FLUKE®
Biomedical

Victoreen® 1060AM

Digital Smart Detector Area Monitor

Operators Manual

March 2005
Manual No. 1060AM-1 Rev. 2

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Section 1
Introduction

1.1 Product Description

The Model 1060 is a smart radiation detector. It is a printed circuit board that supports a wide variety of "front end" radiation detectors and provides electronic digital and analog information about the radiation environment to users.

The Model 1060 collects, interprets, analyzes, stores and communicates radiation detector data from virtually all pulse generating radiation detectors such as Geiger Mueller tubes, proportional tubes, boron tri-fluoride tubes, and photo-multiplier tube/scintillators. To support these radiation detectors the 1060 provides a wide range high voltage suitable to operate most radiation detectors.

In addition, it will simultaneously accept up to 8 analog and 16 digital inputs.

The 1060 provides digital outputs, and is a good citizen on a network. It operates independently or as a member of a larger system.

It is configured by the user through serial software commands, either locally or remotely.

It defaults upon power up or reset to predetermined operational characteristics that can be established and altered by the operator. Such defaults are stored in a non-volatile memory.

The Model 1060 is only 2.8 in x 8.8 in (7.11 cm x 22.29 cm) in size and therefore requires a very small space for mounting. It can be mounted in a variety of enclosures for many different environments.

It provides, via digital communication, raw and conditioned data from any or all of the inputs. It performs a wide variety of calculations on raw data, such as conversion to engineering units, and boxcar or exponential smoothing of data.

Optionally, it can be programmed to make local decisions based upon input data. The available area monitor models are shown below:

Clear Acrylic Enclosure

Model No.	Description
1060AM-CL-ER	Environmental range - 1 µR to 1000 (µR/hr (SI units)
1060AM-CL-LR	Low range - 0.01 mR to 1000 mR/hr (SI units)
1060AM-CL-MR	Medium range - 0.1 mR to 10,000 mR/hr (SI units)
1060AM-CL-HR	High range - 1 mR to 100,000 mR/hr (SI units)
1060MHV-CL	Area Monitor with external MHV probe connection

NEMA 4X Enclosure

Model No.	Description
1060AM-NM-ER	Environmental range - 1 µR to 1000 (µR/hr (SI units)
1060AM-NM-LR	Low range - 0.01 mR to 1000 mR/hr (SI units)
1060AM-NM-MR	Medium range - 0.1 mR to 10,000 mR/hr (SI units)
1060AM-NM-HR	High range - 1 mR to 100,000 mR/hr (SI units)
1060MHV-NM-HR	Area Monitor with external MHV probe connection

1.2 Specifications

1.2.1 Digital Specifications

On-board Computer Intel 80C196, 16 Bit, 16 MHz, Embedded CMOS Microcontroller
1 Serial Ports
3 asynchronous modes
Up to 187.5 K Baud @ 12 MHz
1 Buffer for input/output

HSI high-speed input capture
Interrupt on either rising, falling or a transition

2 Timers
Timer 1, Free running, based on XTAL
Timer 2, Incremented by T2CLK or HSI.1
512 Bytes of RAM

8 Channel, 10 Bit, ADC w/ Sample and Hold Available at PCB connector for external inputs. Two channels are dedicated to jam detection and detector temperature sensing.

Extended temperature range -25°C to +85°C

Memory PROM OTP (One-Time-Programmable)
16K X 16, (256K) Program/Data
48K X 16, (768K) Paged

RAM Static RAM, 64K X 16 (1Mb)

EEPROM Serial IK X 16, for conversion factors, setpoints, historical data (stored upon loss of communications only), etc.

Serial Communications Dual UART: Two RS-485 and one RS-232

The RS-485 is the primary communications link to data acquisition system. The RS-232 is a local diagnostics, local data logging, and set-up port.

Status Indicators 8 LEDs indicating operating status (i.e., communications in progress, normal operation, high voltage ON/OFF)

Switches 8 DIP switches used to initiate various local functions (i.e., high voltage, on/off, etc.)

Digital Outputs 16 latched TTL outputs

Digital Inputs 16 digital inputs with internal pull-up resistors

1.2.2 Analog Specifications

High Voltage Regulated 500 to 2500 VDC, < 1 mV ripple, digitally controlled with 1 V resolution Max
500 microamps at 1400 V

Input Circuitry: Pulse mode input range 3 mV to 7 V suitable for BF3 detectors, proportional counters, Geiger Mueller tubes, and photo multiplier tubes used with scintillators.

Polarity selection: (PMT input only)

High Disc., 0 - 7.50 VDC; set via software
Low Disc., 0 - 1.230 VDC; set via software

Jam detection (anti-jam)

1.2.3 Miscellaneous Specifications

Power Requirements Approximately 12 VDC @ 200 mA - Nominal Voltage range is 7 VDC (minimum) to 16 VDC (maximum). With special adapter can accommodate 24 VDC.

