

**COP820CJ,COP840CJ,COP880C,COP884BC,
COP888CF,COP888CL,COP888EK,COP888FH,
COP888GW,COP8ACC5,COP8AME9,COP8CBE9,
COP8CBR9,COP8CCE9,COP8CCR9,COP8CDR9,
COP8SAA7,COP8SAC7,COP8SBR9,COP8SCR9,
COP8SDR9,COP8SGE5,COP8SGE7,COP8SGG5,
COP8SGH5,COP8SGK5,COP8SGR5,COP8SGR7,
COP912C**

AN-824 Eight Channel Eight Bit PWM Controller



Literature Number: SNOA241

8-Channel 8-Bit PWM Controller

National Semiconductor
Application Note 824
Patrick Furlan
February 1993



8-Channel 8-Bit PWM Controller

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.

AN-824

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 RESCNTERS

          JSR     RELOAD      ;AUTO RELOAD COUNT TO RESCNT"ERS

          LD      OD1,#OFF      ;L CONFIG. REG TO PUSH PULL ONE OUT
          LD      ODO,#OFF      ;L ports to all 1's

PERIOD:   LD      OF0,#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,ODO        ;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,ODO        ;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,ODO        ;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,ODO        ;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+]
    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: 1(800) 272-9959
 TWX: (910) 339-8240

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,
 Ciba 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.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
OMAP Mobile Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Transportation and Automotive	www.ti.com/automotive
Video and Imaging	www.ti.com/video

TI E2E Community Home Page

e2e.ti.com

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2011, Texas Instruments Incorporated