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Light control and diagnostics using a MC9S12GN32 MCU

PWM, ADC and ACMP modules of the S12GN32 microcontroller application example.

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Contents

1 Introduction

This application note has been created to demonstrate the control and protection capabilities S12GN32 provides.

The implementation of this light control and protection system is an example of the numerous automotive market applications for the S12G MCUs family.

AN4303SW contains the source code for a light control system and can be downloaded from www.freescale.com.

The example given may be modified to suit the requirements of a specific application. The PWM module is used to control a bulb light intensity while the ADC is used to continuously monitor load current. A real time protection is triggered in case the S12G analog comparator (ACMP) determines the load current is over a predefined limit.

PWM lighting control provides some advantages over a direct voltage connection. Among the advantages provided are voltage regulation, soft start and dimming control. The combination of the PWM, ADC and ACMP modules, in this implementation, provide the light bulb protection feature.

2 Hardware design

A 4 A bulb is used as the main load of the present application, however this implementation can be used for different type of loads like DC motors or inductive loads with only some adjustments in the diagnostic parameters to meet the new load requirements.

Following is the required system behavior:

1. The load has to be activated until the user indicates so (ON/OFF control).
2. The lamp must dim up/down to the commanded duty value (Light intensity control).
3. The system must be protected against overload, disabling the load after detecting 1.2 times the nominal load value. Once the overload protection has been activated, the system has to remain off until reactivated by the user and the fault is not present anymore.
4. Load current must be monitored periodically to report status of the load (load loss or open).

Figure 1 shows a block diagram of the hardware stages required to accomplish these application requirements.

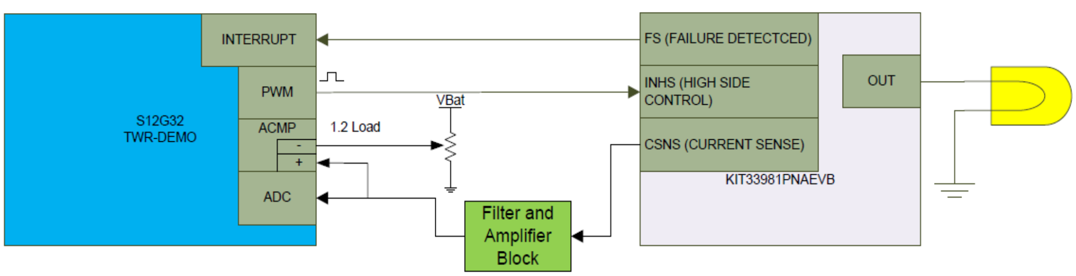

Figure 1. Light Control system interconnection block diagram

As part of the bulb driver, Freescale's single high side switch 33981 is used. It is a high frequency, self-protected 4.0 mΩ RDS(ON) high side switch that is used to replace electromechanical relays. It is suitable to drive loads with high inrush current, as well as motors and all types of resistive and inductive loads. The HS/LS driver 3398EVB provides the following signals from the load under control:

FS is the 33981 failure indicator (active low). It is connected by an interrupt capable pin to the S12GN32 board to disable the system load (see Section 5, "S12GN32 Pin Connections for more details). Some of the load failures, reported from the KIT3381 board, are undervoltage, overtemperature and overccurrent. For further information regarding MC33981, see the device data sheet available from www.freescale.com.

The signal CSNS (load current) is a voltage value proportional to the load current. This voltage value is filtered and amplified to be injected to an S12GN32 ADC channel. This current signal is monitored to determine if any load is present.

MC33981 is used for this application to substitute the power electronics section, to control directly the system load, and the main part of the application is the S12G MCU that evaluates the system control and diagnostics.

The S12GN32 demo board evaluates the system status (load current) and determines if the system load is on or off. The following software design section describes in detail the logic followed to control and diagnose the bulb state.

3 Software design

Figure 2 shows the system logic being followed and how the S12GN32 modules interact.