Enclosures Two standard enclosures are available (all dimensions in inches unless otherwise indicated):

An acrylic plastic tube housing for indoor applications.

P/N	Outside Dimensions	Mounting Hole Pattern
1060AM-CL-xx	3.5 dia x 10 (8.89 x 25 cm)	-

A plastic rectangular housing for NEMA 4 applications (outdoor or indoor).

P/N	Outside Dimensions	Mounting Hole Pattern
1060-NM-xx	3.8 x 11.125 x 4.0 (9.65 x 28.26 x 10.16 cm)	2.9375 x 9.375 (7.46 x 23.81 cm)

User Interface Via any IBM compatible Personal Computer

Model 1060 Circuit Board Size Approximate size: 2.8 in x 8.775 in (7.11 x 22.29 cm) with mounting holes on 2.4 in x 8.375 in (6.1 x 21.27 cm) centers

Auxiliary Voltage An auxiliary voltage of +/- 12 VDC @ 50 mA, non-inductive load, is available to provide power to preamplifiers.

Temperature/Humidity Range The humidity range is 5% to 95% rh, non-condensing over the entire temperature range of 32° to 122°F (0° to 50°C).

Shock and Vibration Mechanical shock and vibration specifications are per ANSI N42.17A, section 8.4 and 8.5.

Software Specifications

Language "C" The software written in Intel "iC96", Version X243

Operating System Real-time, interrupt driven, embedded system

System Operation

As part of a larger system, the 1060 will communicate via serial link to a host computer. In this configuration, the 1060 will recognize its system address and respond to commands.

Main Software Modules

The main software modules include the following:

INITIALIZE

RC

MAIN

APPL.H

The Intel libraries include:

fpal 96,	stdlib,	KR,	string
stdio,	printf,	C 96,	

Software Quality Assurance

The 1060 software follows the quality assurance guidelines set forth in NRC regulatory policies and IEEE standards for Software:

ANSI/IEEE Std 730-1984 Software Quality Assurance Plans

ANSI/IEEE Std 830-1984 Software Requirements Specification

ANSI/IEEE Std 1016-1987 Software Design Specification

The Institute of Electrical and Electronic Engineers. "Software Engineering Standards", c 1987.

ANSI/ANS-10.4-1987, "Guidelines for the Verification and Validation of Scientific and Engineering Computer Programs for the Nuclear Industry"

IEEE Std 175-185 "Floating Point Mathematics".

Specific Functions

The software can perform the following functions:

1. Count pulses from a detector (analog /digital)
2. Calculate the average Counts Per Unit Time
3. Apply dead-time correction
4. Compensate for background radiation
5. Compensate for pressure (requires analog input information)
6. Compensate for flow (requires analog input information)
7. Convert to engineering units
8. Maintain all operating parameters, and data buffers in the event of a power failure
9. Respond to serial communications from supervisory processors:
    - Provide raw detector input
    - Provide uncompensated radiation values
    - Provide compensated radiation values
    - Provide CPS, CPM, CPI
    - Provide historical averages
    - Provide for user alterable parameters
    - Perform self-calibrations and store relevant parameters
    - Provide information in engineering units

- Provide digital input and analog inputs signals, such as for pressure and flow

10. Responds to data entry switches.
11. Updates indicators, and digital and analog outputs, and responds to serial communications within 250 mSec.
12. Task and prioritize Interrupts

1.3 Detector Types

The radiation detected and energy response are a function of the radiation detectors selected. The four most common types are Geiger Mueller tubes used to detect: x-rays, gamma rays, and beta rays; Proportional tubes used to detect alpha particles, and beta rays, BF_3 tubes to detect neutrons, and photomultiplier tubes/scintillators used to detect x-rays and gamma rays.

The standard detectors are listed as follows:

1.3.1 Geiger Mueller Tubes

Model 1B85 Geiger Mueller tubes are routinely supplied for environmental monitoring. These tubes are rugged, relatively large in size, very sensitive to radiation, and are thin walled for enhanced low energy sensitivity.

P/N	Range Name	Range in mR/hr	CPS/mR/hr
380-49	Low	.002 – 200	36.67
90-12	Low	BKGND - 10^3	20

IE qualified Geiger Mueller tubes have demonstrated their reliability in use in various Nuclear Facilities. The tubes supplied are summarized as follows:

P/N	Range Name	Range in mR/hr	CPS/mR/hr
857-210-20	Low	0.01 - 10^3	8.0
857-220-20	Medium	0.1- 10^4	1.2
857-230-20	High	1.0- 10^5	0.53

Many other custom Geiger Mueller tubes are available, upon special request.

