ELECTRON COOLING GUN MODULATOR MANUAL

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1 Introduction

The output of the gun modulator is connected to the electron gun's "control electrode". It is by way of various modulator functions that the gun's electron emission is controlled. Voltage on the control electrode defines the intensity of beam emitted by the gun. The modulator plays a key role in controlling the production of electron beam for cooling electrons in normal operation, in diagnostic operations of the Pelletron and protecting equipment from intense electron beams in various system fault scenarios. The various functions performed by the modulator are as follows:

(1) Modulate the electron beam when the gun is generating DC current for cooling antiprotons.

The electron cooling beam position monitors (BPMs) operate by demodulating 32 kHz imposed on the DC electron beam by the modulator. (Without a periodic AC structure present on the beam, the BPMs would not be able to detect the position of the DC electron beam.)

(2) Pulse the electron beam for diagnostic operation.

Beam is pulsed with narrow pulses at low rep rates when the beam is not needed to be recirculated. The pulse width and amplitude are adjustable.

(3) Shut the gun off rapidly when the permit signal is removed.

A variety of operating conditions are monitored at ground level by a fault detection system that issues a permit signal over a dedicated fiber to the modulator in the terminal. (Electron beam from the Pelletron can put a hole in the beam pipe in a hurry if beam losses are not detected quickly enough.)

(4) Guarantee the gun remains clamped off until after the gun's anode PS totally powered down.

One failure mode is if the power to the terminal is turned off while beam is still on. The modulator protection circuitry will prevent this from happening.

(5) Remain protected during Pelletron high voltage breakdowns.

The control electrode is known to sustain damaging energy when the Pelletron breaks down. The modulator must reliably survive this.

(6) Optionally shut the gun off in modulation mode

Triggered by the TCLK input at the ground end, clamp the gun control electrode to -7 kVdc for the time interval defined by "pulse width" when while in modulation mode. The reason to do this is to periodically clear ions away from the DC beam.

Operation of the modulator requires two modules: the chassis that connects to the control electrode located in the terminal and an interface NIM module on the ground. These two modules communicate with each other by way of a number of fiber optic cables. The interface module on the ground communicates with the ECOOL front end for a connection to ACNET over Ethernet. The interface module communicates over Ethernet via the CEC protocol, so the modulator will respond to any network node using this protocol.

There is an alternative way to communicate with the modulator besides with the use of ACNET via the ECOOL front end. There exists a Labview application specifically for communicating with CEC equipped controllers over Ethernet. This LabView application (RabbitUI as it has been named) can be used for either bench testing the modulator chassis units, or it can be used to communicate with the modulator in operation. This has been useful when questions have arisen concerning ECOOL communication problems. Beams-doc-2109-v1 describes the CEC protocol.

1.1 Modulator operation

Understanding the operation of the modulator requires understanding a little about the operation of the electron gun it controls. It is useful to know that the operation of the electron gun is very similar to that of a triode tube having a cathode, anode and grid. The "control electrode" of the gun functions the same a triode's grid. Refer to drawing 9670-ED-385171 showing the interconnections of the gun and related power supplies.

