Note: MSP as used in this document stands for the MSP microcontroller in both the LCD-90 Pro and the USB-MSP.

Also note, in this document, the following strings represent one byte characters as follows:

BELL (Bell character also known as BEL or CTRL-G. Control+G key on the keyboard. In C "\a". Value = 7)

ESC (Escape character. ESC key on the keyboard. In C "\e" or "\027". Value=27)

CR (Carriage Return. ENTER key or Control+M key on the keyboard. In C "\r". Value = 13)

LF (Line Feed. Control+J on the keyboard. In C "\n". Value = 10)

The MSP (LCD-90 Pro or USB-MSP) will respond to any program that can send and receive ASCII characters through the LCD-90's COM port (i.e. standard COM port, USB to Serial, Bluetooth Serial, WiFi Serial etc.) and/or the LCD-90's and USB-MSP's built-in USB port which presents itself as a virtual COM port. If using the USB port with operating systems other than Microsoft Windows, for example, on an Apple, Linux or Windows CE, first one must install the USB driver for the other operating system. See http://www.ftdichip.com/Drivers/VCP.htm for a list of drivers.

The MSP will respond with standard ASCII characters. Set the program's COM port to the COM port the LCD-90 Pro is plugged into or the USB virtual COM port presented by the USB driver (LCD-90 or USB-MSP), and set 9600 Baud, 8 Data Bits, No Parity, 1 Stop Bit, No Flow Control.

When sending command characters to the MSP, it expects two characters, first the BELL character (CTRL-G), then the command letter.

The BELL character is included to help avoid noise etc. from triggering a command. The BELL character can be typed on a PC's keyboard by holding down the CTRL key then tapping the G key then releasing the CTRL key. In C programming language, the BELL character escape sequence is \a. i.e.to insert BELL in a C string one includes \a.

To copy the BELL character into a text file, open a command prompt or use the Run command and type "copy con mybell.txt (enter key) Ctrl-G Ctrl-Z" and then the mybell.txt file will have one character in it, namely the BELL character. One can do the same for the ESCAPE character i.e. "copy con myescape.txt (enter key) ESC Ctrl-Z"

When the MSP receives one of the commands that need a follow-up string or number from the PC such that the new command is accepted by the MSP, it first sends back a short description of the command followed by a string or number indicating its current condition followed by CRLF. One responds to this with the new string or number followed by CRLF. It is not necessary to wait for the returned string before sending the new string.

 Note the below shows example codes to send MSP in the form of, for example, (BELL #) which would mean send two characters to the MSP: "BELL #" without the spaces i.e. BELL#. We added the spaces to make it easier to read. Also note one can always precede the BELL COMMAND-LETTER with the ESC

character to make sure the MSP is not already waiting to receive a value from an aborted previous command, for example (ESC BELL #).

Following each title of each command that causes the MSP to send back a value or receive a value, is a description of the format of the value. For example Float indicates the value can be in the form of 123.45 or 123 i.e. a string of digits with or without the decimal point. Integer indicates the value is a number with no decimal point allowed. Character String indicates a standard ASCII character string. All values are terminated with CRLF.

Commands Letters (can be uppercase or lowercase i.e. P or p):

GET ID STRING (Character String):
(BELL #): MSP returns its ID string followed by CRLF. (Maximum of 78 character followed by CRLF)

GET and SET ID STRING (Character String):
(BELL $): MSP returns the ID string followed by CRLF. Send it the new ID string followed by CRLF or send it ESC to cancel setting a new string. (Maximum of 78 character followed by CRLF). MSP then sets, stores in flash and sends back new ID string.

