User's Guide

Smart DAC Product Selection Guide

ABSTRACT

Many systems require software to offer sophisticated performance. Applications for self-test in enterprise systems use voltage margining controlled by software to perform regular self-stress tests to check the health of the system. Closed-loop control, temperature compensation or biasing circuits rely on trivial software for sensing and control. Factory tuning and calibration of user-interfacing sub-systems or lighting applications heavily utilize software to perform such adjustments. Some applications that are responsible for human life or can potentially harm the user, require software-free fault-management. While discrete approach or application specific integrated circuit (ASIC) is used, this approach lacks basic intelligence.

Conventional discrete data converters and analog ASICs require a micro-controller unit (MCU) to provide full functionality and basic intelligence. Hardware engineers must deal with the overhead of software development, maintenance and in some cases regulatory approval when designs demand programmable logic. Lack of reusability is another issue that such a design creates. When there is a hardware change many steps must be taken to push the product to market: a requirement is due, updates are needed, additional testing must be done, and sometimes re-qualification is required. Such challenges often times prevent designers from system upgrades. For life-dependent products, the software can also cause some issues. Software faults can cause some unpredictable system behavior, while overloaded micro-controller can miss a vital interrupt or system fail signal. For such systems and teams, the software overhead outweighs the cost of using the MCUs. Any design that eliminates software development is desirable in these systems. Smart DACs and AFE provide software independence.

Because smart DACs eliminate the need for software, smart DACs fill the gap between DAC-based circuits, MCU-based circuits and entirely discrete circuits built with components like precision resistors, capacitors and inductors.

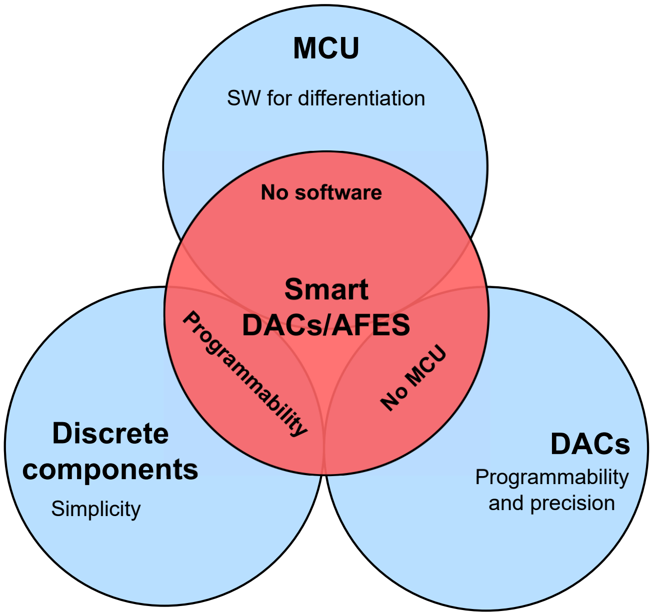

Figure 1-1. Why Smart DAC?

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1 What is a Smart DAC?

Smart DAC is a general purpose (GP) DAC with complementary features designed to simplify software. Typical smart DAC integrates the following features:

- Factory or user programmable non-volatile memory (NVM) to store all configurations
- Waveform generation
  - Saw-tooth, triangular, sinusoidal, square
- Pulth-width modulation (PWM) generation
- Force-sense control
- Programmable comparator with hysteresis
- Programmable digital slew rate control (DAC ramp-up speed)
- Programmable general purpose input, output (GPIO)

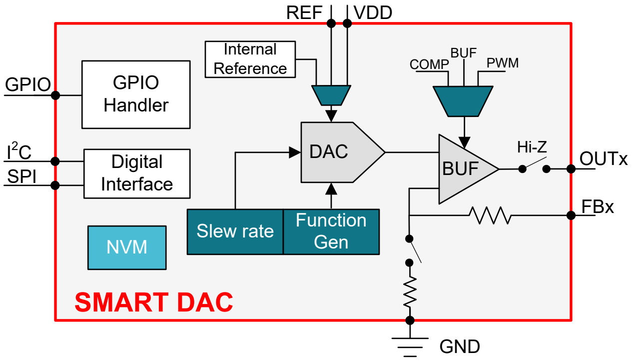


Figure 1-1. Smart DAC Block Diagram

2 What is a Smart Analog Front End (AFE)?

Real-time control loops are often implemented with external hardware and an MCU. Such implementation often requires a variety of discrete components for sensing, filtering, and a control routine mechanism implemented with a micro-controller. Such systems however add complex research and development cycles. In the event of a system upgrade - changes to the regulatory upgrade or system design, software controlled systems are often not reusable. To simplify this, Texas Instruments released smart AFEs which are the devices that contain all of the smart DAC features with additional:

- An integrated and programmable state machine
- An integrated digital or analog sensing mechanism
- Programmable look-up table
- Non-volatile memory to store configurations

Smart AFEs incorporate both a sensing and a controlling mechanism in one chip to remove the need for additional discrete components. With NVM and a variety of configurable tools, smart AFEs eliminate the need for run-time software and can be configured directly by a hardware engineer.

By offloading the real-time logic to the hardware, the system becomes modular and concurrent, allowing the individual blocks to be loosely coupled and replaced without the need to update adjacent blocks. An upgrade of hardware in the system or an addition regulatory requirements does not affect the real-time logic and controlling loop, making the design significantly more versatile compared to the standard MCU approach.

For the subsystems that require run-time updates - smart AFEs also support such requirements by having a versatile and auto detecting SPI and I^{2}C communication protocols available. AFE block diagram gives an example of a common smart AFE.

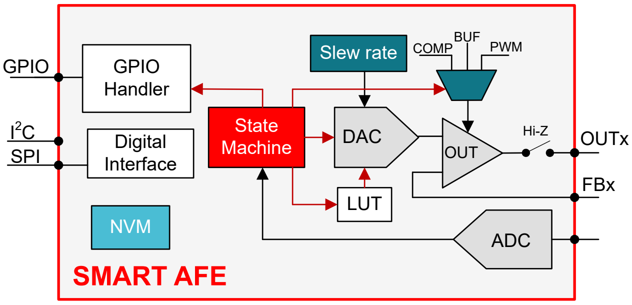


Figure 2-1. AFE Block Diagram

Due to the fact that the control is offloaded from the micro-controller and is independent from the driver and the load - in the event of a hardware update or in case of a supply shortage when needing a hardware replacement - there is no need for a software update since the control loop remains the same.

