Study on Interlocking System in Indonesia

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Abstract In Indonesia, there are various interlocking systems of signaling system that have been installed. According to controlling coverage, the electrical signaling system consists of distributed interlocking type such as Solid State Interlocking (SSI), and centralized interlocking type such as Vital Processor Interlocking (VPI), Westrace, SIL, MIS-08, GL-1 and etc. Moreover, the interlocking system in Indonesia can be classified into relay based interlocking, programmable logic control (PLC) based interlocking, electronic based interlocking and combined based interlocking. In other hand, there are some conditions of Indonesia that appears failures of the equipment. The conditions are social and environmental circumstances of Indonesia such as vandalism, heavy rain and especially large and frequent lightning have caused failures of interlocking devices. Based on analysis of configuration, we recommend interlocking requirements for Indonesia. The requirements are using centralized interlocking type and relay interface for connecting indoor and outdoor equipment. It is supposed to minimalize the failures that caused by the conditions.

***Keywords*:** Interlocking system, centralized interlocking, distributed interlocking, relay interface.

1. Introduction

Signaling system in Indonesian Railway Company is divided into Mechanical Signaling System and Electrical Signaling System and spread in Java Island and Sumatra Island as shown on Figure 1. There are many vendors installed signaling system in separated location and each other cannot be integrated. Moreover, the installed signaling systems in different location are also different interlocking system each other especially on electrical signaling system. In other hand, installed interlocking system is not always fit with Indonesian conditions, so it makes interlocking equipment failures. The conditions are social and environmental circumstances of Indonesia such as vandalism, heavy rain and especially large and frequent lightning have caused failures of interlocking devices. In this paper, it is focused on study of interlocking system in Indonesia to provide the recommendation for interlocking system design in the future.

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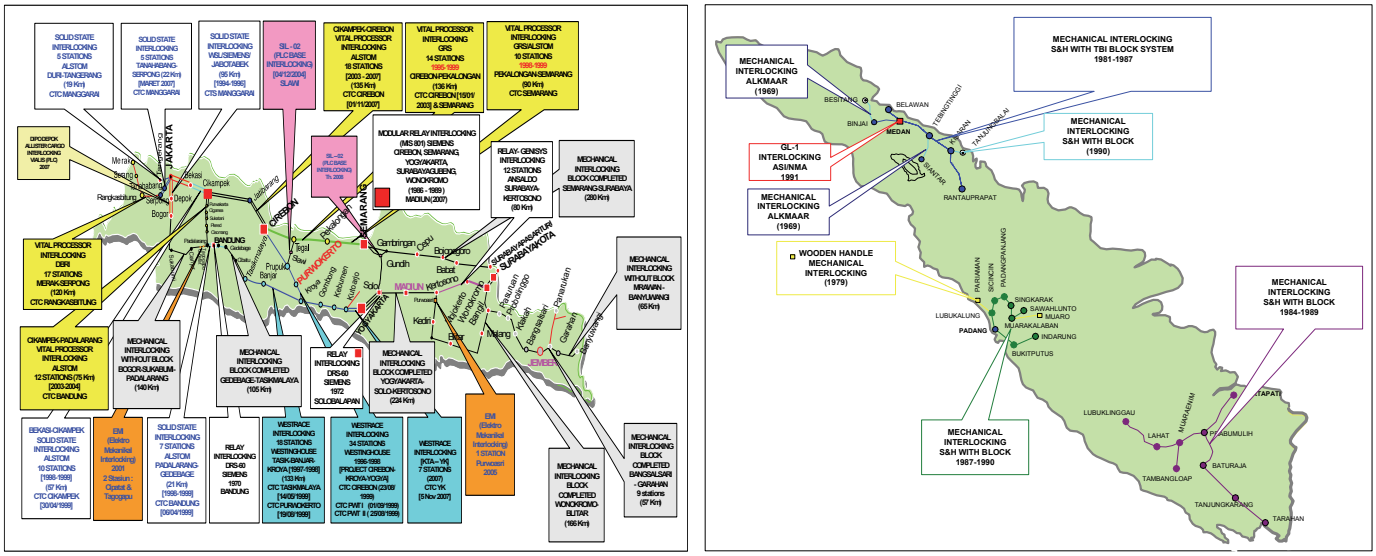


(a) Java Island (b) Sumatra Island

Fig. 1 Map of Installed Interlocking in Indonesia

2. Overview Interlocking System in Indonesia

2.1 Classification of Interlocking

Classification of interlocking in Indonesia can be divided into control coverage and type of interlocking control device. All interlocking systems in Indonesia are almost centralized types that use one interlocking for one station. However, there are several distributed interlocking in some part of Jakarta area and Bandung area that uses one interlocking for controlling several stations.

