

TOTAL ENGINEERING SERVICES TEAM, INC.
(TEST Inc.)

SCADAWARE™

**DIGITAL/ANALOG CONVERTER
2 POINT - DAC02
8/16 POINT - DAC16
PC INTERFACE CARDS**

Document 1200-02

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INTRODUCTION

This document describes the use of industry standard (generic) analog output (AOUT) cards in the TEST RTU/SCADA system. These cards follow the standards set forth by MetraByte corporation with their DAC-02 and DAC-16 analog output cards. These units plug directly into the PC expansion bus and output their analog signals via a card mounted connector, typically a 37 pin D shell. Other cards can be used with this SCADAWARE driver provided they follow the basic interface specification for the original MetraByte cards.

WARNING: *The analog output system contained in the TEST SCADA system relies on digital computer hardware and techniques. Like any other computer based system, the potential exists for hardware and software failures beyond the control of the program. The analog output software and output hardware are not intended for use as a primary safety system. Other means of protecting life and equipment must be provided externally to the computer system in order to prevent injury to personnel or damage to equipment affected by this system. If necessary, external analog backup or bypass systems should be used to provide uninterrupted analog outputs to critical equipment that will be adversely affected by the loss of reliable output from the SCADA system*

SCADAWARE ANALOG OUTPUT SYSTEM DESIGN

The generic PC bus analog output card is a simple device initially designed by MetraByte Corp. but now widely emulated by a number of manufacturers. The board provides a number of independent analog outputs, each controlled by a well defined interface on the PC I/O address bus.

The SCADAWARE driver controls this interface by outputting a raw binary number into the control circuit for each analog output. The raw number is derived from either an Analog Input channel or a PID output channel. Both of these channel types have properties which permit calculation of an integer value from a floating point number. The float is the current value of the channel. The integer is the scaled equivalent of the float within the zero and span of the particular channel. The offset setting is also observed, permitting an automatic 20% instrumentation offset to be included in the scaling if required. Although SCADAWARE works internally with 16 bit integers, the driver will automatically down-scale this to a 12 bit number as required by the analog output circuitry.

OUTPUT SIGNALS

Each analog output board will have options to adjust its physical analog output signals. Typical formats are 0-5VDC, 1-5VDC, and 4-20ma. Each board will support one or more of these formats. This is transparent to SCADAWARE, which is only concerned with outputting a positive integer value between zero and full scale.

All outputs handled by SCADAWARE are unipolar, meaning they are always electrically zero or greater. Negative outputs are not supported by the driver software even if the hardware on the board supports bipolar operation. With unipolar operation, all 12 bits of the digital to analog (D/A) converter are used in the positive region. *Jumpers or whatever on the board must set to properly configure the D/A converter for unipolar operation.*

20% OUTPUT OFFSET

Industrial analog signals often have a 20% offset designed to eliminate operation near the zero point of the physical signal range. Signals such as 1-5VDC and 4-20Ma are typical examples. The output provided by the analog output board may or may not have a built in hardware offset. This depends on the actual signal generation hardware on the circuit card, and is unfortunately not standard in the industry. Fortunately, SCADAWARE can handle either type of hardware.

On boards with 20% offset in hardware, the full 12 bit resolution of the D/A converter is used over the full span of the signal. Boards without the automatic offset will require SCADAWARE to provide the 20% offset, effectively reducing the accuracy of the output by 20%. The choice of 20% offset is made on the channel setup screen within SCADAWARE, and is transparent to the analog output driver itself.

Most applications will require an offset in the analog output, as with 1-5VDC or 4-20ma. This offset can be provided by either the D/A hardware, or by SCADAWARE, *but not both*. Selecting an offset adjustment in a channel setup when using a D/A board with hardware offset will result in a double adjustment.

This is important because correct scaling of the signal from the internal number of the program to the actual output depends on the proper setting of the offsets in both hardware and software. There are four possible combinations, and only one of them is correct for each particular output. If in doubt, try various settings and monitor the analog output to see how it matches the source channel at zero, half scale, and full scale.