3 Smart DAC selection guide

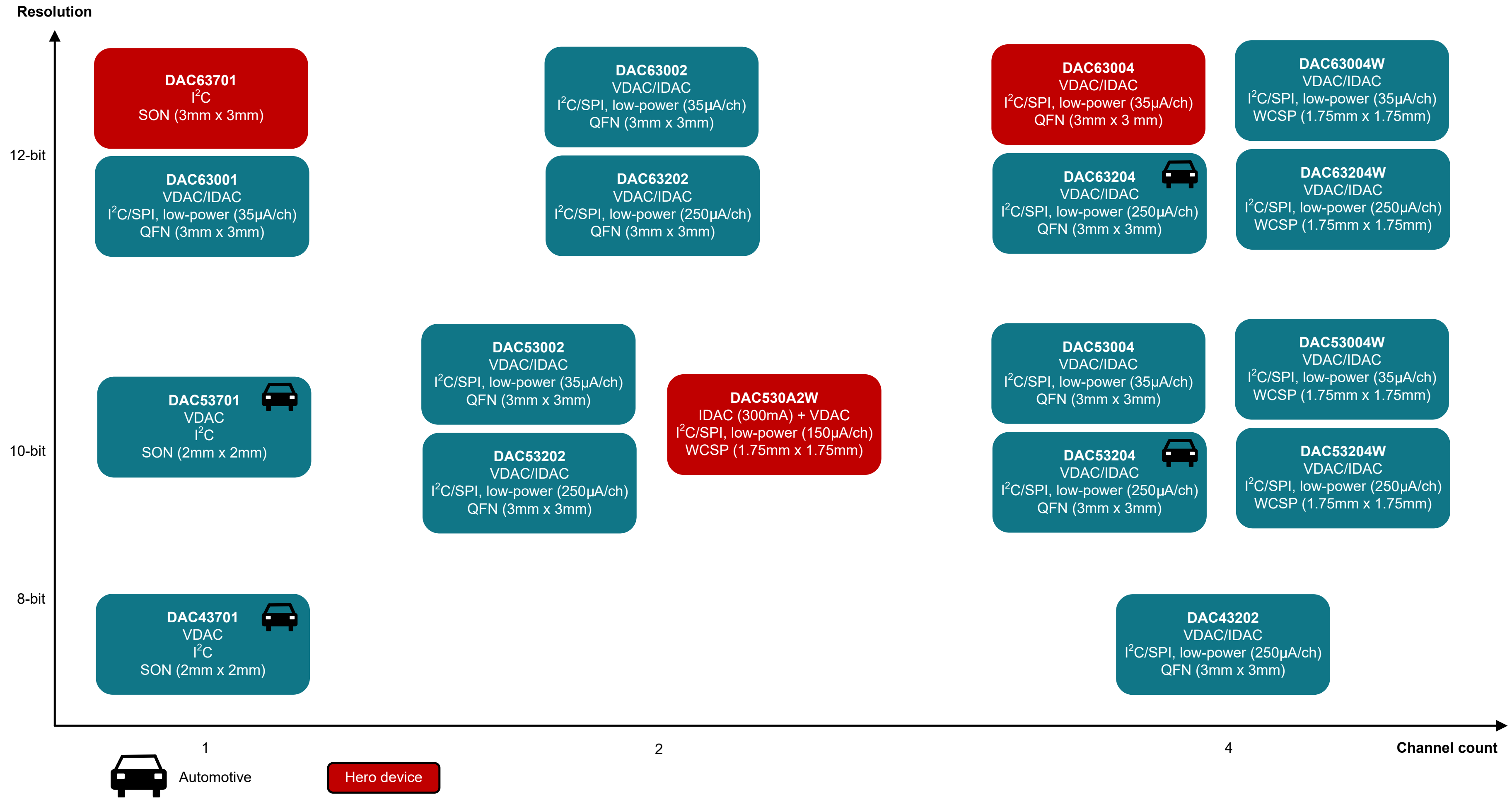


Figure 3-1. Smart DAC Selection Guide

4 Smart AFE Selection Guide

Table 4-1. Smart Analog Front End (AFE) Selection Guide

Part number	Specifications	Description	Application	End Equipment
AFE539A4	3-ch 10-bit VDAC, 1-ch ADC	Digital PI loop with voltage output	TEC control using DC/DC driver	IVD Optical Module
AFE439A2	1-ch VDAC, 1-ch ADC, PWM, GPO	Digital PI loop with PWM and digital output	TEC control using h-bridge driver	IVD Optical Module
AFE639D2	1-ch VDAC, 1-ch ADC	Digital PI loop with voltage output and I^2C sensor interface	TEC control using DC/DC driver	IVD Optical Module
AFE53902-Q1	10-bit, 1-ch VDAC, 1-ch PWM, 1-ch ADC	State machine configured to control the LED output based on the current temperature	Multislope thermal foldback	Automotive lighting Lighting
AFE53902-Q1	8-bit, 1-ch VDAC, 1-ch PWM, 1-ch ADC	State machine configured to control the LED output based on the current temperature	Multislope thermal foldback	Automotive lighting Lighting
DAC43902-Q1	8-bit, 4-ch PWM	State machine configured to control LED animation patterns	Logarithmic fade-in and fade-out Sequential on/off control	Automotive lighting Lighting
DAC43901-Q1	8-bit, 2-ch PWM	State machine configured to control LED animation patterns	Logarithmic fade-in and fade-out Sequential on/off control	Automotive lighting Lighting
DAC539G2-Q1	3 GPI, 1-ch PWM	LUT to convert GPI input to PWM with a unique duty cycle	GPI-to-PWM fault communication	Automotive lighting Wired control Appliances
DAC539E4W	4 programmable comparators, 4 GPOs	LUT to convert comparator outputs into corresponding GPOs	If-then-else fault management	Appleances
AFE539F1-Q1	1-ch ADC, 1-ch PWM	Constant power dissipation control across the load based on the transfer function	Traction inverter/ constant power control	Traction inverter Elevator
AFE532A3W	1-ch IDAC, 1-ch VDAC, 1-ch ADC	Closed loop control and biasing of a laser diode	Laser driver	Optical module Laser

5 Applications

5.1 Lightning

Smart DAC and AFE offers software free control of LEDs for both automotive and commercial applications. This section goes over how to use Smart DAC and AFE in lighting applications and the LED animation capability of these devices.

5.1.1 Light Emitting Diode (LED) Biasing and Linear Fade-In Fade-Out

In the applications where there is a need for a simple LED biasing, smart DAC is a solid choice. In this application the DAC controls the collector current by varying the voltage at the gate of the MOSFET. Force-sense configuration enables this process to be completely autonomous. In addition, the forse-sense configuration maintains the consistency of the LED light output across multiple platforms by adjusting to component mismatch and errors. Smart DAC also contains a GPIO trigger for on and off control capability, and slew rate control for fade-in and fade-out functionality. All of these parameters are configured via internal register values and can be stored in the integrated non-volatile memory, which loads the registers upon power cycle.

Table 5-1. Design Implementation

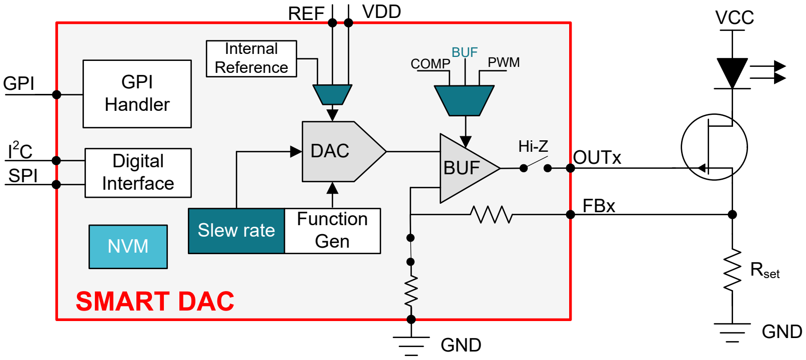


Figure 5-1. Hardware Block Diagram

Design Benefits	Suggested device
- Stability against temperature changes and component variations - Software independent - Fade-in/fade-out animation	- DAC43701 - DAC43204
End Equipment	**Design help**
- Barcode scanner - Appliance - In-vitro diagnostics - Exit/emergency lighting	- LED biasing using smart DAC - Fade-in fade-out calculator

5.1.2 LED Biasing With LED Driver

Brightness of the LED is controlled by a LED driver which is regulated by a PWM signal. Using smart DAC PWM generation capability, the LED driver can be controlled without the need for software. Smart DAC uses the combination of a comparator and an integrated random function generator to create a PWM. Internal registers also allow the set up the amplitude and frequency of the generated signal. Since all of the configurations and registers values are stored in the non-volatile memory, there is no need for any software for such control.