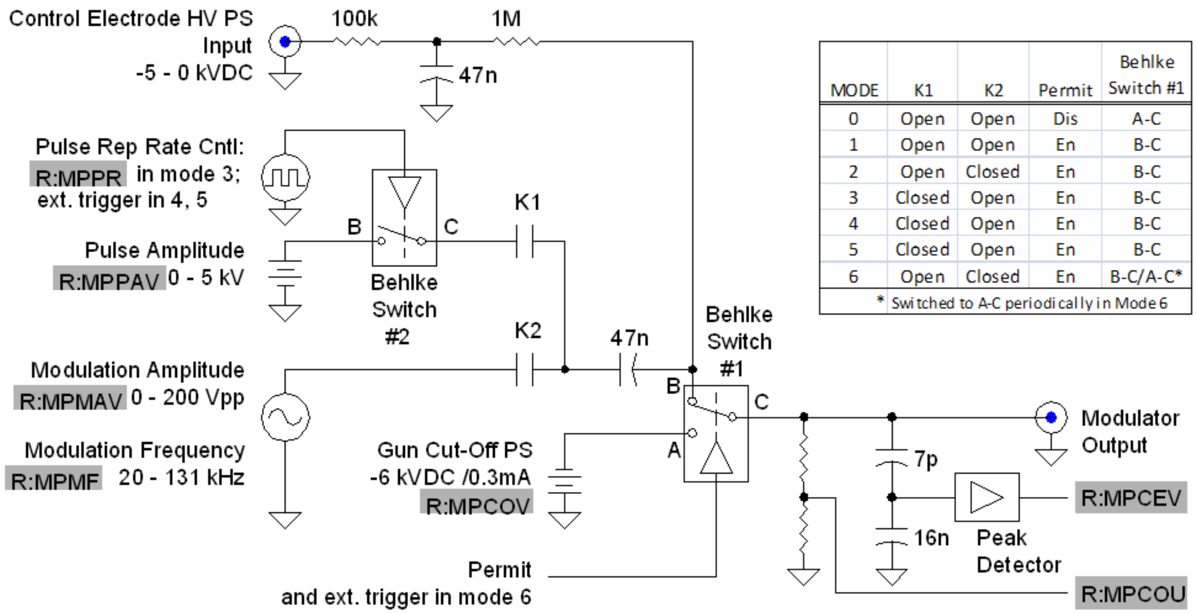
Think of the deck enclosure as "circuit common" for all the electronics in the Pelletron terminal. The gun cathode is hard wired to the deck. The gun anode, the Pelletron terminal, is positive—usually ~20 kVdc. The anode voltage is provided by way of the Anode PS (sometimes referred to as the "bias supply"). A value of -5 kV on the gun control electrode relative to the cathode cuts off electron emission. Raising the control electrode voltage more positive than cut-off increases intensity of beam emission, and the gun is said to be fully on (of fully "open") when the control electrode potential is equal to the cathode.

The amount of DC electron beam is determined by the setting value of the Control Electrode PS. (This power supply is a Glassman, Inc. commercial supply.) This supply is connected to the modulator, and in normal operation, it is this voltage that is routed to the modulator output. This scheme gives the modulator full control of the electron gun emission both for Pelletron operation as well as when it is necessary to clamp the gun off. In normal cooling operation, the modulator adds an AC voltage to the DC Control Electrode PS voltage specifically for the beam position monitors (BPMs) to work. In machine diagnostic operation, it alternatively adds a positive high voltage pulse to the DC control electrode voltage to provide pulsed beam to the control electrode instead of DC beam. In this case the DC control electrode voltage value is set just below gun cut-off so that only the high voltage pulse will cause beam emission. See Figure 1 for a simplified schematic of the modulator circuitry.

The BPMs works in concert with the gun modulator. The Pelletron produces DC electron beam to cool anti protons. But it is impossible to measure the position of the DC electron beam without some AC structure on it. The modulator, therefore, adds an AC signal to the control electrode and provides a signal for the BPMs to work. The BPM system is tuned to detect 32.000 kHz on the electron beam. The BPM system can also measure beam position when the modulator is producing pulsed beam (although at reduced resolution). In this case, the modulator outputs pulses triggered by an external TCLK trigger instead of a continuous 32 kHz. This external trigger is delivered to the modulator chassis over a dedicated fiber from the interface module on the ground.

Different scenarios require the modulator to shut the gun off hard and fast. The modulator switches the control electrode to an internal -6 kVDC supply to shut the gun off. There is a dedicated optical fiber that delivers a "Permit" signal from the interface module to the modulator chassis. This signal originates from a fault detection system on the ground. When the permit is removed the modulator shuts the gun off in less than 1 μs.

Lastly, realize that it is necessary to apply a non-zero voltage to the control electrode to prevent the gun from producing any beam—as long as there is positive anode voltage. For this reason, the modulator is equipped with a simple type of UPS system that keeps itself powered up longer than the anode supply when the motor-generator that delivers power to the Pelletron terminal is turned off. This guarantees there is no beam emission during the time the Pelletron is powered down.