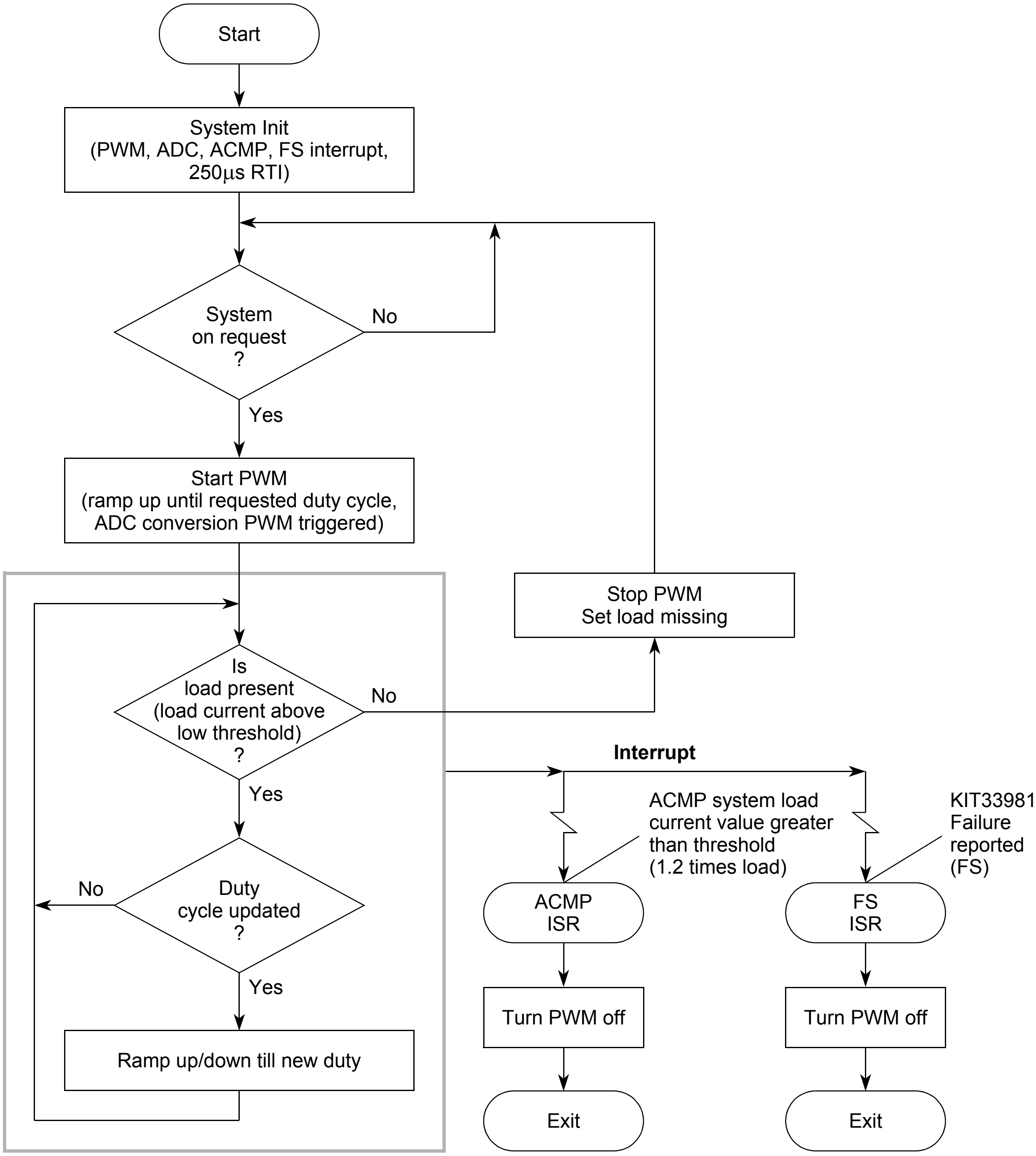

Figure 2. System software logic flow

The PWM module is initialized to generate a 4 KHz signal from the scalable clock (SA) using channel one (PWM_CH1), zero initial duty and negative polarity to start with the bulb light in off state. PWM generation is configured as left aligned and disabled for low power mode (Stop mode is not utilized in this design but PWM module is capable of being used during Wait mode). See PWM_Cfg() function for initialization details in the code included with this application note, the PWM module configuration is done in the pwm_cfg.c file.