DRIVER PROGRAM OPERATION

The Digital to Analog Converter (DAC) analog output boards are controlled by a "driver" program built into SCADAWARE. This software takes care of scanning all channels referenced in the setup and outputting the binary values necessary to operate the D/A converter devices on the boards. The values are obtained from channels in the RTU's data table. Currently, the channel type can be either ANALOG INPUT or PID only. The driver program will obtain "raw" values from the specified channels and output them to the DAC-02 boards.

The driver works as part of a DRIVER task which is scheduled like any other SCADAWARE task. Therefore, the speed of analog output updates will be related to the speed of its DRIVER task. Typical delay settings will provide analog output updates at approximately once per second.

The raw values obtained by the driver will depend on the configuration of the referenced source channels. These values are stored in a 16 bit signed integer format providing a resolution of $\pm 32,765$. For unipolar values, like those used on the DAC-02, the effective range is 0-32,765 (no negatives). For analog inputs channels, the raw value would correspond to the raw analog value read from the field device. The driver takes the 16 bit value and scales it to the 12 bits (unipolar or unsigned) accepted by the analog output hardware. This causes the loss of 3 bits of precision, 1 for the sign and 2 for the value. The resulting 12 bit binary number is output to the DAC latches for conversion by the D/A devices on the board.

DRIVER CONFIGURATION AND STARTUP

The DAC driver program is embedded within SCADAWARE itself. SCADAWARE is configured to use the driver by placing a TASK DRIVER entry in the main configuration (DAT) file. This places it in the normal task execution sequence so that the driver gets a periodic opportunity to scan the TSP input channels and update the corresponding analog outputs. Once a driver is configured and started, no other programming is required to operate the analog outputs.

Configuration of the driver is a 3 step process:

1. Add a TASK DRIVER line to the DAT file
2. Prepare a configuration file defining the hardware and the TSP channel relationships
3. Start the driver task during SCADAWARE startup

DRIVER TASK SETUP

The DAT file for each system controls its overall setup, including task assignments. The task requests are put near the start of the file to tell SCADAWARE which basic operations will be required. An analog output task can be added with the following line:

```
TASK driver, Aout, dac02, myfile.DA2 ; analog output driver.
```

The components of this line are as follows:

1. TASK keyword, allocating a new task in the multi-tasking system
2. Driver keyword, telling SCADAWARE the type of work to be done
3. Aout, tag name (nickname) for the task for use in task references
4. DAC02, type of driver, stands for Digital Analog Converter (02 was original circuit)
5. Myfile.DA2, name of the control file which will configure this driver

When this line is processed during SCADAWARE startup, the program will be allocated and made ready for execution. The actual processing will not begin until the task is started. This is done with a TASK xxx START line in a procedure commonly called STARTUP. Because the above example named the analog output task AOUT, the line in the Startup procedure would look like:

```
Task Aout START ; start processing of analog outputs
```

When SCADAWARE processes the Task Start line, it puts the driver task into the execution loop and sends it a message to process the configuration file named on the Task definition line in the DAT file. In the example, that file would be named Myfile.DA2. Any name can be used, but it normally conforms to the name of the system with the extension of DA2.

The Myfile.DA2 configuration file will contain the detailed information required by the analog output driver. The file is very simple, but is critical to proper execution because it defines the hardware interface to the analog output board. It also defines the relationship between the TSP channels and the corresponding analog outputs handled by the board. A typical analog output configuration file might contain this single line:

```
SCAN P1:p2 $310 DAC02; scan 2 points from P1 at address 310 hex
```

