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Hardware and Software Co-design for Wireless Fire fighting System

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ABSTRACT
Technological growth in modern era leads to varied protection against fire based disasters for people, property and business even though fire fighting still remains area of concern. Fire fighting though being a dangerous profession needs a fire extinguishing system that can be easily implemented, used and with minimum investment. This paper provides a hardware and software co-design for wireless fire fighting system which consists of transmitter and receiver. In case of transmitter side RF module is used with open band frequency 434 MHz interfaced to read multiples input (fire sensing devices) at receiver RF module having frequency at 434 MHz and based on the predefined values it should be able to communicate to receiver. At receiver side as per the received values it should switch on the alarm along with visual indication with activation of respective relays along with predefined time interval which are in turn connected to valve which will flush and throw powder content required to extinguish fire.
Keywords **-** Fire fighting, Transmitter, Receiver, Wireless RF module, Relays.

I. INTRODUCTION

Fire based various hazards and disasters to diesel based generators are considerably high basically in various industrial environments [1].As diesel has fuel flash points varying between 52^0C to 96^0C [17] which makes it a considerable challenge for detection of fire within its scaled values. The goal of this paper is to provide a co-design for hardware and software in terms of design and implementation of wireless fire fighting system which consists of transmitter and receiver [14]. In case of transmitter it transmits signal of fire at engine within its scaled values [18] with RF based wireless band with respect to receiver having alarm and visual based (fire sensing) at the driver side and based on the predefined value with an instant of time it should able to communicate to receiver. At receiver side as per the received values it should switch on the alarm along with visual indication [16] and also activate relays along with predefined time interval for safe exit of driver which are in turn connected to valves which will flush and throw powder content required to extinguish fire[17].

II. PROBLEM DEFINITION

It is been seen that considering a wireless fire fighting system with sensors and ZigBee based device object even though increases the band of communication between transmitter and receiver to about 915 MHz with various wireless sensor motes [16] though needs considerable more power utilization with low value of voltage scaling leading to problem review of efficient voltage scaling [18] to achieve varied temperature conditions of fire detection without additional cost of wireless sensor motes by using RF open band both transmitter and receiver with 434 MHz based efficient communication though the background now is based on fire detection and controlling of transport vehicles used inside industries basically coal fields having diesel as a prime source of generators and vehicles [17].

III. OBJECTIVE

The design and implementation of wireless fire fighting system with proper emphasis given to co-design of software in terms of hardware to detect the fire at the transmitter node and by using RF band of frequency of 434 MHz with the help of intermediate node having PIC (Peripheral Interface Controller)

[18] interfaced with receiver node which in turn, acts as extinguishing node as shown in the fig. 1 below.

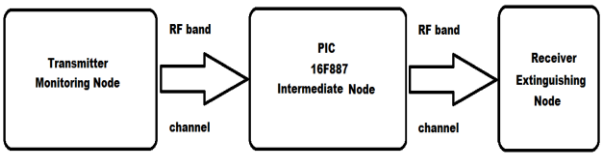

Fig 1. Transmitter and Receiver system used for monitoring and extinguishing

3.1 TRANSMITTER – MONITORING NODE

The transmitter node is used for monitoring the fire at a scalable value of voltage Vref 2.5V to 5V [18] in terms of the variation of temperature from 52^0C to 96^0C with the functional use of ADC input values with external connection of RTD (Resistive Temperature Detector) [19] PT100 shown in fig. 2 below.

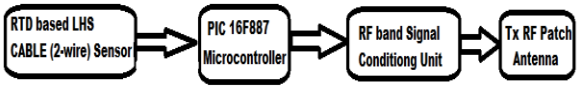

Fig 2. Transmitter Monitoring Node

3.2 INTERMEDIATE NODE

This node is performed for ADC based operations with reference to PIC 16F887 in terms of transmitter and receiver having a utilization of five channels out of ten for ADC based performance metric with varied resistive scaled values in range of 120Ω to 140Ω with ±1/4Vref values.

3.3 RECEIVER – EXTINGUISHING NODE

In this node, the RF patch/whip antenna detects fire indication by providing the continuous alarm with visual indication initiated with a delay of Tb seconds.

