Development of Digital Type Protection Control Unit, IPMAT ⅢS

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Abstract

The Intelligent Protection, Measuring, And Transmission unit ⅢS (IPMAT ⅢS) is a digital protection control tool with various functions of protection, control, measurement, and transmission. It was developed as a successor model of IPMAT Ⅱ/ⅡA. The immunity level improved the visibility and operability by upgrading the user interface (based on JEC-2501-2010 standard). Compared with former models, the measurement accuracy has been improved by increasing the resolution of the analog Input/Output (IO). Still more, a testing mode function was added to improve the work efficiency at the time of equipment inspection. High speed transmission is realized by adding an IO link Ⅲ for data transmission. Regarding the data-save function, data recording time has exponentially increased. This equipment is favorably advanced in maintenance and operational management such that the saved data, including error logs, can also be collected by USB memory.

1 Preface

We have been offering IPMAT Ⅱ/ⅡA as a digital type protection control unit provided with various functions of protection, control, measurement, and data transmission. More than ten years have passed since the development of this models and customer needs have changed. The hardware parts including major components have been discontinued by the manufacturers. Users now require an improvement of immunity.

This paper introduces the features of IPMAT ⅢS developed as a successor model of IPMAT Ⅱ/ⅡA to meet requests for functional improvement.

2 Outlines of IPMAT ⅢS

Table 1 shows a list of specifications. The all-digital system is adopted for the integration of a protection, monitoring, control, and transmission function as a package. Since its adoption, this system realized a compact and intelligent switchgear. We also realized high reliability of the protection function by including the Central Processing Unit (CPU), duplicated from the analog portion. As an optional function, it supports IO link transmission and transducer output resulting in a realized high-speed transmission. **Fig. 1** shows an example of the network system configuration where IPMAT ⅢS is used.

3 Function

3.1 Hardware Configuration

The hardware (analog block and CPU block) comes in a duplex configuration for main and accident detection. A hardware/software configuration with no malfunction due to a single fault is adapted. A wide-area CT has been implemented so that a wide measuring range can be secured.

3.2 Type

IPMAT Ⅱ/ⅡA were classified into 10 types. While for the IPMAT ⅢS, the 5 types in all are integrated for each respective function. **Fig. 2** shows the type of integration. In order to assure interchangeability between the former and new models, the setting file for a former model of IPMAT Ⅱ/ⅡA can be used for the new model.

3.3 Performance Improvements
3.3.1 Immunity

Table 2 shows the JEC-2501-2010 Standard to which the immunity test has conformed. In IPMAT

Table 1 A List of Specifications

A list of IPMAT ⅢS specifications and differences from the former IPMAT Ⅱ/ⅡA model are shown. Meanwhile, the IO link transmission is an optional feature.

Item		Specifications	Difference from IPMAT Ⅱ/ⅡA
Applicable standard		JEC-2500-2010, JEC-2501-2010, JEC-2502-2010	Only JEC-2500-1987
Auxiliary power supply voltage		DC100 V・DC110 V	Same as left
Auxiliary power supply voltage consumption		Regularly 6 W, Max. 20 W	Regularly 10 W
Permissible voltage regulation		−15〜+10% (Temporarily −20〜+30%)	Same as left
Rated frequency		50 Hz or 60 Hz	Same as left
Rated current		5 A or 1 A	Same as left
Rated voltage		VT secondary rating: 110 V EVT tertiary rating: 190/110 V ZPD secondary voltage: 1 V	Same as left
Burden		CT secondary: 0.2 VA, VT secondary: 0.2 VA, EVT tertiary: 0.2 VA, ZCT secondary: 1 Ω, ZPD secondary: 9 kΩ or more	Same as left
Applicable environment	Ambient temperature	Characteristic guaranteed temperature: 0〜40℃ Operational guaranteed temperature: −10〜+55℃ Storage temperature: −20〜+60℃	Operational guaranteed temperature: up to +50℃
	Relative humidity	30〜80%RH (No dew condensation)	Same as left
	Environment	Do not expose to rigorous dust, corrosive gases, rainstorm, or direct sunlight	Same as left
	Altitude	2000 m or below	Same as left
Dimensions	External dimensions	W279 × H196 × D87 mm	W・H: +1 mm, D：−2 mm
	Mounting size	W271 × H86 mm	Same as left (with mounting interchangeability)
	Wiring	Analog input circuit: M3.5-18P Binary input/output circuit: MIC-17/21P Transmission circuit: M3.5-5P A/O circuit: D3100-8P FG: M4	Same as left (with wiring interchangeability)
Input	Number of points	14 points Photo-coupler	Same as left
	Voltage	DC110 V 5 mA	Same as left
Contact-point output	Number of points	3 points (ON, OFF, trip)	Same as left
	Contact capacity	Making capacity: DC100/110 V 10 A (resistance load) Limiting breaking capacity: DC100/110 V 0.1 A (L/R = 8 ms)	Same as left (where, L/R = 7 ms for IPMAT Ⅱ)
Output	Number of points	8 points Open collectors (one of them for WH output)	Same as left
	Voltage	DC100/110 V 60 mA	Same as left
Remote transmission path	Type	IO link Ⅱ/Ⅲ metal	IO link Ⅱ metal
	Transmission path style	Twist pair Bus state	Same as left
	Transmission speed	IO link Ⅱ: 1 M/500 K/250 K/125 Kbps IO link Ⅲ: 5 M/2.5 M/1 Mbps	Same as left for IO link Ⅱ only
	Distance — Distance between polls	IO link Ⅱ: 240/480/800/1000 m IO link Ⅲ: 140/300/600 m	Same as left for IO link Ⅱ only
	Distance — Total distance	IO link Ⅱ: 240/480/800/1000 m IO link Ⅲ: 140/300/600 m	Same as left for IO link Ⅱ only
Transducer output	Output range	DC4〜20 mA output, applicable to 4ch output	Same as left for IPMAT Ⅱ-A only
	Burden	External load resistance: 550 Ω or below (Applicable range: 55〜550 Ω)	Same as left for IPMAT Ⅱ-A only