^{14}C	Beta	0.158	59	5.3
^{l33}Ba	Gamma	0.356	72	6.5
^{129}I	Beta/Gamma	0.029	49	4.4

1.3.2 BF_3 Tubes

These tubes are used to detect neutrons, but must be configured into a detector assembly with the appropriate moderator and attenuator. The part number for this detector assembly is RP-N. In the neutron detector, the moderator/attenuator assembly is a polyethylene cylinder 9.5 in x 8.5 in diameter containing a BF_3 proportional counter and neutron energy compensating materials. This arrangement is based upon the standard reliable Snoopy designs for neutron energy response.

The operating characteristics of the BF_3 tube are as follows:

The BF_3 proportional counter operates at 1150 V.

Active length:	2 in (5.08 cm)
Gas pressure:	20 cm Hg
Fill Gas:	enriched BF_3, 96% Boron 10

Resolving time:	1 microsecond
Plateau Slope:	2% per 100 V
Tube Life expectancy:	>10^{10} counts
Neutron Sensitivity:	2000 counts/mRem (nominal)

The neutron Energy Response is as follows:

The energy range is thermal 0.025 eV to 15 MeV. The accuracy is within 10% of the theoretical ICRP dose rate.
The directionality effect is less than +/- 20% in 3 orthogonal directions.

The standard ranges and engineering units available are:

Rate:	1 μRem/hr to 75 Rem/hr	0 μSv/hr to .75 Sv/hr
	0 μRad/hr to 9 Rad/hr	0 μGy/hr to .09 Gy/hr
	0 CPM to 2.5 x 106 CPM	0 CPS to 41,660 CPS
Integrate:	0 μRem to 1000 Rem	0 μSv to 10 Sv
	0 μRad to 125 Rad	0 μGy to 1.25 Gy
	0 to 10^9 Counts	0 to 10^9 Counts

The tube is insensitive to gamma rays and shows no response in ^{l37}Cs gamma radiation in fields up to 500 mR/hr.

The overall dimensions of the assembly are: 12.50 in diameter and overall length of 10.25 in. The assembly comes with two mounting brackets. The total weight of the assembly is 21 lbs.

The detector assembly operating range is -80°C to +80°C

The detector can be placed up to 10 ft (3 m) away from the Model 1060.

1.3.3 Photomultiplier Tubes/Scintillators

The standard scintillator is a Nal(T1) crystal on a photomultiplier tube. There are two standard detectors configurations, however, many others models are available. Please see the Model 943 series detectors.

P/N	Detects	Nominal HV	Max Dist
1060-XXX	X-rays, gamma rays	750-1100	10 feet
943-36	X-rays, gamma rays	750-1100	1500 feet

Nominally, the calibration would set the high voltage to provide pulse heights of 2mV/keV.

Specifications

Crystal	Nal(T1)
Crystal size	1.5 in x 1.0 in
Housing	Stainless Steel
End window	Aluminum
Temperature range	32° - 122°F, 0° - 50°C
Extended range	32° -150°F, 0° - 65°C
FWHM	less than 9%
Energy Range	70 keV to 3.0 MeV
Weight	3 lbs (1.4kg)
PMT	2 in photocathode, 10 stage
Max voltage	1400 Volts

The Model 1060-xxx scintillation detector does not contain an integral preamplifier, the Model 943-36 does.

1.4 Receiving Inspection

Upon receipt of the package:

1. Inspect the cartons (s) and contents for damage. If damage is evident, file a claim with the carrier and notify Fluke Biomedical, Radiation Management Services at 440.248.9300
2. Remove the contents from the packing material.
3. Verify that all items listed on the packing list have been received and are in good order.

1.5 Storage

If the unit is to be stored prior to use, pack it in the original container if possible, and store in an environment free of corrosive materials, fluctuations in temperature, and humidity, and vibration and shock.

1.6 Procedures, Warnings and Cautions

The equipment described in this manual is intended to be used for the detection and measurement of ionizing radiation. It should be used only by persons who have been trained in the proper interpretation of its readings and the appropriate safety procedures to be followed in the presence of radiation.

Although the equipment described in this manual is designed and manufactured in compliance with all applicable safety standards, certain hazards are inherent in the use of electronic and radiometric equipment.

Warnings and **Cautions** are presented throughout this document to alert the user to potentially hazardous situations. A **Warning** is a precautionary message preceding an operation that has the potential to cause personal injury or death. A **Caution** is a precautionary message preceding an operation that has the potential to cause permanent damage to the equipment and/or loss of data. Failure to comply with **Warnings** and **Cautions** is at the user's own risk and is sufficient cause to terminate the warranty agreement between Fluke Biomedical and the customer.

