Atmel

Application Note

Haptics Design Guide

QTAN0085

1. Introduction

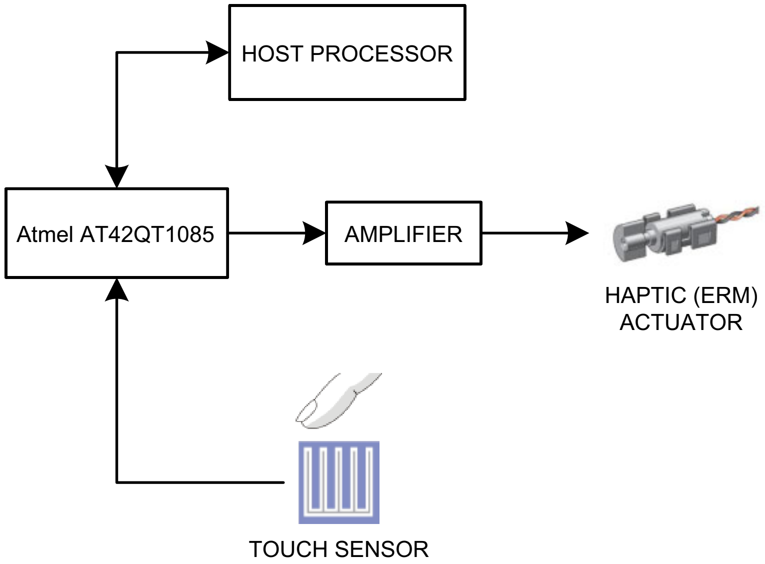
The market-leading capacitive-sensing QTouch® technology from Atmel has been expanded by adding tactile feedback (haptics) to its features. Through partnering with the market leader in haptic technology, Immersion, Atmel drives the actuator that produces the tactile feedback, and the capacitive touch sensing, all in one device.

Haptic feedback provides an intuitive, engaging, and more natural experience for the user interface. Haptics can enable capacitive buttons to feel like mechanical buttons and allow you to customize the feel to suit your application. Haptics tactile sensations combine well with audio feedback and graphics to create a more complete and intuitive multisensory experience.

The primary components in the haptic system are the haptic processor (Atmel MCU), the amplifier circuitry, and the haptic actuator (see Figure 1-1). The Atmel device contains the haptics player – proprietary code that commands the actuator drive-circuit to generate the desired effect upon receiving triggers from the host application. The Atmel device receives haptic-triggering commands from the system processor and *plays* the selected haptic effect from the built-in library. The effect is output to the amplifier, which energizes the haptic actuator.

The AT42QT1085 (QT1085) is the first haptic-enabled application-specific solution in the Atmel QTouch family of capacitive sensors. The QT1085 is an 8-button device.

Figure 1-1. Haptics System Topology



2. Mechanical and Component Design Guidelines

2.1 Introduction

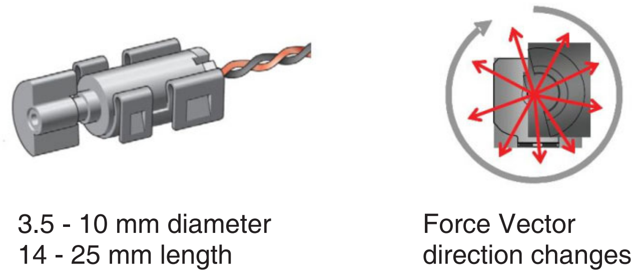
This section describes general process and design decisions required to develop a small system device that incorporates haptic tactile feedback. It provides several examples to illustrate design variations for the more common-usage scenarios. Contact your Atmel account representative if your requirements are not supported by this guide.

2.2 Eccentric Rotating Mass (ERM) Actuators

Atmel's haptic solution supports a number of tested and qualified ERM actuators.

ERM actuators consist of a brushed or brushless actuator with an eccentric (off-center) mass attached to the output shaft. Brushed actuator-type ERMs can be driven with a DC voltage and produce a 2D oscillating reaction force where they are activated. The recommended ERMs use bar-type packaging as shown in Figure 2-1.

Figure 2-1. ERM Actuator and Force Vector



2.3 Mechanical Integration – Whole Device Haptics

The process for integrating haptic feedback into a touch-based device with fixed actuator mounting is as follows:

1. Select an actuator based on the desired effect strength, system geometry, component mass, power budget, and component cost.
2. Determine the actuator location and design the actuator mounting boss (docking sleeve).
3. Select the effects to be used by the system based on the device user interface and how the user interacts with the device.

