



# 54LS138/DM54LS138/DM74LS138, 54LS139/DM54LS139/DM74LS139 Decoders/Demultiplexers

## General Description

These Schottky-clamped circuits are designed to be used in high-performance memory-decoding or data-routing applications, requiring very short propagation delay times. In high-performance memory systems these decoders can be used to minimize the effects of system decoding. When used with high-speed memories, the delay times of these decoders are usually less than the typical access time of the memory. This means that the effective system delay introduced by the decoder is negligible.

The LS138 decodes one-of-eight lines, based upon the conditions at the three binary select inputs and the three enable inputs. Two active-low and one active-high enable inputs reduce the need for external gates or inverters when expanding. A 24-line decoder can be implemented with no external inverters, and a 32-line decoder requires only one inverter. An enable input can be used as a data input for demultiplexing applications.

The LS139 comprises two separate two-line-to-four-line decoders in a single package. The active-low enable input can be used as a data line in demultiplexing applications.

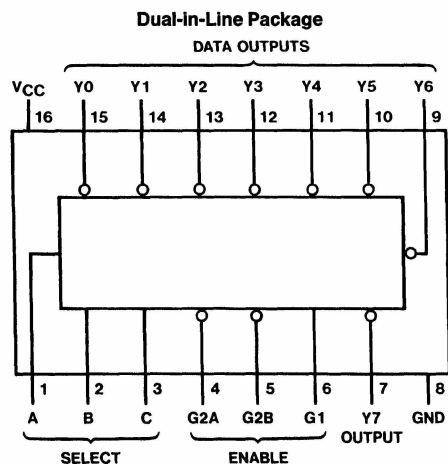
All of these decoders/demultiplexers feature fully buffered inputs, presenting only one normalized load to its driving circuit. All inputs are clamped with high-performance

Schottky diodes to suppress line-ringing and simplify system design.

## Features

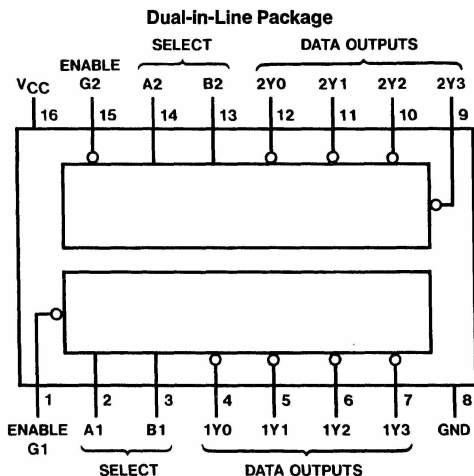
- Designed specifically for high speed:
  - Memory decoders
  - Data transmission systems
- LS138 3-to-8-line decoders incorporates 3 enable inputs to simplify cascading and/or data reception
- LS139 contains two fully independent 2-to-4-line decoders/demultiplexers
- Schottky clamped for high performance
- Typical propagation delay (3 levels of logic)
  - LS138 21 ns
  - LS139 21 ns
- Typical power dissipation
  - LS138 32 mW
  - LS139 34 mW
- Alternate Military/Aerospace devices (54LS138, 54LS139) are available. Contact a National Semiconductor Sales Office/Distributor for specifications.

## Connection Diagrams



TL/F/6391-1

Order Number 54LS138DMQB, 54LS138FMQB,  
54LS138LMQB, DM54LS138J, DM54LS138W,  
DM74LS138M or DM74LS138N  
See NS Package Number E20A, J16A,  
M16A, N16E or W16A



TL/F/6391-2

Order Number 54LS139DMQB, 54LS139FMQB,  
54LS139LMQB, DM54LS139J, DM54LS139W,  
DM74LS139M or DM74LS139N  
See NS Package Number E20A, J16A,  
M16A, N16E or W16A

## Absolute Maximum Ratings (Note)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

|                                      |                 |
|--------------------------------------|-----------------|
| Supply Voltage                       | 7V              |
| Input Voltage                        | 7V              |
| Operating Free Air Temperature Range | –55°C to +125°C |
| DM54LS and 54LS                      |                 |
| DM74LS                               | 0°C to +70°C    |
| Storage Temperature Range            | –65°C to +150°C |

Note: The "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. The device should not be operated at these limits. The parametric values defined in the "Electrical Characteristics" table are not guaranteed at the absolute maximum ratings. The "Recommended Operating Conditions" table will define the conditions for actual device operation.

