

EAP Braille Display Needs and Requirements

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The Boston-based National Braille Press has recently established a Center for Braille Innovation. Part of CBI's mission is to facilitate development of dramatically lower cost electronic braille display devices and the much-sought-after "Holy Braille" of a full-page braille display. Developing new braille technologies is key to improving the extremely low literacy rate (approximately 12%) of all blind students.

Our CBI team is working to aid developers of braille technology by focusing attention and resources on the development of the underlying braille actuator technologies. We are also developing braille-related resources to aid braille display developers. The following braille requirements summary is one of these efforts.

We feel that the exciting field of EAP technology has matured to the point where it can provide real solutions for braille displays. We welcome comments and feedback to anyone who wants to take part.

Most commercially available braille displays have a single line of 20 to 80 braille characters and cost several thousand US dollars. The OEM cost of commercially produced piezo-electric braille cells is stuck around US \$35 per cell, or \$4.38 per braille dot.

There is a need for an order of magnitude less expensive, small, one-line braille displays for education as well as for braille actuator technologies that can produce multiple-line or full-page braille displays.

Current Braille Display Technologies

Virtually all currently sold refreshable braille displays are built up from single-cell braille modules of 8 dots in two columns of 4 dots. Nearly all braille modules available today use piezoelectric ceramic bimorph reeds to actuate the braille dots. The piezo reeds are mounted as a stair stepped stack of cantilevers, each with a braille pin resting on its free end. Each reed can lift the dome top of its 1.5mm diameter braille pin approximately 0.5mm above the reading surface. As shown in Figure 1, a typical module has 4 layers of side-by-side pairs of reeds mounted horizontally, below and parallel to, the top reading surface. Figure 1 also shows the associated data latch and 200V driver circuitry required for, and integrated into, each braille cell

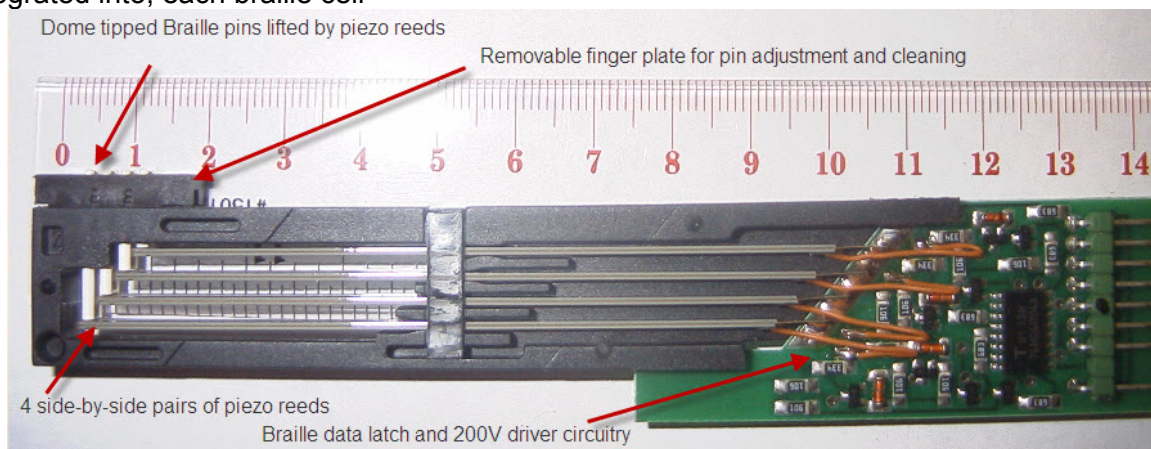


Figure 1. Typical Piezo Bimorph Braille Cell

module.

These modules are horizontally mounted next to each other in arbitrarily long lines (typically 20, 40, or 80 cells). It is possible to mount two of these lines together for a two-line display, but packaging size and cost limit most displays to a single line. These long, cantilevered piezo actuators can not be reasonably packaged into larger multiple-line displays because the footprint of each braille dot's actuator mechanism would need to be in the range of 2.5mm² or less.

Basic Specifications for Refreshable Braille Displays

Traditionally, the cells of embossed paper braille have had a format of six dots, arranged in two columns of three rows. A full page of braille typically has 25 lines of up to 40 cells per line.

Most modern paperless, or refreshable, braille displays have eight dots per cell, arranged in two columns of four rows and are limited to a single line of braille.

The refreshable braille displays that were originally manufactured in the USA had dot dimensions and spacings close to those of 6-dot embossed paper braille. European and Asian refreshable braille displays have employed the slightly larger braille dot spacing that is becoming the world standard for refreshable braille displays.

Specifications for Braille Dots

Refreshable braille specifications are evolving, so the values listed below are only an attempt to present a best fit to the current nominal "standards".

The tops of braille dots are generally domed, with a radius of curvature that is unspecified, but usually larger than the radius of the base of the dots.

Under loading such as the touch of the braille reader's finger, a dot should provide a minimum of 20 grams lifting force, while being depressed <0.1mm from its top height.

Generally, a raised dot should be supported with a force of >25 grams, and 30 grams (0.294 Newtons) or more is preferable.

Parameter	Minimum	Nominal	Maximum	Typical
Braille dot base diameter	1.4mm	1.5mm	1.6mm	1.5mm
Dot height (assuming no depression force from user's finger)	0.48mm	0.5mm	0.9mm	0.7mm
Dot Spacing				
Distance between centers of perpendicularly adjacent dots in the same cell	2.3mm	2.5mm	2.6mm	2.45mm
Distance between centers of corresponding dots in horizontally adjacent cells	6.1mm	6.35mm	6.5mm	6.42mm
Height of 6-dot braille cell lines	10mm	10.75mm	11.15mm	10.55mm
Height of 8-dot braille cell lines	12.25mm	13.25mm	13.75mm	13mm

Dot height uniformity for adjacent dots: ±0.05mm.

Minimum displacement below the reading surface of the top of an unraised dot: 0.025mm.

Braille line spacing, or height, is measured between the centers of a top dot of a cell and the dot in the corresponding position of a vertically adjacent cell.

A braille display might also be used as a tactile graphics display, if it has additional dots to fill in the gaps between lines of braille cells and the gaps between cells within each line of cells. For example,

the display might be an array of evenly spaced dots, with 2.5mm separation between the centers of all perpendicularly adjacent dots. However, braille text on such a display would not have the normal spacing between braille cells and might feel strange to some braille readers.

Displays to be used only for tactile graphics and not for braille text should have even smaller dot separation than normal braille dots (<2.3mm) and should have correspondingly smaller dot base diameters.

Other Functional Requirements for Braille Actuators

- Cell height: ≤30mm, especially for applications such as notetakers, PDAs, etc.
- Minimum dot setup time: 0.050 seconds desired for some applications.
- Minimum dot cycling rate: As high as 10 Hertz for most applications, but 1 Hz may be tolerable for some applications with limited interaction, such as continuous reading of long pages of text on multiple-line or full-page displays.
- Lifetime: 10^7 cycles for single-line displays and correspondingly less for larger, multiple-line or full-page displays that are updated less frequently.
- Operating voltage: Preferably <300V, for safety and electronic driver circuit requirements.
- Power consumption: Most applications call for battery power, but some of the full-page braille display applications may tolerate requirements for AC lines power.

Note: braille actuator technologies should not be ignored simply because they do not perfectly meet all the requirements listed above.

For more information, feel free to call or email me.

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