2.4 Actuator Selection

See Table 2-1 on page 2 for the ERM actuators which are recommended for use with the Atmel devices. These actuators are qualified for both performance and durability. Contact Atmel for specific actuator recommendations for your device.

Note: Atmel does not certify, or offer any warranty, for any of the actuators mentioned in this document. Atmel works with actuator providers to assist them with usage scenario generation, test vector generation, and offers them nominal durability guidelines.

Contact your Atmel account representative to obtain the latest actuator manufacturer recommendations.

Table 2-1. Actuator Selection Criteria

Device Mass	Recommended Actuator	Drive Voltage
Up to 150 g	Sanyo™ NRS-2574i	3.3 V
100 g – 200 g	Jinlong™ Z6DL2A017000B	3.3 V

The mass of the system and the system space requirements play an important role in actuator selection. Guidelines for this are shown in Table 2-2.

Table 2-2. Actuator Guidelines

Actuator	Guideline
Sanyo NRS-2574i	Good for fitting into small places and for devices up to 150 grams.
Jinlong Z6DL2A017000B	Strong and can provide good strength effects for devices weighing between 100 – 200 grams.

Note: Contact the actuator vendor for pricing information.

2.5 Actuator Mounting and Location for Fixed Mounting

2.5.1 Introduction

In small devices, it is suggested mounting the actuator as rigidly as possible to the device casing or main printed circuit board (PCB).

Small devices that utilize fixed mounting techniques can be divided into two distinct usage profiles:

- **Handheld Devices:** These are devices that are used primarily in the user's hand – for example MP3 players.
- **Docking Devices:** These are devices that can be used either in-hand or docked to a fixed mount – for example a GPS device.

There are separate considerations for each of these device types as will be discussed in the following sections.

In addition to mounting location, device and mounting rigidity are of extreme importance. Key elements to remember are:

- **The more rigid the device, the better the vibration transmission.** The goal is to activate the entire device using the vibrating actuator, transmitting vibration both to the hand holding the device as well as the finger interacting with the interface element that triggered the vibration event.

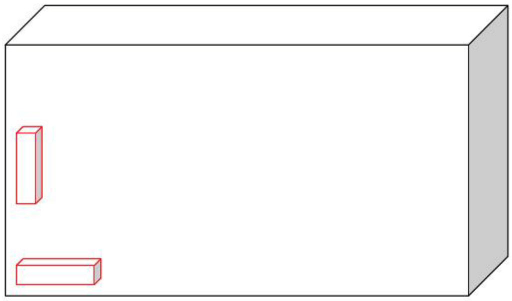
  If the vibration source is not securely fastened to the outer shell (either directly or via a PCB-mounted actuator, with the PCB properly secured to the outer shell), vibration energy will be lost internally in the device rather than being forcefully transmitted to the user.
- **Actuators produce vibration.** If your current generation of handheld device is not designed to transmit vibration, you may have to modify several elements of the device; for example, floating-button capacitors and thin-walled plastic sections. These elements tend to rattle or resonate when the device vibrates and can produce undesirable sounds if not addressed.

2.5.2 Actuator Mounting for Handheld Devices

For handheld devices that are primarily used in the hand, it is often easier to rock the device back and forth around its center of mass rather than move the entire device through its center of mass. Most handheld devices that incorporate vibration feedback have the vibration actuator mounted along an edge of the device, preferably in an area furthest from the center of mass (see Figure 2-2). It is often inconvenient to mount an actuator at, or near, the center of mass, and it does not provide the same quality of rotational shaking that handheld device users are accustomed to.

It must be noted, however, that larger portable devices will need to be very rigid when assembled in order to properly transmit the vibration across the entire device body. For larger handheld devices, an actuator mounted in an extreme corner may not transmit appropriate levels of vibration to the opposite corner of the device as the vibrations get attenuated in the compliance of the assembly.