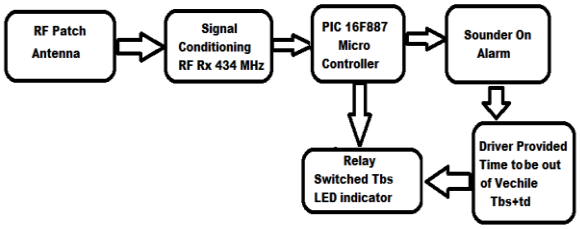

Fig 3. Receiver Extinguishing Node

IV. SOFTWARE CO-DESIGN

Micro C enabled IDE environment is been considered for program based on controlling the ADC for scaling the temperature values in terms of its pre-scaled reduced format following the RTD chart such that in terms of PIC the temperature can be detected.

For European Curve, Alpha = 0.00385, ITS-90 **1° Celsius Increments**

°C	Ohms	Diff.	°C	Ohms	Diff.	°C	Ohms	Diff.	°C	Ohms	Diff.	°C	Ohms	Diff.	°C	Ohms	Diff.
-200	18.52		-140	43.88	0.42	-80	68.33	0.41	-20	92.16	0.39	±0	100.00	0.39	+60	123.24	0.38
199	18.96	0.44	139	44.29	0.41	79	68.73	0.40	19	92.55	0.39	+1	100.39	0.39	61	123.62	0.38
198	19.39	0.43	138	44.71	0.42	78	69.13	0.40	18	92.95	0.40	2	100.78	0.39	62	124.01	0.39
197	19.82	0.43	137	45.12	0.41	77	69.53	0.40	17	93.34	0.39	3	101.17	0.39	63	124.39	0.38
196	20.25	0.43	136	45.53	0.41	76	69.93	0.40	16	93.73	0.39	4	101.56	0.39	64	124.77	0.38
195	20.68	0.43	135	45.95	0.42	75	70.33	0.40	15	94.12	0.39	5	101.95	0.39	65	125.17	0.40
194	21.11	0.43	134	46.35	0.40	74	70.73	0.40	14	94.52	0.40	6	102.34	0.39	66	125.55	0.38
193	21.54	0.43	133	46.76	0.41	73	71.13	0.40	13	94.91	0.39	7	102.73	0.39	67	125.93	0.38
192	21.97	0.43	132	47.18	0.42	72	71.53	0.40	12	95.30	0.39	8	103.12	0.39	68	126.32	0.39
191	22.40	0.43	131	47.59	0.41	71	71.93	0.40	11	95.69	0.39	9	103.51	0.39	69	126.70	0.38
190	22.83	0.43	130	48.00	0.41	70	72.33	0.40	10	96.09	0.40	10	103.90	0.39	70	127.08	0.38
189	23.26	0.43	129	48.41	0.41	69	72.73	0.40	9	96.48	0.39	11	104.29	0.39	71	127.46	0.38
188	23.69	0.43	128	48.82	0.41	68	73.13	0.40	8	96.87	0.39	12	104.68	0.39	72	127.85	0.39
187	24.12	0.43	127	49.23	0.41	67	73.53	0.40	7	97.26	0.39	13	105.07	0.39	73	128.23	0.38
186	24.55	0.43	126	49.64	0.41	66	73.93	0.40	6	97.65	0.39	14	105.46	0.39	74	128.61	0.38
185	24.97	0.42	125	50.06	0.42	65	74.33	0.40	5	98.04	0.39	15	105.85	0.39	75	128.99	0.38
184	25.39	0.42	124	50.47	0.41	64	74.73	0.40	4	98.44	0.40	16	106.24	0.39	76	129.38	0.39
183	25.82	0.43	123	50.88	0.41	63	75.13	0.40	3	98.83	0.39	17	106.63	0.39	77	129.76	0.38
182	26.25	0.43	122	51.29	0.41	62	75.53	0.40	2	99.22	0.39	18	107.02	0.39	78	130.14	0.38
181	26.67	0.42	121	51.70	0.41	61	75.93	0.40	1	99.61	0.39	19	107.40	0.38	79	130.52	0.38
180	27.10	0.43	120	52.11	0.41	60	76.33	0.40				20	107.79	0.39	80	130.90	0.38
179	27.52	0.42	119	52.52	0.41	59	76.73	0.40				21	108.18	0.39	81	131.28	0.38
178	27.95	0.43	118	52.92	0.40	58	77.13	0.40				22	108.57	0.39	82	131.67	0.39
177	28.37	0.42	117	53.33	0.41	57	77.52	0.39				23	108.96	0.39	83	132.05	0.38
176	28.80	0.43	116	53.74	0.41	56	77.92	0.40				24	109.35	0.39	84	132.43	0.38
175	29.22	0.42	115	54.15	0.41	55	78.32	0.40				25	109.73	0.38	85	132.81	0.38
174	29.65	0.43	114	54.56	0.41	54	78.72	0.40				26	110.12	0.39	86	133.19	0.38
173	30.07	0.42	113	54.97	0.41	53	79.11	0.39				27	110.51	0.39	87	133.57	0.38
172	30.49	0.42	112	55.38	0.41	52	79.51	0.40				28	110.90	0.39	88	133.95	0.38
171	30.92	0.43	111	55.78	0.40	51	79.91	0.40				29	111.28	0.38	89	134.33	0.38
170	31.34	0.42	110	56.19	0.41	50	80.31	0.40				30	111.67	0.39	90	134.71	0.38
169	31.76	0.42	109	56.60	0.41	49	80.70	0.39				31	112.06	0.39	91	135.09	0.38
168	32.18	0.42	108	57.00	0.40	48	81.10	0.40				32	112.45	0.39	92	135.47	0.38
167	32.61	0.43	107	57.41	0.41	47	81.50	0.40				33	112.83	0.38	93	135.85	0.38
166	33.03	0.42	106	57.82	0.41	46	81.89	0.39				34	113.22	0.39	94	136.23	0.38
165	33.45	0.42	105	58.22	0.40	45	82.29	0.40				35	113.61	0.39	95	136.61	0.38
164	33.86	0.41	104	58.63	0.41	44	82.69	0.40				36	113.99	0.38	96	136.99	0.38
163	34.28	0.42	103	59.04	0.41	43	83.08	0.39				37	114.38	0.39	97	137.37	0.38