Table 5-2. Design Implementation

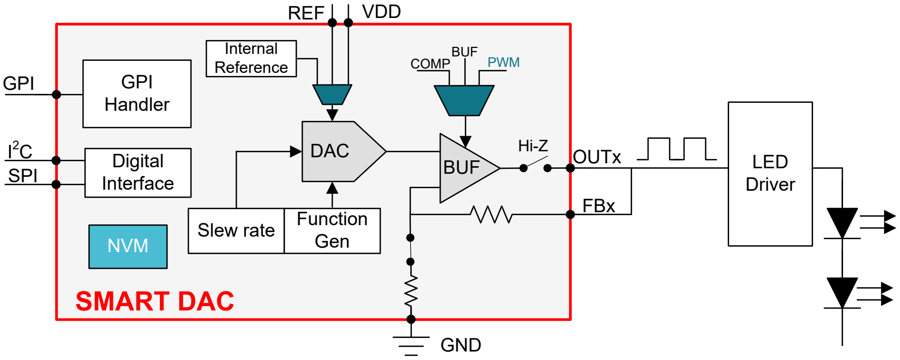


Figure 5-2. Hardware Block Diagram

Design Benefits	Suggested device
- Stand alone, software independent design - Consistent LED output across multiple platforms	- DAC43701 - DAC43204
End Equipment	**Design help**
- Automotive lighting - Appliance - POS printers	- Generating PWM using smart DAC

5.1.3 Analog Thermal Foldback

Protecting the light emitting diodes (LED) from the operating junction temperature rating and doing so with minimal system cost is a challenge particularly in automotive applications. One of the techniques is to reduce or fold back the current through the LED while heating up. This increases the longevity of the LED and maintains that the LED operates safely.

Smart DAC has an ability to implement a simple single slope or multi-slope thermal foldback.

5.1.3.1 Single Slope Thermal Foldback

For a simple single-slope thermal foldback implementation, the feedback pin and the smart DAC PWM generation are used. Analog temperature sensing mechanism such as negative temperature coefficient (NTC) or an analog temperature sensor is connected to the feedback pin of the smart DAC. As the temperature rises, the voltage at the feedback pin drops due to the increase of resistivity of the NTC. The PWM duty cycle generated by the smart DAC decreases as the temperature rises. The PWM in return controls the LED driver and brightness.

The device has an integrated non-volatile memory to store configuration and autonomously generate PWM signal without the need for runtime software.

Table 5-3. Design Implementation

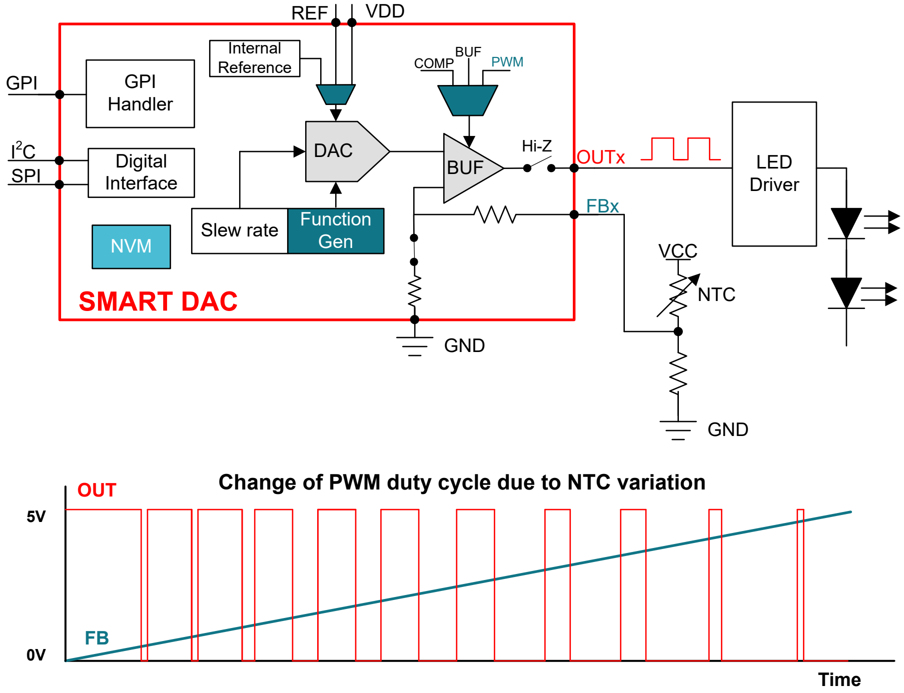


Figure 5-3. Hardware Block Diagram

Design Benefits	Suggested device
• Processor-less single-slope thermal foldback • PWM with duty cycle following foldback curve	• DAC53701 • DAC53202
End Equipment	Design help
• Rear automotive light • Small light	• Generating PWM using smart DAC

5.1.3.2 Multi-Slope Thermal Foldback

To maintain that the LED is lit up at the same luminosity throughout safe temperature ranges, the current through LED needs to be increased progressively by higher margin and at some point, when the temperature reaches a critical level, completely shut off the current and the LED. Usually software is required for such operation to process the temperature and adjust the slope of the current.

AFE53902-Q1 is the device that can implement thermal foldback with no need for software. This device has an integrated ADC which senses the temperature from an analog temperature sensor or a simple NTC. The input is then compared to the look-up table which is entirely customizable by the user. The LUT outputs in the operating region of the LED the current temperature is, and what the biasing current in such region needs to be. Using this information, the internal state machine adjusts the PWM duty cycle based on the temperature range and the desired LED output. All configurations including the look-up table can be stored in the non-volatile memory to remove the need for run-time software. Alternatively, if the PWM signal is required to stay constant, voltage output of the AFE can be used. The voltage controls current adjustment setting of the LED driver.