MODE	K1	K2	Permit	Behlke Switch #1
0	Open	Open	Dis	A-C
1	Open	Open	En	B-C
2	Open	Closed	En	B-C
3	Closed	Open	En	B-C
4	Closed	Open	En	B-C
5	Closed	Open	En	B-C
6	Open	Closed	En	B-C/A-C*

* Switched to A-C periodically in Mode 6

Figure 1. Modulator chassis simplified circuit diagram.

1.2 Modulator operating modes

Control of the electron gun is determined by setting the modulator to one of a number of operating modes. There are a total of seven modes; of these, the user has control of six.

Mode 0: This mode is entered automatically by the modulator chassis whenever the permit signal is removed. In this mode, the control electrode is clamped to the -7 kV cut-off voltage. There is no way for the user to exit this mode other than to re-establish the permit signal. Also in this mode, the modulator disables the gun anode PS.

Mode 1: This is the mode that the modulator switches to when it is powered up and also whenever the permit signal is re-established after it had been disabled. The modulator outputs the control electrode PS DC voltage, but the modulation is turned off and the pulser is off. Also, in the mode the anode PS is enabled.

Mode 2: This is the normal "modulation mode". An AC sine wave voltage is added to the control electrode PS DC voltage and output to the control electrode. The modulation frequency is settable from above 20.0 kHz to 130 kHz at a voltage from 0 – 200 Vpp.

Mode 3: This is one of the modes that outputs high voltage pulses—when the modulator is said to be in "pulse mode". The modulator outputs high voltage pulses instead of an AC modulating signal. In this mode, the pulses are free-running and are asynchronous to external system timing. The pulse rate is settable from 1 - 5 Hz. This is never used in operation, since the BPMs do not work with the pulses asynchronous with the TCLK trigger. It is uses on the bench when testing pulse mode operation.

Mode 4: This is the pulse mode of choice when operating the Pelletron in pulsed beam diagnostics. The pulses are triggered by the TCLK trigger—usually at 1Hz intervals. TCLK trigger is driven by the $EB event. The pulse amplitude is settable from 0 – 5 kV. The modulator defaults to a 2 μs pulse width when switching between different modes, but the pulse width is settable from 1 – 30 μs.

Mode 5: This mode is another pulsed mode and referred to as the "negative pulse mode". It was added to investigate effects of electron beam with ions, but is not used. This mode would be used by setting the Control Electrode PS for a desired level of DC electron beam, and the modulator will pulse negative to cut the beam off periodically for a time interval determined by pulse width. The pulsing is triggered by the TCLK trigger. The pulse amplitude determines how far the negative-going pulses go into the gun cut-off region. Both the pulse width and amplitude are settable with these respective parameters.

Mode 6: This is another modulation mode. It was also added to investigate ion effects. Operation is the same as in mode 2, but the output is switched to -7 kVdc for the time duration set by the pulse width. Beam cut-off is triggered by the TCLK trigger. The pulse width must be set to a sufficient value to allow time for ions to clear.

2 ACNET Parameters

The following tables list all the ACNET parameters assigned for the modulator. Descriptions provided for each of the listed ACNET parameters provide some details for understanding modulator operation and functionality. Refer to the Figure 1 circuit diagram to help understand the devices defined as ACNET parameters.

R:MPMOD	MPS Operating Mode
Settable parameter	
The range of modes are 0 – 5. Settable modes are 1 – 5. Mode 0 means the gun permit is disabled, and the user is prevented from changing to any other mode until the permit is re-enabled. Mode 0: Permit is disabled. Output is clamped to -6 kVDC. Mode 1: Modulator and pulser are both off. Mode 2: Modulation mode. Mode 3: Pulser free-run mode. Mode 4: Pulser mode, positive pulses, triggered by TCLK. Mode 5: Pulser mode, negative pulses, triggered by TCLK. Mode 6: Modulation mode, clamp gun off for "pulse width" time interval triggered by TCLK	
Status bit 1:	"." (grn) - An OK condition indicating the gun permit is enabled. The mode can be set to any desired operating mode.
	"*" (rd) - Permit is disabled. The mode will be 0.
Status bit 2:	"." (grn) - The output HV gun permit switch is on and not faulted.
	"F" (rd) - The output HV gun permit switch is faulted. A bad sign.
Status bit 3:	"." (grn) - An OK condition indicating the modulator chassis is set to remote – the normal operation setting.
	"L" (yel) - The modulator chassis is set to local – only used for bench testing.