Fig 4. RTD prescaling based Chart

4.1 ALGORITHM

Step 1: PIC 16F887 is initialized by checking its all ports interfaced with Analog pins configured.
Step 2: Tristate register A (Port A) is considered as input.
Step 3: Remaining Analog pins are considered high as digital input and output.
Step 4: Register C and B are considered as outputs.
Step 5: Initializing do while loop for temporary register for 10 bit result of ADC.
Step 6: Register B will be scaled with lower 8 bits of result in terms of PORT B.
Step 7: While PORT C will receive 2 most significant bits of result.
Step 8: Loop ends similar condition for PORTS A and D will also be considered.

V. METHODOLOGY

In this paper hardware co-design is been implemented using PIC microcontroller 16F887 having 10 bit scaled values but as per problem statement it is analyzed to Prescaled values to reduce its bit length and thus increase its speed through optimization of less bits for greater values of temperature using a RTD (Resistive Temperature Detector) based microcontroller along with transmitter H12E (Encoder) which is mainly paired with H12D (Decoder) receiver which should work with reference to frequency considered as 434 MHz open band frequency communicating under radio frequency with respect to receiver module using a RF Patch/Whip Antenna length having ranges of 30,50 and 100 meters. While Software Co-Design has been implemented using Micro C/C++ IDE based cross compiler [20]. ICSP (In circuit Serial programming) [18] interface will be used to in circuit

program with the help of PIC kit-3 with real time environment and debugged using PIC microcontroller.

VI. RESULT EVALUATION

As this fire monitoring and extinguishing system is using RF module based wireless signal conditioning either amplification circuit as shown in figure 5 and 6 respectively. Even though as there is detection of fire it has also, sound based alarm system unit which continuously provides notification of fire.