## Recommended Operating Conditions

| Symbol   | Parameter                      | DM54LS138 |     |      | DM74LS138 |     |      | Units |
|----------|--------------------------------|-----------|-----|------|-----------|-----|------|-------|
|          |                                | Min       | Nom | Max  | Min       | Nom | Max  |       |
| $V_{CC}$ | Supply Voltage                 | 4.5       | 5   | 5.5  | 4.75      | 5   | 5.25 | V     |
| $V_{IH}$ | High Level Input Voltage       | 2         |     |      | 2         |     |      | V     |
| $V_{IL}$ | Low Level Input Voltage        |           |     | 0.7  |           |     | 0.8  | V     |
| $I_{OH}$ | High Level Output Current      |           |     | –0.4 |           |     | –0.4 | mA    |
| $I_{OL}$ | Low Level Output Current       |           |     | 4    |           |     | 8    | mA    |
| $T_A$    | Free Air Operating Temperature | –55       |     | 125  | 0         |     | 70   | °C    |

## 'LS138 Electrical Characteristics

over recommended operating free air temperature range (unless otherwise noted)

| Symbol   | Parameter                         | Conditions                                                                           | Min  | Typ<br>(Note 1) | Max   | Units         |
|----------|-----------------------------------|--------------------------------------------------------------------------------------|------|-----------------|-------|---------------|
| $V_I$    | Input Clamp Voltage               | $V_{CC} = \text{Min}, I_I = -18 \text{ mA}$                                          |      |                 | –1.5  | V             |
| $V_{OH}$ | High Level Output Voltage         | $V_{CC} = \text{Min}, I_{OH} = \text{Max}, V_{IL} = \text{Max}, V_{IH} = \text{Min}$ | DM54 | 2.5             | 3.4   | V             |
|          |                                   |                                                                                      | DM74 | 2.7             | 3.4   |               |
| $V_{OL}$ | Low Level Output Voltage          | $V_{CC} = \text{Min}, I_{OL} = \text{Max}, V_{IL} = \text{Max}, V_{IH} = \text{Min}$ | DM54 |                 | 0.25  | V             |
|          |                                   |                                                                                      | DM74 |                 | 0.35  |               |
|          |                                   | $I_{OL} = 4 \text{ mA}, V_{CC} = \text{Min}$                                         | DM74 |                 | 0.25  |               |
| $I_I$    | Input Current @ Max Input Voltage | $V_{CC} = \text{Max}, V_I = 7V$                                                      |      |                 | 0.1   | mA            |
| $I_{IH}$ | High Level Input Current          | $V_{CC} = \text{Max}, V_I = 2.7V$                                                    |      |                 | 20    | $\mu\text{A}$ |
| $I_{IL}$ | Low Level Input Current           | $V_{CC} = \text{Max}, V_I = 0.4V$                                                    |      |                 | –0.36 | mA            |
| $I_{OS}$ | Short Circuit Output Current      | $V_{CC} = \text{Max}$<br>(Note 2)                                                    | DM54 | –20             | –100  | mA            |
|          |                                   |                                                                                      | DM74 | –20             | –100  |               |
| $I_{CC}$ | Supply Current                    | $V_{CC} = \text{Max}$ (Note 3)                                                       |      | 6.3             | 10    | mA            |

Note 1: All typicals are at  $V_{CC} = 5V, T_A = 25^\circ\text{C}$ .