R:MPMAV	MPS Modulation Amplitude
Settable parameter	
This parameter is settable only after the mode has been set to 2. After setting the mode to 2, the amplitude must be set to a non-zero value to obtain an output signal. The amplitude is automatically set to 0 whenever the mode is changed from 2.	
Status bit 1:	"." (grn) - An OK condition indicating the modulation output relay is closed and will allow modulation out.
	"O" (rd) - The modulation output relay is open.

R:MPMF	MPS Modulation Frequency
Settable parameter	
The modulation frequency can be set at any time. The valid range of settable frequencies is form 20,000 Hz to 131,000 Hz.	

R:MPPAV	MPS Pulse Amplitude
Settable parameter	
This parameter is settable only when the mode is first set to 3, 4 or 5. After setting the mode to any of these modes, the amplitude must be set to a non-zero value to obtain an output signal. The amplitude is automatically set to 0 whenever the mode is changed from any of these modes.	
Status bit 1:	"." (grn) - An OK condition indicating the pulser output relay is closed and will allow pulses out.
	"O" (rd) - The pulser output relay is open.
Status bit 2:	"." (grn) - An OK condition indicating the HV pulser switch is on and not faulted.
	"F" (rd) - The HV pulser switch is either faulted or turned off (as when in mode 0).

Status bit 3:	"." (grn) - An OK condition indicating the pulser at a low level is enabled and capable of pulsing. The mode will be set to 3, 4 or 5.
	"T" (rd) - The pulser is disabled and incapable of pulsing.
Status bit 4:	"." (grn) - An OK condition indicating 5 Vdc power is applied to the HV pulser switch.
	"5" (rd) – The 5 Vdc power to the HV pulser switch is off.

R:MPPW	MPS Pulse Width
Settable parameter	
Defines width of the output high voltage pulse in modes 3, 4 and 5; and in mode 6 defines length of time output is clamped to -7 kVDC while outputting AC modulation. Pulse width can only be changed when in these modes that use this parameter. Valid pulse widths are 1 – 30 μs.	

R:MPPR	MPS Mode 3 Pulse Rate
Settable parameter	
Mode 3 is the pulser running free running mode. In this mode, MPPR will define the pulse rate. Optional rates are .25, .5, 1, 2 and 4 Hz.	

R:MPCOU	MPS Control Electrode DC Bias Voltage
Read only parameter	
This is a read back of the control electrode DC voltage at the output of the Modulator. If the gun permit is enabled it will be (or should be) the value of the Glassman, Control Electrode DC PS. If the gun permit is disabled it will be the value of the gun cut-off voltage (MPCOV).	

R:MPCOV	Gun Cut-Off Voltage
Read only parameter	
This parameter reads back of the output of the HV DC power supply used to cut off the gun. This power supply is never turned off.	

R:MPCEV	MPS Control Electrode Signal (Vac)
Read only parameter	
This is a read back of the AC peak detected signal on the output control electrode. It will indicate the modulation amplitude in modes 2 and 6, and it will indicate the amplitude of the output pulses when in modes 3 or 4. It will not indicate pulse amplitudes when in mode 5.	

R:MPPCV	MPS Pulse Amplitude Reference
Read Only parameter	
This is a read back of the actual voltage driving the power supply defining the amplitude of the pulser.	

R:MPLNV	MPS Line Voltage
Read only parameter	
This is a measure of the line voltage of one of the three phases of deck level AC power. It can serve as a positive indication of the modulator functionality, which includes all the communication.	

