

# Reconfigurable Multichannel EMI Sensor Panel Array for Vehicular Applications

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**Abstract**— In the literature, it is found much studies on a multichannel electromagnetic induction sensor placed a single panel. But, operating adjacent panel array is a challenging problem due to presence of strongly electromagnetic interference between multichannel sensor panels. Each panel of this array occurs undesired electromagnetic interference on the others because of electromagnetic field radiated from each own transmitter coils and power units. In this paper, expandable or decreasable modular multichannel sensor panel array design that can be operated adjacent has been described for manned or unmanned vehicle. Thanks to modular structure, multichannel sensor panels can be easily mounted vehicles having different widths. In addition, the modular panel array has a capable of detecting and locating buried tiny or big metallic objects with high accuracy while moving at a reasonable speed. In the proposed design, adjacent multichannel EMI sensor panels can operate without affecting each other. Operating side by side of multichannel EMI sensor panels have been carried out by a power synchronization unit obtaining synchronization between control unit and power unit. The effectiveness of the proposed design on the detection performance and their advantages have been demonstrated using experimental data.

## I. INTRODUCTION

An electromagnetic induction (EMI) sensor named as metal detector emits and gathers time- varying magnetic fields from search coil to detect, characterize and locate metallic objects under the ground. In pulse induction EMI sensor, the current is flowed for a short period of time on search coil, then an instantaneously flyback voltage occurs in the coil when the current stopped. The eddy currents on metallic objects cause a delay in the damping time at the receiver unit. Thus, a sample taken over this delayed damping curve constitutes the detection of metal [1]-[3]. As the number of receiving coils increases, analog hardware structure becomes more complex. The timing control is critical step to prevent unwanted signals on the each receive coils on a multichannel EMI sensor (M-EMI sensor). The vehicle mounted M-EMI sensor array has been developed to clean the unexploded ordnance area safety and faster [4]-[6]. Thanks to a M-EMI sensor panel having a large scanning surface, buried metallic objects placed different location at the same line can be detected simultaneously. For a single M-EMI sensor panel, the electromagnetic interference on the each receive coils can be eliminate with time synchronization between the channels. However, when multiple individual M-EMI sensor panels are operated adjacent to each other, it is not adequate to make only time synchronization to eliminate noise

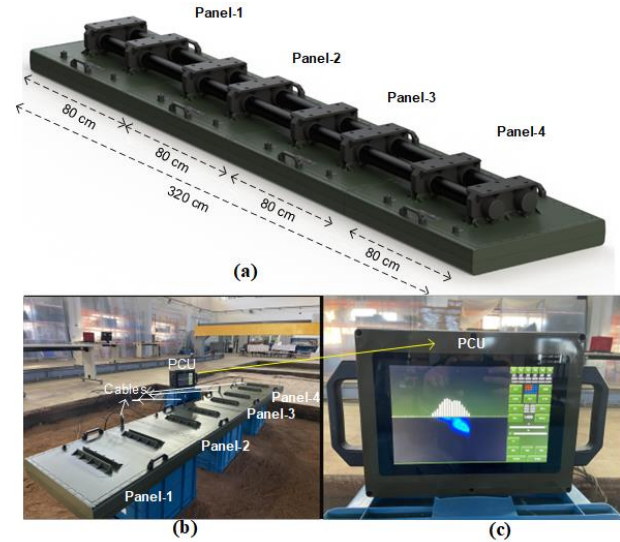


Fig. 1. Reconfigurable modular multichannel EMI sensor panel array.

on the receiver coils. In this study, a new design that allows the adjacent operation of individual multi-channel EMI sensor panels for vehicle applications is presented. A reconfigurable EMI sensor panel array that can operate adjacent has been obtained by the help of controlled power unit provided synchronization between the individual modular panels. Thus, it becomes possible to be increased or decreased the EMI sensor channel according to usage, requirements and vehicle widths by the help of reconfigurable modular sensor panel structure. In addition, the proposed system is detected tiny or highly metallic objects with high accuracy.

## II. SYSTEM ARCHITECTURE AND EXPERIMENTAL RESULTS

The proposed modular M-EMI sensor panel array is shown in Fig.1a. Each modular M-EMI sensor panel is length of 80 cm and each of them contains 8 receive and one transmit coils. The control unit of the proposed system support to operate up to 48 channels with adjacent 6 M-EMI sensor panels. The four individual M-EMI sensor configuration supporting 32 channel is shown as Fig.1b. Beside this each panel can be used individually. The system is controlled by the Processing and control unit (PCU) shown as in Fig.1c. The PCU displays response of 32 channels with graphic bar and waterflow diagram to the operator. The settings of the proposed system such as detection sensitivity of the systems, ground balance, effective

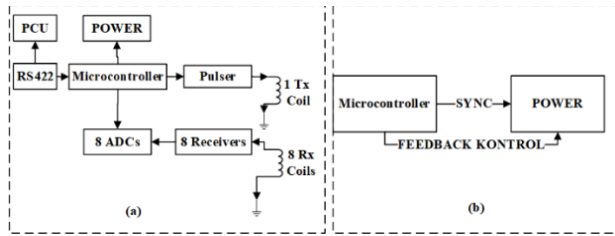


Fig. 2. (a) Block diagram of single panel. (a) multichannel EMI sensor, (b) power synchronization unit.

