Preface

The present volume contains selected papers of The 2014 International Seminar on Instrumentation, Measurement and Metrology (ISIMM 2014) held on August 27-28, 2014 in Yogyakarta Indonesia. The seminar, which has been jointly organized by Department of Physics, Faculty of Mathematics and Natural Sciences, Universitas Gadjah Mada and Department of Physics, Faculty of Mathematics and Natural Sciences, Institut Teknologi Bandung has accepted 166 abstracts. After having reviewed the abstracts, 100 papers were presented in the conference. Finally, under a tight peer-review process by at least two expert referees for each paper, 58 papers were accepted for publication in Applied Mechanics and Materials.

The papers are categorized into two groups that cover new developments and research results related to (a) Sensors and Instrumentation and (b) Methods of Measurement and Metrology. For more detail, they include Measurement systems and theory, instruments and sensor technology, signal processing, metrology, non-destructive testing and evaluation.

Finally, we are grateful to Indonesian Physical Society (HFI), Physics and Applied Physics Society of Indonesia (PAPSI), National Standardization Agency of Indonesia (BSN), Research Center for Calibration, Instrumentation and Metrology (Puslit KIM-LIPI), Calibration Laboratory - LPPT UGM, and Indonesian Society for Non-Destructive Testing (AUTRI) for their technical supports to this seminar, and Trans Tech Publications for producing the volume. Last but not least, we also wish to thank reviewers for invaluable comments and suggestions.

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Table of Contents

Applied Mechanics and Materials
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A Computer-Based Marine Automatic Radar for Rain Detection

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Keyword: Automatic, Radar, Optocoupler, Signal, Rain

Abstract. An improved rain detection system has been developed using a marine radar. The rain detection system is composed of a Furuno 1932 Mark II marine radar (radar scanner and display units), a radar control circuit, a signal conditioning circuit, an analog to digital converter (ADC), and a computer with a graphical user interface (GUI). The combination of the microcontroller and optocoupler in the radar control circuit was able to replace the omnipad and pushbutton control and it was also employed to activate the radar and the sector blanket mode. The signal conditioning circuit along with the ADC and the clutter removal made the video and navigation signals from the display unit become ADC-counted rain data. By comparing the ADC-counted rain data of the Furuno marine radar with the reflectivity obtained by GMR X Band weather radar, it was found that the Furuno rain detection sensitivity only spans from 30-55 dBZ.

Introduction

Indonesia archipelago has a very unique geographic condition, it is also possessed a conditions where very warm sea water surrounded this archipelago that will trigger the convective activity which would generate rainfall with high frequency [1]. The moist from sea breeze that flow through the mountain slope will generate convective clouds which in certain condition would produce rainfall [2]. That is why the diurnal variation in this tropical region generally reach its maximum in the late afternoon-evening and also in the morning due to this convective activity [3].

One of instruments for rainfall measurement is weather radars, which is capable of detecting raindrop movement, locating the precipitation position, and estimating their type (rain, snow, etc). Weather radars are also able to measure precipitation in spatial coverage and within a large area [4]. On the other hand, in marine radars, sea wave and rain become unwanted objects or clutter. Marine radars were designed to operate continuously and able to overcome heavy outdoor condition that makes it easy in maintenance [5]. The general functions of marine radars are to navigate, observe targets around it including coast, boats, and other solid objects.

Technology developments of marine radars could be utilized into local weather radars for urban applications. These developments however could not be applied with either the general weather radar equation or the Marshal Palmer method due to their system limitation [6]. For this reason another variable was used as a radar output with a relative value toward weather radar reflectivity with scale according to observation result. On the other hand, many applications based on computer-microcontroller connected to Matlab GUI that have been developed in automation and control field [7-9]. This paper reports an improved rain detection system that is composed of the Furuno 1932 Mark II marine radar (radar scanner and display units), a radar control circuit, a signal conditioning circuit, an analog to digital converter (ADC), and a computer with a graphical user interface (GUI). The radar control circuit will act to replace the omnipad and pushbutton control and it was also employed to activate the radar and the sector blanket mode. The signal conditioning circuit along with the ADC and the clutter removal will make the video and navigation signals from the display unit become ADC-counted rain data.