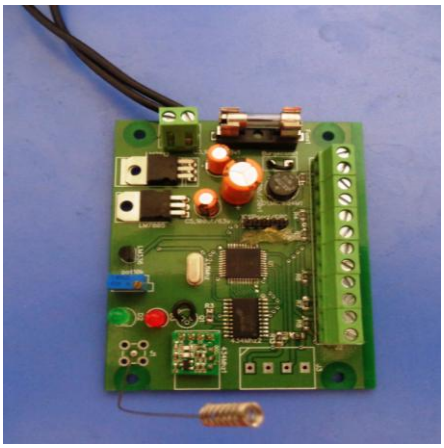

Fig 5. Wireless Transmitter Unit

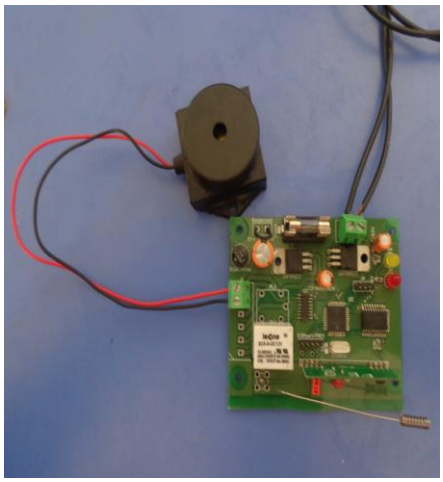

Fig 6. Wireless Receiver Unit

In terms of occurrence of fire based accidents, inherent time with some duration is provided for safeguarding the human lives with reference to diesel based industrial transport vehicles [4]. The result of system based evaluation time in Fig.7.

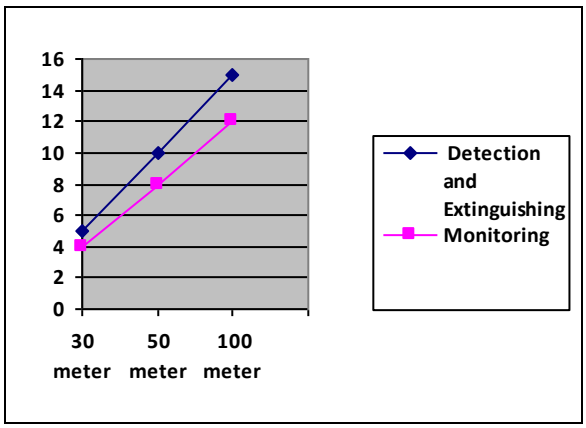

Fig 7. Overall Evaluation Time Vs Distance

VII. CONCLUSION AND FUTURE SCOPE

The fire born accidents are mostly occurred without proper adequate monitoring, detection procedure and extinguishing system even though industrial sectors use adequate measures and technological paradigm of various techniques and measures [1]. This paper thus, has result based on immediate monitoring and detection and its proposed work in the co-design based on hardware and software implementation of wireless fire fighting system using open RF band of frequency ranging from 433MHz to 434MHz with power optimization in terms of scaling of values of voltage for drastic change in temperatures laying its background to diesel owned generators used in in-house as well as outer transportation. Evaluation result is been obtained in terms of various distances as shown in Fig.7. Though prospective view with adequate need of higher end transport vehicles WSNs motes [6] [10] with all channel based ADC prescaling in terms of PIC based microcontroller and can be extended to either to ARM [20] [8] based microcontroller with increased credibility of WSNs nodes with transmitter as well as receiver for various systolic environments.

REFERENCES

Journal Papers:

[1] Gottuk, T. D., Peatross, M. J., Roby, R. J. and Beyler, C. L. "*Advanced Fire Detection Using Multi-Signature Alarm Algorithm*," Fire Suppression and Detection Research Application Symposium, pp. 140-149, February 24 -26, Orlando 1999.

[2] Badrinath, R.B., Srivastava, M., Mills, K. Scholtz, J. and Sollins, K. "*Special issue on smart spaces and environments*," IEEE Personal Communications, pp. 45-54, Oct 2000.