Table 5-4. Design Implementation

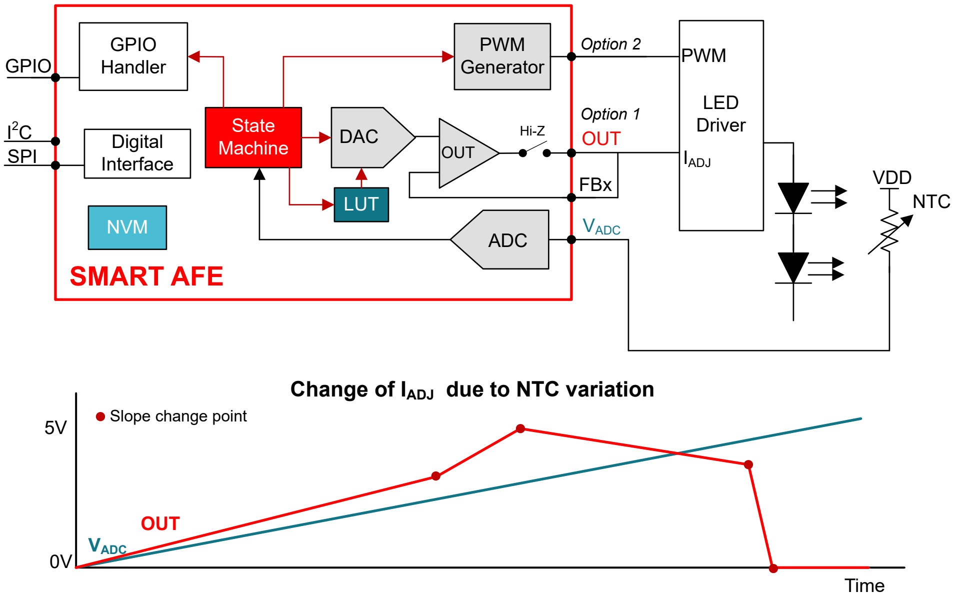


Figure 5-4. Hardware Block Diagram

Design Benefits	Suggested device
• Processor-less multislope thermal foldback • Look-up table to program foldback points and slopes • Sensing and control in one chip • PWM or voltage output options • NVM to store all configurations to remove the need for run-time software	• AFE53902-Q1 • AFE43902-Q1
End Equipment	Design help
• Rear automotive light • Small light	• Device data sheet

5.1.4 Logarithmic Fade-In/Fade-Out

The human eye does not perceive light linearly. To trick the eye, logarithmic fade-in and fade-out is often used to make dimming look more natural. Most of the time a combination of a micro-controller and a LED driver is used for such application. The micro-controller calculates all of the required timings and progressively increases the duty cycle of the PWM to much logarithmic dimming requirement.

With DAC43902 however, there is no need for software to implement such operation. The smart DAC using the internal state machine progressively increases (if fading-in) or decreases (if fading out) the duty cycle of the PWM signal supplied to LED driver. This increase/decrease of the PWM duty cycle produces logarithmic animation to the LEDs.

The dimming timing, PWM frequency, and duty cycle can be customized through the internal registers and stored into the device non-volatile memory to remove the need for run-time software.

Table 5-5. Design Implementation

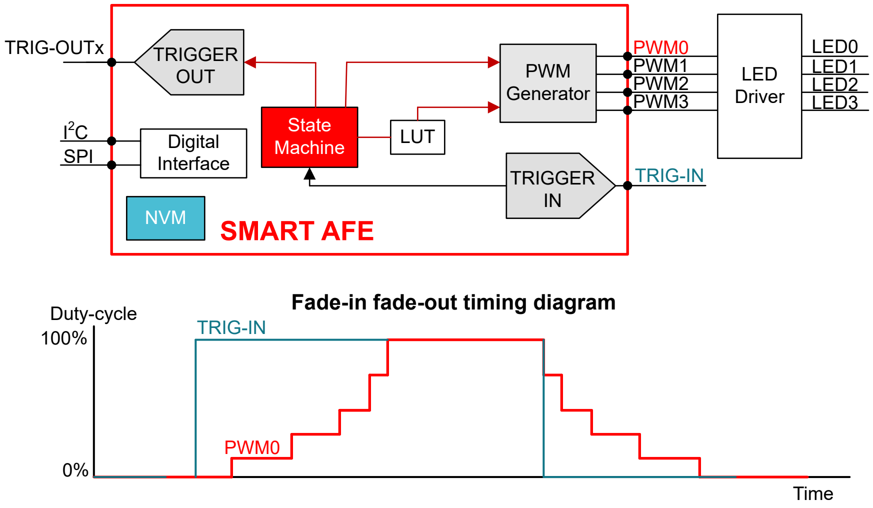


Figure 5-5. Hardware Block Diagram

Design Benefits	Suggested device
- Processor-less logarithmic dimming - Logarithmic increase of PWM duty cycle - PWM output up to 48.8kHz - Fully customizable timing - NVM to store all configurations to remove the need for run-time software	- DAC43901 - DAC43902
End Equipment	**Design help**
- Rear automotive light - Appliances - Interior light	- Device data sheet

5.1.5 LED Sequencing

Smart DAC is able to create sequencing animation for LED or an array of LEDs for applications such as a turn indicator. Turn indicator requires the LED arrays to light up with a specific delay and then to turn off after certain time. Normally to set up this behavior the software is utilized. Smart DAC can implement such application without the need for any software.

AFE43901-Q1 (2 PWM channels) or AFE43902-Q1 (4 PWM channels) control the LED driver. After receiving a trigger signal, each PWM channel gets activated with a predefined delay. The delay is completely customizable through the device internal registers. In cases where more PWM channels are desired, the AFE43902-Q1 can be cascaded by connecting TRIG-OUT pin to TRIG-IN pin of the next device. All of the configurations can be stored in the device non-volatile memory for software free operation.

Table 5-6. Design Implementation

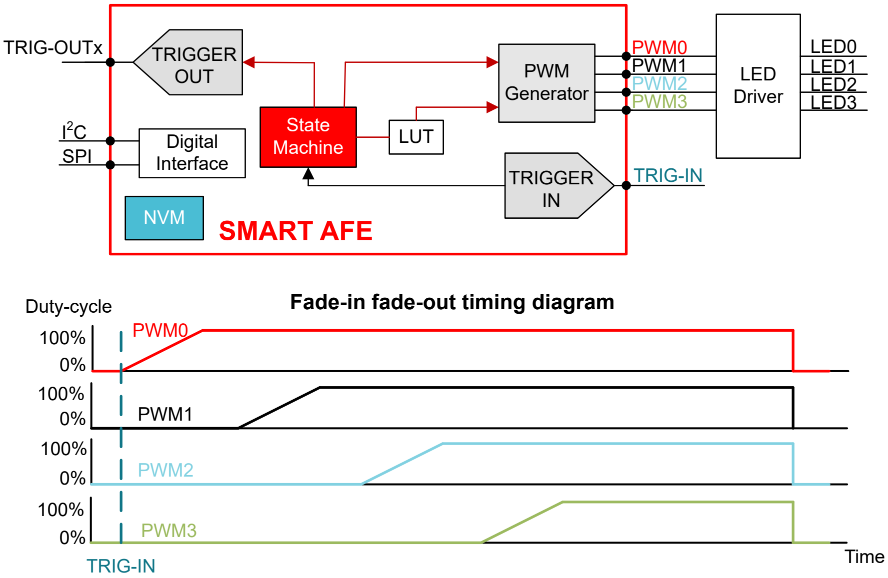


Figure 5-6. Hardware Block Diagram

Design Benefits	Suggested device
- Professor-less logarithmic fading of LED - Fading trigger - Slew rate to control the speed - PWM or voltage output - Non-volatile memory to store all configurations	- AFE43901-Q1 - AFE43902-Q1
End Equipment	Design help
- Indication LED - Turn indicator	- Device data sheet

5.2 Control

5.2.1 Voltage Margining and Scaling With Voltage Output Smart DAC

Adjustable power supplies, such as low dropout regulators (LDOs), DC/DC converters, or SMPS provide a feedback (FB) input that is used to control the desired output of the power supply. Smart DAC is an excellent design to control such systems. Non-volatile memory stores the power-on voltage level which along with true Hi-Z power down (even when VDD is off) capability eliminates the need for power-up sequencing and maintains predictable power-on. In addition, 2 voltage levels (margin-high and margin-low) can be stored in the non-volatile memory and can be triggered between each other with the GPI pin. The device also has a slew-rate control feature, allowing for a configurable voltage ramp up to eliminate power supply glitches. Smart DACs also offer programmable current output capability for current voltage margining.