Hardware and Software Design

A rain detecting system based on a Furuno 1932 Mark II [10] marine radar is schematically described in Fig. 1. It consists of a radar scanner, a radar display, a controller, a signal conditioning unit, a signal processing unit, and a computer [11]. The radar scanner is composed of an antenna, a slotted waveguide, a magnetron, and a rotator, while the radar display consists of a signal processor, a limiter, an intermediate-frequency (IF) amplifier and a cathode tube [10]. The Furuno radar with power of 4 kW transmits electromagnetic wave with frequency of 9.4 GHz through its antenna into the atmosphere. The reflected echoes that were generated by a target are then received by the antenna, forwarded to the display unit through the signal cable. The signal conditioning unit will convert the received radar echo (video signal) and another signal (navigation signal) into desired signal and pass them into the signal processing unit and computer. The controller controls and activates the radar display.

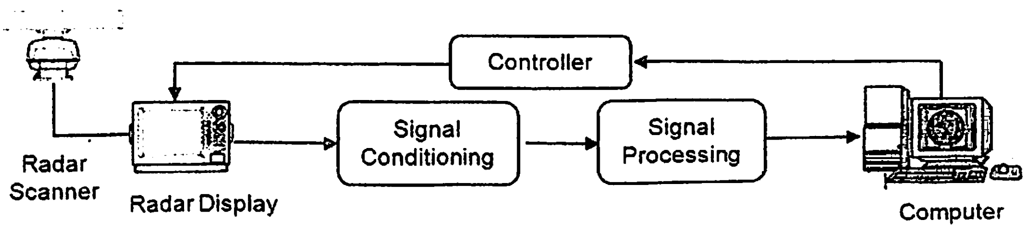


Fig 1. Schematic diagram of rain detecting system [11].

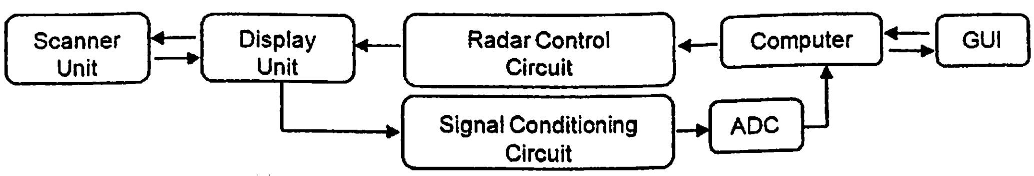


Fig 2. Block diagram of improved rain detecting system

Figure 2 illustrates the block diagram of improved system. The received signal from the scanner unit is sent to the display unit and converted to the desired signal through the signal conditioning circuit, which consists of optocoupler, voltage divider, and buffer circuits. The video and navigation signals from the display unit are treated by the signal conditioning circuit without losing its original characteristics. The conditioned value is then sent to the signal processing unit consisting of a 10 bit ADC (analog to digital converter) with 4 I/O channels. This ADC digitizes the conditioned signal and the digital signal is then filtered and processed by using the Matlab 2011a [11]. The processed digital signal contains polar and cartesian data producing spatial values and representing the target echo. This target echo is next processed with clutter removal to extract the ground clutter signal and to obtain rain data.

Computer is the main control that connects the interface system of the Matlab GUI with the radar control circuit and to synchronize the radar activity and radar sampling. The radar control circuit consisting of a microcontroller, an optocoupler, and a voltage divider is used for replacing the pushbutton and omnipad of the navigation board inside the display unit. The radar active command (for activating the transmitting and receiving processes) and navigation setting are handled by the GUI through the radar control circuit.