According to interlocking control device, the interlocking type consist of relay based interlocking, programmable logic control (PLC) based interlocking, electronic based interlocking and hybrid based interlocking that combines electronic modules and relay.

2.2 Main Installed Interlocking in Indonesia

There are 3 main interlocking systems that installed in Indonesia such as VPI (Vital Processor Interlocking) made by Alstom, SSI (Solid State Interlocking) made by Alstom and Wetrace made by Westinghouse as shown on Table 1.

2.2.1 VPI

Vital processor interlocking (VPI) used modules base on electronic component with relay interface for connecting to outdoor equipment. The interlocking system used single processor with fail safe system controlled by VRD relay. The system was designed for mainline railroad with small station and for large station with expanding non-vital and vital interlocking system. The VPI consists of control modules that contain a set of plug-in Printed Circuit Boards. The boards are applied in varying quantities to meet the needs of a specific location. The control modules are divided into vital modules and non-vital modules. The vital modules are CPU/PD, VRD, I/O Bus, DI and SBO, whereas the non-vital modules are composed of

CSEX/CSEX2, NVI and NVO as shown Figure 2a.

Table 1 Interlocking Type of Electrical Signaling System in Indonesia

Nu.	Interlocking	Type of Control Equipment	Vendor	Centralized/ Distributed	Line/ Station
1	VPI	Electronic	DBRI	Centralized	Merak - Serpong
2			GRS	Centralized	Cirebon - Semarang
3			ASI	Centralized	Cikampek - Cirebon
4	Westrace	Electronic	WBSA	Centralized	Cirebon - Kroya, Tasikmalaya - Kroya
					Kroya - Yogyakarta
5	MIS-801	Relay	Siemens	Centralized	Cikampek, Cirebon, Yogyakarta, Wonokromo
					Semararang tawang, Surabaya gubeng
6	DRS-60	Relay	Siemens	Centralized	Bandung, Solo
7	SSI	Electronic	WSL	Distributted	Jabotabek
			Gec - Alstom		Tanah abang - Serpong, Duri - Tangerang
					Tanah abang - Pasar senen,
					Bekasi - Cikampek, Padalarang - Gedebage
8	Ansaldo/ Genesys	Relay & Electronic Modules	Ansaldo	Centralized	Kertono - Surabayagubeng
9	GL-1	Relay & Electronic Modules	ASI/NMA	Centralized	Medan
10	Alister Cargo	PLC	Vossloh IT Sweden	Centralized	Jakarta/ Depok
11	SIL	PLC	Len Industri	Centralized	Citayam - Cibinong

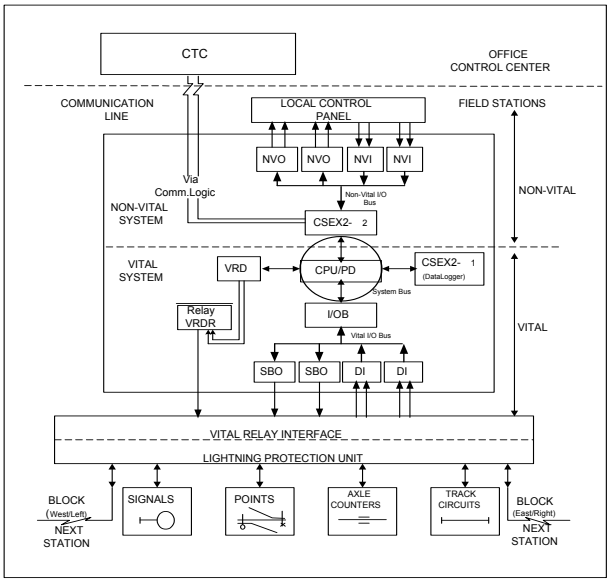
2.2.2 SSI

SSI is full electronic based interlocking system that developed base on British Railways Standard, and it manufactured by Westinghouse Signal Limited (WSL) and GEC-Alstom. The interlocking system uses triple processor with redundant principle that output execution result 2:1. The system has been designed for large station and some small stations for 1 interlocking, whereas the interlocking cans control remotely 2 or 3 small stations. The SSI modules are divided into vital and non-vital. The vital modules consist of MPM, DLM, Data link, TFM, whereas the non-vital modules contain control panel, programmable controller, FEPOL, PPM, DMPM and technician terminal as shown on Figure 2b.