Table 5-7. Design Implementation

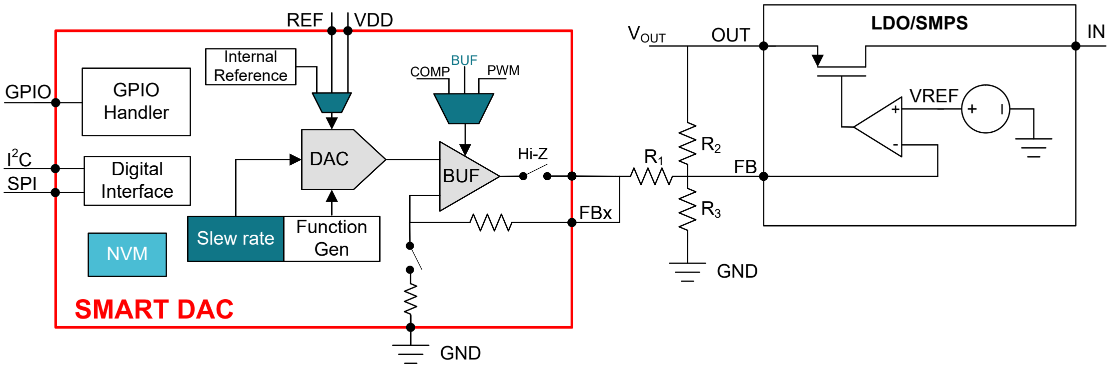


Figure 5-7. Hardware Block Diagram

Design Benefits	Suggested device
- High-Z output - Slew rate control for glitch free margining - EEPROM that store margin high and margin low voltage levels - GPIO - Non-volatile memory to store all configurations	- DAC53204 - DAC53204W - DAC53701
End Equipment	**Design help**
- PC - Rack server - Ultrasound smart probe	- Voltage margining and scaling with voltage output DAC - Voltage margining and scaling with current output DAC

5.2.2 Thermoelectric Cooling (TEC) Control

Peltier element or often called thermoelectric cooling (TEC) is a kind of semiconductor that changes the temperature based on magnitude and the direction of the current. TEC is often used in the application where localized temperature stability is important. Such applications include lasers (optical modules, laser cutters, lidar), in-vitro diagnostics to maintain fluid temperature (chemistry/gas analyzer, flow cytometer, etc.) and many more. to drive the Peltier element DC/DC or H-bridge drivers are commonly used. Such control however requires some sort of digital loop with a PI controller. Such control is often implemented through routine software. Smart DAC offers hardware and software-free implementation of a TEC control.

5.2.2.1 TEC Control Using DC/DC Driver

Buck-boost converters are often used to drive the TEC element where TEC is positioned between VOUT and VIN pins of the power supply and VOUT is changed by varying current at VFB pin.

AFE539A4 is an excellent design for such control. AFE539A4 integrates sensing (ADC), digital loop (PI loop with a set point), voltage output for VFB control of the buck-booster, and comparator for over current protection. All of these parameters are fully adjustable through the device internal registers.

The device has an integrated non-volatile memory to store all of the configurations eliminating run-time software requirement. If set point has to be adjusted run-time, the device supports I^{2}C or SPI communication protocols.

If digital sensors are used, AFE639D2 has a capability to read the temperature sensor through I^{2}C communication.

Table 5-8. Design Implementation

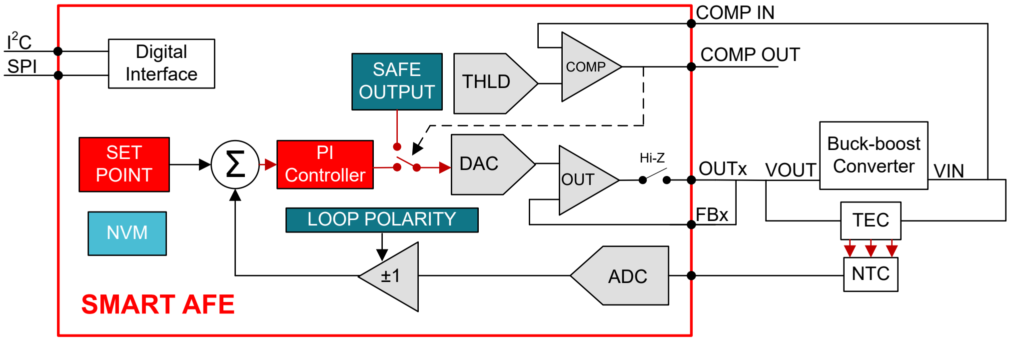


Figure 5-8. Hardware Block Diagram

Design Benefits	Suggested device
• Integrated DAC and ADC • Fully integrated closed loop real-time control • Completely independent from software design • Highly modular design • Non-volatile memory to store all configurations	• AFE539A4 • AFE639A2
End Equipment	**Design help**
• IVD • Optical modules	• Closed-loop TEC control

5.2.2.2 TEC control using h-Bridge driver

High-power TEC usually requires a H-Bridge to drive. H-Bridge requires 2 control signals: PWM to control average power and a digital direction pin to control the direction of the current flow.

AFE439A2 is an excellent for such topology. The device integrates sensing (ADC), digital loop (PI loop with a set point), PWM and digital output. Based on the ADC input, the PI loop dictates the duty cycle and direction pin to maintain the set-point temperature of the TEC.

The device has an integrated non-volatile memory to store all of the configurations eliminating run-time software requirement. If set point has to be adjusted run-time, the device supports I^{2}C or SPI communication protocols.

Table 5-9. Design Implementation

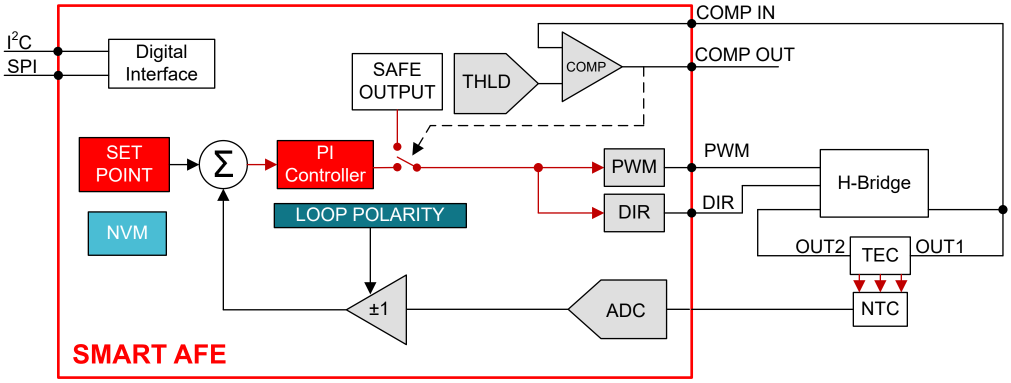


Figure 5-9. Hardware Block Diagram

Design Benefits	Suggested device
- Integrated DAC and ADC - Fully integrated closed loop real-time control - Completely independent from software design - Highly modular design - H-Bridge drive for higher power TEC control - Non-volatile memory to store all configurations	- AFE439A2
End Equipment	**Design help**
- IVD - Optical modules	- Closed-loop TEC control

5.2.3 Analog Power Control (APC) of a Laser

Analog power control of a laser is a simple circuit designed to control power through a laser module (combination of a laser diode and a photodiode). Smart DAC provides a closed loop control of such system.