3 Ethernet Communication

Both the interface module and the modulator chassis are equipped with Rabbit Core modules, RCM3010. This gives both modules Ethernet capability. It is the interface module that communicates with the ACNET front end, so it is the unit that is connected to the network in normal operation. Figure 3.1 shows this configuration.

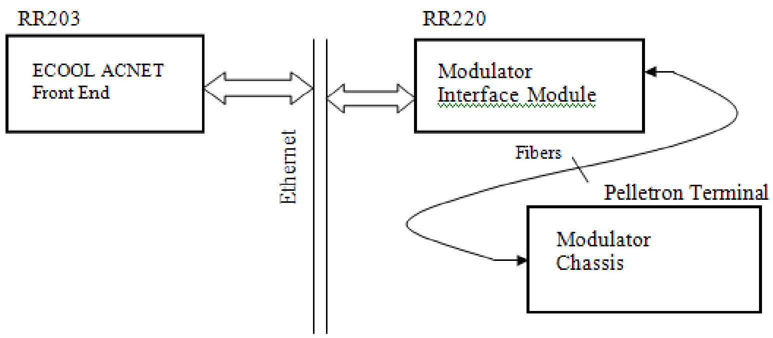


Figure 3.1. Modulator configuration with the communications network in normal operation.

Two each of both the Modulator Interface and the Modulator Chassis have been built. All four of the modules have IP addresses assigned for them. Table 3.1 lists the network assignments assigned to these four modules.

There is always an issue with the IP address assignments when swapping out the Modulator Interface NIM module. The ECOOL ACNET front end must know the IP address of the Interface Module installed. If the Interface module is simply swapped out without exchanging the RCM3010 cards, then the ECOOL front end will not know that the IP address of the Interface module has changed. Swapping out modules in this manner will require notifying the individual maintaining the ECOOL front end so that an appropriate change can be made to the front end. The alternative is to do something with the Interface module itself, either: 1) swap the RCM3010 cards (assuming that the card that was in operation was working just fine), or 2) reprogram the Interface module that will be installed in order for it to have the same IP address of the unit that is being taken out of operation. In this second case, the MAC address must we re-assigned with the networking department, because MAC addresses must be registered (or assigned with) registered IP addresses.

Table 3.1a. *Modulator chassis and interface module network parameters possibly wrong!!!.*

	Modulator Chassis #1	Modulator Chassis #2	Interface #1	Interface #2
Domain Name	GunModTerm.fnal.gov	GunModTerm.fnal.gov	GunModGnd.fnal.gov	GunModGnd.fnal.gov
IP Address	131.225.137.35	131.225.137.35	131.225.137.36	131.225.137.116
VLAN	4	4	4	4
Local Port	4524	4524	4524	4524
Network Mask	255.255.255.0	255.255.255.0	255.255.255.0	255.255.255.0
Gateway	131.225.137.200	131.225.137.200	131.225.137.200	131.225.137.200

Table 3.1b. *Modulator chassis and interface module network parameters.*

	Modulator Chassis #1	Modulator Chassis #2	Interface #1	Interface #2
Domain Name	GunModTerm.fnal.gov	GunModTerm.fnal.gov	GunModGnd.fnal.gov	GunModGnd.fnal.gov
IP Address	131.225.137.35	131.225.136.116	131.225.137.36	131.225.136.116
VLAN	4	3	4	3
Local Port	4524	4524	4524	4524
Network Mask	255.255.255.0	255.255.255.0	255.255.255.0	255.255.255.0
Gateway	131.225.137.200	131.225.136.200	131.225.137.200	131.225.136.200

3.1 Network connections when bench testing

Because both the Interface module and the Modulator chassis BOTH have Ethernet capability, there are optional ways of connecting a Modulator on the bench. It can either be operating and communicated with of Ethernet either with or without the Interface Module. Figure 3.2 shows the two different ways of connecting the modulator for testing.

Figure 3.2 shows the use of a PC running the LabView program RabbitUI. This is the preferred way to control the modulator on the bench.

