AN2155

PSoC® EMI Design Considerations

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Associated Project: No

Associated Part Family: All PSoC 1, PSoC 3, PSoC 4, and PSoC 5LP parts

Software Version: NA

Related Application Notes: Click here.

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AN2155 discusses how to design PSoC® array-based systems for compliance with EMC standards, promoting easier qualification of new designs and a more robust, low-cost system design.

1 Introduction

Every electronic device is required to comply with specific limits for emitted energy and susceptibility to external upsets. These limits are specified by the FCC in the U.S. and by similar regulatory bodies in other countries. The regulations help ensure that electronic devices will not interfere with each other; for example, your computer will not interfere with your television, or worse, a hospital X-ray machine or ventilator will not corrupt the operation of a critical medical monitor.

Modern high-speed digital electronics are capable of generating very high-speed signals that have the potential to radiate substantial amounts of noise. CMOS analog and digital circuits have essentially infinite input impedance. As a result, they can be sensitive to external fields, so suitable precautions must be taken to ensure their proper operation in the presence of large amounts of radiated and conducted (interfering) energy.

This application note outlines the basic specifications involved and provides guidance for secure and compliant designs.

If you are new to PSoC, refer to the following documents to learn about the device and the available tools:

- AN75320 – Getting Started with PSoC 1
- AN54181 – Getting Started with PSoC 3
- AN79953 – Getting Started with PSoC 4
- AN77759 – Getting Started with PSoC 5LP

2 Specifications

Computing devices are regulated in the U.S. by the FCC under 47 CFR Part 15, Subpart B, “Unintentional Radiators.” The standards for Europe and the rest of the world are adapted from CENELEC. These regulations are covered by the CISPR standards (dual labeled as “EN xxxxx”) for emissions and the IEC standards (also dual labeled as “EN xxxxx”) for immunity and safety concerns.

The general emission’s specification is EN 55022 for computing devices. This standard covers both radiated and conducted emissions. Medical devices in the U.S. are not regulated by the FCC, but rather by FDA rules, which include the requirements of EN 55011, the European norm for medical devices. Devices that contain motor controls are covered by EN 55014, and lighting devices are covered by EN 50015. These specifications have essentially similar performance limitations for radiated and conducted emissions.

Radiated and conducted immunity (susceptibility) performance requirements are specified by several sections of EN 61000-4. This standard also covers line voltage transients, ESD, and safety issues.

Each section of the electronics industry has its own additional standards. For example, power meters are covered by EN 61036, which calls out specific performance parameters with EN 55022. Power-line communication devices are covered by EN 50065, which includes voltage-level allowances in certain bands and restrictions on harmonic energy from signaling frequencies.

3 Emissions

3.1 Radiated

Emissions result primarily as a consequence of digital transients on inputs and outputs. To the greatest extent possible, the bandwidth of digital outputs should be limited. The PSoC 1 device has an I/O limited to 12 MHz by the global bus structure. PSoC 3, 4, and 5LP devices limit the I/Os to 33 MHz, with a selectable slew rate. This clocking limitation provides a first line of defense against radiated emissions.

PSoC devices CY8C22xxx, CY8C24xxx, CY8C27xxx, CY8C3xxx, CY8C4xxx, CY8C5xxx and all planned future generations provide the option to enable slower rise and fall times, which limits harmonic energy in the digital outputs. This option is not available in the earlier generation parts, CY8C25xxx and CY8C26xxx.

High-speed traces on the board should be kept as short as practical. If the signal leaves the board to drive an external load, it should have a series-terminating resistor at the chip to provide the necessary bandwidth limit. Fifteen to 50 ohms is usually sufficient on high-speed lines. Note that a digital output that is at a logic one is directly connected (by the output P-channel FET's $R_{DS(ON)}$) to V_{DD}. Thus, the V_{DD} bus is directly connected to the output, and any high-frequency noise that appears on the V_{DD} bus will also appear on the output. It is important to provide a well-coupled, high-frequency bypass capacitor from V_{DD} to V_{SS} at the PSoC chip. The capacitor bypass traces should be very short, and ground and power planes should be used where possible.

If you are using CapSense®, the capacitive touch sensing feature in PSoC, refer to AN64846 – Getting Started with CapSense for EMI considerations.

3.2 Conducted

Emissions result as a function of comparatively low-frequency RF conduction into the power supply system. Placing high-frequency bypass capacitors at the PSoC power pins and a bulk bypass capacitor to support large instantaneous load demands near the PSoC device effectively prevents decoupling of the PSoC chip and its direct loads from the power system.

Switching power supply transients are not a PSoC chip problem per se, but they represent the bulk of conducted emissions. Standard design practices for reducing this noise include the use of differential and common mode inductors on the input power connection and the use of high-voltage capacitors from the AC line and AC neutral to earth ground.

4 Susceptibility

4.1 Radiated

Electrical energy can influence system measurements and potentially the operation of the processor core. The interference enters the PSoC chip at the printed circuit board level through the pins. Radiated energy is highly unlikely to interfere directly with the chip.

Careful board layout, as well as a good PSoC project design, will prevent upsets from radiated energy. These steps include the following:

1. Minimize source impedances (where possible) of signal sources coming to the chip.
2. Minimize loop areas of input signal traces.
3. Use ground planes where possible.
4. Set unused outputs to strong digital output, with logic state to zero.

4.2 Conducted

Electrical energy influences system measurements and upsets the operation of the processor core by driving the PSoC chip's power supply out of range. Power-line inputs should be protected with common mode and differential mode chokes, along with transient voltage suppressors such as metal-oxide varistors (MOVs).

