is growing. The outbreak of the catenary line may be due to overloading, short circuit, a thunder; it can also be voluntary in the case of works on the catenary, and in cases of traffic heavy loads hauled by the CMG and TFM diesel locomotive to avoid contact with the overhead line.

In Figure 8, there are triggers in all substations of SNCC. The outbreak of the HT / SNEL line only lasts a few minutes, at most a few hours and is done on a part of the catenary, technicians SNCC are not involved; but when it comes triggers the catenary line technicians SNCC go into substations to perform switching manually.

The growing development of mobile telecommunications makes integrate in applications as diversified than useful and current, home automation, industrial applications for remote monitoring and manipulation of complex systems but also in security systems, defense and to protect property and persons [26,27,28,29]. At present the signaling clippings is done by cell phone using the network of local GSM operators: Airtel, Vodacom, Africell, Tigo or Orange. The Heads of station in charge of traffic, call by cell phone in Likasi town to report any interruption whatever its origin. The difficulty is found at the level remote control. For substations located near the town of Likasi, this is more or less easy, because technicians can easily reach the substation referred, and engagement can occur in less than one hour; but, for remote substations intervention can take several hours even some days; which constitutes a significant loss for the company and for its customers.

Mobile phones are discharged progressively and when they are working. If mobile phones in the substations are discharged the wireless Control will not be possible. Therefore, telephones used must have greater autonomy and station managers will begin to power the phones in time and hours scheduled to avoid disabling the wireless remote.

4. Conclusion

The results can be summarized as follows:

1. Upon issue (in the OC): To make an engagement or trigger signal, we need a cell phone. The maneuver is carried out simply as we are to call our correspondents, that is to say, made the party's number is; in our case, the numbers of the phones in the substations, and then launched the call. The command does not cost anything, because we do not need of dropping out in the substation.
2. At the reception (in the sub-stations): Two mobile phones are used, one has the SIM cards having the switch on numbers, that is to say, it receives the trigger signal for the equipment; the second cellphone has a SIM cards having the triggering numbers. The wireless remote control proposed in this article can be used for control of electric, electronic and electromechanical equipment remotely and wherever or equipment that you control manually.

The use of GSM transmission network for the remote execution of more or less complex actions such as handling of electrical and mechanical equipment is a promising avenue to explore for modern surveillance systems and security or also Automation. Our product range on using a mobile phone to initiate and trigger remotely and without physical media breakers and disconnectors located in the substations of SNCC, so to avoid loss of time when moving agents into the substations to perform the same operation on site. With the remote control without son, in case of a tripping, the traffic disruption will last only the time will train stations chiefs to report the outage.

Using an ordinary mobile phone for remote control can be applied in all situations where you can avoid unnecessary movement for switching on and for triggering, for stopping and starting, for ignition and extinction electronics, electrical and electromechanical remotely and without physical presence.

References

[1] S.D. Barman, A.W. Reza, N. Kumar, M.E. Karim, and A.B. Munir, “Wireless powering by magnetic resonnant coupling: Recent trends in wireless power transfert system and its applications”, Renewable and Sustainable Energy Reviews, vol. 51, pp. 1525-1552, 2015.

[2] Z. Bi, T. Kan, C.C. Mi, Y. Zhang, Z. Zhao, and G.A. Keoleian, “A review of wireless power transfert for electric vehicles: Prospects to enhance sustainable mobility”, Applied Energy, vol. 179, pp. 413-425, 2016.

[3] A. Mansour, R. Mesleh, and M. Abaza, “New challenges in wireless and free space optical communications”, Optics and Lasers in Engineering, vol. 89, pp. 96-108, 2017.

[4] H. Elkhorchani, and K. Grayaa, “Novel home energy management system using wireless communication technologies for carbon emission reduction within a smart grid”, Journal of Clearner Production, vol. 135, pp. 950-962, 2016.

[5] J. Han, H. Lee, and K.R. Park, “Remote-controllable and energy-saving room achitecture based on ZigBee communication”, IEEE Transactions on Consumer Electronics, vol. 55, no. 1, pp. 264-268, February 2009.

[6] G. Song, F. Ding, W. Zhang and A. Song, “A wireless power outlet system for smart homes”, IEEE Transactions on Consumer Electronics, vol. 54, no. 4, pp. 1688-1691, November 2008.

[7] J. Heo, C.S. Hong, S.B. Kang, and S.S. Joon, “Design and implementation of control mechanism for standby power reduction”, IEEE Proceedings in Consumer Electronics, 9-13 Jan. 2008, pp. 179-185.

[8] S. Park, M.I. Choi, B. Kang, and S. Park, “Design and implementation of smart management system for reducing power consumption using ZigBee wireless communication module”, Procedia Computer Science, vol. 19, pp. 662-668, 2013.

