IC OUTPUTS
– TERMS & DEFINITIONS

These terms and their definitions are taken from EIA/JEDEC Standard No. 99-A, *Terms, Definitions, and Letter Symbols for Microelectronic Devices*, clause 2.2.6, Types of Outputs.

All the outputs described here can be categorized as either bipolar or unipolar. Figures 1 and 2 show the hierarchy in these two families. A given output can be described using any of the names that apply to it; care should be exercised to select the most descriptive name considering its construction and application.
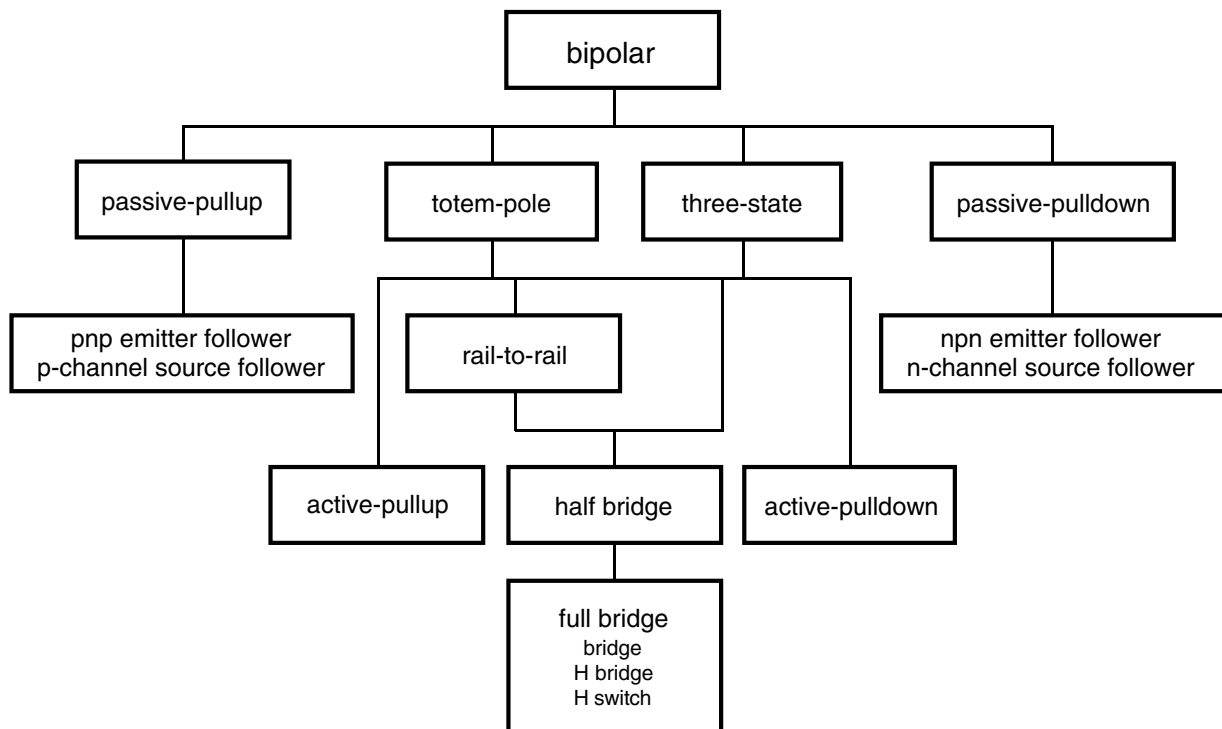
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                                    bipolar

    passive-pullup      totem-pole      three-state      passive-pulldown

   pnp emitter follower                                  npn emitter follower
  p-channel source follower   rail-to-rail              n-channel source follower

              active-pullup    half bridge    active-pulldown

                               full bridge
                                 bridge
                                 H bridge
                                 H switch
```

Figure 1 — Hierarchy of bipolar outputs

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┌─────────────────────┐
│      unipolar        │
└─────────────────────┘
┌─────────────────────┐
│     open-circuit     │
│     open-element     │
└─────────────────────┘
     ┌──────────────┐          ┌──────────────┐
     │  sink driver │          │ source driver│
     └──────────────┘          └──────────────┘
     ┌──────────────┐          ┌──────────────┐
     │low-side driver│         │high-side driver│