ⅢS, by optimizing the design of the circuit pattern for the external noise, immunity performance was ensured, which can clear the load switching test even under the severest condition assumed during operation. The protection relay is installed close to the circuit breaker from where the shield plate removed. The test result indicates that the obtained values were considerably better than the standard level. The immunity performance was confirmed to be higher than the former model.
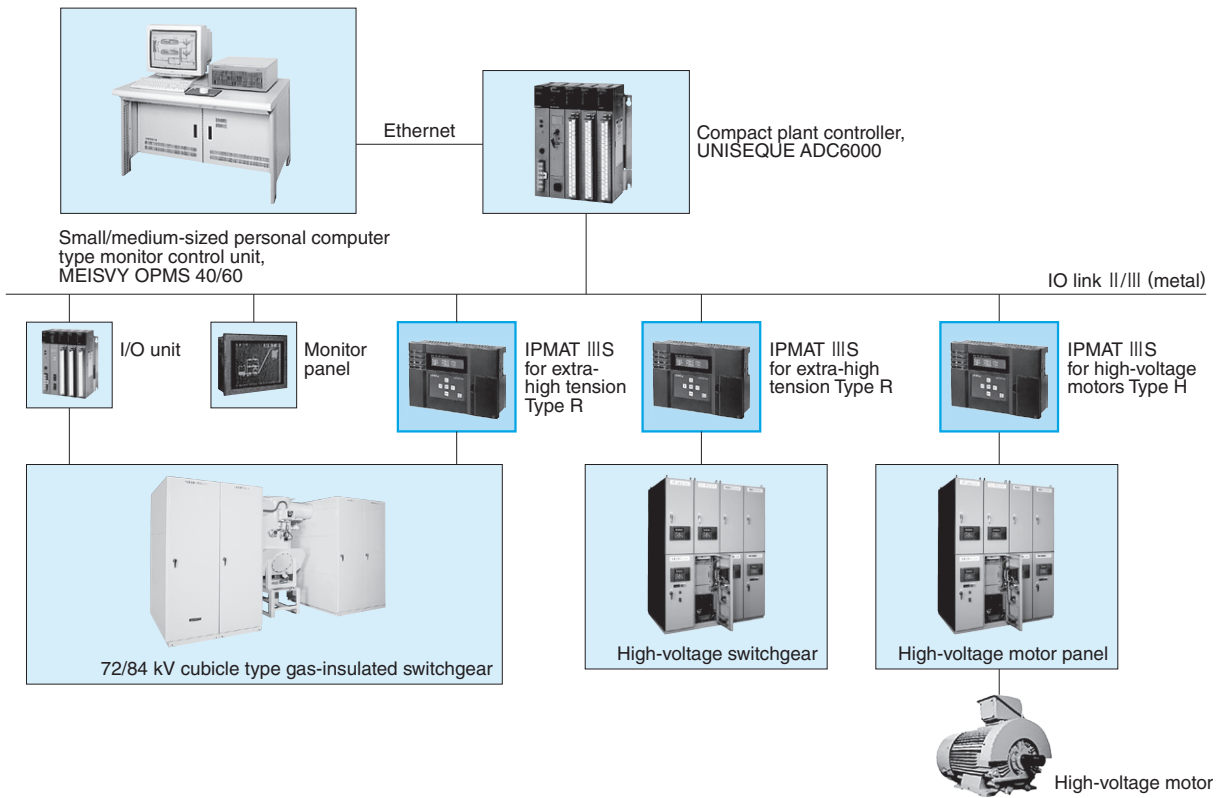
An example of a network system is shown when three types of IPMAT ⅢS models are introduced. When a transmission function (optional) is used, the system can be connected to a local transmission path (IO link Ⅱ/Ⅲ: metal) and any network system can be established according to the system scale and application.