The ADC module is configured to convert a single channel, with 8-bit resolution and using external trigger. This conversion is triggered by the PWM_CH1 to convert CSNS voltage which is proportional to the current flowing through the load. The S12GN32 uses this current value to determine if system load is present or if it has failed.

Finally the ACMP module is configured to generate an interrupt after detecting that load current has gone over 1.2 times the nominal value. In the interrupt service routine, the PWM signal is stopped, deactivating the load in this way.

The system restores the load after the user manually activates the PWM output (changing PWM_Off variable to zero), however if the fault is still present PWM output will be deactivated again.

ACMP is used to compare a pre-calibrated voltage value (1.2 times the nominal bulb current) with the CSNS voltage. If an overcurrent failure is present (CSNS > 1.2 times load current), ACMP generates an interrupt and the PWM signal is immediately turned off.

4 Tools

The CodeWarrior IDE has been used to develop the software project, and debugger's visualization tool environment is used to provide an interface to control the system (on/off) and signal monitoring (PWM in %, filtered current and raw current).

A multilink debugger can be used to debug code and program the S12GN32 MCU.

If a tower board system is used, you can use the USBDM debugger embedded on the demo board.

5 S12GN32 Pin Connections

Table 1. S12GN32 MCU

PIN #	PIN Name and Function	Signal	Description	SW variable
14	PP1 (PWM1 and ADC ETRIG1)	PWM (load control signal)	Duty cycle to be output to system load	PWM_Duty_Cmd
27	AN1 (ADC Ch1)	CSNS	Load current in volts, used to monitor open load diagnostic	ADC_Ch1_Flt, ADC_Ch1_Raw_8bit
32	ACMPM	Overcurrent Limit	Reference voltage used for overload diagnostics	N/A but will be used to trigger CSNS_Diagnostic
30	ACMPP	CSNS	Load current in volts, used to monitor overload diagnostics	N/A but will be used to trigger CSNS_Diagnostic
8	PJ0	FS	Failure signal generated by KIT33981	FS_Diagnostic

6 Software debugging

After setting up the S12GN32 target board and debugger, open the CW project named TWR_PWM_ADC_ACMP.mcp and click on the debug button, or press F5.

Table 2 shows the variables used in the application for control and diagnostics indication.

Table 2. Software variables

Variable	Range	Description
PWM_Off	0: PWM is active 1: PWM is inactive	Used to start PWM generation, this variable will be modified to 1 when a diagnostic is active
PWM_Duty_Cmd	0-255 counts	This variable determines the active duty cycle in the PWM signal
OpenLoad	0: System load is working 1: System load is missing or too low	This variable will indicate when the system load has been lost
ADC_Ch1_Raw	0-255	Unfiltered load current value
ADC_Ch1_Flt	0-65535	Filtered load current value

An additional feature has been added with the visualization tool providing the possibility to use visual indicators and charts to monitor the application.

NOTE

A full license of CodeWarrior is required to use the visualization feature. The Visualization application file is included together with the AN4303SW.zip package with the name of PWM_Ctrl.vtl.

The normal operation of the system is shown in Figure 3.