The output of the DAC controls the gate voltage across MOSFET which along with the drain resistor controls the amount of current flow through the laser. The intensity of the laser is monitored by the photodiode, output of which is sensed by the feedback pin of the smart DAC to close the loop. Smart DAC also integrates a programmable comparator which can be used for over-current protection.

This configuration is resilient to temperature variations of the laser diode along with resister/component mismatch and FET aging. This configuration also maintains the consistency of the laser across multiple platforms. Integrated non-volatile memory is used to store all of the biasing parameters and insures software-free operation.

Table 5-10. Design Implementation

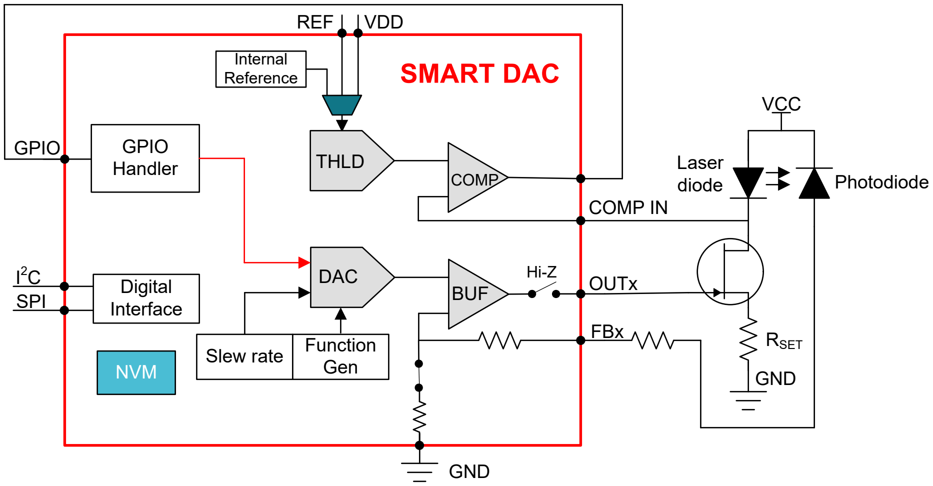


Figure 5-10. Hardware Block Diagram

Design Benefits	Suggested device
• Closed loop control of a laser bias point • Auto-calibration of a biasing point across multiple systems • Configurable GPI to turn on/off the DAC or bring the DAC to safety level in case of a fault • NVM to store all configuration for software-free operation	• DAC53202 • DAC53701
End Equipment	Design help
• IVD • Appliances • Barcode scanner • Laser pointer	• PSpice simulation

5.2.4 Constant Power Control

AFE539F1-Q1 is a device designed to maintain a constant power dissipation across a load independently from the applied voltage. This kind of use-case is particularly important in the safety applications such as traction inverter DC link capacitor discharge control.

The AFE539F1-Q1 integrates an ADC to sense the power across the load and a configurable discharge transfer function within the state machine. According to the input and transfer function, the device outputs the PWM to control the average power across the load.

With integrated non-volatile memory, there is no need for any run-time software.

Table 5-11. Design Implementation

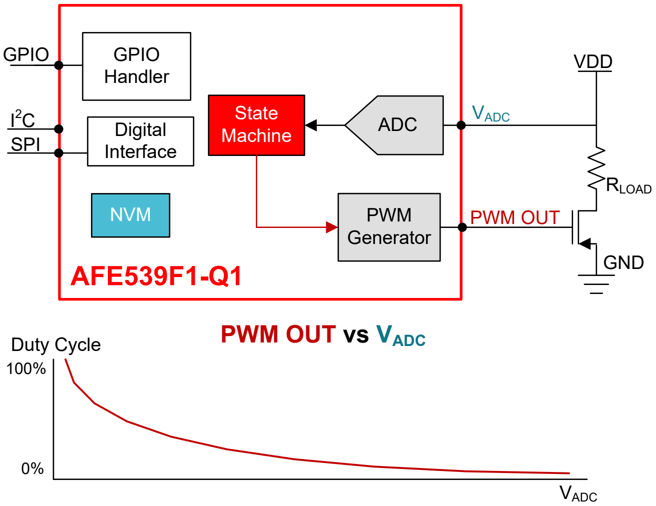


Figure 5-11. Hardware Block Diagram

Design Benefits	Suggested device
• ADC that monitors the power • Power dissipation configurable transfer function • NVM to store all configuration for software-free operation	• AFE539F1-Q1
End Equipment	Design help
• Traction inverter	• Device data sheet

5.3 Microcontroller Independent Fault Management and Communication

Various systems particularly in the medical field and appliances - require additional software independent way to implement system fault management or fault communication. This is particularly important in systems that are responsible for human life or safety. Discrete implementation of such fault management circuit can be cumbersome in terms of the need for numerous discrete components and potentially lack of intelligence and if-then capabilities.

This section covers in detail all designs that smart DAC and AFE provide for fault management and communication.

5.3.1 Programmable Comparator Using Smart DAC

Any smart DAC output channel can be individually configured as a programmable comparator with output buffer being a comparator, VFB node an input to the comparator and an internal DAC ladder as an programmable threshold. Internal features allow the user to set up programmable hysteresis by adjusting internal register values. The GPI can be used as a comparator input and act as a latching comparator. The GPI behavior can be programmed as desired (turn the device on/off, bring the device output to a safety level state, etc.). All of the configurations can be stored in the non-volatile memory for software-free operation. This simple design enables control of critical modules and in case of a major failure to quick response to the failure without the latency of software processing.

Table 5-12. Design Implementation

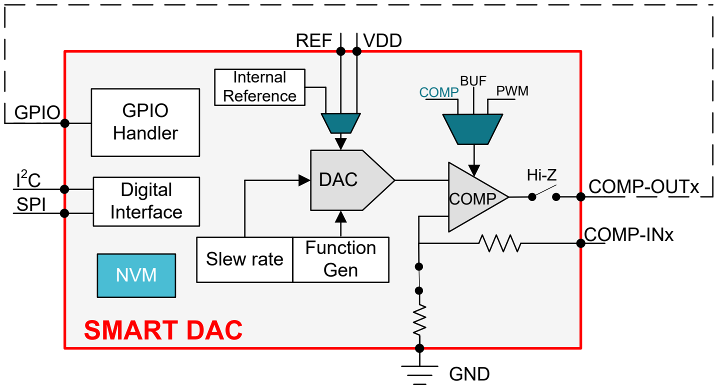


Figure 5-12. Hardware Block Diagram

Design Benefits	Suggested device
- Programmable hysteresis and latching functions independent from MCU - Programmable threshold independent from hardware - GPOI for latching comparator function - NVM to store all configurations	- DAC53701 - DAC43204
End Equipment	Design help
- Medical equipment - Appliances	- Programmable comparator using smart DAC - Programmable comparator with hysterisis

5.3.2 GPI-to-PWM

To gather and communicate simple faults from system to system often times require software implementation. Take rear lighting of a car as an example: there are a few LED drivers which output digital fault signals which needs to be somehow communicate to the main processor located in the front of the car. To do so, another micro-controller is normally utilized.