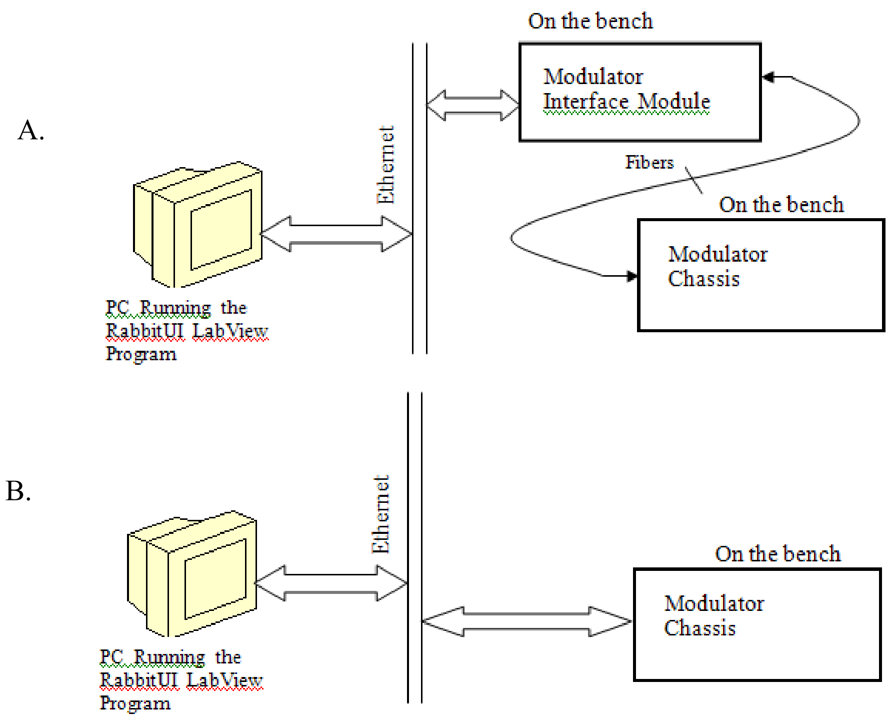


Figure 3.2. Two different ways of connecting a Modulator chassis with testing it on the bench.

3.2 Ethernet Client/Server Communication Data Structures

The convention for communication between the interface module (server) and the front end (client) is by implementing the protocol spelled out in the document *The Compact Ethernet Communication (CEC)Protocol,* Beams-doc_2109-v1. In conformance with this protocol, four data arrays are defined for the modulator and are shown in Tables 3.2 – 3.5.

Analog scale factors are shown in the Analog Range column. The analog binary codes are 16-bit unsigned, unipolar for the ADC and DAC parameters.

Table 3.2. *Array of analog readings. Used for Message Type Code 0.*

Element No.	ACNET Parameter	Device Description	Displayed Units	Analog Range 0x0000 - 0xFFFF
0	R:MPMAV	Modulation amplitude	Vpp	-/+ 2048 Vpp
1	R:MPCEV	Control electrode peak detector	kVpp	-/+10.24 kV
2	R:MPPAV	Pulser amplitude	Vpp	-/+10.24 kV
3	R:MPCOV	Gun cut-off HV PS	kVdc	-/+10.24 kV
4	R:MPPCV	Pulse Amplitude Control	V	-/+10.24 V
5	R:MPCOU	Control Electrode output Vdc	kVdc	-/+10.24 kV
6	R:MPLNV	Line voltage	Vrms	-/+144 Vrms
7	na	spare	na	-/+10.24 V
8	R:MPMF	Modulation frequency	Hz	unsigned value is Hz/2
9	R:MPMOD	Operating mode number	none	Modes: 0,1,2,3,4, 5 & 6
10	na	Fiber link stopped counter	none	Integer, 0-value