Figure 2-2. Actuator Mounting Locations in Handheld Devices



2.5.3 Actuator Mounting for Docked Device

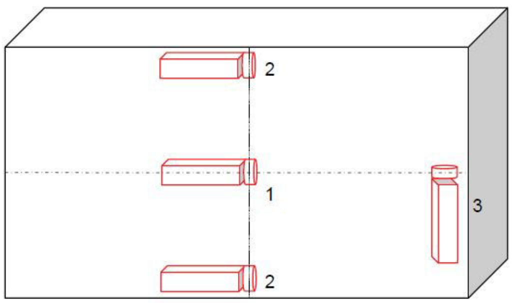
For devices that are primarily used while docked, consistency of haptic sensations across the user touch interface is of greater importance. When the device is docked, the user will only be reacting with the user interface touch elements and will not experience the haptic effects through the hand as in handheld devices.

Motor placement makes a difference. Ideally, the force imparted by the ERM acts through the center of mass of the device. Assuming the device is largely isotropic [1], the center of mass would be coincident with the physical center of the device. In this case, the ideal mounting scenario would be to mount the ERM so that its long axis is parallel to the long axis of the device, and the eccentric mass runs through the mass center. In Figure 2-3 on page 4 this is shown as position *1*.

If it is not possible to place the actuator at the center of mass, the next best placement is to move the actuator up or down vertically, while maintaining the horizontal placement. This is shown as positions *2* in Figure 2-3 on page 4.

Alternatively, the ERM can be mounted with its axis parallel to the short axis of the device, this shown as position *3* in Figure 2-3. Note that the mass center still runs through the rotational mass. Try to keep the actuator as close to the device center as possible.

Figure 2-3. Typical Actuator Mounting Locations in Docked Devices



1. Having physical properties that are the same regardless of the direction of measurement.

2.6 Mounting Techniques

In the prototyping phase, actuators can be mounted to the device housing using a plastic clip and pressure-sensitive adhesive. Use of a viscous cyanoacrylate adhesive also works for prototyping:

1. Apply a small bead of adhesive to the housing.
2. Place the actuator in the desired location.
3. Apply a bead of adhesive on each side of the actuator to fill the gap.

In production, a mounting feature for the actuator should be incorporated into the device housing. It is important that the mounting feature offers a very snug fit, without compromising the actuator housing. Overstressing the actuator housing will adversely affect the actuator durability.

PCB-mounted actuator designs like the Sanyo NRS-2574i are normally reflow-solderable and are designed for surface-mount assembly. For this type of actuator, make sure that the PCB is rigidly affixed to the outer shell of the device in order to maximize vibration transmission.