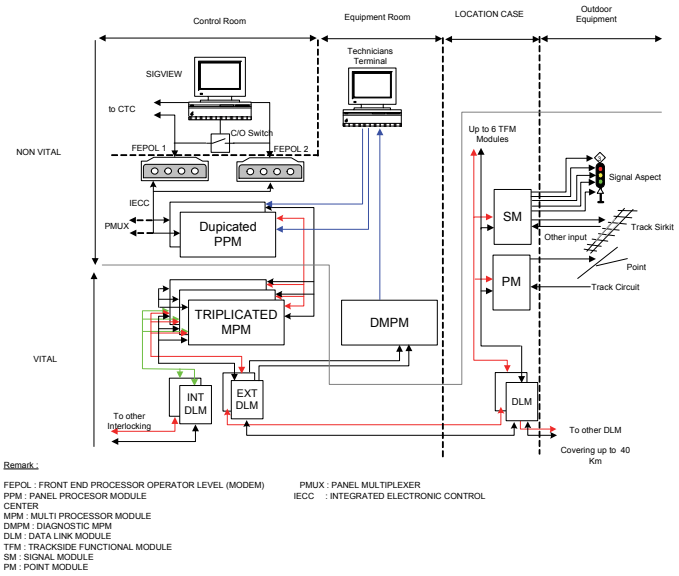
2.2.3 Westarce

Westrace is full electronic based interlocking made by Westinghouse Brake & Signal Ltd. Australia (WBSA). Westrace system is adoption from some technology and the capacity is smaller because it is designed for small station. The interlocking system uses single processor with fail safe system controlled by OPCR relay and interfacing to outdoor equipment by relay.

Westrace consists of 2 main components that are vital logic equipment (VLE) and Configuration System (CS) or Graphical Configuration System (GCS). VLE is physical equipment of Westrace such as VLM, VPIM, VROM, VTC, NVC, and etc. as shown on Figure 3.



(a) VPI



(b) SSI

Fig. 2 Block Diagram VPI and SSI Interlocking

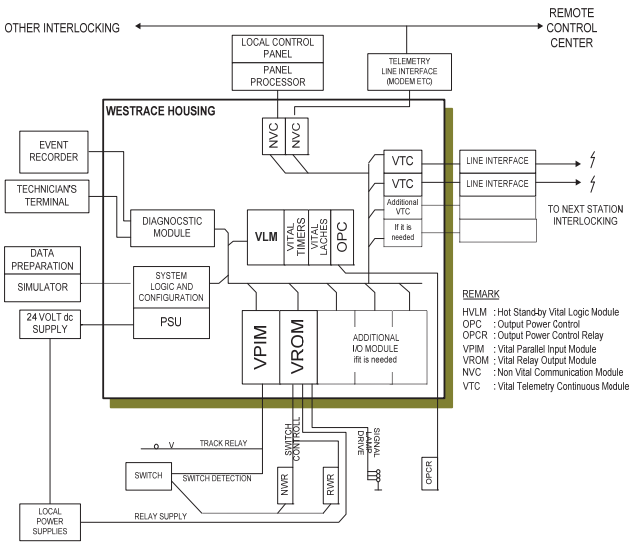


Fig. 3 Block Diagram Westrace Interlocking

Table 2 Performance of Main Installed Interlocking

Interlocking type	Common Problems/ Symptoms
VPI	Local control panel is failure caused by damaged button or indicator lamp SBO driver output is failure caused by lightning or other induction
SSI	Module failure of TFM, datalink and PPM that caused by lightning and other induction Datalink communication is intermittent VDU is sometimes blank and the PC has to be restarted
Westrace	VPIM and VPROM are failure caused by lightning or other induction It is sensitive, if there is lightning or other induction then the system autoreset

3. Evaluation

3.1 Influence Factors of Interlocking Performance

There are some influence factors that impact to interlocking performance especially main installed interlocking as shown on Table 2.

3.1.1 Environmental

As tropical climate country, Indonesia has temperature range from 17^{o}C to 38^{o}C and has relative humidity range between 70% and 90%. Moreover, the rainfall in Indonesia can be described by the rainy days range and the precipitations range per year. In 2012, the rainy days range is from 88 days to 231 days and the precipitations range is 1098 mm to 5041 mm. Furthermore, the high rainfall raises annually flood on some cities in Indonesia. However, on dry season the temperature is so hot especially at outside.

