Application Note

Automatic Air Freshener

AN-CM-316

Abstract

This application note describes the HVPAK IC configurated as a control unit for Automatic Air Freshener, reducing the number of external components and adding new features.

The application note comes complete with a design file that can be found in the Reference section.

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Tables

1   Terms and Definitions

CMP	Comparator
CCMP	Current Comparator
CNT	Counter
CTRL	Control
DC	Direct Current
DFF	The D-type Flip Flop
DLY	Delay
FSM	Finite-state Machine
GPO	General Purpose Output
HV	High Voltage
IC	Integrated Circuit
I/O	Input / Output
LUT	Look-up Table
MOSFET	Metal–oxide–semiconductor Field-effect Transistor
MF	Multy-function Macrocell
OSC	Oscillator
PIR	Passive Infrared
SW	Switch

2   References

For related documents and software, please visit: HVPAK™ | Renesas

Download our free Go Configure Software Hub software Ref. [1] and use the GreenPAK development tools Ref. [2] to freeze the design into your own customized IC in a matter of minutes. Dialog Semiconductor provides a complete library of application notes Ref. [3] featuring design examples Ref. [1] as well as explanations of features and blocks within the Dialog IC.

[1]   GreenPAK Designer Software, Software Download, and User Guide, Dialog Semiconductor

[2]   GreenPAK Development Tools, GreenPAK Development Tools Webpage, Dialog Semiconductor

[3]   GreenPAK Application Notes, GreenPAK Application Notes Webpage, Dialog Semiconductor

[4]   SLG47105 Datasheet, Dialog Semiconductor

Design file: https://www.renesas.com/us/en/document/scd/cm-316-gp-file

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3 Introduction

This application note describes the HVPAK IC configured as a control unit for Automatic Air Freshener, reducing the number of external components and adding a new function.

Quote from the original device manufacturer description:

Automatic Air Freshener (see Figure 1) offers the confidence that your bathroom has freshness that won't disappear. The automatically time-released fragrance creates an environment that has more freshness, less worry. Whenever you need a controlled burst of fragrance, just use the boost button so that freshness lingers, but odors don't.

Figure 1: Automatic Air Freshener

The device can be set to spray every 9, 18, or 36 minutes or by pushing the Boost button, spray at will. Figure 2 shows the original PCB. As can be seen, it contains 1 IC, 8 resistors, 4 capacitors, 1 diode, and H-bridge build of 4 MOSFET transistors. This application note offers an alternative design that reduces the component count down to 1 IC, 1 Resistor, and 1 capacitor. Which reduces cost and simplifies the design. Also, there is a possibility to connect a PIR motion sensor as a trigger. In this

case, the device will spray only when motion is detected with an interval of no less than 9/18/36 minutes.