Adequate warnings are included in this manual and on the product itself to cover hazards that may be encountered in normal use and servicing of this equipment. No other procedures are warranted by Fluke Biomedical. It shall be the owner's or user's responsibility to see to it that the procedures described here are meticulously followed, and especially that Warnings and Cautions are heeded. Failure on the part of the owner or user in any way to follow the prescribed procedures shall absolve Fluke Biomedical and its agents from any resulting liability.

Indicated battery and other operational tests must be performed prior to each use to assure that the instrument is functioning properly. If applicable, failure to conduct periodic performance tests in accordance with ANSI N323-1978 (R1983) Radiation Protection Instrumentation Test and Calibration, paragraphs 4.6 and 5.4, and to keep records thereof in accordance with paragraph 4.5 of the same standard, could result in erroneous readings or potential danger. ANSI N323-1978 becomes, by this reference, a part of this operating procedure.

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Section 2
Installation/Replacement

2.1 Installation

The device power must be turned OFF during installation/replacement to prevent possible damage.

CAUTION

Many components on the printed circuit board are static sensitive. ESD precautions should be observed when handling the printed circuit board assembly.

CAUTION

If readings from a device's position indicates that the radiation rate is relatively high, CAUTION should be observed when replacing or working on this unit. High rates can quickly cause the operator's cumulative exposure to increase with the potential for injury.

CAUTION

There is a potential shock hazard when the Model 1060 board is exposed and the unit is operating. Be especially careful not to touch any components in the high voltage area, or connections to the detector.

2.1.1 Connections - 1060AM-NM (NEMA 4 Enclosure)

The following information lists the I/O connections for the Model 1060AM-NM, NEMA 4 Enclosure:

J1	**Power connector (3-pin Male)**
1	+12 VDC
2	GND
3	Chassis/Earth GND

J2	**RS-232 Connector (5-pin Female)**
1	Tx Data
2	Rx Data
3	DTR
4	DSR
5	Signal Ground

J3 RS-485 Connector (4-pin Female)

J4 RS-485 Connector (4-pin Female)
1 A
2 B
3 GND
4 Termination (120Ω)
RS-485 - In multi-drop applications, it may be necessary to terminate the input furthest from the computer system. To terminate the communications lines, install a jumper between Pin 2 and Pin 4.

J5 I/O Connector (6-pin Female)
1 4-20mA
2 GND
3 Meter +
4 GND
5 Alarm Lamp
6 GND

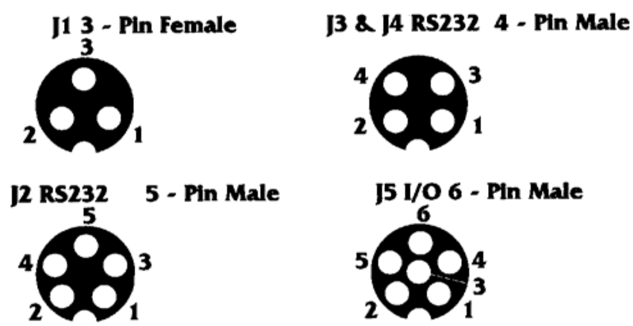

Figure 2-1. Contact Arrangements (View from wiring side/user connections)

2.1.2 Connections - 1060AM-CL Family

The following information lists the I/O connections for the Model 1060AM-CL family (clear acrylic cylinder housing):

J1 Power connector (2mm Pin)
Center Pin +12 VDC
Sleeve GND

J2 RS-232 Connector (DB9F) (From 1060)
2 Tx Data
3 Rx Data
4 DTR
5 GND
6 DSR

J3 & J4 RS-485* Connector (RJ11 Modular)
1 Not Used
2 Not Used
3 CHAN 3-A
4 CHAN 3-B

*RS-485: In multi-drop applications, it may be necessary to terminate the input furthest from the computer system. To terminate the communications lines, install a jumper on the 1060 PCB -J2 Pins 12 &

13. Some commercial RS-485 to RS-232 converters require the external communications device (1060) to be connected A to A and B to B. Other units may require A to B and B to A. Ensure the correct connection is made.

J5	**I/O Connector (6-pin Female)**
1	4-20 mA
2	GND
3	Meter +
4	GND
5	Alarm Lamp
6	GND

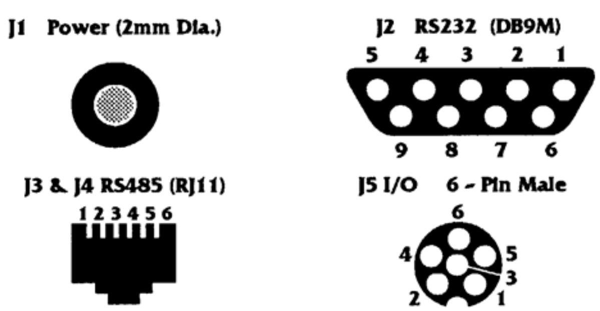

Figure 2-2. Contact Arrangements (View from wiring side/user connections)

2.2 Interface Requirements

The Model 1060 is designed to communicate remotely with a host computer and locally with a laptop computer. The protocol of that communication is described as follows.