     └──────────────┘          └──────────────┘
┌─────────────────────┐   ┌─────────────────────┐
│  pnp open-emitter   │   │  npn open-emitter   │
│  pnp emitter follower│  │  npn emitter follower│
│  npn open-collector │   │  pnp open-collector │
│ p-channel open-source│  │ n-channel open-source│
│p-channel source follower│ n-channel source follower│
│ n-channel open-drain│   │ p-channel open-drain│
└─────────────────────┘   └─────────────────────┘
           ┌─────────────────────┐
           │      push-pull       │
           └─────────────────────┘
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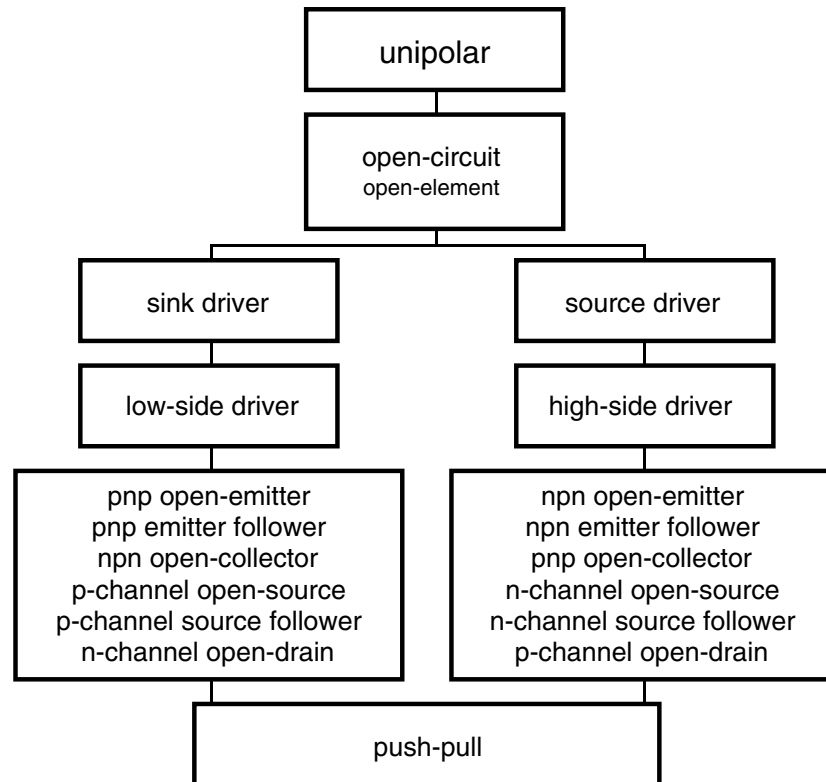
Figure 2 — Hierarchy of unipolar outputs

active-pulldown output: A bipolar (three-state or totem-pole) output whose source-current capability significantly exceeds its sink-current capability.

active-pullup output: A bipolar (three-state or totem-pole) output whose sink-current capability significantly exceeds its source-current capability.

bipolar output: An output having internal connections through two active devices to two supply voltages so that, according to the relative states of the active devices, the output can source or sink current through the load.

> NOTE — A bipolar output can also be a three-state output; i.e., it can be switched into a high-impedance state to both supply voltages simultaneously.

bridge (output): Synonym for "full-bridge (output)".

emitter follower: An output circuit whose output load is connected in the emitter circuit of a transistor and whose input is applied between the base and the remote end of the emitter load, which may be at ground potential.