Table 3 Configuration of installed Interlocking Comparison

Nu.	Aspect	Relay	Hybrid	Electronics
1	Brand	· DRS-60 · MIS-801	· GL-1 · Ansaldo	· SSI (Solid State Interlocking) · VPI (Vital Processor Interlocking)
2	Functionality			
a	Topology of Interlocking	Distributed interlocking Normally one interlocking for one station It's possible one interlocking to control two stations whereas remotely control one station	Distributed interlocking Normally one interlocking for one station	Centralized interlocking or distributed interlocking Distributed type interlocking normally control one station by
b	Implementation of interlocking logic function	Logic function is implemented by relay vital circuit with vital or non-vital logic function (hardwired)	Logic function is implemented by relay vital circuit (hardwired) Logic function of non-vital interlocking is implemented by logic software of non-vital electronic processor (electronic module)	Logic function of vital interlocking is implemented by logic software of vital electronic processor (electronic module) Logic function of non-vital interlocking is implemented by logic software of non-vital electronic processor (electronic module)
c	User Interface/Panel Control	LCP (Local Control Panel) that logic function is controlled by vital relay or combine with non-vital relay	LCP (Local Control Panel) that logic function is controlled by non-vital electronic processor Visual Display Unit (VDU) is enable to be used but it need interfacing software with non-vital processor	LCP (Local Control Panel) that logic function is controlled by non-vital electronic processor Visual Display Unit (VDU) is enable to be used but it need interfacing software with non-vital processor
d	Operational Method/ Panel Control	Entrance-Exit button (NX) for forming route Manual buttons for individual operation	Entrance-Exit button (NX) for forming route Manual buttons for individual operation	Entrance-Exit button (NX) for forming route Manual buttons for individual operation
3	Physical Design			
a	Interlocking component	· Single or modular Relay	· Single relay · Modular is applicable · Electronic Card/ PCB	· Electronic Card/ PCB Module · Relay is usually used as interface
b	Mounting Method	· Mounting frame on the rack	· Mounting frame on the rack	· Card housing standard 19"
c	Wiring	· Single relay : individual terminal wiring · Modular : plug connector	· Single relay : individual terminal wiring	· Pin input/output wiring
d	Space need	For small/medium stations need about 6 -10 standard racks Need special room for relay	For small/medium stations need about 4 -6 standard racks Need special room for relay	For small/medium stations need about 2-4 standard racks Need special room for relay For closed rack design, it doesn't need special room
e	Diagnostics System	No available Trouble shooting is directly on relay circuit	Available in non-vital processor	Available in vital processor or non-vital processor
f	Protection from lightning induction or other EMC	No available/ no need to connect with outdoor Necessary for power supply line	For non-vital processor is needed	For vital and non-vital processor are needed
4	Flexibility			
a	Enable to modify according to station layout change	Wiring modification of vital function relay in majority Wiring modification of non-vital function relay in majority	Wiring modification of vital function relay in majority Modification of pin input/output assignment module in minority Modification of non-vital software	Modification of pin input/output assignment of vital & non-vital module in minority Modification of vital and non-vital software
b	Enable to modify according to feature addition of system such as interconnected with CTC, Data Logger, Remote Control, ATP, etc.	Needs addition of subsystem non-vital module that interfaces with relay Wiring modification of non-vital function relay in majority	It's possible to use non-vital electronic module if there is serial communication Modification of non-vital software	It's possible to use non-vital electronic module if there is serial communication Modification of non-vital software
c	Enable to component addition according to outdoor equipment addition.	Additional relay or relay module Needs additional rack if there is no space for new relay/relay module	Additional relay or relay module Needs additional rack if there is no space for new relay/relay module	If there is a spare I/O port it doesn't need additional module Additional relay interface (minor) Additional housing if there is no space for new module

In addition, the lightning frequency in Indonesia is high, even the highest of thunderstorm days per year in the World located on Bogor city (Southern Jakarta) according to National Lightning Safety Institute. The thunderstorm days per year are 322 days that recorded in 1988. These conditions influence frequently to failure of interlocking equipment especially interface module that connecting with outdoor equipment.

3.1.2 Vandalism

There is prominent issue about vandalism especially on track side area that impact to failure of signaling equipment. So, the installed equipment on the track side has to be protected by additional case.

3.2 Configuration Analysis

The configuration analysis can be described on Table 3 that explain comparison of relay based, hybrid based and electronics based interlocking. The comparison displays the lack and advantage of interlocking type in Indonesia.

3.3 Recommendation

According to configuration and performance analysis, we provide some recommendation for designing interlocking in Indonesia that are: centralized interlocking, relay interface for connection indoor and outdoor equipment, minimalizing installed equipment on track side, and using local control via Visual Display Unit (VDU).

3. Conclusion

The conditions in Indonesia especially the lightning influences to the performance of installed interlocking directly, whereas vandalism does not influence directly but it has to be considered for designing the interlocking. In this paper, we propose some recommendations for fitting the conditions of Indonesia on designing interlocking, as below: centralized interlocking, using relay interface for connection indoor and outdoor equipment, minimalizing installed equipment on track side, local control using VDU. For future, we will conduct a research about centralized interlocking using relay interface for Indonesia designed by considering the recommendation.

Acknowledgment

This project has been supported thanks the grant of Korea Agency for Infrastructure Technology Advancement (KAIA) No. 010403.

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