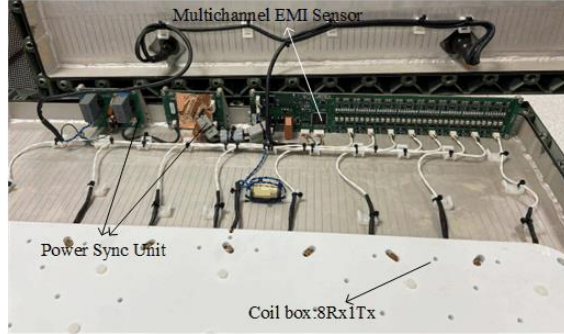


Fig. 3. Implementation of M-EMI sensor and power synchronization unit.

period selection etc. are done on the PCU. Each bar on the PCU screen gives the response of each receive coil. The block diagram and implementation of the single panel is shown in Fig.2 and Fig.3, respectively. The communication between each M-EMI sensor panel between PCU is provided by RS 422 line. Each panel radiate a short and long amplitude pulses on ground surface with the synchronization message from PCU to acquire ground balance. The received signals from ground surface digitalize on receiver unit and send to PCU with RS422 line. The sampled data is processed to provide ground balance. Then, processed data send from PCU to the microcontroller of each panel. Thus, the mineralized structure of the soil and the metals in the soil are separated from each other. Another problem of this modular system is electromagnetic interference between the modular panels caused by power units. Each panel contains own switch mode power units which emits high electromagnetic noise. Therefore, the system must be synchronized to the power units. For this, it needs two types of synchronization which are own synchronization of the panel, synchronization of the panels with each other. Power synchronization within the panel is achieved by locking the synchronous message transmitted from the PCU to the power synchronization signal triggered on microcontroller in the panel. Another problem is the power synchronization between panels. Since the power circuits in the panels are not connected to each other, the power unit of any panel induce electromagnetic interference on other panels. All panels are operated sequentially. When a single panel complete the own process, it shuts down the own power unit simultaneously, and then it is fed through by the help of a capacitor until the next process time. Thus, the electromagnetic interference caused power units between the panels has been prevented by the feeding capacitor named as power synchronization unit in Fig.3. The performance of the proposed system has been tested in MEKTAM test area. The adjacent 4

panels containing 32 channel EMI sensor have been towed with a wooden carrier. A tiny metal whose is 4x50mm copper cylinder and metallic disc whose radius is 20 cm was buried at 5 cm and 20 cm depth in the ground, respectively. After ground balance processing, the targets have been detected saliently on the PCU at reasonable speed. The experimental setup and results of the systems is shown as Fig.4.

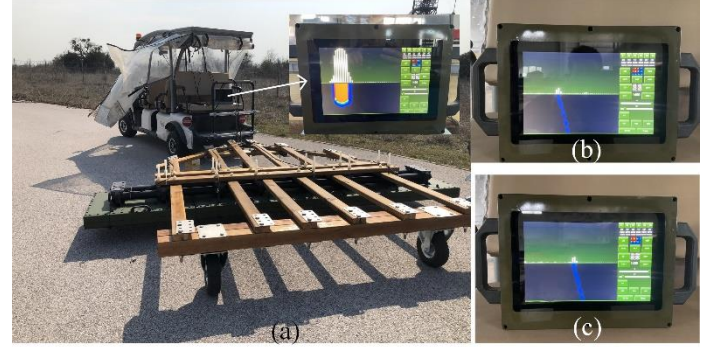


Fig. 4. (a) Towed panel array and metal disc response of second panel, (b) tiny metal response of third panel, (c) tiny metal response of the fourth panel.

### III. CONCLUSION

It has been described how each individual M-EMI sensor panel can be operated without interfering each other when they are adjacent. A modular array structure is obtained by solving the electromagnetic interference caused by the power unit and transmitter coil in each individual panel on the other panels. Thus, it has been achieved a multi-channel sensor array that can be mounted on vehicles having many different widths. Finally, it has been achieved not only a reconfigurable M-EMI sensor panel array with different widths but also high accuracy M-EMI sensor panel detecting from tiny metal to high metal is designed.

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