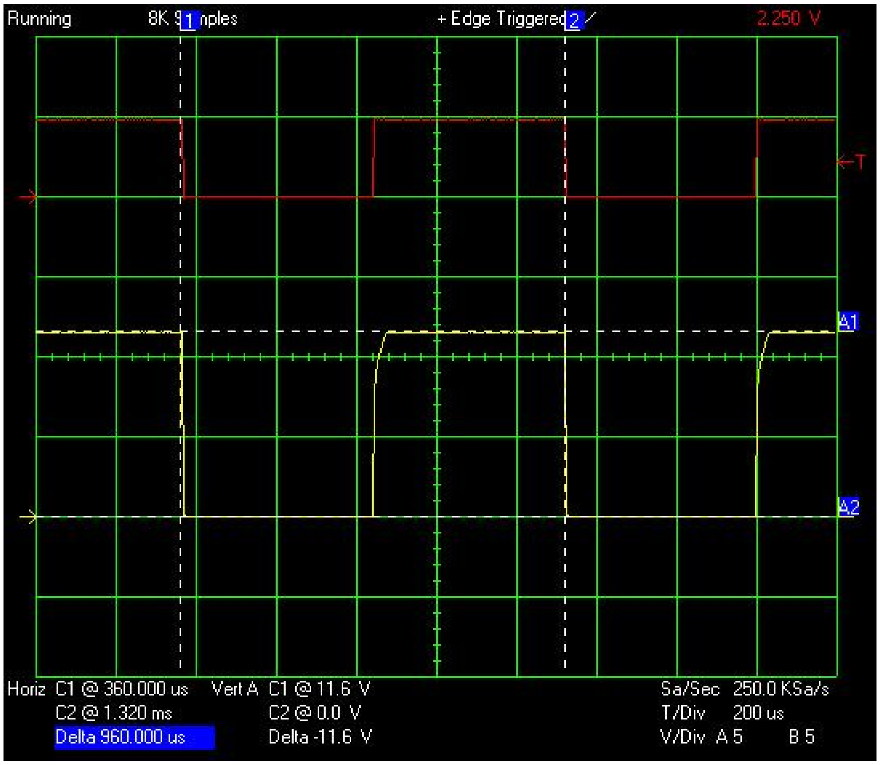

Figure 3. Normal system operation

In Figure 3 the red line is the PWM control signal from CH1, and the yellow line is the load control signal.

Figure 4a shows the debugger's visualization tool diagnostics and control signals. Figure 4b shows the light control with a 50% duty cycle and the half of the current load.

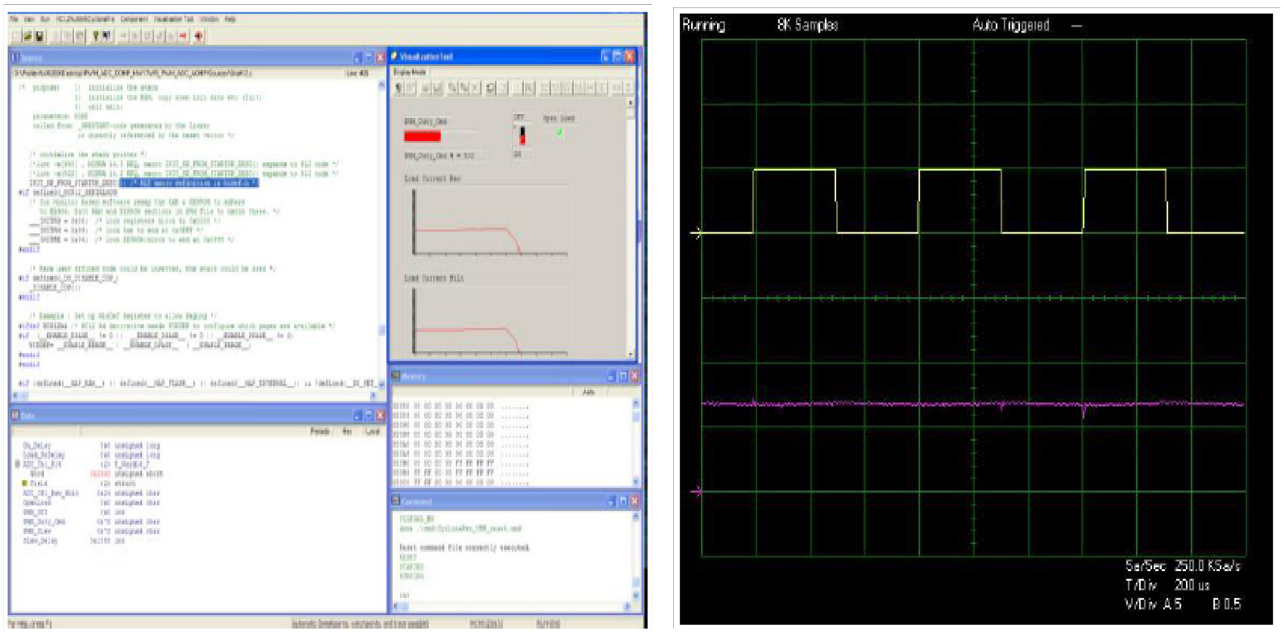

Figure 4a

Figure 4b

Figure 4. System load control demonstration

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