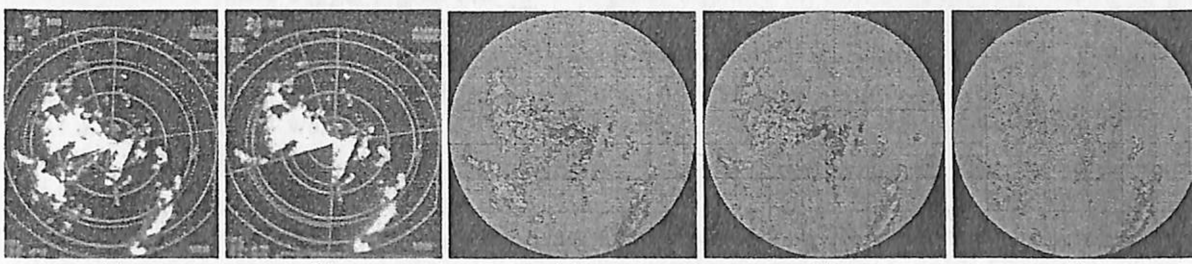
Results and Discussion

In the signal conditioning circuit, the navigation signals from the unit display varying from $\pm$ 12 V and $\pm$ 9 V were converted into $\pm$ 5 V by using the 4N26 optocoupler and then fed into the ADC of the signal processing circuit. Meanwhile the video signal varying from 0 to -4V was directly digitized by the ADC. Under the ADC post–trigger mode, an external trigger was needed. For this reason, the optocoupler converted the 12 V pulse trigger signal from the navigation signal into the 5

V pulse signal with turn off time response of 32 μs. This signal triggered the ADC to start sampling and digitizing radar navigation and video signal in one full circle (360^0) radar azimuth scan.

The combination of the microcontroller and optocoupler in the radar control circuit was able to replace the omnipad and pushbutton control in the navigation switch board. Omnipad characteristics with 0-5 V transition and 2.2 or 2.8 V stand by condition for up-down left-right control were controlled by the optocoupler triggered by pull-up microcontroller digital pin 6-9, meanwhile pin 1-5 are used to control the pushbutton for radar setting with calculated optocoupler resistance of ± 70 Ω. The GUI Matlab sent command to the microcontroller through the serial port of the computer via RS232 communication so that the computer could control and set the radar through its serial port.

One of the marine radar navigation setting applications is sector blanket in which the transmitted beam is blocked in certain azimuth sector while the radar is operating. The sector blanket was initially manually activated in the navigation menu. Now, the improved system is able to do it through software. It has been found that the GUI was capable of controlling the radar activation in the radar display, giving the sector blanket that blocks $180 - 250^0$ azimuth area, and sampling radar data without or in the sector blanket as given in Figs. 3.(a)-3.(d), respectively. The sampled radar data were then processed by using the ground clutter removal to obtain ADC-counted rain data as demonstrated in Fig. 3.(e).



(a) (b) (c) (d) (e)

Fig 3. Sector blanket mode: (a). radar activation, (b) radar sector blanket, (c) sampling results without sector blanket, (d) sampling results in sector blanket, (e) rain data.

For a preliminary validation, the GMR X Band (9.41 GHz, 25 kW) weather radar of GAMIC Gmbh was used because its operating frequency is the same with that of the Furuno 1932 Mark II marine radar. It was far away placed from the Furuno marine radar in order to prevent interference between them. The observation was conducted from September 30, 2013 until October 17, 2013. The ADC-counted rain data resulted from 22 rain events during the observation were then compared with the reflectivity values obtained from the GMR weather radar in the same time and target coordinate.