The communication interface to the model 1060 is serial, balanced, full or half-duplex, RS-485 signals with 8 data bits, no parity, 1 stop bit at 9600 baud rate.

Computers with an RS-232 communication port(s) can be converted toRS-485 via adapters to permit remote communication with multi-dropped Model 1060s.

2.3 Enclosures

See enclosure specifications, for size of standard enclosures and dimensions for mounting.

2.4 Detector Setup and Control

The model 1060, when supplied with a detector is factory setup for proper operation. The detector parameters, found on the Calibration Data Sheet, are entered into the 1060 to provide a calibrated system. Some applications may involve the replacement of the detector, or the use of a detector from another manufacturer. Under these circumstances, caution must be exercised to prevent damage to the detector and/or the 1060.

2.4.1 Input Channel Selection

The Select Input Channel command (SIC) allows one of the four input processing circuits to be activated as the input to the pulse processing circuitry. The following codes are used to select the active channel.

Input	Channel	Hex Entry	TLA
GM input	C	68	
PMT with preamp input			
Positive pulse	A	42	
Negative pulse	A	43	
Proportional	D	50	
Neutron input	D	70	
PMT w/o preamp	B	44	

2.4.2 High Voltage Adjustment

The Set High Voltage (SHV) command allows the user to adjust the high voltage for the appropriate detector. Photo multiplier tube/scintillation detectors generally require that the overall gain be set by the high voltage. The high voltage setting affects the input pulse amplitude and for this reason controls the calibration of the detector. A detector/1060 provided as a system is factory calibrated. Typical 943 family of detectors are set to obtain approximately 1 V pulse amplitude/0.5 MeV. When adjusting the high voltage, caution must be exercised so as not to exceed the rating of the detector.

2.4.3 Low Discriminator Adjustment

The Set Low Discriminator (SLD) command controls the voltage threshold above which input pulses will be processed. Input pulses with an amplitude less than the low discriminator setting will not be counted. The typical setting is approximately 0.200V or 100 KeV.

2.4.4 High Discriminator Adjustment

The Set High Discriminator (SHD) command controls the voltage threshold below which input pulses will be processed. Input pulses with amplitude that exceeds the high discriminator setting will not be counted. The typical setting is approximately 7.00 V or 3.5 Mev.

2.4.5 Using other detectors

Typically, the high voltage setting and the low discriminator setting are used to calibrate the system. These values may be found on the Calibration Data Sheet, or through the manufacturer of the detector. Follow the manufacturers recommended calibration procedure when calibrating the system. Caution must be exercised when setting the high voltage so as not to exceed the detector rating.

2.4.6 Typical Multi-Drop Interface (Block Diagram)

Figure 2-3 illustrates the typical multi-drop interface block diagram.

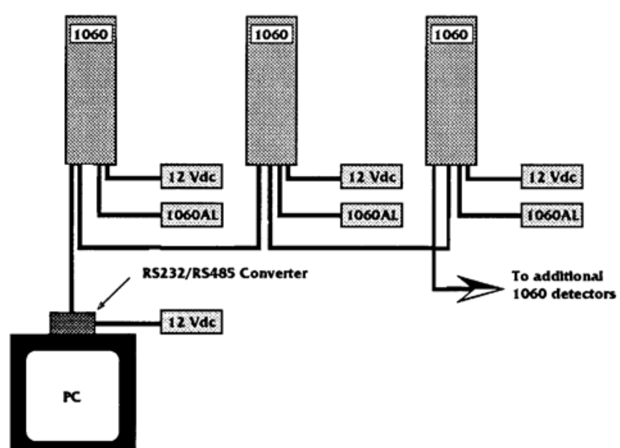

Figure 2-3. Block Diagram

Section 3
Operation

3.1 Communication Protocol

Communication Port Command Entry Syntax

RS-232 Communication Port 1:

This port (9-pin connector) is used for local communication.

Commands from the computer are of the form:

CMD<cr>

Responses from the 1060 are of the form:

RSP<cr>

where: CMD = TLA (Three Letter Acronym) command

RSP = Response from 1060

<cr>= Carriage Return

RS-485 Communication Port 2 and Port 3:

These ports are used in multi-drop configuration; commands must be preceded with the 1060 unit ID:

ID<sp><CMD><cr>

where ID=1060 ID, <sp>Space, CMD one listed below, <cr>=Carriage Return

Responses from the 1060 with matching ID are of the form:

<ID><sp><RSP><cr>

where ID=1060 ID, <sp>Space, RSP=Response to command, <cr>=Carriage Return

3.2 Terminal Operation

Command Set

The following COMMAND SET is comprised of STANDARD, SETUP and RADIATION commands.

