Applying technology in transportation


Technical Paper

Join the Resolution

A Guide to Specifying the Requirements of Full Matrix LED Displays.

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VMS
VARIABLE MESSAGE SIGNS

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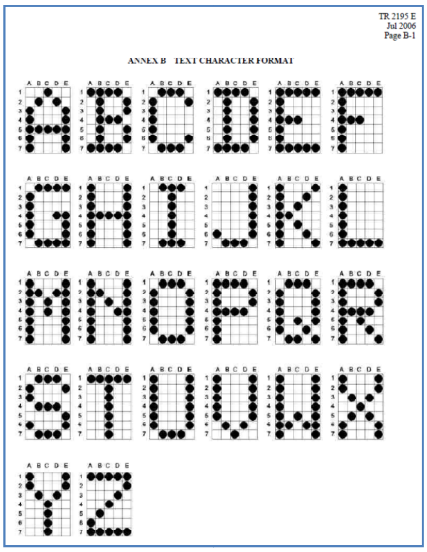
1. Summary

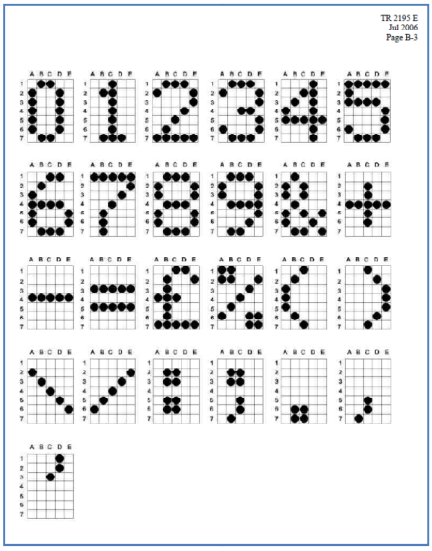
As roadside electronic displays have become more advanced over the last 15 years there has been a transition from signs which were limited to displaying simple upper case letters and numbers to more sophisticated full matrix displays, which can display a full range of alphanumeric symbols and graphics. These changes offer displays with greater flexibility and functionality, but can also provide customers with a bewildering range of options. This paper is intended to offer a guide to those who want to understand what type of display they really need for their application. The paper provides some background to the evolution of displays and the standards which are there to help. The paper also goes through some worked examples to illustrate how some simple calculations can be used to ensure that a display will meet the needs of the customer.

2. Background

2.1. Text Based Displays

For text based signs a standard font has been developed by the Highways Agency based on an array of 7 rows and 5 columns. The following figures are extracts from a Highways Agency specification for MS3 type signs.





This font offers the minimum requirements for a text based display system. Although there are fonts which use lower resolutions these can be very difficult to read and have not been approved for use on road applications.

2.2. What Character Height do I need?

The answer to this question is not as simple as you may have hoped and there are many factors which affect the result. Listed below are some of the factors which need to be taken into account when considering character height:

- **Visual Acuity** (See below)
- **Vehicle Approach speed** – The 85th percentile figure is usually used rather that the actual speed limit of the road.

- **Units of Information** – This is the amount of information the driver needs to understand in the time available to read the sign. A unit of information is a word or a pictogram or a simple code i.e. A1 J64 would be 1 unit of information.
- **Text Style / Font** – The type of text / Font used can have a significant effect on readability. Which is why, wherever possible, previously approved fonts should always be used. Mixed cased text is easier to read because the brain will used the shape of the words to aid our comprehension.
- **Display Optical Performance** – The design of the sign optical system will also affect legibility. A sign which is too bright in low ambient lighting conditions will cause the message to flare and be difficult to read. A sign with poor contrast ratio or poor uniformity will also make the message difficult to read. The optical performance criteria in the European Standard for Variable Message Signs EN 12966 helps to ensure that displays will have good legibility in all viewing conditions.
- **Read time** – The time available to read the message is clearly related to the vehicle approach speed. However other factors which can reduce the time available to the driver should also be considered:
    - Road Curvature
    - Obstructions – Bridges, Buildings, Trees etc..
    - High sided vehicles
    - Alternating or dual language messages