> NOTE — The term "emitter follower", as applied to linear circuits, usually refers to passive-pulldown or passive-pullup (bipolar) outputs; as applied to emitter-coupled logic (ECL) circuits, to open-emitter (unipolar) outputs.

full-bridge (output): Two half-bridge outputs with the load connected between them.

> NOTE — The outputs are normally operated in a complementary fashion, i.e., as one output goes high, the other goes low. If one or both outputs are three-state outputs or if the operation is not complementary, the load current can be turned off.

half-bridge (output): A bipolar (three-state or totem-pole) power-driver output.

H bridge: Synonym for "full-bridge (output)".

high-side driver: A source driver whose primary connection within the integrated circuit is through an active device to a positive supply voltage.

H switch: Synonym for "full-bridge (output)".

> NOTE — The term "H switch" is usually applied to forward-off-reverse switching (using one or two three-state outputs) or forward-reverse switching applications.

low-side driver: A sink driver whose primary connection within the integrated circuit is through an active device to the circuit common.

open-circuit output (of an integrated circuit): A unipolar output whose only connection within the integrated circuit is through an active device, usually a transistor, to one of the supply voltages.

> NOTES
>
> 1 For the purpose of this definition, the presence of any parasitic components and freewheeling, flyback, and clamp diodes is ignored.
>
> 2 When the active device is in its on state, the output voltage approaches the voltage of the supply to which it is connected (through the active device); when the device is in its off state, the output impedance to any other terminal of the integrated circuit is high and the output voltage is determined by the external circuit to which the output is connected.
>
> 3 Outputs of this generic class are usually classified according to the name of the element of the active device to which they are connected within the integrated circuit, e.g., open-collector output, open-drain output, etc.
>
> 4 For graphic symbols, see "sink driver" and "source driver".

open-collector output: An open-circuit output whose internal connection is to the collector of a bipolar transistor.

> NOTE — For graphic symbols, see "sink driver" (for npn) or "source driver" (for pnp).
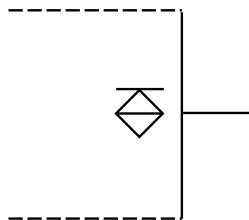
open-drain output: An open-circuit output whose internal connection is to the drain of a field-effect transistor.

> NOTE — For graphic symbols, see "sink driver" (for n-channel outputs) or "source driver" (for p-channel outputs).

open-element output (of an integrated circuit): Synonym for "open-circuit output (of an integrated circuit)".

open-emitter output: An open-circuit output whose internal connection is to the emitter of a bipolar transistor.

> NOTE — For graphic symbols, see "source driver" (for npn) or "sink driver" (for pnp).

open-source output: An open-circuit output whose internal connection is to the source of a field-effect transistor.

> NOTE — For graphic symbols, see "source driver" (for n channel) or "sink driver" (for p channel).

passive-pulldown output: An output similar to an open-circuit output except that, in addition to having an internal connection through an active device to a supply voltage, it also has an internal connection through a passive device, usually a resistor, to a second supply voltage that is more negative (less positive) than the first supply voltage.

> NOTE — According to the state of the active device, the output voltage can swing between levels approaching the two supply voltages.

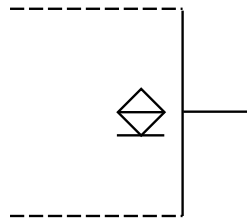> Graphic symbol (ref. ANSI/IEEE Std 91 and IEC 617-12):

> NOTE — The bar above the diamond indicates that the output is at the high logic level when the active device is in its on state.

passive-pullup output: An output similar to an open-circuit output except that, in addition to having an internal connection through an active device to a supply voltage, it also has an internal connection through a passive device, usually a resistor, to a second supply voltage that is more positive (less negative) than the first supply voltage.

NOTE — According to the state of the active device, the output voltage can swing between levels approaching the two supply voltages.