Table 3.3. *Array of analog settings. Used for Message Type Codes 1 & 3.*

Element No.	ACNET Parameter	Device Description	Displayed Units	Analog Range 0x0000 - 0xFFFF
0	R:MPMOD	Operating mode number	none	Modes are: 0,1,2,3,4, 5 & 6
1	R:MPMF	Modulation frequency	Hz	0 - 131,072 Hz (2 Hz resolution)
2	R:MPMAV	Modulation amplitude	Vpp	Integer values: 0 - 200
3	R:MPPAV	Pulse amplitude	Vp	-/+10.24 kV
4	R:MPPW	Pulse width	µs	Integer values: 1 - 30 µs
5	R:MPPR	Pulse rate	Hz	Code values: (1) 1,2,3,4,5 & 6
6	none	Modulation frequency scalar magnitude, 2^N	none	N values are: 1-10

(1) Pulse rate is coded for communication as integers. Code values: 1, 2, 3, 4, 5 and 6 correspond to: 0.25, 0.5, 1, 2, 4 and 8 Hz, respectively.

Table 3.4. *Array of status. Used for Message Type Code 2.*

Element Number	Bit Number	Device	
0	0	Permit En/Disabled (1 = en, 0 = dis)	R:MPMOD
	1	HV Relay K1 Open/Closed (1 = op, 0 = cl)	R:MPPAV
	2	HV Relay K2 Open/Closed (1 = op, 0 = cl)	R:MPMAV
	3	Behlke #1 Fault (1 = fault, 0 = no fault)	R:MPMOD
	4	Behlke #2 Fault (1 = fault, 0 = no fault)	R:MPPAV
	5	Behlke #2 +5V Sts (K4) (1 = on, 0 = off)	R:MPPAV
	6	Pulser Enabled (1 = en, 0 = dis)	R:MPPAV
	7	Local/Remote (1 = local, 0 = remote)	R:MPMOD
1	0	Frequency meas. timed out (1=timed out, 0=not)	
	1	Freq. meas. rolled over (1=rolled over, 0=not)	

Table 3.5. *Array of control. Used for Message Type Code 4.*

Element Number	Bit Number	Device	
0	0	Chassis Reset (data value 1 = reset)	R:MPMOD

4 Circuit Description

The modulator system consists of two modules: the modulator chassis located in the Pelletron at the deck level and the interface module located in a two-wide NIM module at ground. The interface module communicates with ACNET by way of the ECOOL front end with UDP/IP over Ethernet.

The modulator chassis is constructed in two sections. One half is considered “low voltage” and the other half is consider “high voltage”. A plate serving as a shielding panel separates the two sections. Refer to drawing 9650-ED-385146 for the wiring diagram of the modulator chassis.

The modulator controller is the three PCBs assembly located in the low voltage section. The first board of the three-board controller is a highly configurable digital board. Its key components are an 8-bit computer on a sub-credit card size PCB that is a Rabbit Core Module (RCM) model RCM3010 and an Altera complex programmable logic (CPLD) IC model EPM1270. The second board is a data acquisition board with 16 channels of 16-bit ADC and 4 channels of 14-bit DAC. The third board contains miscellaneous circuitry specific for the modulator.

4.1 Addressing Circuit Devices

This section documents a convention employed on the digital controller board.

Conceptually, the circuitry on the three-board controller is done by individual circuits that have addresses assigned to them. These addressable circuits are referred to as “devices”. All devices are written to or read by the RCM by way of a 6-bit address and an 8-bit data bus. A device, then, includes specific circuitry to perform its function in addition to its address decoder. All decoding is in the Altera ECM1270 IC. This approach uses the “external I/O” functionality of the R3000 microprocessor on the RCM3010. (The Dynamic C documentation also refers to this feature as “auxiliary I/O”.) Also as part of this convention, all communication between the RCM and Altera chip is initiated by the RCM. The Altera decodes commands and responds. The action to be performed by a device is defined by the data value written to it.

This system design approach is an alternative to using dedicated I/O lines from the RCM to control hardware. One can employ this approach in configuring the digital controller board. However, in practice the RCM becomes quickly I/O limited if one were to attempt to design a system of even modest complexity. Utilizing external I/O addressing, however, easily enables 64 different devices of any complexity to be controlled by the RCM. Library routines have been written for the RCM to streamline software code development using this external I/O addressing scheme.