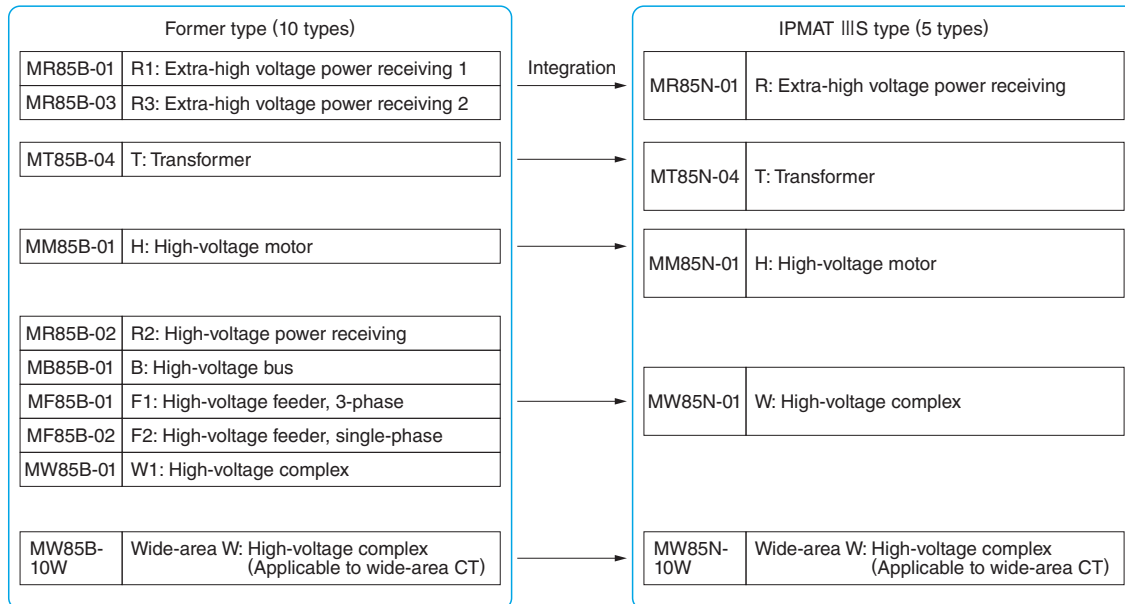
Former type (10 types)			IPMAT ⅢS type (5 types)	
MR85B-01	R1: Extra-high voltage power receiving 1	Integration	MR85N-01	R: Extra-high voltage power receiving
MR85B-03	R3: Extra-high voltage power receiving 2			
MT85B-04	T: Transformer		MT85N-04	T: Transformer
MM85B-01	H: High-voltage motor		MM85N-01	H: High-voltage motor
MR85B-02	R2: High-voltage power receiving		MW85N-01	W: High-voltage complex
MB85B-01	B: High-voltage bus			
MF85B-01	F1: High-voltage feeder, 3-phase			
MF85B-02	F2: High-voltage feeder, single-phase			
MW85B-01	W1: High-voltage complex			
MW85B-10W	Wide-area W: High-voltage complex (Applicable to wide-area CT)		MW85N-10W	Wide-area W: High-voltage complex (Applicable to wide-area CT)