Graphic symbol (ref. ANSI/IEEE Std 91 and IEC 617-12):

NOTE — The bar below the diamond indicates that the output is at the low logic level when the active device is in its on state.

push-pull output: 1) Two open-circuit outputs operating in complementary fashion so that as the resistance of one increases, the resistance of the other decreases.
2) Originally a synonym for "totem-pole output"; this usage is now deprecated.

NOTE — The term "push-pull output" is usually applied only to linear circuits.

rail-to-rail driver: A bipolar (three-state or totem-pole) output that can swing between voltage levels that are essentially equal to the supply voltages.

NOTE — This is typically accomplished by driving the active devices from boost voltages or charge pumps.
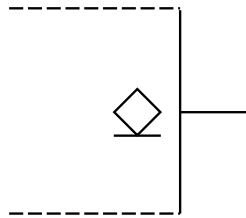
sink driver, (current-): A unipolar output whose primary connection within the integrated circuit is through an active device to the least positive (most negative) supply voltage (typically the circuit common).

NOTES

1 When the active device is in its on state, the output voltage approaches the voltage of the supply to which it is connected by the active device; when the device is in its off state, the output is pulled up to the most positive (least negative) supply voltage through the external circuit to which the output is connected.

2 Examples of sink drivers are npn open-collector, pnp emitter-follower, pnp open-emitter, n-channel open-drain, p-channel open-source, and p-channel source-follower outputs.

Graphic symbol (ref. ANSI/IEEE Std 91 and IEC 617-12):

NOTE — The bar below the diamond indicates that the output is at the low logic level when the device is in its on state.

source driver, (current-): A unipolar output whose primary connection within the integrated circuit is through an active device to the most positive (least negative) supply voltage.

NOTES

1 When the active device is in its on state, the output voltage approaches the voltage of the supply to which it is connected by the active device; when the device is in its off state, the output is pulled down to the least positive (most negative) supply voltage through the external circuit to which the output is connected.

2 Examples of source drivers are pnp open-collector, npn emitter-follower, npn open-emitter, p-channel open-drain, n-channel open-source, and n-channel source-follower outputs.
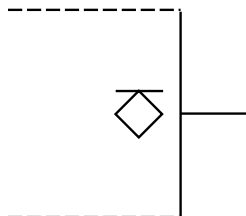
Graphic symbol (ref. ANSI/IEEE Std 91 and IEC 617-12):

NOTE — The bar above the diamond indicates that the output is at the high logic level when the device is in its on state.

source follower: An output circuit whose output load is connected in the source circuit of a field-effect transistor and whose input is applied between the gate and the remote end of the source load, which may be at ground potential.

> NOTE — The term "source follower", as applied to linear circuits, usually refers to passive-pulldown or passive-pullup (bipolar) outputs; as applied to logic circuits, to open-source (unipolar) outputs.

three-state output: A bipolar output both of whose active devices can be caused to be in the off state at the same time, thus presenting a high-impedance state at the output similar to the off state of an open-circuit output.

> NOTE — When the active devices are not in their simultaneous off states, the output acts like a totem-pole output.

> Graphic symbol (ref. ANSI/IEEE Std 91 and IEC 617-12):
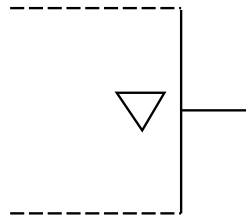
totem-pole output: A bipolar output whose active devices are so controlled that as the resistance of one increases, the resistance of the other decreases so that, according to the relative states of the two active devices, the output voltage can swing between levels approaching the two supply voltages.

> NOTES

> 1 The term "totem-pole output", as commonly used, does not include three-state outputs.

> 2 No standard qualifying symbol, as part of a graphic symbol, exists to designate the totem-pole output. In ANSI/IEEE Std 91 and IEC 617-12 these outputs are identified by the absence of the qualifying symbol.

unipolar output: An output that, depending on its design, can either source or sink current, but not both.

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