

# Solid State Rod Control System Power/Logic Cabinet/Pulse-to-analog Converter Printed Circuit Cards

## Background

System printed circuit (PC) cards are periodically selected for a complete review and redesign as appropriate. Redesign focuses on addressing known reliability detractors, replacing obsolete components, and adding redundant circuits and other features to improve reliability and maintainability. This enables Westinghouse to offer redesigned PC cards for the rod control system (RCS).

## Description

The enhanced cards are direct fit, form and function replacements that can be implemented under 10 CFR 50.59. The redesigned cards can be mixed with the older cards, and no system modifications or wiring changes are required to install them except for a minor wiring change for an optional feature to actuate the non-urgent alarm. The new cards are qualified to operate in temperatures of up to 120 F. System design requirements are 50 F to 104 F ambient surrounding the cabinets.

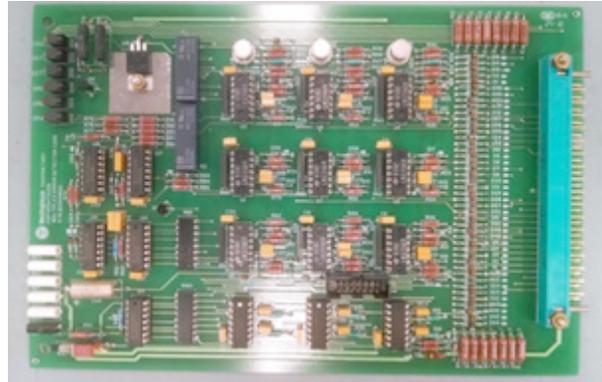
## Manufacturing and Testing of Redesigned Cards

The redesigned PC cards are manufactured and inspected per IPC-A-610 Class II standards. They are tested in the Westinghouse Automated Board Test System (WABTS), burned in for 100 hours, and then retested in the WABTS. The cards are then functionally tested in the RCS cabinets (power, logic, pulse-to-analog converter cabinets) before shipping.

## Power Cabinet Cards

Westinghouse has redesigned all of the power cabinet cards including regulation, phase control, firing, multiplexing error detector, signal process, failure detector and alarm cards.

The redesigned cards include redundant circuits to minimize single-point vulnerabilities, improving system reliability.



Multiplexing error detector card – 6D31108G01

## Firing Card

The firing card has been redesigned to increase system reliability. This third-generation card achieves redundancy through two identical circuits: primary and backup. A failure detection circuit allows it to determine when a failure has occurred and switch over if necessary to the other circuit. An amber light-emitting diode (LED) indicates a failure and green LEDs indicate which circuit is currently operating. An optional output activates the non-urgent alarm annunciator in the event of a circuit failure; this option would require additional cabinet modifications.



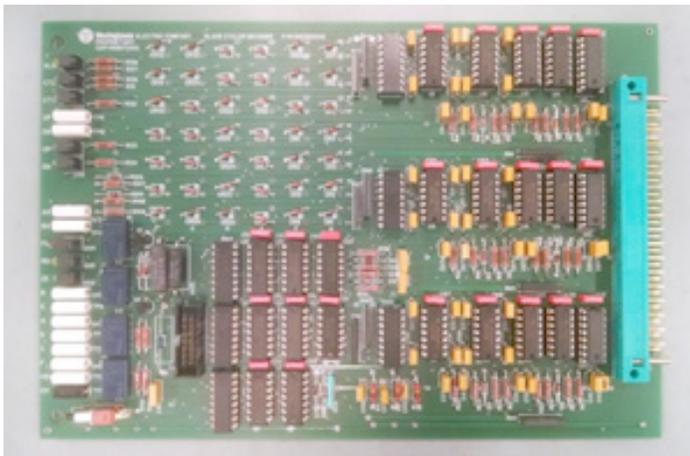
Firing card – 10060D44G01

## Logic Cabinet Cards

Westinghouse redesigned all logic cabinet cards except the pulser/oscillator card. The new cards replace obsolete Motorola® High Threshold Logic (MHTL) chips and Midwec capacitors with components that have a history of reliable operation in other Westinghouse systems. The redesigned critical logic cabinet PC cards, including slave cyclor decoder, supervisory logic II, supervisory buffer memory, I/O AC amplifier, I/O failure detector, I/O relay driver, I/O pulse shaper and I/O receiver, include redundant circuits, additional test points and LEDs to minimize single-point vulnerabilities, improving system reliability.

### Slave Cyclor Decoder

A third-generation slave cyclor decoder card has been designed due to obsolescence. Three identical circuits provide redundancy: primary, backup and monitoring. A failure detection circuit allows it to determine when a failure has occurred and switch over if necessary to the other circuit. An amber LED indicates a failure and green LEDs indicate which circuit is currently operating. An optional output activates the non-urgent alarm annunciator in the event of a circuit failure; this option would require additional cabinet modifications.



