WHITE PAPER

Ali Shirsavar,
R&D Engineer
Biricha Digital Power

John Rice,
Member Group Technical Staff
Texas Instruments

Texas Instruments

Digital power supply considerations for the analog engineer

Introduction

Using microcontrollers to control switch-mode power supplies (SMPS) continues to gain momentum. Increasingly, analog engineers are being asked to design digitally controlled power supplies where the control loop is implemented in the digital domain using Z transforms. This leaves the analog engineer with the task of understanding, and possibly even programming, a discrete time control loop with an embedded processor; a task possibly not undertaken since university days.

Most analog power supply designers are already well versed in continuous time-control theory, and expanding their knowledge to discrete time control is not necessarily their most challenging obstacle. Embedded system programming, however, is most likely outside the "comfort zone" of the analog power supply designer. This is understandable as embedded systems engineering is a vast field, and becoming an expert in real-time programming generally takes years of dedicated work. As such, it is unrealistic to expect an analog power supply designer to be successful at developing a digital power supply without providing a means of simplifying the task.

Fortunately the nature of digital-power coding is such that it requires only a small subset of programming skills. For example, digital-power control typically requires the configuration of high-resolution pulse width modulators (PWMs), analog-to-digital converters (ADCs), interrupts and perhaps some house keeping, sequencing and communication tasks. That said, perhaps the most worrisome challenge to the analog designer is the task of programming a discrete time-control loop, and rightfully so. However, in general this code, regardless of topology, can be made available by semiconductor companies and their partners–further reducing the programming burden.

For example, analog engineers typically use either a Type II or Type III analog controller; in digital domain these become a two-pole two-zero (2p2z) or a three-pole three-zero controller (3p3z) respectively. There is absolutely no need for the analog designer to reinvent this code when highly optimized pre-written and validated code can be provided. Hence, all the programming burdens can be lifted from the power supply designer leaving him/her with the principle task of comprehending the subtleties of stabilizing a digital control loop.

Recognizing the above, Biricha Digital Power, in conjunction with Texas Instruments (TI), has developed a series of easy-to-use library functions with the analog engineer in mind. The libraries, called the C2000™ Chip Support Library (CSL) and available from Biricha, work on TI's C2000 platform of microcontrollers (MCUs) and are designed to allow easy and intuitive programming of voltage-mode and current-mode digital power supplies. These library functions cover all of the peripherals that are needed for digital power and hence hundreds of lines of code can be simplified to a handful clearly documented and easy-to-understand macro statements. Furthermore, digital 2p2z, 3p3z for both voltage mode and current control are also included in the libraries. The functions are highly optimized assembly macros and hence there is little penalty in execution time.

The two examples on the following page represent the magnitude of code simplification that can be achieved:

Example 1: Configuring a 100-kHz PWM pin without the CSL libraries:

```
EPwm1Regs.TBCTL.bit.SYNCOSEL = TB_SYNC_IN;
EPwm1Regs.TBCTL.bit.PHSEN = TB_ENABLE;
EPwm1Regs.TBPHS.half.TBPHS = 100;
EPwm1Regs.TBPRD = PWM1_TIMER_TBPRD;
EPwm1Regs.TBCTL.bit.CTRMODE = TB_COUNT_UP;
EPwm1Regs.ETSEL.bit.INTSEL = ET_CTR_ZERO;
EPwm1Regs.ETSEL.bit.INTEN = PWM1_INT_ENABLE;
EPwm1Regs.ETPS.bit.INTPRD = ET_1ST;
```

Configuring the same 100-kHz PWM pin using the CSL library functions:

```
PWM_config( PWM_MOD_1, PWM_freqToTicks(100000), PWM_COUNT_UP );
```

Example 2: The code for setting up and initialising the z-domain difference equation coefficients of a 3p3z voltage-mode controller:

```
#define K   (.78)
#define A1  (+1.46818)
#define A2  (-0.314933)
#define A3  (-0.153248)
#define B0  (1.784224053)
#define B1  (-1.629063952)
#define B2  (-1.780916725)
#define B3  (1.632371281)

... ...

CNTRL_3p3zInit(&my_piccolo_3p3z
,_IQ15(REF)
,_IQ26(A1),_IQ26(A2),_IQ26(A3)
,_IQ26(B0),_IQ26(B1),_IQ26(B2),_IQ26(B3)
,_IQ23(K),MIN_DUTY,MAX_DUTY
);
```

As can be seen from the above examples, much of the code needed for digital power can be greatly simplified and frankly is often pre-written. The analog power supply designers can now embark upon digital design with confidence that they will not get bogged down with writing extensive amounts of highly complex code.

While the above gives design flexibility and full access to the features of the MCU, in many applications such detailed programming is not necessary. For simple applications where only a few power stages are required, the job of the power supply designer can be further simplified by using software wizards which automate code generation. Figure 1. below represents a GUI application included in the CSL which aims to remove programming burden all altogether. The user will select specifications such as the number of power stages, switching frequency, which PWM and ADC pins to be used and then the code can be automatically generated.

Whether you are an analog or digital designer, the aforementioned tools serve to simplify the development of a digital power supply. For further information on these tools and training on the subtleties of digital power, visit: **www.ti.com/biricha**

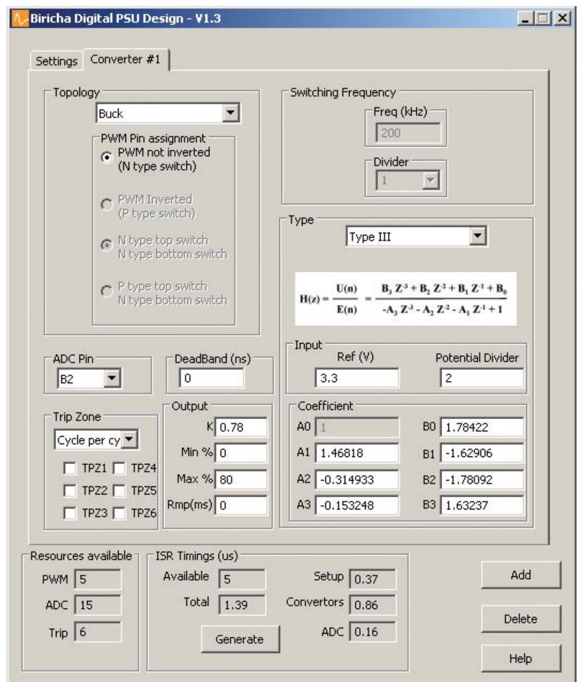

Figure 1. Digital power-automated code-generation tools.

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Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265