Table 4.1 lists the modulator chassis devices and their assigned addresses. The values in the Data column are the data values written to the data bus to activate a specific function. Circuitry in the Altera has been designed to decode and control hardware in accordance with the defined functions shown in Table 4.1.

Commands issued by the RCM are accompanied with a strobe. There are three types of strobes that can be configured, chip select (CS), read and write, that are differentiated by slightly different timing. (In practical terms, there is basically no difference between these three strobes in a write process in view of the fact that the address and data are not stable, coming from the RCM, until the trailing edge of these strobes.) Table 4.2 shows the strobes and their characteristics that have been configured for the modulator.

Table 4.1. *Modulator chassis device address assignments.*

Device	Function	Address	Data	Strobe Pin
LTC1867, 8-Ch ADC, DAQ Bd. U6	Set CS on	0x6001	0x01	PE3[1]
	Set CS off		0x00	
	ADC convert		0x02	
LTC2614, Quad DAC, DAQ Bd. U4	Set CS on	0x6002	0x01	PE3
	Set CS off		0x00	
Pulse width control	Set pulse width	0x8003	Value	PE4
K1 relay (HV pulsing)	Set relay closed	0x8004	0x01	PE4
	Set relay open		0x00	
K2 relay (modulation)	Set relay closed	0x8005	0x01	PE4
	Set relay open		0x00	
Status register: Permit, Behlke switches, relays	Read digital status	0xA006	Value	PE5
Mode Register	Set mode into logic register	0x8007	Value	PE4
Frequency scalar for frequency measurement	Set scalar N value to divide the measured frequency by 2^N	0x8008	Value	PE4
AD9832 DDS Frequency Synthesizer, setting modulation frequency	Set CS on	0x8009	0x01	PE4
	Set CS off		0x00	
AD5200 digital potentiometer, setting modulation amplitude	Set CS on	0x800A	0x01	PE4
	Set CS off		0x00	

(1) PE3 must to be >100ns wide for LTC1867 CONVERT strobe.

Table 4.2. *Strobe configurations.*

Pin	Type	Sense	Wait States	Address Range
PE3	CS	Active HI	3[1]	0x6000 – 0x7FFF
PE4	Write	Active HI	1	0x8000 – 0x9FFF
PE5	Read	Active HI	1	0xA000 – 0xBFFF

(1) PE3 must to be >100ns wide for LTC1867 CONVERT strobe.

The following lists several standards adopted in the design regarding the use of Rabbit Semiconductor's External I/O bus convention in the communication between the RCM module and the Altera ECM1270 CPLD chip.

A. The use of External (or "Auxiliary") I/O is used for control of all devices. The library support in Utils.lib is used for utilizing External I/O. All software driver libraries are designed for use with External I/O.

B. All strobes are decoded in the Altera. No strobe controls an IC by itself Each strobe is "anded" with the A=B output of an 8-bit comparator.

C. One address is assigned for each device. When more than one function is required to fully control the device, numerical values are assigned, written to the data bus and decoded for each of the different functions.

D. The action of reading and writing to the same device will be done with different strobe pins. The 8-bit address will be different for encoding the strobe pins, but the address of the lower 6 bits will be the same, so the address decoder will be responding to the same address.

The following concern the use of the strobes. With one write instruction to an external address, data is presented on the data bus and a strobe is issued. Configuration information of the strobes used for the modulator is listed in Table 4.2. A routine in Utils.lib is available for strobe configuration; each of the three strobes must be, and have been, configured individually. What is important to remember about strobes is that the 4 MSbits of the 16-bit address define which strobe will be issued with an external I/O write or read command. Only the 6 LSbits of the 16-bit address are brought out of the RCM and decoded in the Altera for the 10 defined devices. Thus, writing to a 16-bit address identifies both the specific device to be addressed as well as which strobe will be issued.

For example, to write to the LTC1867 issuing the PE3 strobe configured for chip select (CS) timing, the Dynamic C command is 'ExtIOWrite(0x6001, data)'. To read back data from this same device (if this were a sensible thing to do) with the PE5 strobe the command would be 'ExtIORead(0xA001)'. Refer to Dynamic C documentation for more information about external I/O functionality.