A list of IPMAT ⅢS integration objects is shown for 10 types of conventional models.

3.3.2 Interface

Fig. 3 shows a configuration of IPMAT ⅢS. For IPMAT ⅢS, the user interface was improved with a universal design. The Light Emitting Diodes (LED) has a structure that can be recognized from the side to improve visibility.

In addition, a Liquid Crystal Display (LCD) was adopted, which is devised to support the notation in Kanji. The number of switches decreased from for-mer 18 to 12 so that visually intuitive operation can be performed with ease.

The standard test items and specified values of JEC-2501-2010 to which the immunity test has conformed are shown.

Test items aiming at doubled durability of JEC-2501	JEC-2501-2010		
	Power source	Instrument transformer	Control binary input/output
Static electricity discharge immunity	Contact discharge: 8 kV Air discharge: 15 kV		
Commercial power frequency immunity	300 V for 10 s 150 V for 10 s		
Damped oscillatory wave immunity	2.5 kV	2.5 kV	2.5 kV
EFT/B immunity	2.0 kV	1.0 kV	1.0 kV
Rectangular wave impulse immunity	1.0 kV	1.0 kV	1.0 kV
Surge immunity	2.0 kV 1.0 kV	2.0 kV 1.0 kV	2.0 kV 1.0 kV
Commercial power frequency magnetic field immunity	30 A/m for 60 s 300 A/m for 2 s		
Radio frequency magnetic field conduction interference immunity	10 V 150～80 MHz		
Radiant radio frequency magnetic field immunity	10 V/m 80～1000 MHz 1400～2700 MHz		
Electric waves (Power Stand-ard B-402)	150/400/900 MHz：5 W Mobile: 800 MHz, 1.8 GHz Wireless LAN: 2.4 GHz, 5.2 GHz		

3.4 Functional Improvements
3.4.1 Input/Output (IO)

The analog IO resolution of IPMAT ⅢS is a 13-bit (formerly 12-bit) and 12-bit (formerly 10-bit) for the A/D converter and the A/O converter, respec-tively. Compared with former models, accuracy is improved and more accurate signal processing is possible. In the contact output, three outputs (ON/OFF trip) may be selected according to the applica-tion.

3.4.2 Data-Save Function

The Data-Save function automatically records the waveform data and relay operation information from 18 cycles before to 9 cycles after, a circuit breaker trip due to a grid power system accident, while IPMAT Ⅱ recorded from 6 cycles before to 2 cycles after, and IPMAT ⅡA recorded from 11 cycles before to 5 cycles after. In IPMAT ⅢS, more informa-tion is recorded. This information can also be recorded automatically in the event of a relay oper-ation other than a trip or in the event of an error. The analysis is performed by connecting to a Personal Computer (PC) with a dedicated tool installed. The status at the time of an accident can
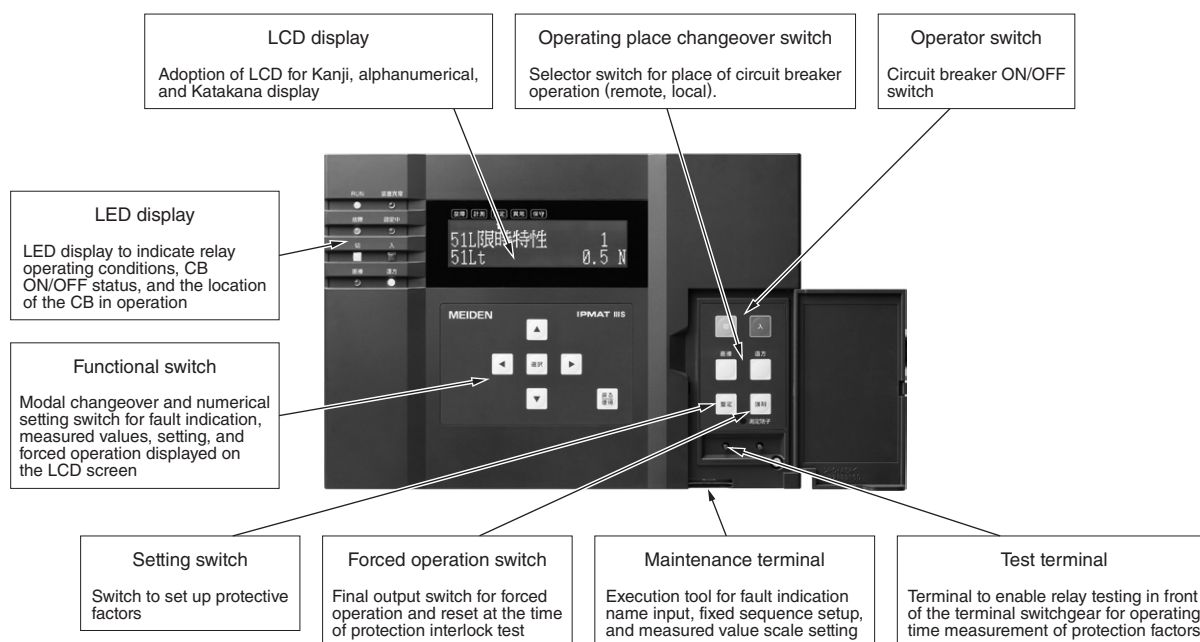