DAC539G2-Q1 provides software-free way to solve this kind of problem. The device takes 3 GPIs as an input. The input is mapped in the internal LUT to the corresponding PWM duty cycle signal. For example: if input is 0 0 0, the output PWM is 100% duty cycle, if input is 0 0 1, the output PWM is 87.5% duty cycle, and so on. Hence, up to 8 different fault condition can be monitored and communicated. As the output is PWM duty cycle is modulated, such communication only requires a single wire and can be transmitted across 3-5 meters. GPI-to-duty cycle relationship is fully customizable within device LUT and can be stored in the device non-volatile memory for software-free operation.

Table 5-13. Design Implementation

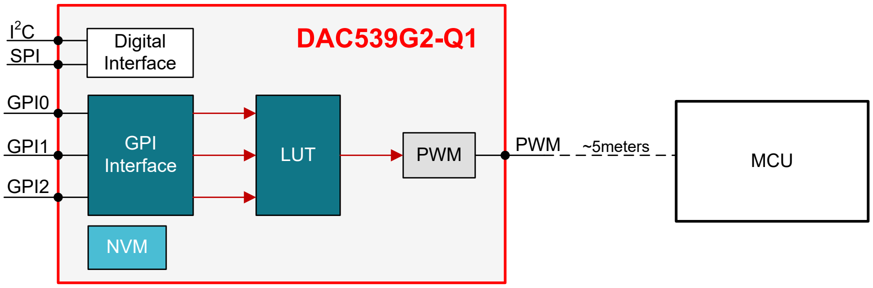


Figure 5-13. Hardware Block Diagram

Design Benefits	Suggested device
- Up to 8 different fault signals that can be transmitted - Mode pin to select between digital interface and stand alone mode - Medium length (3-5m) software-less fault management and communication - NVM to store all configurations	- DAC539G2-Q1
End Equipment	**Design help**
- Rear light - Wired control	- Device data sheet

5.3.3 If-Then-Else Logic

In systems where safety is important such as medical patient monitoring equipment, there is often a requirement for redundant safety and or software-free fault monitoring. For such systems, smart DAC is a great design.

DAC539E4W integrates 4 independently programmable comparators that can monitor up to 4 different lines. The output of the comparator is internally routed to the user configurable look-up table. Such look-up table outputs GPOs with programmable delay based on the comparator input. For example: if comparator outputs are 0 0 0 0, the GPO is 1 1 1 1, if comparators output 0 0 0 1, the GPI is 1 1 1 0, so on. The comparator-to-GPO relationship can be set-up within the LUT and stored in the non-volatile memory for software-free operation.

Table 5-14. Design Implementation

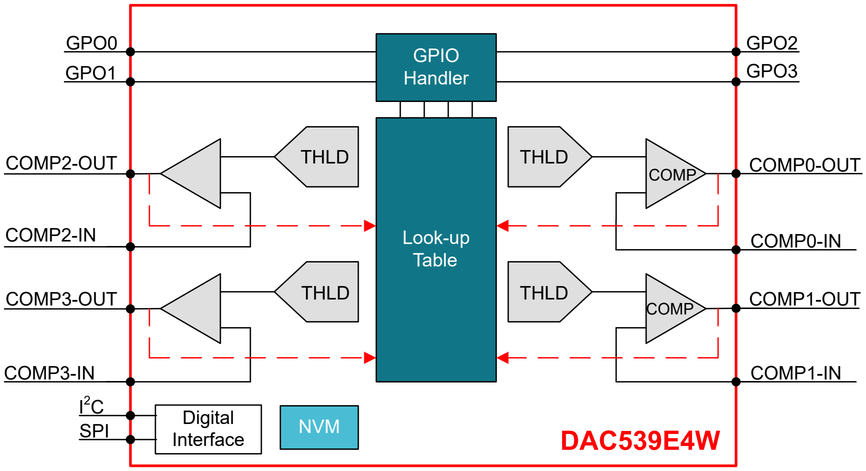


Figure 5-14. Hardware Block Diagram

Design Benefits	Suggested device
• 4 independent comparators mapped to 4 GPOs • Monitoring and detection of up to 16 different monitoring conditions • Mode pin to switch between digital communication (SPI/I^{2}C) or GPIO mode • Small size and low power for small, battery-powered applications	• DAC539E4W
End Equipment	**Design help**
• Cordless power tool • Vaccum robot	• Device data sheet

5.4 Driver

5.4.1 Lens Positioning Control for Camera Module Auto-Focus and Image Stabilization

In camera modules, voice-coil motor (VCM) is often used to control the lens displacement for auto-focus and image stabilization. VCM is a very simple design as the lens displacement is directly proportional to the amount of current flowing though the motor.

High current output smart DAC is an excellent design to drive the VCM. DAC530A2W is a small (1.75mm x 1.75mm), low-power (150uA), precision current source smart DAC. The device is able to source up to 300mA of current. Second channel of the device can be configured as a programmable comparator for over-current protection and monitoring. Non-volatile memory is used to store all of the configuration for predictable power-up and software reduction.

Table 5-15. Design Implementation

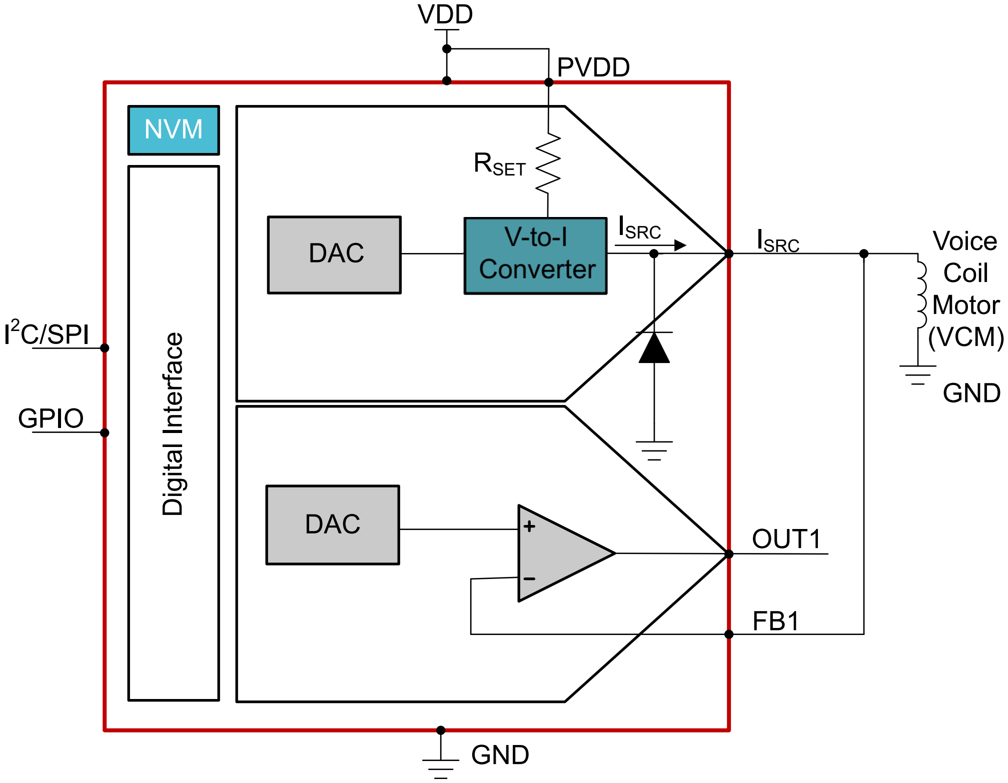


Figure 5-15. Hardware Block Diagram

Design Benefits	Suggested device
- Comparator/supervisor mode for short circuit detection - High-precision current source - NVM to store all configuration for software-free operation	- DAC530A2W
End Equipment	**Design help**
- IP network camera - Dahsboard camera	- Device data sheet

5.4.2 Laser Drive

High-current output smart DAC is a highly integrated design for laser driver.