Note 2: Not more than one output should be shorted at a time, and the duration should not exceed one second.

Note 3:  $I_{CC}$  is measured with all outputs enabled and open.

**'LS138 Switching Characteristics**at  $V_{CC} = 5V$  and  $T_A = 25^\circ C$  (See Section 1 for Test Waveforms and Output Load)

| Symbol    | Parameter                                          | From (Input)<br>To (Output) | Levels<br>of Delay | $R_L = 2\text{ k}\Omega$ |     |                      |     | Units |
|-----------|----------------------------------------------------|-----------------------------|--------------------|--------------------------|-----|----------------------|-----|-------|
|           |                                                    |                             |                    | $C_L = 15\text{ pF}$     |     | $C_L = 50\text{ pF}$ |     |       |
|           |                                                    |                             |                    | Min                      | Max | Min                  | Max |       |
| $t_{PLH}$ | Propagation Delay Time<br>Low to High Level Output | Select to<br>Output         | 2                  |                          | 18  |                      | 27  | ns    |
| $t_{PHL}$ | Propagation Delay Time<br>High to Low Level Output | Select to<br>Output         | 2                  |                          | 27  |                      | 40  | ns    |
| $t_{PLH}$ | Propagation Delay Time<br>Low to High Level Output | Select to<br>Output         | 3                  |                          | 18  |                      | 27  | ns    |
| $t_{PHL}$ | Propagation Delay Time<br>High to Low Level Output | Select to<br>Output         | 3                  |                          | 27  |                      | 40  | ns    |
| $t_{PLH}$ | Propagation Delay Time<br>Low to High Level Output | Enable to<br>Output         | 2                  |                          | 18  |                      | 27  | ns    |
| $t_{PHL}$ | Propagation Delay Time<br>High to Low Level Output | Enable to<br>Output         | 2                  |                          | 24  |                      | 40  | ns    |
| $t_{PLH}$ | Propagation Delay Time<br>Low to High Level Output | Enable to<br>Output         | 3                  |                          | 18  |                      | 27  | ns    |
| $t_{PHL}$ | Propagation Delay Time<br>High to Low Level Output | Enable to<br>Output         | 3                  |                          | 28  |                      | 40  | ns    |

**Recommended Operating Conditions**

| Symbol   | Parameter                      | DM54LS139 |     |      | DM74LS139 |     |      | Units      |
|----------|--------------------------------|-----------|-----|------|-----------|-----|------|------------|
|          |                                | Min       | Nom | Max  | Min       | Nom | Max  |            |
| $V_{CC}$ | Supply Voltage                 | 4.5       | 5   | 5.5  | 4.75      | 5   | 5.25 | V          |
| $V_{IH}$ | High Level Input Voltage       | 2         |     |      | 2         |     |      | V          |
| $V_{IL}$ | Low Level Input Voltage        |           |     | 0.7  |           |     | 0.8  | V          |
| $I_{OH}$ | High Level Output Current      |           |     | -0.4 |           |     | -0.4 | mA         |
| $I_{OL}$ | Low Level Output Current       |           |     | 4    |           |     | 8    | mA         |
| $T_A$    | Free Air Operating Temperature | -55       |     | 125  | 0         |     | 70   | $^\circ C$ |

**'LS139 Electrical Characteristics**

over recommended operating free air temperature range (unless otherwise noted)