In the original design, the time delay for the motor is 1 second. But the motor speed is voltage-dependent and usually takes less than 1 second to spray. In this case, the motor will be mechanically forced to stop causing a huge current through the H-Bridge. That forces to use a lot more powerful transistors increasing the overall cost of the device and significantly reduces battery life. All these issues do not exist in the proposed design thanks to the current protection.
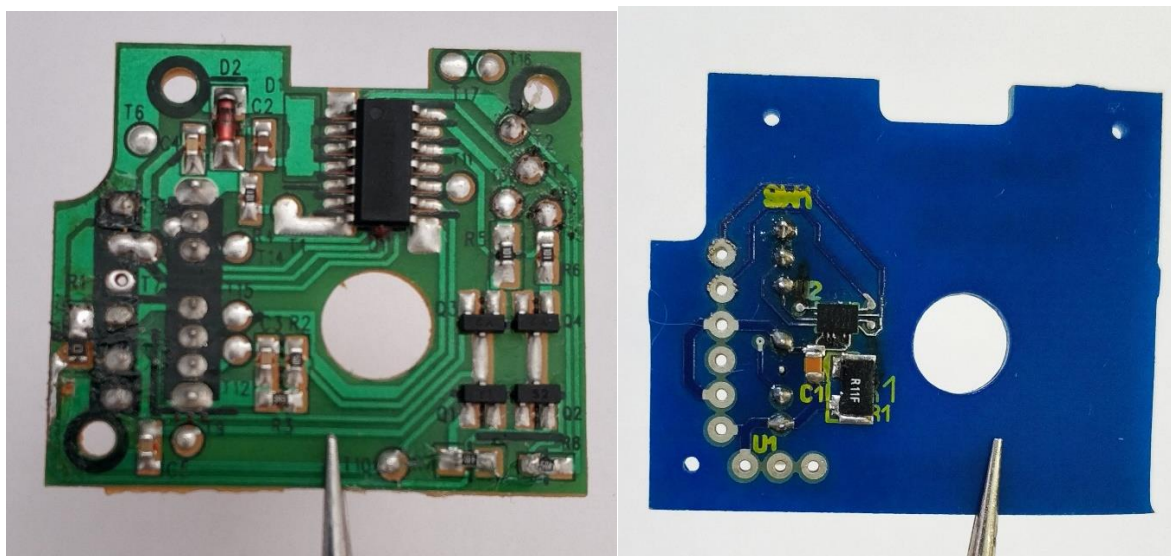

Figure 2: Original PCB (left) and Modified PCB (right)

4 Schematic Diagram and Design

In this design the SLG47105V works below the specification. The device is powered from two AA size batteries connected in series providing 3 Volts when batteries are fresh, and 2.5 Volts when batteries are down. The HV part of the SLG47105V performance is guaranteed down to only 3.0 V. But in this design, the output current is no higher than 240 mA (guaranteed by current protection) and the two H-Bridges are connected in parallel. This allows reducing the H-Bridge output resistance and therefore the device can easily operate below 3 V.

The schematic diagram can be found on Figure 3. For the HVPAK design refer Figure 4.