GET CURRENT CONDITIONS (Character Strings, Floats and Integers):
(BELL ?): MSP returns 17 lines of characters describing current conditions. Each line ends with CRLF. The last line ends with CRLFCRLF i.e. a blank line. (Maximum of 78 character followed by CRLF, per line)

GET and SET CALIBRATION FACTOR (Float):
(BELL C) sets MSP's calibration factor for its display (LCD-90), for alarm and for ASCII out of radiation data. MSP sends back current CALB in the form of ASCII characters representing a floating point number. Send new calb followed by CRLF, for example "105.0CRLF" and MSP sets, stores in flash and sends back new CALB. To cancel setting new CALB, send an ESC. Calibration factors for various Aware RMs standardized to Cs 137: RM-60: 105.0; RM-70: 149.0; RM-80: 354.0; RM-G90: 960.0

DEADTIME (Float):
(BELL E) sets MSP deadtime in 1/1000th of a microsecond for its display (LCD-90), for alarm and for ASCII out of radiation data. MSP sends back current deadtime in the form of ASCII characters representing a floating point number in the form of deadtime in microseconds. Send new deadtime followed by CRLF, for example "120.543CRLF" (120.543 microsec. deadtime) and MSP sets, stores in flash and sends back new deadtime. To cancel setting new deadtime, send an ESC.

RADIATION UNITS (Integer):
(BELL V) sets MSP's radiation units for display (LCD-90), alarm and ASCII out of radiation data. 0=cps 1=cpm 2=microR 3=microSV 4=milliR 5=Total. MSP sends back current UNITS setting (ASCII 0,1,2,3,4 or 5). Send new units character (0,1,2,3,4 or 5) followed by CRLF and MSP sets, stores in flash and sends back new UNITS code. To cancel setting new UNITS, send an ESC.

DECIMAL PRECISION (Integer):
 (BELL .) (the period character) sets LCD-90's decimal precision i.e. the number of digits to the right of the decimal point, anywhere from 0 to 3. MSP sends back current decimal precision. Send new decimal precision followed by CRLF and MSP sets, stores in flash and sends back new decimal precision. To cancel setting new decimal precision, send an ESC.

RUNNING AVERAGE DEPTH (Integer):
(BELL I) (The letter I or i) sets MSP's running average depth in seconds for display, alarm and ASCII out of radiation data. MSP sends back current running average depth (anywhere from 1 to 120 seconds). Send new running average depth (from 1 to 120) followed by CRLF and MSP sets, stores in flash and sends back new running average depth. To cancel setting new running average depth, send an ESC.

INTERNAL ALARM LEVEL (Float):
(BELL A) sets MSP's internal alarm level. MSP sends back current alarm level in the form of ASCII characters representing a floating point number in the form equal to the alarm level. Send new alarm level followed by CRLF, for example "220.00CRLF" and MSP sets, stores in flash and sends back new alarm level. To cancel setting new alarm level, send an ESC. Notes about alarm level: With radiation units of CPS, CPM or MicroR/hr (see Radiation Units command above) the alarm level is in CPS, CPM or microR/hr. If radiation unit is microSv/hr, the alarm level represents microSV/hr. divided by 100. If radiation unit is milliR/hr, the alarm level represents milliR/hr. divided by 1000.

ALARM ACTIONS, EVENT LED and CLICKER (Integer):
L (BELL L) sets MSP's alarm action with alarm condition (either the internal alarm or externally triggered alarm) as-well-as how the MSP will flash the Event LED and sound the clicker (LCD-90) with each detection. MSP sends back current setting in the form of ASCII digits (base 10). Send new setting (base 10) followed by CRLF. To cancel setting the new value, send ESC.

The ALARM ACTIONS, EVENT LED and CLICKER setting is represented by a four byte number in ASCII base 10 format.

The bottom byte: 0 = No Alarm LED or Buzzer; 1 = Alarm LED; 2 = Alarm Buzzer; 3 = Alarm LED and Buzzer.

The second from bottom byte: 0 = No Alarm Vibrator; 1 = Alarm Vibrator.

The third from bottom byte: 0 = No Click; 1 = Short Click; 2 = Medium Click; 3 = Medium-Long Click; 4 = Long Click.

The top byte: 0 = No Event LED; 1 = Short Event LED; 2 = Long Event LED.

For example, for short event LED (00000001), medium-long click (00000011), no alarm vibrator (00000000), alarm LED and alarm buzzer (00000011), the binary number is 00000001000000110000000000000011, (hex 01030003) and the ASCII base 10 number is 16,973,827.

