

8-Channel 8-Bit PWM Controller

National Semiconductor
Application Note 824
Patrick Furlan
February 1993



INTRODUCTION

This application note discusses a cost effective implementation of an 8-channel DAC to replace potentiometers.

TECHNICAL OVERVIEW

The COP822C was considered for the application. At the outset since the DACs were replacing pots, speed of conversion was not an issue. The issue became in that how fast a frequency with 8-bits of resolution on eight channels could be implemented in software. This would then determine the response time and therefore the filtering components to convert the varying duty cycle squarewave to a DC voltage. A simple RC can be used or for better response a pie filter can be used. Depending on the load, buffering may be required. In preliminary testing ripple was less than 1-bit.

IMPLEMENTATION

Software was then written to determine the time required to execute one loop of the program that determined the resolution that could be achieved for 8 separate channels. The routine is basically a small loop that decrements 8 registers or counters and reloads these counters after 8-bits of resolution. It was determined that the loop could be done in 40 μ s. This is the limiting factor. From this 40 μ s (100 Hz instruction cycle frequency) per bit for 8 bits of resolution, the period turns out to be 10 ms. Therefore, in 10 ms all 8 channels are updated with their on/off times.

Since the outputs are constantly running, interrupts are not used so that the PWM outputs stay more stable. Also, this provides a faster throughput. Interface to the chip can be

done in either a serial (MICROWIRE/PLUSTM) or parallel fashion, depending on best fit for the application. For a serial implementation the Microwire busy bit can be polled each loop. If parallel interface is required, there are enough pins on the device to implement a simple handshake exchange; i.e., have 3 address lines, 4 data lines and a chip select. In either case, it requires a two byte protocol: address and data. Data is the PWM "on time" to determine duty cycle.

CONCLUSION

This low cost implementation of an 8-channel 8-bit PWM controller has multiple features. Besides a low speed DAC, PWM control in conjunction with NSC DMOS power products could also be a cost effective peripheral for power drive applications. It should be noted that using this approach, there is no CPU time for doing other tasks. One last item to note is the COP800 output structure. Depending on application the outputs (G and L) can be configured in TRI-STATE® mode, thereby putting the external filter in a holding pattern or low leakage state. In this way other small routines i.e., interface, could be accomplished.

Due to the software implementation methodology, there is flexibility, i.e., in the number of channels, resolution and the interface. Also, since it is based around a COP800 solution, packing (pins) and operating frequency including crystal options are also flexible.

TRI-STATE® is a registered trademark of National Semiconductor Corporation.
MICROWIRE/PLUSTM is a trademark of National Semiconductor Corporation.