STANDARD commands are always available to all communication ports. SETUP commands (marked "s") are used to configure the 1060 and are made available through Switch S2 as follows:

Port 1 (RS-232), S2, Position 2 ON = Setup commands available.

Port 2 (RS-485), S2, Position 3 ON = Setup commands available.

Port 3 (RS-485), S2, Position 4 ON = Setup commands available.

RADIATION commands (marked "r") are used to poll the 1060 for specific radiation data.

To enter Setup mode, enter the command ESM (Switch 2 must be ON). This will enable the SETUP and disable the RADIATION commands. To exit Setup mode, enter XSM. This will disable the SETUP and enable the RADIATION commands.

3.2.1 COMMAND SET

The COMMAND SET is comprised of STANDARD, SETUP, TEST, and RADIATION commands.

STANDARD commands are always available to all communication ports.

SETUP commands (marked "s") are used to configure the 1060 and are made available through switch S2 as follows:

Port 1 (R-S232), S2, Position 2 ON = Setup commands available

Port 2 (RS-485), S2, Position 3 ON = Setup commands available

Port 3 (RS-485), S2, Position 4 ON = Setup commands available

SETUP MODE disables RADIATION commands.

SETUP MODE cannot be entered while Pulse Output is active.

TEST commands (marked "t") are used to test parts of the hardware.

At this time, only the hardware that is exercised is the analog output.

TEST MODE and SETUP MODE can both be active.

TEST MODE can be entered while Pulse Output is active.

RADIATION commands (marked "r") are used to poll the 1060 for specific radiation data.

To enter Setup mode, enter the command ETM. This will enable the TEST and disable the RADIATION commands. The analog output driver is disabled and the user can drive the output via commands ANS, DAC, and LOG (see the following COMMAND SET list). To exit TEST mode, enter XTM. This will disable the TEST and enable the RADIATION commands. The analog output driver is enabled.

ANS	t	Analog out per Counts per Second entered
CPH	r	Counts per Hour (read counts averaged over 60 min)
CPM	r	Counts per Minute (read counts averaged over 60 sec)
CPS	r	Counts per Second (read latest second count value)
DAC	t	DAC POT output per numeric entry 0 to 255
ESM	r	Enter Setup Mode (enable Setup Commands, disable Radiation Commands) Pulse output cannot be active
ETM	t	Enter Test Mode (enable Test Commands and Radiation Commands) Analog meter is controlled by Test Commands.
LOG	t	Drive analog meter numeric input, i.e. LOG 10, needle moves to position 10.
MHV		Measure High Voltage through Analog to Digital converter)
RxH	r	Counts per Hour (using Conversion Factor x, where x=0 to 9)
RxM	r	Counts per Minute (using Conversion Factor x, where x=0 to 9)
RxS	r	Counts per Second (using Conversion Factor x, where x=0 to 9)
RAB		Reset Averaging Buffers (Resets counting buffers)
RCx		Read Conversion Factor x, where x=0 to 9
RCR		Read Conversion Factor CPM to mR/Hr
RDI		Read Digital Input (Reads 16 digital inputs)
RDO		Read Digital Output (Reads 16 digital outputs)
RGT		Read GM Threshold setting from EEPROM
RHD		Read High Discriminator Voltage setting from EEPROM
RHS		Read High Scale analog output (shown in units of mR/hr.)
RHV		Read High Voltage (Reads HV setting from EEPROM)
RIC		Read Input Control byte (detector input channel)
RID		Read 1060 unit Identification
RLD		Read Low Discriminator Voltage setting from EEPROM
RLS		Read Low Scale analog output (shown in units of mR/hr.)
RRH	r	Read mR/Hr (averaged over 60 minutes)
RRM	r	Read mR/Hr (averaged over 60 seconds)

RRS	r	Read mR/Hr (latest second mR/Hr value)
RSH	r	Read Sieverts (averaged over 60 minutes)
RSM	r	Read Sieverts (averaged over 60 seconds)
RSS	r	Read Sieverts (latest second Sievert value)
RTA		Read TAU (deadtime)
SCx	s	Set Conversion Factor x, where x = 0 to 9
*SCR	s	Set Conversion Factor CPM to mR/Hr (enter CPM per mR/hr)
SDO		Set Digital Output (Sets 16 digital outputs)
SFD	s	Set output Format Decimal (integer)
SFE	s	Set output Format Engineering (default, x.xxExx)
SFH	s	Set output Format Hex (integer, 16 hex digits)
SGT	s	Set GM Threshold (Sets Thresh., stores in EEPROM)
SHD	s	Set High Discriminator (Sets Hi Discrim., stores in EEPROM)
SHS	s	Set High Scale analog output (entered in units of mR/hr)
SHV	s	Set High Voltage (Sets HV, stores setting in EEPROM)
SIC	s	Set Input Control
SID	s	Set unit Identification
SLD	s	Set Low Discriminator (Sets Lo Discrim., stores in EEPROM)
SLS	s	Set Low High Scale analog output (enter in units of mR/hr)
*STA	s	Set TAU (deadtime correction);
VER		Read firmware Version and Revision level
XSM	s	Exit Setup Mode
XTM	t	Exit Test Mode