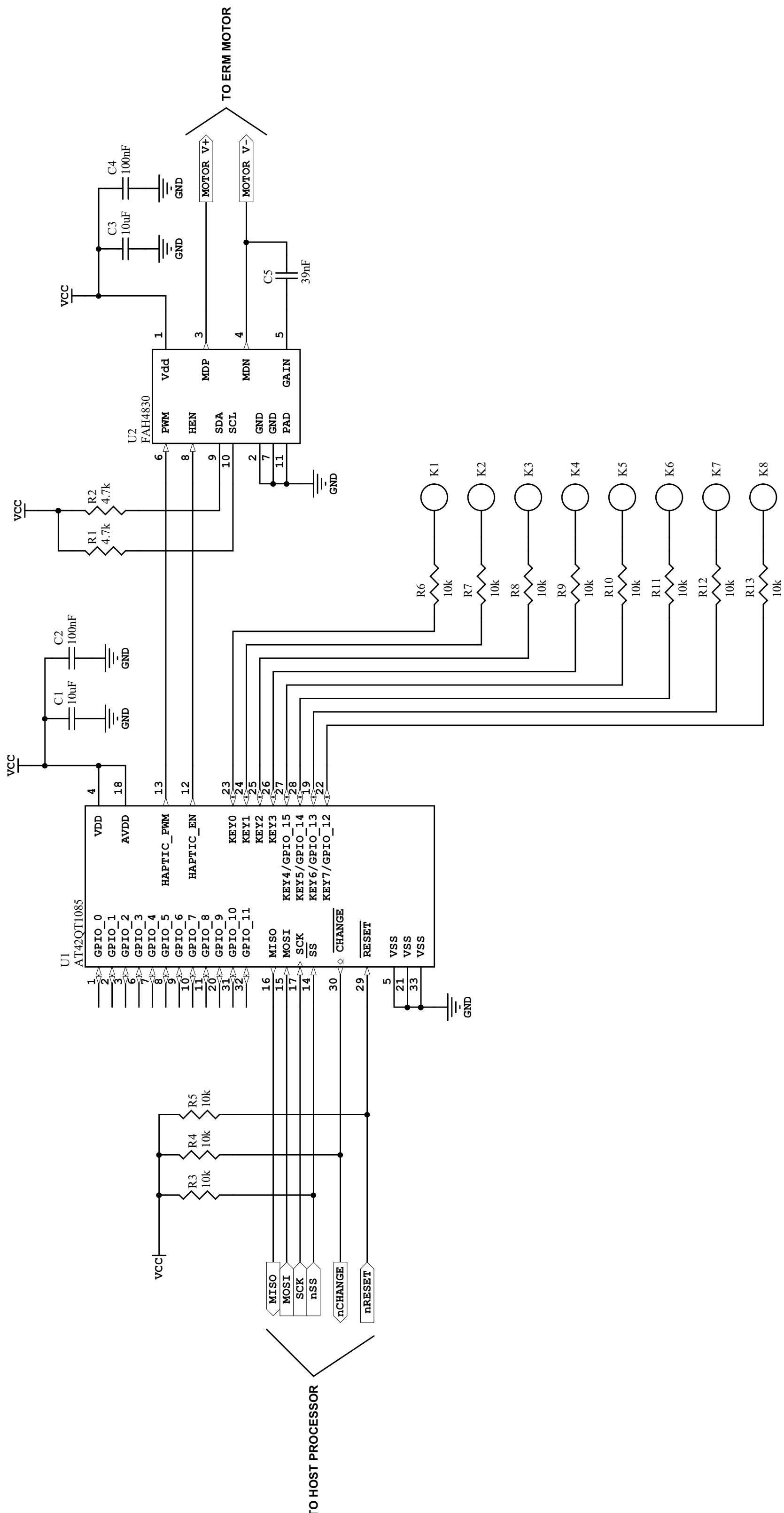
3. Electrical System Guidelines

The ERM drive circuit is compatible with a Fairchild FAH4830 driver for DC motors (ERM) (see Figure 3-1 on page 6). The driver is designed to operate either directly from battery voltage or from a regulated DC power supply in the 1.8 V – 6.0 V range, depending on the actuator selection.

The specified actuator drive circuit implementation draws less than 1 μA in the SHUTDOWN or power-save state.

The actuator drive circuit, as it is currently implemented, does not compensate electrically for supply voltage variation. Similarly, the haptics controller does not compensate for battery voltage in its commanded output, as it does not sense battery charge level. You may choose to operate from a regulated source if the supply voltage variation is noticeable and adversely affects perceived vibration strength.

Figure 3-1. ERM Drive Circuit



4. Haptic Effects

Fourteen unique effect definitions are stored in the QT1085 device and may be triggered via the GPIO pins of the microcontroller. Typically, for processors running user-interface software, the haptic feedback software implementation can be either application specific or system wide.

In application-specific implementations, a particular application triggers effect playback in response to any variety of system events. Most common events include button presses and other gestures like sliding and flicking.

Table 4-1. Haptic Effect Descriptions

Index	Haptic Effect Description
0	No Effect
1	Strong Click
2	Strong Click at 60 percent strength
3	Strong Click at 30 percent strength
4	Sharp Click
5	Sharp Click at 60 percent strength
6	Sharp Click at 30 percent strength
7	Soft Bump
8	Soft Bump at 60 percent strength
9	Soft Bump at 30 percent strength
10	Double Click
11	Double Click at 60 percent strength
12	Triple Click
13	Soft Buzz
14	Strong Buzz

In system-wide implementations, the user-interface framework implements the haptic effect triggers. This implementation has the benefit of haptically-enabling common user-interface "widgets", like buttons and lists. The net result is that all applications immediately exhibit consistent haptic playback behavior. This implementation is beneficial for the rich operating environments found in many of today's electronic devices.

Two protocols are supported for communications between the haptic processor and the system processor: SPI and the GPIO pins on the haptic processor.

References

- AT42QT1085 Product Information – www.atmel.com/products/bsw/
- FAH4830 Datasheet – www.fairchildsemi.com/
- ERM Motors – www.precisionmicrodrives.com

Revision History

Version	Date	Comments
AX	May 2011	Initial release of document
BX	February 2013	New template Changed ERM driver device Changed supply voltage Changed ERM circuit

Notes

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