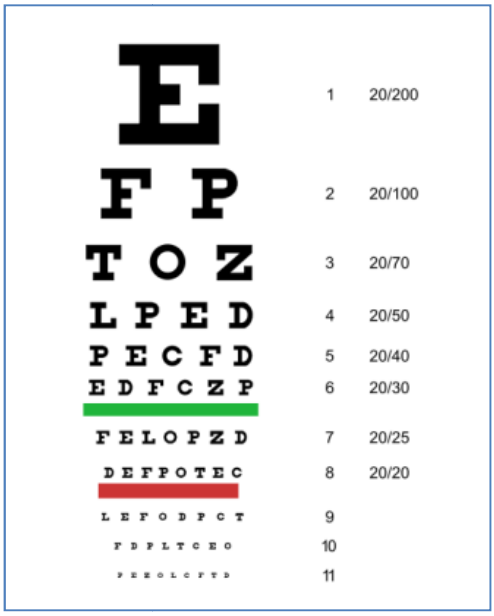
As a simple guide the following table can be used; which has been taken from Highways Agency specification TR2516. The information in this table is the result of years of experience of deployment of variable message signs and many viewing trials.

Size Range	85 Percentile Approach Speed (MPH)	Maximum Number Of Words In Message	Min Equivalent Character Height (mm)	Optical Performance Requirements
A	Up to and including 30	3	60	1 or 2
B	Up to and including 40	7	100	1 or 2
C	Up to and including 50	7	160	1 or 2
D	Up to and including 60	7	240	1
E1	Over 60	3	320	1
E2	Over 60	7 (#1)	320	1
F	Over 60	7	400	1

Table 3.3 - Class Selection

NOTE (#1): Messages up to 7 words may be displayed on 320mm character height signs, only if the same message is displayed on two consecutive signs.

2.3. What is Visual Acuity?



Visual Acuity is a measure of the ability of the human eye to resolve detail. In standard eye tests this is often recorded as a pair of numbers, i.e. 20/20 vision. The first number is the distance (in feet) between the subject and the chart and the second number relates to the size of the text (or actually the separation of the lines which make up a letter). The metric equivalent of 20/20 (Normal vision) is 6/6, i.e. at 6 meters a person can resolve details 1.75mm apart or 6 arc minutes. This equates to a character height of 10mm at 6 meters.

Visual Acuity provides us with a relationship between distance and minimum character height. For a person with 20/20 vision the relationship between distance (d in meters) and the minimum character height (h in millimetres) which can be read is:

$$d = 0.6 \times h$$

Although Visual Acuity provides us with a good guide to the capabilities of the human eye, care should be taken when applying this information to light emitting signs. As discussed previously there are many other factors which can influence the legibility of an outdoor light emitting sign. For LED signs, d = 0.7 x h, is often used as a rule of thumb, which reflects the improved legibility of a light emitting display.

3. Rules for Character and Line spacing

The illustration to the right shows the correct spacing, as defined in the European standard for Variable Message Signs EN 12966.

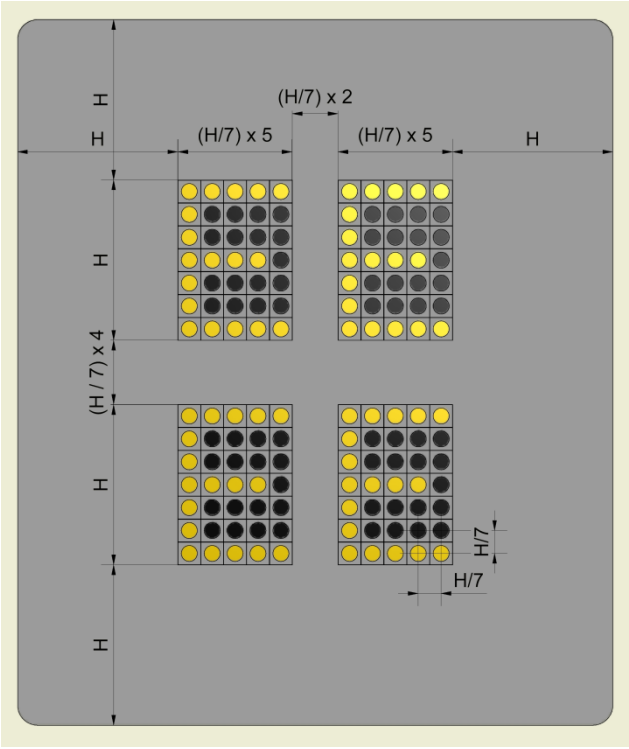
H is the character height.