NOTE

Commands SCR and STA must be used to enter the CPM to mR/hr conversion factor and deadtime correction. These values must be entered whenever a new detector is installed. These values can be found on the detector calibration sheet.

3.3 LED Definitions

1. Heartbeat (flash pulse indicates proper operation)
2. HV ON
3. RS-232 (Port 1) Command accepted and processed
4. RS-232 (Port 1) Character received
5. RS-485 (Port 2) Command accepted and processed
6. RS-485 (Port 2) Character received
7. RS-485 (Port 3) Command accepted and processed
8. RS-485 (Port 3) Character received

3.4 DIP Switch Definitions

1. ON = HV ON
2. ON = Port 1 (RS-232) Setup commands available
3. ON = Port 2 (RS-485) Setup commands available
4. ON = Port 3 (RS-485) Setup commands available
5. Open
6. Open

7. Open
8. ON = Terminal vs Computer communication format (Reserved)

3.5 Data Output

The standard communication is a block of 8-bit ASCII characters. Standard network protocol is defined in Section 3.1. Terminal data protocol and commands are defined in Section 3.2.

3.6 Operational Checkout

The LEDs indicate normal operation and are defined in Section 4.1.10. A visual review of their status will provide a quick check of operability of the Model 1060.

3.7 Counts

3.7.1 Counts per second

The number of counts from the detector is accumulated for 0.1 seconds. Ten of these intervals are summed to arrive at a Counts Per Second (CPS) total.

3.7.2 Counts per minute

Each Counts Per Second (CPS) value is stored in a buffer location. Sixty CPS values are summed to arrive at a Counts Per Minute (CPM) total.

3.7.3 Counts per hour

Each Counts Per Minute (CPM) value is stored in a buffer location. Sixty CPM values are summed to arrive at a Counts Per Hour (CPH) total.

3.7.4 Counts in mR/Hr

Counts in mR/Hr are provided using CPM to mR/Hr conversion factor.

3.7.5 Counts in Sieverts

Counts in Sieverts are provided using mR/Hr to Sieverts conversion factor.

3.7.6 Counts per Correction Factor

Counts per correction factor are provided using correction factors 0 through 9.

Section 4
Theory of Operation

4.1 General

4.1.1 Detector Input

The Model 1060 has four separate input terminal points, one for each type of detector: Geiger Mueller tube, proportional tube, BF_3 tube, and photomultiplier/scintillator. These points are inputs to analog circuits that condition the signal pulse from the detector. The conditioned pulse is then input into the "Clock2" input of the Intel 80C196 microprocessor. The microprocessor counts both the rising edge and the trailing edge of the signal pulse.

4.1.2 High Voltage Supply

The Model 1060 takes the +5 VDC power and utilizes a switching power supply and a step up transformer to produce a range of voltages from 500 to 2500 VDC. A 1000:1 divider provides feedback for regulation of the high voltage. The high voltage is digitally controlled with a resolution of 1 V. A 12-bit analog to digital converter provides the high voltage setting to the microprocessor. The microprocessor has the ability to completely shut off the high voltage.

4.1.3 Auxiliary DC Power

A +/- 12 VDC power is provided via a switching power supply from the +12 unregulated input power. This voltage is available at an edge connector to provide power for detectors that contain preamplifiers. The output of this supply is 50 mA. A non-inductive load is recommended.

4.1.4 Jam Detection

The low discriminator output is buffered and charges a capacitor through an RC network. This voltage is then monitored by one of the 8 analog input channels of the microprocessor. At a predetermined voltage threshold corresponding to a high-count rate, approximately equal to twice the detector maximum, and/or approaching continuous discharge, the microprocessor will shut down the high voltage and indicate that a jam condition has occurred.

4.1.5 Thresholds

An upper and lower threshold provide an energy window for pulses. The microprocessor will only recognize those pulses within the magnitude established by the thresholds. The range of the lower threshold is from 0 to 1.25 V.

The range of the upper threshold is from 0 to 7 V and must be higher than the lower threshold. The upper threshold may be disabled if desired. Both thresholds are under software control. The resolution of the upper and lower thresholds are 25 mV and 5 mV respectively.