LCD display
Adoption of LCD for Kanji, alphanumerical, and Katakana display

Operating place changeover switch
Selector switch for place of circuit breaker operation (remote, local).

Operator switch
Circuit breaker ON/OFF switch

LED display
LED display to indicate relay operating conditions, CB ON/OFF status, and the location of the CB in operation

Functional switch
Modal changeover and numerical setting switch for fault indication, measured values, setting, and forced operation displayed on the LCD screen

Setting switch
Switch to set up protective factors

Forced operation switch
Final output switch for forced operation and reset at the time of protection interlock test

Maintenance terminal
Execution tool for fault indication name input, fixed sequence setup, and measured value scale setting

Test terminal
Terminal to enable relay testing in front of the terminal switchgear for operating time measurement of protection factors

Fig. 3 | Configuration of IPMAT ⅢS

A condition of the opened switch cover is shown. For IPMAT ⅢS, the number of switches is decreased and switches directly relating to circuit breaker ON/OFF, setting, and relay operation are covered in order to prevent misoperation. When the function switch in the center is actuated, the LCD displays fault indications, measured values, and setting values in a changeover mode. An LCD is used to visualize the operating condition of a circuit breaker and the location of the operated circuit breaker.
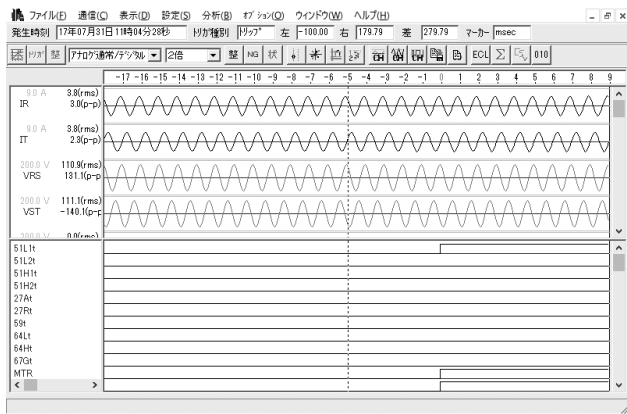
An example of a PC screen display is shown for IPMAT ⅢS analysis tool.

be checked with the data-saved accident waveform. **Fig. 4** shows an example of the PC screen display of the analysis tool.

3.4.3 Test Mode Function

Conventionally, when checking the function of equipment, unnecessary outputs have been hard-locked by means of external auxiliary relays and output wire detachment. IPMAT ⅢS, however, has a test mode function that holds binary input/output and transmission data and can suppress external alarms and transmission outputs when inspecting the equipment. By this mode setting, the equipment can be inspected without any hardware measures.

3.4.4 Setting File

Settings for each relay and transmission can be made a setting file. When making a setting, connect the PC to read and write the file. To make a setting, a PC is used to read and write the setting file.

3.4.5 Transmission

For transmission, the IO link of our unique remote IO transmission path is used. Conventionally, this function was available for the IO link Ⅱ transmission only, but it also supports the IO link Ⅲ transmission by changing a setting file. By adding the IO link Ⅲ support, it realizes the improved transmission rate and an increase of number of nodes.

3.4.6 MicroUSB

IPMAT Ⅱ/ⅡA used serial communication to acquire data, however, recent PCs do not have a serial communication interface. IPMAT ⅢS is equipped with a MicroUSB port, which improves the convenience of the tool. It is used for reading/writing files and reading analysis files that are saved in the case of accidents or abnormalities. It can also be used to write files saved in the USB memory.

4 Postscript

This paper introduced the features of IPMAT ⅢS developed as a successor model of IPMAT Ⅱ/ⅡA. We are going to expand the application of IPMAT ⅢS in the future. In the future the transmission system will be configured to comply with the IEC 61850 standard.

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