In C language, one can use the strtoul library function to convert binary numbers to an unsigned long, then sprintf to convert the unsigned long to an ASCII base 10 digit string ready to send to the MSP as in:

unsigned long alarm_event_click;
char digits_buffer[12];

```
                //LED_ACT_BYTE CLICK_ACT_BYTE ALARM_VIB_BYTE ALARM_ACT_BYTE
alarm_event_click =stroul("00000010""00000011""00000000""00000011",NULL,2);
```

sprintf(digits buffer,"%u", alarm_event_click);
//Now digits buffer contains the ASCII digits for sending to the MSP.
//In the above example the ASCII digits will be "33751043"

Another example, for short event LED, medium-long click, no alarm vibrator, alarm LED and alarm buzzer, the ASCII number is 16973827 (hex 01030003).

For an example of setting the ALARM ACTIONS, EVENT LED and CLICKER using nothing more than a batch file, see http://www.aw-el.com/command_batch_files.zip

CURRENT RADIATION LEVEL (Float + Character String + Integer):
(BELL P) or (ESC BELL P) causes MSP to immediately send the current running average radiation level in the form of an ASCII characters floating point number. MSP applies the calibration factor, the deadtime (see above) and uses the current decimal precision (see above). This is the same number that is being used to compare the alarm level and which is displayed on the LCD-90's display, followed by TAB units TAB time code, followed by carriage-return line-feed. The below Z and J commands apply.

An example return when sending (BELL P) or (ESC BELL P):
"1.143 MICROSV 1379559248CRLF" ("1.143(TAB)MICROSV(TAB)1379559248CRLF")

To omit the UNITS i.e. just the radiation level TAB time-code:
(ESC BELL Z BELL P) returns "1.143(TAB)1379559248CRLF"

To omit the time-code i.e. just the radiation-level TAB UNITS:
(ESC BELL J BELL P) returns "1.143(TAB)MICROSVCRLF"

To omit both the UNITS and time-code i.e. just the radiation level:
(ESC BELL Z BELL J BELL P) returns "1.143CRLF"

TOGGLE UNITS CHARACTER STRING:
(BELL Z) toggles on-off the units character string following the value for ASCII output of radiation levels. Sending ESC resets the Z toggle to on so if you're not sure the current state of the toggle and you want to turn it off, send (ESC BELL Z).

TOGGLE TIME-CODE STRING:
(BELL J) toggles on-off the time codes following the value for ASCII output of radiation levels. Sending ESC resets the J toggle to on so if you're not sure the current state of the toggle and you want to turn it off, send (ESC BELL J).

SET DATE-TIME (Integer):
(BELL T) sets MSP's date-time. MSP sends back current time (UNIX time code + 18000). Send it the new time code (UNIX time +18000) followed by CRLF, and MSP sets and sends back the new time. One could set the MSP time to UNIX time zero by setting a time code of zero. For an example of syncing the MSP's time code to the PC's clock using nothing more than a batch file, see http://www.aw-el.com/command_batch_files.zip

A note about MSP's real-time clock when its internal UNIX time code is set to less than or equal to 1000000000 (Sat Sep 08 21:46:40 2001):

To match Aw-Radw's method of cancelling out any effect of variation between local time and GMT, the clock routine within the MSP first subtracts 18000 from its internal UNIX time, before the clock routine reports the time, as-long-as the UNIX time is greater than 1000000000 (Sat Sep 08 21:46:40 2001). If the MSP's UNIX time code is set to less than 1000000000, the clock routine will not subtract the 18000. This allows a clock that starts at zero hrs. zero minutes, zero seconds when its internal UNIX time code is set to zero. (Added with firmware version 2.4B).

To convert the returned UNIX time code to Excel-Quattro-Lotus spreadsheet time code, one can use the formula: +((X-18000)/86400)+25569 where X equals the UNIX time code returned.

One could use the conversion formula in a spreadsheet by importing the ASCII data such that column A contains the radiation values, column B contains the UNIX time code and column C contains the formula +((B1-18000)/86400)+25569. Format column C to display as Date-Time format, then one could graph column A as Y-axis and column C as X-axis.