For more details, see the following application notes:

- AN57821 – PSoC 3, PSoC 4, and PSoC 5LP Mixed Signal Circuit Board Layout Considerations
- AN80994 – PSoC 3, PSoC 4, and PSoC 5LP EMC Best Practices and Recommendations

5 EMI Testing

Radiated emission measurements are made first in an anechoic chamber to generate a list of suspect frequencies. The equipment under test is then relocated to an open area test site. Radiated emission measurements are made at the EUT azimuth and antenna height such that the maximum radiated emission level will be detected. This requires the use of a turntable and an antenna positioner that can adjust the antenna’s height as well as shift its orientation from horizontal to vertical.

Conducted emission measurements are made over the frequency range from 150 kHz to 30 MHz to determine the line-to-ground radio noise voltage conducted from the device power input terminals that are directly (or indirectly via a separate transformer or power supplies) connected to a public power network. Equipment is tested with power cords that are normally used or that have electrical or shielding characteristics that resemble the cords normally used..

Radiated immunity is measured in a shielded anechoic chamber large enough to contain the system under test and allow adequate control over field strength. The system under test is maintained in uniform field strength.

Frequency stepping and power requirements are as specified in the relative standards. The output of the system under test is monitored for disturbance.

Conducted immunity is tested by applying the RF signal to external power and signal cables with clamps that surround the cable. In this case, the power and signal cables act as passive, receiving antenna networks.

6 Design Example

Cypress development kits are examples of PSoC designs that pass required EMI tests. Figure 1 shows the CY8CKIT-044 PSoC 4 M-Series Pioneer Kit.

Figure 1. CY8CKIT-044

You can download the kit design files from the CY8CKIT-044 web page for more information.

Figure 2 and Figure 3 show the radiated emission from the kit in the frequency range of 30 MHz to 1 GHz.

Figure 2. Spectral Diagram Measured by a Vertical Antenna

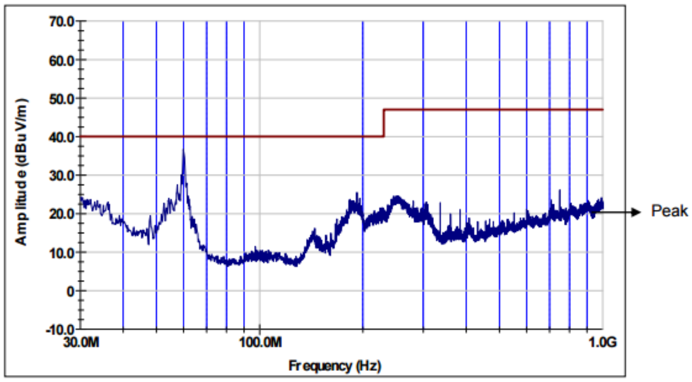
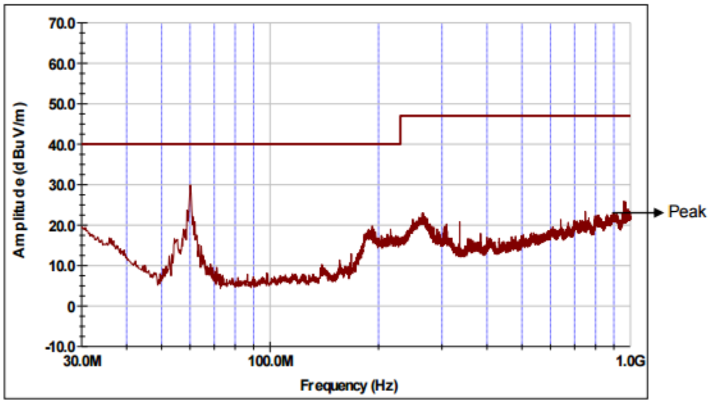


Figure 3. Spectral Diagram Measured by a Horizontal Antenna



7 Summary

Designing for electromagnetic emissions and susceptibility is a system-level consideration. This application note covered a few generic considerations. The test methodologies for radiated and conducted cases of emission and susceptibility were also described.

8 Related Application Notes

- AN75320 – Getting Started with PSoC 1
- AN54181 – Getting Started with PSoC 3
- AN79953 – Getting Started with PSoC 4
- AN77759 – Getting Started with PSoC 5LP
- AN57821 – PSoC 3, PSoC 4, and PSoC 5LP Mixed Signal Circuit Board Layout Considerations
- AN80994 – PSoC 3, PSoC 4, and PSoC 5LP EMC Best Practices and Recommendations

9 Design References

Designing for EMC considerations is an important and exhaustively published topic. Following are the author's favorite references:

- Henry Ott, *Noise Reduction Techniques in Electronic Systems,* 2nd Edition. John Wiley & Sons.
- David Terrell and R. Kenneth Keenan, *Digital Design for Interference Specifications: A Practical Handbook for EMI Suppression.* Newnes.
- William D. Kimmel and Daryl D. Gerke, *Electromagnetic Compatibility in Medical Equipment: A Guide for Designers and Installers.* IEEE Press.

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Document History

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**	1513664	VED	11/02/2007	Recataloged Application Note
*A	3223359	KANT	04/07/2011	Updated title. Updated Abstract. Updated introduction.
*B	4363701	QVS	04/28/2014	Updated in new template. Completing Sunset Review.
*C	4787186	NIDH	06/18/2015	Included PSoC 4 information Corrected typo Added references to related application notes Updated template Removed the example of obsolete kit and replaced it with CY8CKIT-044
*D	5702127	AESATMP8	04/19/2017	Updated logo and Copyright.

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