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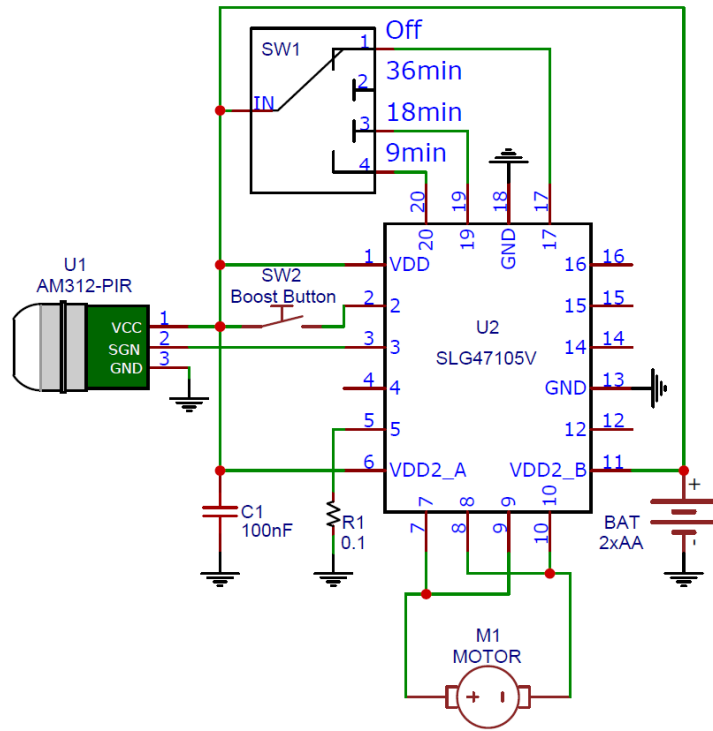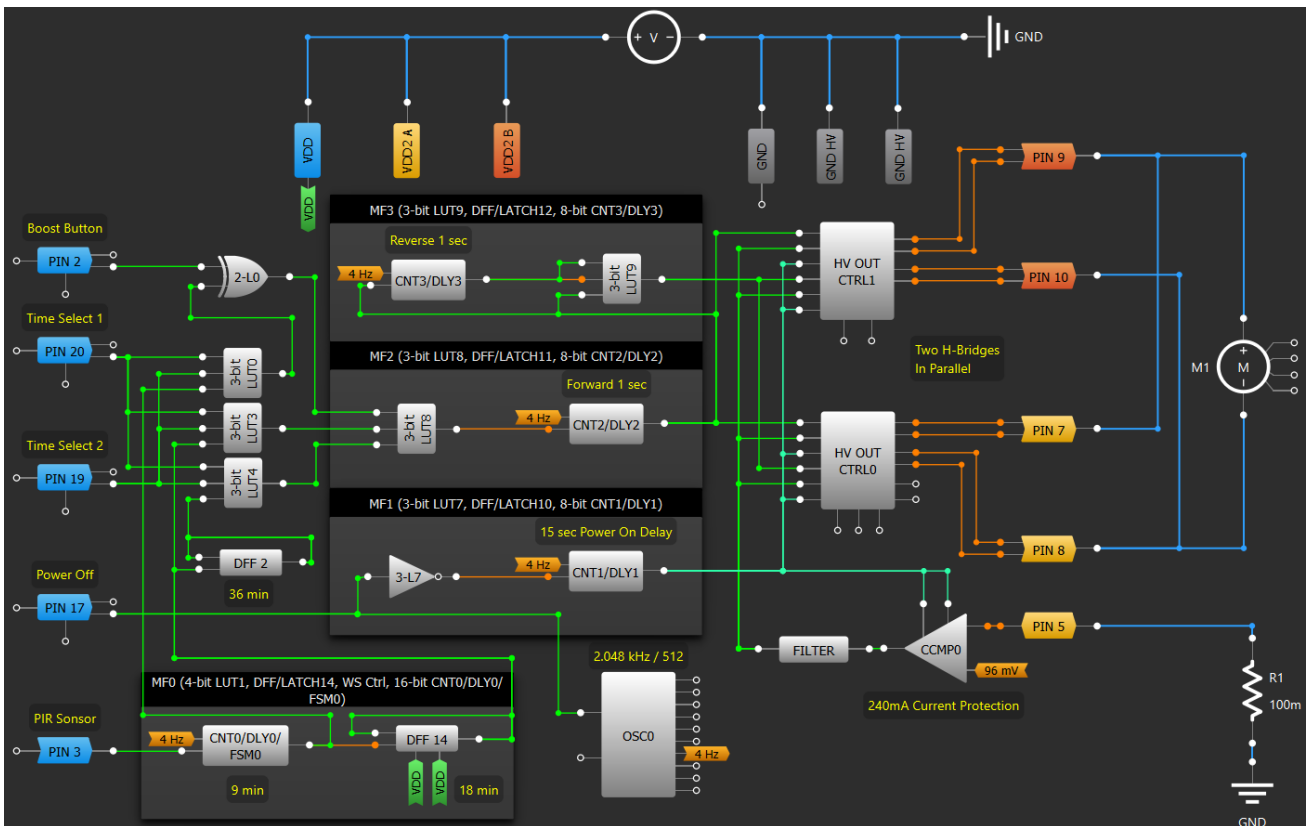**Figure 3: Schematic Diagram**