[4] Jiang, X., Hong, J. I., Takayama, L. A. and Landay, J. A. "*Ubiquitous Computing for Fire fighters: Field Studies and Prototypes of Large Displays for Incident Command*," CHI Letters (Human Factors in Computing Systems: CHI *04*), Vienna, Austria, April 24 - 29, 2004.

[5] Krishnamurthy, S., Stankovic, J., Abdelzaher, T., Luo, L., Stoleru, R., Yan, T., Gu, L., Hui, J. and Krogh, B "*Energy-Efficient Surveillance System Using Wireless Sensor Networks*," MobiSYS '*04*, June 6 -9, 2004, Boston, MA

[6] Xu, N., Rangwala, S., Chintalapudi, K.K., Ganesan, D., Broad, A., Govindan, R. and Estrin, E "*A Wireless Sensor Network For Structural Monitoring*," SenSys'04, November 3–5, 2004, Baltimore, Maryland, USA.

[9] Ruiz, B.L. et al, "*A management architecture for Wireless Sensor Networks*," IEEE Communications Magazine, *vol. 23*, pp. 862 – 872, February 2006.

[10] Culler, D., Estrin, D. and Srivastava, M. "*Overview of Sensor Networks*," Computer, *37(8)*, pp.41- 49, Aug 2009.

[11] Tellez, C., Rodriguez, O. and Lozano, C. "*Biomedical signal monitoring using wireless sensor networks*," LATINCOM '09 IEEE Latin-American Conference on Communications, Medellin 2009.

[12] Lozano, C. and Rodriguez, C. "*Design of Forest Fire Early Detection System Using Wireless Sensor Networks*," OJEEE 2009.

[13] Cheng, K., Ge, Q. and Wen, C. "*Wireless Intelligent Fire Fighting Systems Software Platform R&D*," Internet of Things (iThings/CPSCom), 2011 IEEE International Conference on and 4th International Conference on Cyber, Physical and Social Computing, pp 94 – 99, 19-22 Oct. 2011.

[14] Islam, T., Abdullah, S., and Sarowar, G. "Enhanced Wireless Control System for Smoke and Fire Detection," *International Journal of Computer and Electrical Engineering*, *Vol. 5*, No. 2, April 2013.

[15] Jadhav, S.P. and Deshmukh, U.V. "*Forest Fire Monitoring System Based On ZIG-BEE Wireless Sensor Network*," International Journal of Emerging Technology and Advanced Engineering *Volume 2*, Issue 12, December 2012

[16] Reddy, N.P., Basarkod, I.P. and Manvi, S.S. "*Wireless Sensor Network based Fire Monitoring and Extinguishing System in Real Time Environment*," Int. J. Advanced Networking and Applications *Volume: 03, Issue: 02*, pp 1070-1075, 2011.

[17] FORREX Dafo Suppression system "*Standard Rules, Manual Guide*," 2012-13.

Books:

[18] Matic, N. "*The PIC Microcontroller Book," Microchip* (Microelektronika Publishers, 2010).

[19] Shiengold, D. "*Transducer Interfacing Handbook*," (Analog Devices and Publishers, 1980).

[20] Kamal, R. "*Embedded System- Architecture and Design*," (Mc Graw Hill edition 1999).

Note that the title of the book is in lower case letters and italicized. There is no comma following the title. Place of publication and publisher are given.

Proceedings Papers:

[3] Ruiz, B.L., Isabela G., Siqueria and Leonardo, B. "*Fault Management in Event Driven Wireless Sensor Networks*," *Proceedings ACM Oliveira* 2004.

[7] Steingart, D., Wilson, J., Redfern, A., Wright, P., Romero, R and Lim, L. "*Augmented Cognition for Fire Emergency Response: An Iterative User Study*," *Proceedings of the 1st International Conference on Augmented Cognition*, Las Vegas, NV, 22-27 July 2005.

[8] Leland, Eli S., Lai, Elaine, M. and Wright, P. "*A Self Powered Wireless Sensor for indoor environmental monitoring*," *ASME proceedings*, *vol.9*, pp. 64 – 70, CA 2005.