[9] D. Zhang, Z. Chen, H. Zhou, L. Chen, and X.S. Shen, “Energy-balanced cooperative transmission based on relays selection and power control in energy harvesting wireless sensor network”, Computer Networks, vol. 104, pp. 189-197, 2016.

[10] A.S. Adedjouma, G. Adjovi, L. Agai, et B. Degbo, “Un système d’antivol de voiture à télécommande GSM doté d’une fonction de géolocalisation par GSM et GPS,” Ecole Polytechnique d’Abomey-Calavi, vol. 1, pp. 1-8, 2006.

[11] G. Enzner, and P. Vary, “Frequency-domain adaptive Kalman filter for acoustic echo control in hands-free telephones,” Signal Processing, vol. 86, pp. 1140-1156, 2006.

[12] Deltadore, “Télécommande téléphonique GSM à synthèse vocale,” 2 Décembre 2003, pp. 12.

[13] B. Kotnik, Z. Mezgec, J. Svecko, and A. Chowdhury, “Data transmission over GSM voice channel using digital modulation technique based on autoregressive modelling of speech production,” Digital Signal Processing, vol. 19, pp. 612-627, 2009.

[14] C.D. Oancea, “GSM Infrastructure Used for Data Transmission,” in Proceedings on Advanced Topics in Electrical Engineering, 12-14 May 2011, Bucharest, pp. 1-4.

[15] Jp. Muller, “Le mobile GSM,” Mulhouse, 2009, pp. 43 (www.ta-formation.com/cours/p-gsmmobile.pdf).

[16] JP. Manguian, “Les radiocommunications,” Presses universitaires de France, Collection Que sais-je, no. 2723, Editions Juillet 1993.

[17] M.L. Rebaiaia, D.A, Kadi, and A. Merlano, “A Methodology of Modelling and Evaluating the Reliability of a Radio-communication Network,” IFAC Proceedings, vol. 43, Issue 3, 2010, pp. 92-97.

[18] Y. Niva, H. Motogi, C. Nishizaki, M. Urakami, T. Seta, M. Kobayashi, and M. Minami, “Ship-to-Ship Radio-communication Trial by Using Wireless LAN,” Int. Journal of e-Navigation and Maritime Economy, vol. 3, pp. 32-39, 2015.

[19] D.W. Mohammed, R. Waddingham, A.J. Flewitt, K.A. Sierros, J. Bowen, and S.N. Kukureka, “Mechanical properties of amorphous indium-gallium-zinc oxide thin films on compliant substrates for flexible optoelectronic devices,” Thin Solid Films, vol. 594, pp. 197-204, 2015.

[20] J. Redoutey, “Introduction aux dispositifs optoélectroniques utilisés en électronique de puissance, ” pp. 16. 12 Octobre 2013.

[21] M. Aono, T. Goto, N. Tamura, N. Kitazawa, and Y. Watanabe, “Photoconductivity study of amorphous carbon nitride films for opto-electronics devices,” Diamond & Related Materials, vol. 20, pp. 1208-1211, 2011.

[22] T. Zhan, J. Ma, X. Yi, S.W. Koh, J. Wang, X. Wu, G. Wang, and J. Li, “Wireless-driven LED Semiconductors Lighting System,” in Proceedings of Forum on Solid State Lighting, 6–8 November 2014, Guangzhou, China, pp. 71-75.

[23] Les Avis de l’Ademe, “L’éclairage à diodes électroluminescentes (LED),” ADEME, Septembre 2014. (www.ecocitoyens.ademe.fr).

[24] M. Fleutry, “Dictionnaire encyclopédique de l'électronique–anglais/français,” La Maison du dictionnaire, Paris 1991.

[25] P. Horowitz & Winfield Hill, “Traité de l'électronique analogique et numérique,” Elektor/Publitronic, vol. 2, Roissy 1996.

[26] J. Seo, K. Cho, W. Cho, G. Park, and K. Han, “A discovery scheme based on carrier sensing in self-organizing Bluetooth Low Energy networks,” Journal of Network and Computer Applications, vol. 65, pp. 72-83, 2016.

[27] T. Val, P. Fraisse, et D. Andreu, “Vers l'utilisation de Bluetooth pour la commande à distance de robots mobiles,” Journal Européen des Systèmes Automatisés, Hermès, 2004, vol. 37, pp.859-892, Aout 2003.

[28] J.M. Cabero, I. Urteaga, V. Molina, F. Liberal, and J.L. Martin, “Reliability of Bluetooth-based connectivity traces for the characterization of human interaction,” Ad Hoc Networks, vol. 24, pp. 135-146, 2015.

[29] SIEMENS, “TEL50.GSM, Instructions Générales, Secteur Industriel,” Building Technologies, février 2011, 28 Pages.