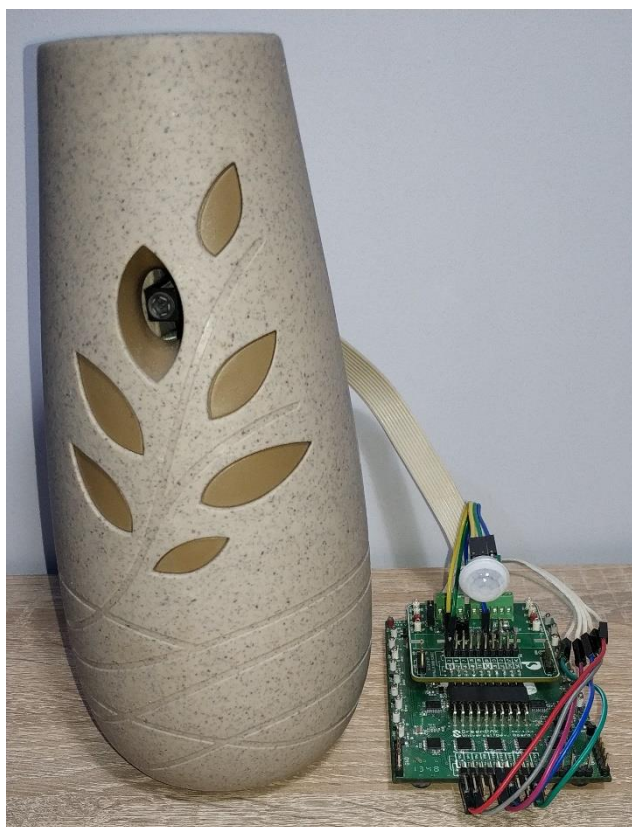
Figure 4: HVPAK Designer Project

Figure 5: Prototype

The design has five control inputs and one analog input for the current sensor:

- PIN#2 – Boost button, allows spraying at will despite the time delay previously set
- PIN#3 – PIR sensor input
- PIN#5 – current sensor input
- PIN#17 – power control, off when HIGH, on when LOW
- PIN#19 – time select 2
- PIN#20 – time select 1

For PIN configuration refer to Table 1

4.1 Design Operation

The CNT0/DLY0/FSM0 macrocell (part of MF0) provides 9 min time delay. It can be configured as a Counter/FSM for periodic spray or as One Shot for using a PIR sensor as a trigger, see the Macrocell Configuration subsection. The DFFs 14 (part of MF0) and 2 are configured as frequency dividers by 2, thas providing two more time intervals of 18 and 36 minutes respectively.

The 3-bit LUTs 0, 3, 4, and 8 (part of MF2) along with 2-bit LUT0 serve to decode the position of the four-way switch SW1 allowing to power on the device and choose the desired time delay. Also, to bypass the delay by pressing the Boost Button SW2.

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The CNT1/DLY1 along with the 3-bit LUT7 (both part of MF1) are designed to delay power on by 15 seconds preventing spraying at the user right after the device is powered on.

The CNT2/DLY2 (part of MF2) is set to One Shot which turns on the motor via HV OUT for 1 second. That causes the device to spray. And then, the CNT3/DLY3 (part of MF3) gives a signal to reverse the motor (also for 1 second via HV OUT) setting the device into the initial position.

In this design, both HV OUTs intend to work in parallel, and their output pins must be externally connected: PIN9 with PIN7 and PIN10 with PIN8.

The CCMP0 is used to protect the output stage from the current higher than 240 mA.

The FILTER is added after the CCMP0 to filter out spikes and ripples that may appear while sensing high currents.

The 1-second delay for the motor to go forward and 1 second to go reverse is designed for low battery operation. When the batteries are fresh it takes less than 1 second to spray and go back to the initial position. In this case, the motor will be blocked mechanically and the current consumption will rise significantly and may damage the output stage. But the designed current protection will prevent that to happen. Also, it will prolong the battery life.

All time-depended microcells are clocked from a single oscillator 2.048 kHz divided by 512.