The minimum character spacing is equal to 2/7 H.

The minimum line spacing is equal to 4/7 H.

The display cell (pixel) pitch is equal to 1/7 H for this basic font.

The illustration shows the basic 7x5 font, but the same proportions should be true for text of any resolution.



4. Why is the display resolution important?

With a full matrix display there are no separate characters, so it is important to understand what the capabilities of the display matrix will be:

- How many line and characters can be displayed?
- At which character heights
- Is the resolution sufficient to display pictograms / graphical symbols clearly

4.1. What happens if the display resolution is too low?

If the display resolution offered is too low this may mean it is impossible to display all the messages you want using the minimum font size and spacing. This will greatly restrict the use of the sign and may mean that the sign ultimately becomes unfit for purpose and needs to be replaced. If the sign is required to display pictograms and graphical symbols then the sign must have a high enough resolution to display these with sufficient detail to ensure legibility.

4.2. Why shouldn't I just buy the highest resolution display available?

By selecting the highest possible display resolution you are giving yourself the greatest flexibility however there can be some drawbacks. A high resolution will mean a display with a high density of electronics which can mean:

- Additional cost
- Impact on reliability
- Increased power consumption

5. The effect of different resolutions

If we consider the example of an urban variable message sign which must be able to display 4 Lines of 15 characters, with a character height of 160mm. We can calculate from the formula below that the sign must have the following parameters:

- 4 Lines of 160mm high characters
- 15 Characters per line
- Minimum number of columns = 103 Display Cells (pixels)
- Minimum number of Rows = 40 Display Cells (pixels)
- Lowest Resolution, Display Cell Pitch = 160mm / 7 = 22.86mm
- Overall Sign Width = 2,675mm
- Overall Sign Height = 1,235mm

Display Cell Pitch (mm)	*Display Resolution*	*Number of Display Cells*	*Maximum Text Display*	*Minimum Character Height*
22.86	103 x 40	4,120	4 Lines x 15 Characters	160mm
15.00	157 x 61	9,577	5 Lines x 22 Characters	105mm
10.00	236 x 92	21,712	8 Lines x 34 Characters	70mm
7.20	327 x 127	41,529	11 Lines x 46 Characters	50mm

High resolution will mean greater definition and clearer pictograms, but will also result in a greater density of electronics. Any resolution with a display cell (pixel) width greater than 22.86mm will result in a sign which is unable to display the required number of characters without some compromise which would impact legibility.

6. Some simple calculations

In this section we have listed some simple calculations which can be used determine key display parameters. An excel spreadsheet is available from Variable Message Signs Limited which can be used to perform these calculations and several other useful functions. This spreadsheet can be requested by sending an email to support@vmslimited.co.uk .

X = Number of Columns of display cells (pixels)

Y = Number of Rows of display cells (pixels)

C = Number of Characters per Line (any spaces in a message count as a character)

L = Number of Lines

P = Display Cell (pixel) Pitch (mm)

H = Character Height (mm)

W = Overall Sign Width (mm)

D = Overall Sign Height (mm)

T = Maximum read time

S = 85^{th} percentile speed (mph)

To calculate the minimum number of rows and columns of LEDs required to display a number of characters and Lines:

$$X = (C \times 5) + ((C - 1) \times 2)$$

$$Y = (L \times 7) + ((L - 1) \times 4)$$

To calculate the size of a sign:

$$W = (X \times P) + (H \times 2)$$

$$D = (Y \times P) + (H \times 2)$$

To calculate the maximum read time of a display:

$$T = (H \times 0.7) / (S \times 0.447)$$

7. Some worked Examples

7.1. Example 1

I need a car park sign in a congested urban area, which will provide information to drivers about 5 different car parks in the city centre.