PERIODICALLY RECIEVE RADIATION LEVEL FROM MSP (Float + Character String + Integer):
(BELL N) causes MSP to send the radiation level (same floating point number that is being displayed on the LCD-90's display or used internally by the USB-MSP), followed by TAB units TAB time code, followed by carriage-return line-feed, sent periodically according to the display's running average depth. The above Z and J apply.
Example output: 0.629(TAB)MICROSV(TAB)1379559238CRLF

For example to receive the MSP's average value once per 60 seconds in the form of CPM (counts per minute), first use the V command above or the LCD-90's menu system (or Aw-Radw) to set the MSP's radiation units to CPM. Next use the I command (sets running average for display and alarm as described above) to set the running average depth to 60 seconds and then send N. As indicated above, MSP then begins sending the display's number in the form of CPM (the 60 second running average CPM), followed by the tab character, followed by the UNITS string, followed by the tab character, followed by the UNIX time code followed by CRLF. The numbers received have applied the MSP's dead-time correction unless the dead-time is set to zero. In the case of MicroR, MicroSV and MilliR display units, the MSP's calibration factor is applied.

(Note the following PERIODICALLY RECIEVE RADIATION LEVEL FROM MSP examples are followed by a link to a text file containing the example. You can download these files using Chrome, Firefox or by entering the address into Notepad's File-Open-Filename dialog or any other program with a File-Open-Filename dialog. Windows Explorer will also download the files but it will strip out the CRLF and replace them with a space).

Example characters to send to MSP for CPM readings with running average of 60 seconds, once per 60 seconds, send (ESC BELL V 1 CR LF BELL i 60 CR LF BELL N).
CPM_60SECS.txt

Example characters to send to MSP for CPS readings with running average of 1 seconds, once per 1 second, send (ESC BELL V 0 CR LF BELL i 1 CR LF BELL N).
CPS_1SECS.txt

Example characters to send to MSP for CPS readings with running average of 1 seconds, once per 1 second with no caption and no time, and two digits to the right of the decimal point, send (ESC BELL Z BELL J BELL V 0 CR LF BELL . 2 CR LF BELL i 1 CR LF BELL N). CPS_1SECS_NO_CAPTION_NO_TIME.txt
Example characters to send to MSP for CPS readings with running average of 1 seconds, once per 1 second with no caption and no time, and no decimal point, send:
(ESC BELL Z BELL J BELL V 0 CR LF BELL . 0 CR LF BELL i 1 CR LF BELL N).
CPS_NO_PREC_NO_CAPTION_NO_TIME.txt

Example characters to send to MSP for microR/hr. readings with running average of 30 seconds, once per 30 seconds, send (ESC BELL V 2 CR LF BELL i 30 CR LF BELL N).
MICROR_30SECS.txt

Example characters to send to MSP for microSV/hr. readings with running average of 20 seconds, once per 20 seconds, send (ESC BELL V 3 CR LF BELL i 20 CR LF BELL N).
MICROSV_20SECS.txt

Example characters to send to MSP for microSV/hr. readings with running average of 20 seconds, once per 20 seconds, without the trailing (TAB)units(TAB)time-code send (ESC BELL Z BELL J BELL V 3 CR LF BELL i 20 CR LF BELL N).
MICROSV_20SECS_NO_UNITS_NO_TIME.txt

Sending ESC stops the output.

FLASH STORAGE OF RADIATION DATA FILE TBU (Time Base Unit) in seconds (Integer):
(BELL F) sets radiation data file flash storage TBU from 1 sec. to 65535 secs. MSP sends back current default flash storage TBU (from 1 to 65535 seconds). Send new default flash storage TBU followed by CRLF and MSP sets, stores in flash and sends back new flash storage TBU. To cancel setting new flash storage TBU, send an ESC. Note if the MSP is storing radiation data to flash, this command will close the file and stop the storing. For example (BELL F 60 CR LF) tells MSP to store the 60 second average radiation level to Flash, once per 60 seconds, when it receives the START STORING command.