The following pages show the code used in evaluating the concept as well as the filter components. Basically, eight register with varying "on times" were loaded so that the PWM outputs could be analyzed along with software performance. The remaining code for MICROWIRE/PLUS and the exact filter components are not finalized.

```
; COP822 - 8-Channel 8-Bit PWM Output
.CHIP      820

INIT:      LD      0EE,#00      ;clear control reg.
           LD      0EF,#00      ;clear psw, int, etc.
           LD      SP,#02F      ;TOP OF STACK ??

           LD      008,#05      ;LOAD 8 AUTO RELOAD RESCNT'ERS
           LD      009,#25      ;RAM ADDR 8 THROUGH 0FH
           LD      00A,#50      ;TEST ONLY, IN REAL LIFE THESE
           LD      00B,#90      ;GET LOADED THROUGH MICROWIRE
           LD      00C,#125
           LD      00D,#160
           LD      00E,#210
           LD      00F,#250

; PLACE TO TRANSFER RELOAD COUNTERS TO RESCNT'ERS

           JSR      RELOAD      ;AUTO RELOAD COUNT TO RESCNT'ERS

           LD      0D1,#OFF      ;L CONFIG. REG TO PUSH PULL ONE OUT
           LD      0D0,#OFF      ;L ports to all 1's

PERIOD:    LD      0F0,#255      ;255 * THROUGH LOOP = 8-BIT RES.

RESCNT:    LD      B,#00        ;START OF RAM MAP FOR RESCNT'ERS
           LD      A,[B]        ;DEC "ON TIME" COUNTERS
           DEC      A
           X        A,[B+]      ;PUT BACK FOR NEXT TIME
           IFEQ     A,#00        ;WHEN CNT = 0, PORT LOW
           RBIT     0,0D0        ;DO = MEMORY MAP FOR PORT L

;2ND PWM OUTPUT
           LD      A,[B]        ;DEC "ON TIME" COUNTERS
           DEC      A
           X        A,[B+]      ;PUT BACK FOR NEXT TIME
           IFEQ     A,#00        ;WHEN CNT = 0, PORT LOW
           RBIT     1,0D0        ;DO = MEMORY MAP FOR PORT L

;3RD PWM OUTPUT
           LD      A,[B]        ;DEC "ON TIME" COUNTERS
           DEC      A
           X        A,[B+]      ;PUT BACK FOR NEXT TIME
           IFEQ     A,#00        ;WHEN CNT = 0, PORT LOW
           RBIT     2,0D0        ;DO = MEMORY MAP FOR PORT L

;4TH PWM OUTPUT
           LD      A,[B]        ;DEC "ON TIME" COUNTERS
           DEC      A
           X        A,[B+]      ;PUT BACK FOR NEXT TIME
           IFEQ     A,#00        ;WHEN CNT = 0, PORT LOW
           RBIT     3,0D0        ;DO = MEMORY MAP FOR PORT L
```

```

;5TH PWM OUTPUT
    LD      A,[B]          ;DEC "ON TIME" COUNTERS
    DEC     A
    X       A,[B+]        ;PUT BACK FOR NEXT TIME
    IFEQ    A,#00         ;WHEN CNT = 0, PORT LOW
    RBIT    4,ODO         ;DO = MEMORY MAP FOR PORT L
;6TH PWM OUTPUT
    LD      A,[B]          ;DEC "ON TIME" COUNTERS
    DEC     A
    X       A,[B+]        ;PUT BACK FOR NEXT TIME
    IFEQ    A,#00         ;WHEN CNT = 0, PORT LOW
    RBIT    5,ODO         ;DO = MEMORY MAP FOR PORT L
;7TH PWM OUTPUT
    LD      A,[B]          ;DEC "ON TIME" COUNTERS
    DEC     A
    X       A,[B+]        ;PUT BACK FOR NEXT TIME
    IFEQ    A,#00         ;WHEN CNT = 0, PORT LOW
    RBIT    6,ODO         ;DO = MEMORY MAP FOR PORT L
;8TH PWM OUTPUT
    LD      A,[B]          ;DEC "ON TIME" COUNTERS
    DEC     A
    X       A,[B+]        ;PUT BACK FOR NEXT TIME
    IFEQ    A,#00         ;WHEN CNT = 0, PORT LOW
    RBIT    7,ODO         ;DO = MEMORY MAP FOR PORT L

; NOTE 255 TIMES IS NOW IN LOOP, SOON TO BE INTERRUPT.
    DRSZ    OFO           ;PERIOD TERMINATOR = OFO
    JMP     RESCNT        ;FINISH 255 TIMES

;DEC OFO IF ZERO RESET RES COUNTERS AND PUT PORT L HI.
    LD      ODO,#OFF      ;PORT L HI
    JSR     RELOAD
                                ;This is place Microwire should be checked.
    JMP     PERIOD        ;START PERIOD OVER WITH NEW COUNTS

; RELOAD WILL PUT RAM FROM ADDR 8 TO F IN 0 TO 7.
RELOAD
    LD      X,#008        ;1ST RELOAD COUNTER
    LD      B,#00         ;ST RESCNT
    LD      A,[X+]
    X       A,[B+]
    LD      A,[X+]
    X       A,[B+]
    LD      A,[X+]
    X       A,[B+]
    LD      A,[X+]
    X       A,[B+]
    LD      A,[X+]
    X       A,[B+]
    LD      A,[X+]
    X       A,[B+]
    LD      A,[X+]
    X       A,[B+]
    LD      A,[X+]
    X       A,[B+]
    LD      A,[X+]
    X       A,[B+]
    RET
.END

```

LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform, when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.



National Semiconductor Corporation
2900 Semiconductor Drive
P.O. Box 58090
Santa Clara, CA 95052-8090
Tel: (600) 272-9959
TWX: (910) 339-9240

National Semiconductor GmbH
Livny-Gargan-Str. 10
D-82256 Fürstenfeldbruck
Germany
Tel: (81-41) 35-0
Telex: 527849
Fax: (81-41) 35-1

National Semiconductor Japan Ltd.
Sumitomo Chemical
Engineering Center
Bldg. 7F
1-7-1, Nakase, Mihama-Ku
Chiba-City,
Chiba Prefecture 261
Tel: (043) 299-2300
Fax: (043) 299-2500

National Semiconductor Hong Kong Ltd.
13th Floor, Straight Block,
Ocean Centre, 5 Canton Rd.
Tsimshatsui, Kowloon
Hong Kong
Tel: (852) 2737-1600
Fax: (852) 2736-9960

National Semicondutores Do Brazil Ltda.
Rue Deputado Lacorda Franco
120-3A
Sao Paulo-SP
Brazil 05418-000
Tel: (55-11) 212-5066
Telex: 391-1131931 NSBR BR
Fax: (55-11) 212-1181

National Semiconductor (Australia) Pty, Ltd.
Building 16
Business Park Drive
Monash Business Park
Nottingham, Melbourne
Victoria 3168 Australia
Tel: (3) 558-9999
Fax: (3) 558-9998

National does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied and National reserves the right at any time without notice to change said circuitry and specifications.