| Symbol   | Parameter                         | Conditions                                                                           | Min  | Typ<br>(Note 1) | Max   | Units         |
|----------|-----------------------------------|--------------------------------------------------------------------------------------|------|-----------------|-------|---------------|
| $V_I$    | Input Clamp Voltage               | $V_{CC} = \text{Min}, I_I = -18 \text{ mA}$                                          |      |                 | -1.5  | V             |
| $V_{OH}$ | High Level Output Voltage         | $V_{CC} = \text{Min}, I_{OH} = \text{Max}, V_{IL} = \text{Max}, V_{IH} = \text{Min}$ | DM54 | 2.5             | 3.4   | V             |
|          |                                   |                                                                                      | DM74 | 2.7             | 3.4   |               |
| $V_{OL}$ | Low Level Output Voltage          | $V_{CC} = \text{Min}, I_{OL} = \text{Max}, V_{IL} = \text{Max}, V_{IH} = \text{Min}$ | DM54 | 0.25            | 0.4   | V             |
|          |                                   |                                                                                      | DM74 | 0.35            | 0.5   |               |
|          |                                   | $I_{OL} = 4 \text{ mA}, V_{CC} = \text{Min}$                                         | DM74 | 0.25            | 0.4   |               |
| $I_I$    | Input Current @ Max Input Voltage | $V_{CC} = \text{Max}, V_I = 7 \text{ V}$                                             |      |                 | 0.1   | mA            |
| $I_{IH}$ | High Level Input Current          | $V_{CC} = \text{Max}, V_I = 2.7 \text{ V}$                                           |      |                 | 20    | $\mu\text{A}$ |
| $I_{IL}$ | Low Level Input Current           | $V_{CC} = \text{Max}, V_I = 0.4 \text{ V}$                                           |      |                 | -0.36 | mA            |
| $I_{OS}$ | Short Circuit Output Current      | $V_{CC} = \text{Max}$<br>(Note 2)                                                    | DM54 | -20             | -100  | mA            |
|          |                                   |                                                                                      | DM74 | -20             | -100  |               |
| $I_{CC}$ | Supply Current                    | $V_{CC} = \text{Max}$ (Note 3)                                                       |      | 6.8             | 11    | mA            |

**Note 1:** All typicals are at  $V_{CC} = 5 \text{ V}$ ,  $T_A = 25^\circ\text{C}$ .**Note 2:** Not more than one output should be shorted at a time, and the duration should not exceed one second.**Note 3:**  $I_{CC}$  is measured with all outputs enabled and open.**'LS139 Switching Characteristics**at  $V_{CC} = 5 \text{ V}$  and  $T_A = 25^\circ\text{C}$  (See Section 1 for Test Waveforms and Output Load)

| Symbol           | Parameter                                          | From (Input)<br>To (Output) | R <sub>L</sub> = 2 kΩ  |     |                        |     | Units |
|------------------|----------------------------------------------------|-----------------------------|------------------------|-----|------------------------|-----|-------|
|                  |                                                    |                             | C <sub>L</sub> = 15 pF |     | C <sub>L</sub> = 50 pF |     |       |
|                  |                                                    |                             | Min                    | Max | Min                    | Max |       |
| t <sub>PLH</sub> | Propagation Delay Time<br>Low to High Level Output | Select to<br>Output         |                        | 18  |                        | 27  | ns    |
| t <sub>PHL</sub> | Propagation Delay Time<br>High to Low Level Output | Select to<br>Output         |                        | 27  |                        | 40  | ns    |
| t <sub>PLH</sub> | Propagation Delay Time<br>Low to High Level Output | Enable to<br>Output         |                        | 18  |                        | 27  | ns    |
| t <sub>PHL</sub> | Propagation Delay Time<br>High to Low Level Output | Enable to<br>Output         |                        | 24  |                        | 40  | ns    |