The validation resulted in a logarithmic graph as written in Eq. (1) and demonstrated in Fig. 4 due to the logarithmic receiver system with the regression coeficient value (R^2) of 0.903. It is shown that the Furuno rain detection sensitivity only spans from 30-55 dBZ (5-78 ADC count) representing higher precipitation. The Furuno radar showed well compared with GMR radar but less sensitive However, for lower precipitation, the Furuno marine radar was less sensitive probably due to its low radar power.

$$\text{dBZ Furuno} = 7.338 \times \ln(\text{ADC count}) + 22.71 \quad (1)$$

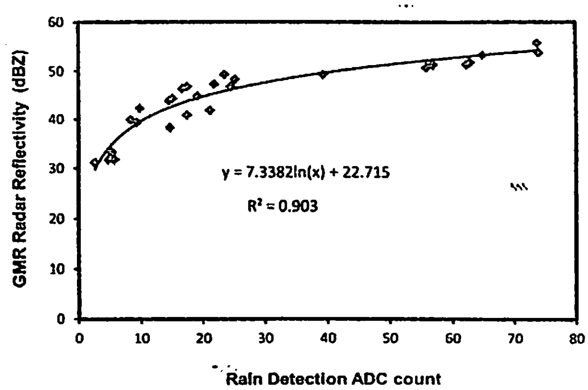


Fig 4. Comparison between the Furuno ADC count and GMR observation

Conclusion

An improved rain detecting system based on the Furuno 1932 Mark II marine radar has successfully been developed. The developed signal conditioning circuit with its optocoupler could convert the 12 V pulse trigger signal into the 5 V pulse signal with turn off time response of 32 μs. The radar control circuit using the microcontroller-optocoupler combination could replace omnipad and pushbutton control and be applied in radar activation and sector blanket mode. By comparing the ADC-counted rain data of the Furuno marine radar with the reflectivity obtained by GMR X Band weather radar, it was found that the Furuno rain detection sensitivity only spans from 30-55 dBZ.

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References

[1] M. D. Yamanaka, H. Hashiguchi, S. Mori, et al, HARIMAU Radar-profiler network over the Indonesian maritime continent, J. Disaster Res. 3 (2008) 78-88.

[2] F. Renggono, H. Hashiguchi, S. Fukao, M. D. Yamanaka, S.-Y. Ogino, N. Okamoto, F. Murata, B. P. Sitorus, M. Kudsy, M. Kartasasmita, and G. Ibrahim, Precipitating clouds observed by 1.3-GHz L-band boundary layer radars in equatorial Indonesia, Ann. Geophys. 19 (2001) 889-897.

[3] W. M. Gray and Jr. Jacobson, Diurnal variation of deep cumulus convection, Mon. Weather Rev. 105 (2006) 1171-1188.

[4] T. Einfalt, K.A. Arnbjerg-Nielsenb, C. Golza, N.E. Jensenc, M. Quirmbachd, G. Vaese, B. Vieux, Towards a roadmap for use of radar rainfall data in urban drainage, J. Hydrol. 299 (2004) 186-202.

[5] L. Pedersen, N. E. Jensen, H. Madsen, Calibration of local area weather radar-Identifying significant factors affecting the calibration, J. Atmos. Sci. 97 (2010) 129-143.

[6] J.E.Nielsen, N.E. Jensen, M. R. Rasmussen, Calibrating LAWR weather radar using laser disdrometer, Atmos. Res. 122 (2013) 165-173.

[7] P. P. Sethu, A. Selvaraj, S. Surendar, A wireless speed control of ac drive system, Int. J. Adv. Res. Electr. Electron. Instrum. Eng. 3 (2014) 448-455.

[8] M. P. Dhiman, D. Anand, K. Grover, PC based speed control of induction motor, Int. J. Emerg. Trends Electr. Electron. 2 (2013) 81-84.

[9] G. S. Nhivekar, S. S. Nirmale, R. R. Mudholker, Implementation of fuzzy logic control algorithm in embedded microcomputers for dedicated application, Int. J. Eng. Sci. Technol. 3 (2011) 276-283.

[10] Furuno Electric Co Ltd, Operator's guide to marine radar, USA, 2008.

[11] A. Awaluddin, Pengembangan sistem pengolah sinyal radar cuaca berbasis radar Furuno 1932 Mark II, Thesis, ITB, Bandung, 2013, pp.29-35.