The location where the sign is to be installed has an 85th percentile speed of 28mph.

Normally the sign will display 5 numbers, showing the number of spaces in each car park. This is 5 units of information but we must also consider that on a car park sign the driver will have other static information to read.

Since this sign has a very clearly defined role and is only required to display simple text and number it would not be appropriate to recommend a full matrix display.

From the information above we would recommend using 100mm high LED character modules. This gives legibility at upto 60m from the sign which at a road speed of 28mph. We know that at this location the sign can only be seen from a maximum distance of 40m due to the curvature of the road. From our 'simple calculation' section we work out that the maximum possible read time is:

$$T = 40 / (S * 0.447)$$

$$T = 40 / (28 * 0.447)$$

$$T = 3.2 \text{ seconds}$$

For a 100mm character the pitch required between the display cells (pixels) is 100 / 7 = 14.29mm

Therefore the solution for this application is to offer a sign with discrete characters, where each character is 100mm high and is comprised of a matrix of 7 rows and 5 columns.

7.2. Example 2

I need a multi-line sign in a congested urban area, which will provide information to drivers on 4 lines of 15 characters. The display is also required to display pictograms

The location where the sign is to be installed has an 85th percentile speed of 45mph.

Normally the sign will display up to 4 lines of 15 characters, giving advisory information to drivers.

From the information above we would recommend using 160mm high LED character modules. This gives legibility at up to 100m from the sign which at a road speed of 45mph. We know that at this location the sign can only be seen from a maximum distance of 70m due to the obstructions by the side of the road. From our 'simple calculation' section we work out that the maximum possible read time is:

$$T = 70 / (S * 0.447)$$

$$T = 70 / (45 * 0.447)$$

$$T = 3.5 \text{ seconds}$$

For a 160mm character the maximum pitch between the display cells (pixels) is:

$$160 / 7 = 22.85\text{mm}.$$

Using this spacing between the LEDs would result in an array of 103 x 40 display cells (pixels). Although this is adequate to display the basic text this would not allow mixed case fonts and would only support basic graphics and pictograms. For most traffic pictogram's the minimum resolution which can be used to produce a recognisable image is 32x32 display cells (pixels). However 64x64 will result in a much clearer image.

Therefore the minimum resolution we would offer for this application would be a 15mm, dual colour display. If the client wants to make extensive use of graphics and ensure maximum flexibility we would recommend a 10mm pitch to give a very fine resolution.

7.3. Example 3

I need a multi-line sign in a semi-urban dual carriageway, which will provide text and pictogram information to drivers.

The location where the sign is to be installed has an 85th percentile speed of 62mph.

Normally the sign will display up to 4 lines of 15 characters or full sign pictograms, giving advisory information to drivers.

Since this sign has a very clearly defined role and is required to display text and graphics it would be appropriate in this case to recommend a full matrix display.

From the information above we would recommend using 320mm high LED characters. This gives legibility at up to 220m from the sign which at a road speed of 62mph. We know that at this location the sign can be seen from a maximum distance of 220m, as there are no known obstructions. From our 'simple calculation' section we work out that the maximum possible read time is:

$$T = 220 / (S * 0.447)$$

$$T = 220 / (62 * 0.447)$$

$$T = 9.6 \text{ seconds}$$

For a 320mm character the pitch required between the display cells (pixels) is:

$$320 / 7 = 42.85\text{mm}$$

Using this spacing between the LEDs would result in an array of 103 x 40 display cells (pixels). Although this is adequate to display the basic text this would not allow mixed case fonts and would only support basic graphics and pictograms. For most traffic pictogram's the minimum resolution which can be used to produce a recognisable image is 32x32 display cells (pixels). However 64x64 will result in a much clearer image.

Therefore the minimum resolution we would offer for this application would be a 20mm, dual colour display. If the client wants to make extensive use of graphics and ensure maximum flexibility we would recommend a 15mm pitch to give a very fine resolution.