DAC530A2W is a small (1.75mm x 1.75mm), low-power (150uA), precision current source smart DAC. The device is able to source up to 300mA of current. The second channel of the device can be configured as a programmable comparator for over-current protection and monitoring. For closed loop control of a laser with photo-diode, AFE532A3W is an excellent option. Apart from current sourcing, AFE532A2W integrates an ADC channel that can be used for feedback photo-diode sensing. All of the configurations are stored in the non-volatile memory for software-free operation.

Table 5-16. Design Implementation

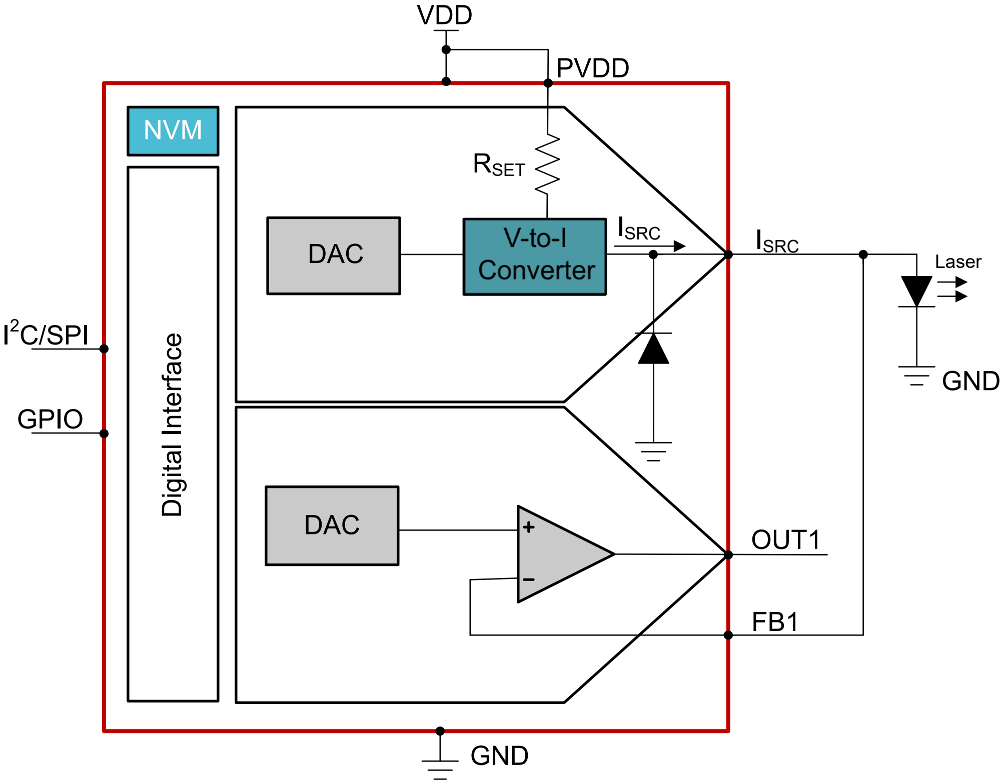


Figure 5-16. Hardware Block Diagram

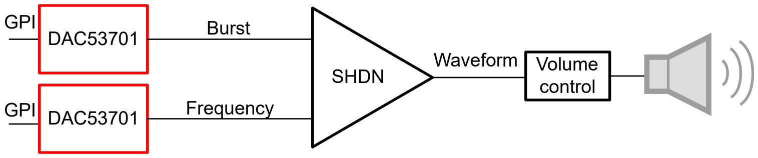
Design Benefits	Suggested device
- Comparator/supervisor mode for short circuit detection - ADC channel for feedback monitoring - Low-power of operation (150uA) - NVM to store all configuration for software-free operation	- DAC530A2W - AFE532A3W
End Equipment	**Design help**
- Optical module	- Programmable FET biasing

5.5 Miscellaneous Smart DAC Applications

5.5.1 Software-less Medical Alarm Generation

DAC53701 is able to generate an IEC60601-1-8 complaint medical alarms without the need for any software. The DAC is capable of supplying the wave forms required for visual, audible and primary alarms used in medical applications. DAC53701 is a part of smart DAC family with integrated EEPROM and preprogrammed wave forms for the alarms. Internal registers enable set-up custom burst and custom timing between pulse to generate the exact alarm sequence. The DAC53701 has a GPI to toggle on and off so the whole system can operate when MCU is down or even without an MCU.

Table 5-17. Design Implementation



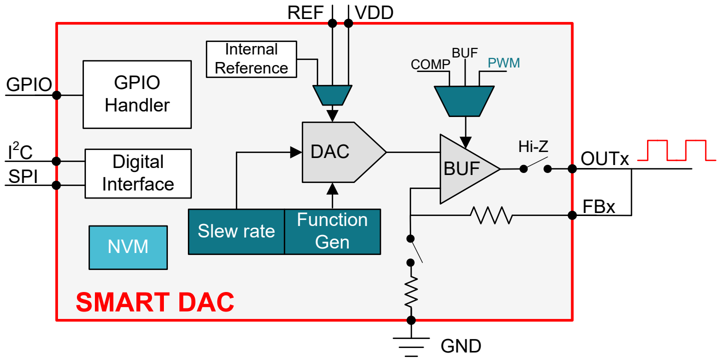
Design Benefits	Suggested device
• Configurable pulse rise and fall times • Configurable burst patterns • Fully IEC60601-1-8 complaint patterns • GPI for control • All patterns are pregenerated and stored in NVM	• DAC53701
End Equipment	**Design help**
• Infusion pump • Patient monitor	• Hardware-based smart DAC medical alarm • Medical alarms with smart DAC

5.5.2 555 Timer

Smart DAC is a good choice as a better alternative to the 555 timers. Smart DAC is capable of generating an output pulse train with variable frequency and duty cycle. Integrated AWG is able to generate a fully customizable square wave. While conventional 555 timers rely on the external capacitor leading to large variation in the output frequency, smart DAC uses the internal oscillator which is more precise.

All of the register values which are the output settings can be stored in the NVM and reduce the need for the external software. If frequency, amplitude or the duty cycle needs to be updated run-time, device supports I^{2}C or SPI modes of communication.

Table 5-18. Design Implementation



Design Benefits	Suggested device
- AWG able to generate triangle, sawtooth and square waves - Complete control of the output through internal registers - High precision - Non-volitile memory to store all of the configurations	- DAC53701 - DAC53202
End Equipment	**Design help**
- Fingerprint biometrics - PWM - Precision timing	- 555 timer using smart DAC - PWM generation using smart DAC

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