START STORING RADIATION DATA TO A NEW INTERNAL FLASH FILE:
(BELL S) starts radiation data file Flash storage once per FLASH STORAGE OF RADIATION DATA FILE TBU (see above). If the MSP is already storing data to a file, it will close that file then start storing to a new file. Example start storing to flash once per 30 seconds (BELL F 30 CR LF BELL S).

STOP STORING RADIATION DATA TO INTERNAL FLASH FILE:
(BELL X) stops radiation data file Flash store. It is OK to send this even if MSP is not storing.

ERASE ALL INTERNAL FLASH RADIATION FILES:
(BELL R) erases all radiation data file(s) in Flash memory freeing it up for more data.

DOWNLOAD STORED RADIATION DATA FILES (Float + Character String + Interger):
(BELL M) to receive radiation data stored in flash with MSP's calibration factor and deadtime correction applied and expressed in units with desired decimal precision, MSP sends (assuming a ten second TBU for Flash Storage):

Start File 1

Units: MICROSV
Calb: 105.000
Dead Time: 121.000
Secs. Per pt.: 10
File Start Time: 1379559160
1.086 MICROSV 1379559170 (Value TAB units TAB time code) (Note time codes are UNIX time +18000)
1.429 MICROSV 1379559180
0.914 MICROSV 1379559190
1.543 MICROSV 1379559200
1.200 MICROSV 1379559210
0.571 MICROSV 1379559220
Total Points: 6
End File

Start File 2
Units: MICROSV
Calb: 1121058816
Dead Time: 121.000
Secs. Per pt.: 10
File Start Time: 1379559228
0.629 MICROSV 1379559238
1.143 MICROSV 1379559248
0.686 MICROSV 1379559258
0.457 MICROSV 1379559268
1.086 MICROSV 1379559278
0.914 MICROSV 1379559288
Total Points: 6
End File 2

The MSP will send the above for each data file stored in flash. If there are no files it returns NO FILES.

Each line ends with CRLF and a blank line separates each file. The download ends with CRLFCRLF. Sending an ESC stops download. Note the act of downloading the data file does not stop the storing to the data file i.e. one can download the file(s) even while the MSP is storing to a file.

The "TOGGLE UNITS CHARACTER STRING" Z (see command description above), the "TOGGLE TIME-CODE STRING" J (see command description above) and the "DESCRIPTION OF FILES WHEN DOWNLOADING TOGGLE" Q (see command description below) apply to the download.

DOWNLOAD STORED RADIATION DATA FILES IN RAW COUNT MODE (Float + Character String + Integer): D (BELL D) to receive radiation data stored in flash in raw count mode i.e. with no calibration factor or deadtime correction applied. LCD-90 sends (assuming 10 second TBU for Flash Storage):

Start File 1
Raw Count Mode
Secs. Per pt.: 10
File Start Time: 1207516030
4 1207516040

3 1207516050
6 1207516060
Total Points: 3
End File 1

The MSP will send the above for each data file stored in flash. If there are no files it returns NO FILES.

Each line ends with CRLF and a blank line separates each file. The download ends with CRLFCRLF. Sending an ESC stops download. Note the act of downloading the data file does not stop the storing to the data file i.e. one can download the file(s) even while the MSP is storing to a file.

The "TOGGLE UNITS CHARACTER STRING" Z (see command description above), the "TOGGLE TIME-CODE STRING" J (see command description above) and the "DESCRIPTION OF FILES WHEN DOWNLOADING TOGGLE" Q (see command description below) apply to the download.

DESCRIPTION OF FILES WHEN DOWNLOADING TOGGLE:
(BELL Q) toggles on-off the descriptions of the files when downloading from Flash memory i.e. the MSP sends just the value-TAB-units-TAB-timecode without the descriptions at the top and bottom of the file values. For use with the M or D command.

0.629 MICROSV 1379559238
1.143 MICROSV 1379559248

ESCAPE:
(ESC) aborts downloading from flash, real-time mode, MSP from waiting for a settings value and also returns the Q, Z and J commands back to the default on. ESC does not need the BELL character but it can be included with no effect.

If you have any questions, no matter how small, feel free to contact us.

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