**Function Tables**

LS138

| Inputs |        |   | Outputs |   |    |    |    |    |    |    |    |    |
|--------|--------|---|---------|---|----|----|----|----|----|----|----|----|
| Enable | Select |   |         |   |    |    |    |    |    |    |    |    |
| G1     | G2*    | C | B       | A | Y0 | Y1 | Y2 | Y3 | Y4 | Y5 | Y6 | Y7 |
| X      | H      | X | X       | X | H  | H  | H  | H  | H  | H  | H  | H  |
| L      | X      | X | X       | X | H  | H  | H  | H  | H  | H  | H  | H  |
| H      | L      | L | L       | L | L  | H  | H  | H  | H  | H  | H  | H  |
| H      | L      | L | L       | H | H  | L  | H  | H  | H  | H  | H  | H  |
| H      | L      | L | H       | L | H  | H  | L  | H  | H  | H  | H  | H  |
| H      | L      | L | H       | H | H  | H  | L  | H  | H  | H  | H  | H  |
| H      | L      | H | L       | L | H  | H  | H  | H  | L  | H  | H  | H  |
| H      | L      | H | L       | H | H  | H  | H  | H  | H  | L  | H  | H  |
| H      | L      | H | H       | L | H  | H  | H  | H  | H  | H  | L  | H  |
| H      | L      | H | H       | H | H  | H  | H  | H  | H  | H  | H  | L  |

\*  $G2 = G2A + G2B$ 

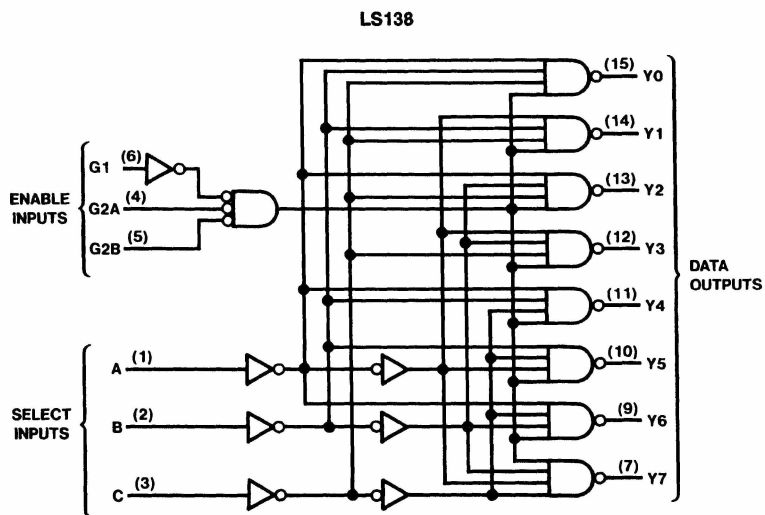
H = High Level, L = Low Level, X = Don't Care

LS139

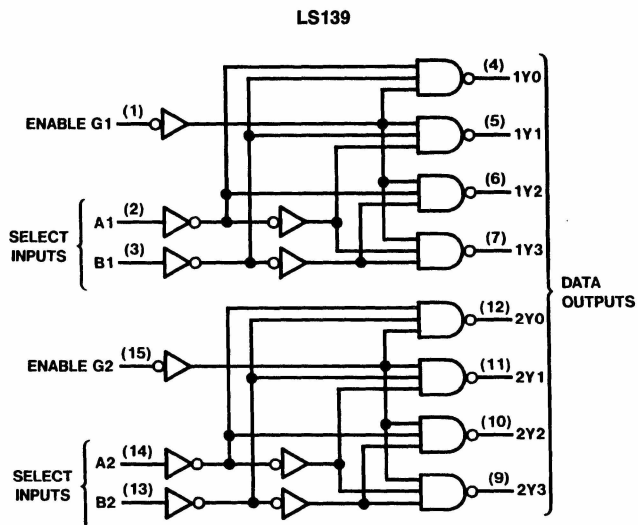
| Inputs |        |   | Outputs |    |    |    |
|--------|--------|---|---------|----|----|----|
| Enable | Select |   |         |    |    |    |
| G      | B      | A | Y0      | Y1 | Y2 | Y3 |
| H      | X      | X | H       | H  | H  | H  |
| L      | L      | L | L       | H  | H  | H  |
| L      | L      | H | H       | L  | H  | H  |
| L      | H      | L | H       | H  | L  | H  |
| L      | H      | H | H       | H  | H  | L  |

H = High Level, L = Low Level, X = Don't Care

## Logic Diagrams



TL/F/6391-3



TL/F/6391-4