4.2 Macrocell Configuration

Table 1: PIN settings

Properties	PIN 2	PIN 3, 17, 19, and 20	PIN 5	PIN 7, 8, 9 and 10
I/O selection	Digital input	Digital input	Analog input/output	Digital output
Input mode OE=0	Digital in with Schmitt trigger	Digital in with Schmitt trigger	Analog input/output	None
Output mode OE=1	None	None	Analog input/output	HIGH and LOW side on
Resistor	10k	1M	Floating	--
Resistor value	Pull Down	Pull Down	Floating	--
OCP deglitch time enable	--	--	--	Without deglitch time
Control delay of OCP retry	--	--	--	Delay 492 us

Table 2: LUT settings

IN2	IN1	IN0	2-bit LUT0 OUT	3-bit LUT0 OUT	3-bit LUT3 OUT	3-bit LUT4 OUT	3-bit LUT7 OUT	3-bit LUT8 OUT	3-bit LUT9 OUT
0	0	0	0	0	0	0		0	0
0	0	1	1	0	0	1		1	0
0	1	0	1	0	0	0		1	0
0	1	1	0	0	1	0	Inverter	0	0
1	0	0	--	0	0	0		1	0
1	0	1	--	1	0	0		0	0
1	1	0	--	0	0	0		0	1
1	1	1	--	0	0	0		0	0

Table 3: DFF Settings

Properties	DFF 2	DFF 14
Type	DFF/LATCH	--
Mode	DFF	DFF
Second Q select	None	--
nSET/nRESET option	None	None
Initial polarity	Low	Low
Q output polarity	Inverted (nQ)	Inverted (nQ)

Table 4: CNT/DLY Settings

Properties	16-bit CNT0/DLY0/FSM0 (MF0)	8-bit CNT1/DLY1 (MF1)	8-bit CNT2/DLY2 (MF2)	8-bit CNT3/DLY3 (MF3)
Type	CNT/DLY	--	--	--
Mode	**One shot** (for PIR sensor triggered operation) **Counter/FSM** (for periodic operation)	Delay	One shot	One shot
Counter data	2159	59	3	3
Edge select	Rising	Rising	Rising	Falling

Properties	16-bit CNT0/DLY0/FSM0 (MF0)	8-bit CNT1/DLY1 (MF1)	8-bit CNT2/DLY2 (MF2)	8-bit CNT3/DLY3 (MF3)
DLY IN init. value	Initial 0	Initial 0	Initial 0	Initial 0
Output polarity	Non-inverted (OUT)	Inverted (nOUT)	Non-inverted (OUT)	Non-inverted (OUT)
Mode signal sync.	Bypass	Bypass	Bypass	Bypass
Clock	OSC0 / 512	OSC0 / 512	OSC0 / 512	OSC0 / 512

Table 5: FILTER Settings

Properties	FILTER/EDGE DET
Type	FILTER
Output polarity	Non-inverted (OUT)

Table 6: OSC Settings

Properties	OSC0
Control pin mode	Power down
OSC power mode	Auto Power On
Clock selector	OSC
'CLK' predivider by	1
'OUT0' second divider by	1
'OUT1' second divider by	1

Table 7: Current Sense CMP0

Properties	CCMP0
Sleep CTRL	Auto
OUT polarity	Inverted OUT
IN+ gain	x4
Connections	
VREF source selection	Static from registers
IN- source	96 mV

Table 8: HV Output Settings

Properties	HV OUT CTRL0	HV OUT CTRL1
Slew rate	Slow for motor drive	Slow for motor drive

Properties	HV OUT CTRL0	HV OUT CTRL1
HV OUT mode	Half-bridge	Half-bridge
Mode control	IN-IN	IN-IN
Thermal shutdown	Enable	None

5   Conclusions

This app note shows how easy it is to design an improved and cheaper version of the control unit used in the Automatic Air Freshener using the SLG47105 HVPAK. Reducing costs is achieved by reducing the external component count. Adding a current sensor allows prolonging battery life and protects the device from overcurrent and short circuit at the output. Also, adding a trigger (whether it's a PIR motion sensor, simple switch, or any other external device) improves the device operation by preventing spraying when no one is around thas saving batteries even more, and saving spray liquid.

Revision History

Revision	Date	Description
1.0	4-Jun-2021	Initial Version