4.1.6 Analog inputs

There are 8 analog inputs, but two are reserved, one for jam detection and one for local temperature measurement, usually, the detector. The other 6 are made available to the user on an edge connector. The input range is 0 to 5 V DC, with 10-bit resolution. Typical uses for these inputs are for process transducers. All are read by software.

4.1.7 Digital inputs

There are 16 TTL level digital inputs with pull up resistors. They may be used to indicate the state of various process conditions. All are read by software.

4.1.8 Digital outputs

There are 16TTL level digital outputs under software control. They may be used as input signals to drive process equipment.

4.1.9 Communication

The software transmits parallel data from the microprocessor to the Dual UART that converts it to serial data and controls the transmission to external devices. Two RS-485 serial channels are provided. These channels are for multi-drop communication. There is one RS-232 port for local communication.

4.1.10 Engineering Units

The software will convert raw counts to any engineering unit that the Model 1060 has been programmed and calibrated for. Raw counts as well as converted units can be combined to provide appropriate engineering units.

4.1.11 Error Analysis

From the sensitivity of the detectors and the Gaussian distribution statistical model for radioactive decay measurements, the measurement error can be calculated directly as a function of exposure rate and the counting time for each detector.

For this distribution the standard deviation is the square root of the number of counts ($= \sqrt{\text{Total Counts}}$). The total number of counts is equal to the exposure rate times the tube characteristic times the total counting time (Total Counts = Exp. Rate x Tube Char. x Time). The total counts is the mean or expected measurement.

It is also given for Gaussian distributions that 99.73% of the actual measurements will fall within the mean plus or minus three standard deviations ($\mu \pm 3s$). This is then chosen as the error range.

From the above discussion the accuracy of any detector can be computed.

4.1.12 Minimum Detectability

Minimum detectability, in the presence of a radiation background, is usually calculated at the 50% and 95% confidence level. A good first approximation to each is as follows: First, determine the mean and standard deviation of the background. Look up the sensitivity of the detector to the nuclide. Factor in any geometry efficiency. The 50% confidence level is the activity level, accounting for geometry and sensitivity, of the nuclide at the mean plus three standard deviations of the background. For the 95% confidence level use the mean plus 4.645 standard deviations of the background.

4.2 Functional Description

To be provided later.

4.3 Circuit Description

To be provided later.

Section 5
Calibration, Maintenance and Troubleshooting

5.1 Calibration

5.1.1 Precautions

Only trained and qualified personnel operating within the protocols of an approved radiation protection program should be permitted to calibrate any radiation detector.

5.1.2 Exposure

The Model 1060 is calibrated at the factory against NIST traceable standards. The calibration is detector specific.

Calibrations other than to standard nuclides are available upon request. Model 1060s will always provide raw counts, but if calibrated, will also provide engineering unit information.

5.2 Maintenance

The instrument power should be turned OFF any time that the instrument is opened to prevent possible damage.

CAUTION

Many components on the printed circuit board are static sensitive. ESD precautions should be observed when handling the printed circuit board assembly.

CAUTION

If readings from a device's position indicates that the radiation rate is relatively high, CAUTION should be observed when replacing or working on this unit. High rates can quickly cause the operator's cumulative exposure to increase with the potential for injury.

CAUTION

There is a potential shock hazard when the Model 1060 board is exposed and the unit is operating. Be especially careful not to touch any components in the high voltage area, or connections to the detector.

5.3 Corrective Maintenance

5.3.1 Board Replacement

To be provided later.

5.3.2 Detector Replacement

To be provided later.

5.3.3 Circuit Troubleshooting

To be provided later.

5.4 Troubleshooting

CAUTION

Many components on the printed circuit board are static sensitive. ESD precautions should be observed when handling the printed circuit board assembly.

CAUTION

If readings from a device's position indicates that the radiation rate is relatively high, CAUTION should be observed when replacing or working on this unit. High rates can quickly cause the operator's cumulative exposure to increase with the potential for injury.

CAUTION

There is a potential shock hazard when the Model 1060 board is exposed and the unit is operating. Be especially careful not to touch any components in the high voltage area, or connections to the detector.

5.5 Replacement parts

Part Number	Description
1060-100-10	Model 1060 Printed Circuit Board
90-128	RS-232 to RS-485 Converter
1060MHV-CL	Acrylic Tubular Housing
1060MHV-NM	Plastic Rectangular Housing
380-49	1B85 GM tube for Environmental
857-210-20	Low Range 1E rated GM tube
857-220-20	Medium Range rated 1E GM tube
857-230-20	High Range 1E rated GM tube
90-12	Energy Compensated GM Probe
PR-N	Neutron Detector Assembly
1060-xxx	NaI(T1) Detector
943-36	NaI (T1) Detector with Preamp

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