1. SCAN - Define a new analog output scan group
2. P1:P2 - Where the driver obtains the current value (PID or Analog Inputs only). An unambiguous RTU channel range specification tells the driver the group of channels to be sent to the analog output board. In systems with more than one logical RTU, the RTU name should be specified along with the channel range.
3. \$310 - Hex address of first port on the PC bus. Sequential addresses are assumed
4. No - Duplicate address requirement. The partially decoded addresses used on some DAC-02 boards cause every port to appear twice in the PC's I/O address range. See below for more details.
5. DAC02 - Optional: Board type. Tells driver to use a 2 port board (see below)

PC BUS ADDRESS

Each AOUT card will occupy a number of sequential addresses within the PC I/O address space. Systems with more than one board can be handled by a single driver provided the boards are sequentially addressed in a logical manner. The driver can handle boards with partially decoded addresses, such as the boards manufactured by the Metrabyte Corp. More sophisticated boards which completely decode the PC address bus can also be handled, such as those from Computer Boards Inc. The only difference is that the partially decoded boards appear at duplicate addresses while the fully decoded boards appear only once.

SCADAWARE controls the analog outputs in unipolar format only. This allows for 0-5 VDC,

1-5VDC, and 4-20ma type outputs. The bipolar outputs allowing plus and minus voltages are not needed or supported. Multiple boards can be handled, either as one group with sequential addresses, or as multiple groups handled by the same driver.

Several sequential PC addresses are required for each port, and each board occupies at least four sequential addresses. Boards with partial address decoding occupy a total of eight slots because the first four addresses are duplicated in the following four slots. This is a nuisance when more than one board is installed, and later manufacturers provided complete address decoding so that only four addresses are required. This allows for twice as many analog outputs to be installed in the same amount of I/O address space.

DUPLICATE ADDRESSES

The fourth parameter is a Yes/No choice which determines if the driver accounts for "duplicate addresses" on the output board. Some boards (including MetraByte) do only partial decoding of the I/O port address. This means the decoding circuitry does not use all available address bits. This causes the board to appear at multiple places in the address space, normally in subsequent 4 port blocks. The driver needs to know this only when more than one board is installed. This is so it can correctly calculate the start address of the next board, which is immediate when NO duplicates are involved, or offset by the number of ports when duplicate addressing is used.

Example: A series of 2 port boards starting at \$310 which have no duplicate addresses will have the following port addressing:

BOARD	PORT	OUTPUT
1	\$310	1
1	\$312	2
2	\$314	3
2	\$316	4
etc		

Note that each analog output takes 2 address slots in the PC I/O address space, even when crossing board boundaries. The same setup with boards that do have duplicate addressing is:

BOARD	PORT	OUTPUT
1	\$310	1
1	\$312	2
1	\$314	1 (dupe)
1	\$316	2 (dupe)
2	\$318	3
2	\$31A	4
2	\$31C	3 (dupe)
2	\$31E	4 (dupe)
etc		

Notice that each port appears twice because the inadequate address decoding on the board causes each port group to appear twice. Although each two output board occupies 4 ports in the address space, it consumes a total of 8 because of the duplication. Informing the driver of the duplication causes it to make the appropriate adjustment when calculating the starting address for each sequential board.

BOARD TYPE

The fifth (optional) parameter on the SCAN line allows selection of an analog output board other than the default DAC-02 dual output board. The choices for board type are:

DAC02	Dual output board (default)
DAC16	16 channel board (sometimes populated with only 8 points)

The low level operation and addressing of these boards are slightly different, so the driver needs to know which one is being used. Any generic boards other than the MetraByte brand must emulate one of the above boards in order to be used with SCADAWARE.

SAMPLE SETUP FILE

The following sample DA2 file contains all the available options:

```
; setup for 4 outputs on two sequential DAC-02 boards
msg Setting up PID outputs
scan p1:p3 $300 no ; first 3 on boards 1 and 2
scan a6:a6 $306 no ; rest of board 2
; setup 8 points from analog inputs
SCAN A8:A16 $340 no DAC16 ; use half of a 16 point board
```

Note the use of comments on the command line following the semicolon. THESE COMMENTS ARE A GOOD IDEA so you and others can understand the contents of the file

--end--

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