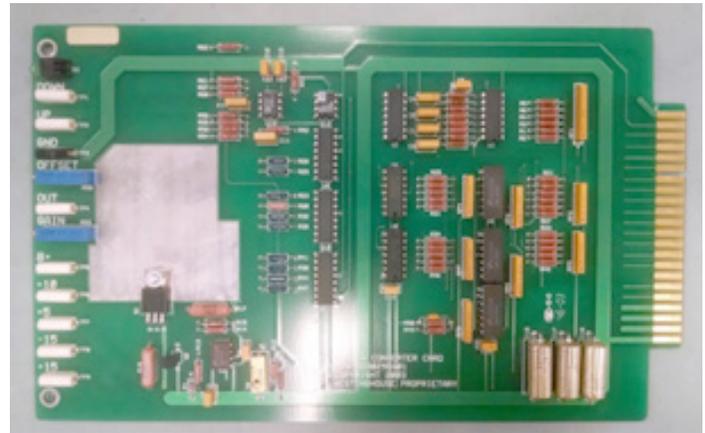
Slave cyclor decoder card (movable) – 10105D10G03

### Rod Control System/Analog Rod Position Indication System Pulse-to-analog Converter Cards

Westinghouse has redesigned all pulse-to-analog (P/A) converter PC cards including digital-to-analog (D/A) converter and counter cards. The redesign addresses obsolete MHTL chips, D/A converter module and memory cores with available complementary metal-oxide semiconductor (CMOS) components that have a history of reliable operation in other Westinghouse systems.

#### Redesigned P/A D/A Converter Card

The redesigned card improves offset drift, D/A linearity and accuracy. The gain is now more stable. The card has been designed as a direct replacement of the original converter card, making wiring changes in the P/A converter unit unnecessary, and it can also be mixed with the older cards.



D/A converter card – 6D30246G01

### Redesigned P/A Converter Counter Card

The card has been completely redesigned to address obsolete memory core assemblies and MHTL chips with available CMOS components. A high-value capacitor holds the count on power loss or card removal for about one week.

The P/A converter includes four control banks: A, B, C and D – each includes one D/A converter card and two counter cards. The new design counter card cannot be mixed with the old design counter card in a specific control bank and must be replaced in pairs.

## Benefits

The redesigned cards use readily available state-of-the-art components, providing improved heat transfer and air flow through changes in the physical layout and use of low-profile components. High-profile components have been eliminated to minimize broken solder joints from board handling. The new components are also more energy-efficient, reducing heat generation and transfer between components, which substantially increases the mean time between failures and reliability of the system.

Additional test points and LEDs monitor performance of redundant circuits and power supply voltages, including the zero-volt bus. Incandescent lamps on power and logic cabinet cards are replaced by LEDs for longer life.

## Experience

Seventy Westinghouse solid state rod control systems are in operation in nuclear plants around the world. The first RCS was installed in 1969. Westinghouse is committed to support and maintain the operating RCSs through an ongoing design enhancement program to improve the operation and reliability of the system.

The following table references currently available part numbers in addition to previous card generation part numbers.

*Motorola is a trademark or registered trademark of its respective owners. Other names may be trademarks of their respective owners.*

## Rod control system PC part numbers

Cabinet	Description	Original Part #	2nd Generation Part #	3rd Generation Part #
Logic	Bank Overlap Decoder	3359C71G01	6D30535G01	N/A
Logic	Bank Overlap Display Dr	3359C53G01	2D82872G01	N/A
Logic	Bank Overlap Logic 1A	3362C58G01	6D30527G01	N/A
Logic	Bank Overlap Logic II/IIA	3361C01G01	6D30540G01	N/A
Logic	Counter	3360C94G01	2D39973G01	10105D13G01
Logic	Failure Detector	3360C83G01	6D30544G01	N/A
Logic	I/O AC Amplifier	3359C65G01	6D30536G01	N/A
Logic	I/O Receiver	3359C59G01	6D31111G01	N/A
Logic	I/O Relay Driver	3359C77G01	6D31110G01	N/A
Logic	Master Cyclor Logic	3359C68G01	6D30537G01	N/A
Logic	Master Cyclor Selector	3359C56G02	6D30538G02	N/A
Logic	Pulse Shaper	3359C74G01	6D31109G01	N/A
Logic	Pulser /Oscillator	3360C91G01	No Plan to Redesign	N/A
Logic	Shutdown C&D Logic	3361C51G01	6D30542G01	N/A
Logic	Slave Cyclor Decoder, Lift	3359C62G01	2D39972G01	10105D10G01
Logic	Slave Cyclor Decoder, Mov	3359C62G03	2D39972G03	10105D10G03
Logic	Slave Cyclor Decoder, Stat	3359C62G02	2D39972G02	10105D10G02
Logic	Slave Cyclor Logic	3359C80G01	2D82868G01	N/A
Logic	Supervisor Buffer Memory	3359C83G01	2D82869G01	N/A
Logic	Supervisory Data Logging	3361C08G01	2D82870G01	N/A
Logic	Supervisory Logic II	3360C77G01	2D82871G01	10105D11G01
Logic	Supervisory Logic I	3360C97G01	6D30534G01	N/A
Logic	Supervisory Logic III	3360C80G01	6D30532G01	N/A
Power	Alarm	6050D13G01	6D31106G01	N/A
Power	Failure Detector	6050D15G01	6D30539G01	N/A
Power	Firing	6050D12G01	1C31021G01	10060D44G01
Power	Multiplexing Error Detector	6050D14G01	6D31108G01	N/A
Power	Phase Control	6050D11G01	6D30340G01	N/A
Power	Regulation, Gripper	6050D16G01	1048F56G03	6D30113G03
Power	Regulation, Lift	6050D16G02	1048F56G04	6D30113G04
Power	Signal Process	6050D17G01	6D31107G01	N/A
P/A Converter	D/A Converter	6064D62G01	6D30246G01	N/A
P/A Converter	D/A Converter Counter	6064D59G01	6D30543G01	N/A