NLC Induction Modulator

New IGBT Control System

Conceptual Design

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Purpose

• Review the existing control system for the 4-Pack NLC Induction Modulator.

• Provide an overview of new IGBT control and monitoring schemes for the next generation induction modulator.
Existing Control System Overview

200V P/S

Modulator 152 IGBTs
- Cell Ready
- IGBT Gate Trigger Present
- IGBT Over-Current
- Cell Failure

152 Wires

Modulator 76 Master/Slave Trigger Distribution & Control

4 Cables

Allen Bradley PLC

HV P/S
- Interlocks
- Controls

Modulator Control and Status Display Panel

8-Bit Pulse-Width Data
3-Bit Address / Control

Modulator/Klystron DC Monitor

Modulator/Klystron Status

PLC Control Interface

4-Channel Triggers

HV P/S Blanking Pulse

Modulator Pulsed Voltage / Current

NIM Trig. In

4 Klystron Beam Currents

200VDC Sense

Fiber-Optic Trig. Inhibit

Klystron Protection
- Voltage Faults
- Water Interlocks
- RF Faults
- Filament Current Level/Time Out

Modulator Protection
- Water Interlocks
- Temperature Interlocks
- Door Interlocks
- HV P/S Over-Voltage
- Loss of Control Power
- Loss of 200VDC P/S
- Trigger Rate/Pulse-Width Limit
PLC Control Interface Functions

- Provide an advance trigger for HV DC supply. The blanking pulse allows the P/S to regulate its final voltage before the modulator is firing.
- Provide 3 modulator trigger combinations:
  - Full PW (Normal) Pulses
  - Short (Turned-Off Early) Pulses
  - Delayed (Turned-On Late) Pulses
- There is a total of 4 different timing channels selectable by jumpers on the distribution board.
- Convert modulator pulsed voltages and klystron beam currents into DC voltages for PLC monitoring.
- Detect modulator and/or klystron arcs, and disable triggers until resetting by the PLC.
Trigger Timing Diagram

NIM Trigger In

P/S Advance Trigger
0-500uS On-Board Adj.

Modulator Trigger
2-Channel Full PW
0-4.5uS PLC Adj.

Modulator Trigger
3-Channel Short PW
0-4.5uS PLC Adj.

Modulator Trigger
3-Channel Delay
0-4.5uS PLC Adj.
New Control System Overview

- Modulator 84 IGBTs Control and Status
- 42 Cells Master/Slave Trigger Distribution

- Allen Bradley PLC
  - Modulator Control and Status Display Panel

- Control Interface
  - Mod / Klystron DC Monitor
  - Status

- HV P/S
  - Interlocks
  - Controls

- Modulator Protection
  - Water Interlocks
  - Temperature Interlocks
  - Door Interlocks
  - HV P/S Over-Voltage
  - Loss of Control Power
  - Loss of 2000VDC P/S
  - Trigger Rate/Pulse-Width Limit

- Klystron Protection
  - Vacuum Faults
  - Water Interlocks
  - RF Faults
  - Filament Current Level/Time Out

- NIM Trig. In
- 4 Klystron Beam Currents

- Modulator Pulsed Voltage / Current
- Fiber-Optic Trig. Inhibit

- RS-485 Computer
- Modulator Trigger
- HV P/S Blanking Pulse
Changes From the Present Control

• A single modulator trigger applies to all IGBTs.
• One serial link ties all core drivers together.
• A microcontroller places on each gate-drive board allowing:
  – The control of each IGBT trigger-timing individually.
  – The monitoring and the status of each core driver.
  – The control and monitoring of an on-board HV power supply when it is available.

• An on-board 15V to 200V DC-DC converter eliminates the distribution of 200V source.
# Microchip 8-Bit Microcontroller

## PIC16C7X

### 8-Bit CMOS Microcontrollers with A/D Converter

#### Devices included in this data sheet:
- PIC16C72
- PIC16C73
- PIC16C73A
- PIC16C74
- PIC16C74A
- PIC16C76
- PIC16C77

#### PIC16C7X Microcontroller Core Features:
- High-performance RISC CPU
- Only 35 single word instructions to learn
- All single cycle instructions except for program branches which are two cycle
- Operating speed: DC - 20 MHz clock input, DC - 200 ns instruction cycle
- Up to 8K x 14 words of Program Memory, up to 368 x 8 bytes of Data Memory (RAM)
- Interrupt capability
- Eight level deep hardware stack
- Direct, indirect, and relative addressing modes
- Power-on Reset (POR)
- Power-up Timer (PWRT) and Oscillator Start-up Timer (OST)
- Watchdog Timer (WDT) with its own on-chip RC oscillator for reliable operation
- Programmable code-protection
- Power saving SLEEP mode
- Selectable oscillator options
- Low-power, high-speed CMOS EPROM technology
- Fully static design

#### PIC16C7X Peripheral Features:
- Wide operating voltage range: 2.5V to 6.0V
- High Sink/Source Current 25/25 mA
- Commercial, Industrial and Extended temperature ranges
- Low-power consumption:
  - < 2 mA @ 5V, 4 MHz
  - 15 μA typical @ 3V, 32 kHz
  - < 1 μA typical standby current

- Timer0: 8-bit timer/counter with 8-bit prescaler
- Timer1: 16-bit timer/counter with prescaler, can be incremented during sleep via external crystal/clock
- Timer2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- Capture, Compare, PWM module(s)
- Capture is 16-bit, max. resolution is 12.5 ns.
  - Compare is 16-bit, max. resolution is 200 ns
  - PWM max. resolution is 10-bit
- 8-bit multichannel analog-to-digital converter
- Synchronous Serial Port (SSP) with SPI™ and I²C™
- Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI)
- Parallel Slave Port (PSP) 8-bits wide, with external RD, WR and CS controls
- Brown-out detection circuitry for Brown-out Reset (BOR)