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Guide sheet for handling the Hardware components of embedded Projects

Document Presented To:

BGSW Apprenticeship Program

Contents

1 Electrical Specifications for Components

In embedded systems, handling electronic components with care and understanding their specifications is crucial to prevent damage, ensure safety, and guarantee that the final project works as intended. This guide provides detailed instructions on safely managing and handling various electronic components, focusing on electrical specifications, safety precautions, and best practices.

Each electronic component has specific electrical characteristics that need to be followed to prevent malfunction or damage. Below are common parameters, including how they impact the component's functionality and lifespan.

1.1 Power-Supply Voltage

Definition: The voltage supplied to a component for proper operation.

Importance: Providing the correct power-supply voltage is essential for optimal functioning. Supplying voltage above or below the rated voltage can cause overheating, reduced efficiency, or permanent damage.

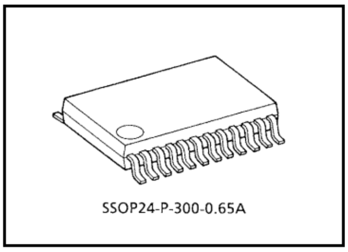
Recommended Handling: Always verify the voltage rating before connecting to a power source. Use a regulated power supply or appropriate voltage regulators.

Driver IC for Dual DC motor

TB6612FNG is a driver IC for DC motor with output transistor in LD MOS structure with low ON-resistor. Two input signals, IN1 and IN2, can choose one of four modes such as CW, CCW, short brake, and stop mode.

Features

- Power supply voltage ; VM=15V (Max.)
- Output current ; Iout=1.2A(ave) / 3.2A (peak)
- Output low ON resistor ; 0.5Ω (upper+lower Typ. @VM≧5V)
- Standby (Power save) system
- CW/CCW/short brake/stop function modes
- Built-in thermal shutdown circuit and low voltage detecting circuit
- Small faced package (SSOP24 : 0.65mm Lead pitch)
- Response to Pb free packaging



質量: 0.14 g (標準)

1.2 Supply Current

Definition: The amount of current a component draws during operation.

Importance: Overcurrent can cause excessive heating and potential damage to the component. Components with low current ratings (e.g., sensors) can be permanently damaged by excessive current.

Recommended Handling: Ensure current limits are respected and use fuse protection or current-limiting devices in the circuit..

Electrical Characteristics

(V_{DD} = 1.8V, V_{LED+} = 5.0V, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
POWER SUPPLY						
Power-Supply Voltage	V_{DD}	Guaranteed by RED and IR count tolerance	1.7	1.8	2.0	V
LED Supply Voltage V_{LED+} to PGND	V_{LED+}	Guaranteed by PSRR of LED driver	3.1	3.3	5.0	V
Supply Current	I_{DD}	SpO_2 and HR mode, PW = 215μs, 50sps		600	1200	μA
		IR only mode, PW = 215μS, 50sps		600	1200	
Supply Current in Shutdown	I_{SHDN}	T_A = +25°C, MODE = 0x80		0.7	10	μA

1.3 Input High Voltage (VIH)

Definition: The minimum voltage level recognized as a logical "high" state.

Importance: If the input voltage is lower than VIH, the component might not register a "high" signal and behave erratically.

Recommended Handling: Ensure that the signal voltage is sufficiently above the VIH rating to avoid signal misinterpretation. Use level shifters if necessary.

Electrical Characteristics (unless otherwise specified, Ta = 25°C, V_{cc}=3V, VM=5V)

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Supply current	Icc(3V)	STBY=Vcc=3V, VM=5V	---	1.1	(1.8)	mA
	Icc(5.5V)	STBY=Vcc=5.5V, VM=5V	---	1.5	2.2	
	Icc(STB)	STBY=0V	---	---	1	μA
	IM(STB)		---	---	1	
Control input voltage	VIH		Vcc×0.7	---	Vcc+0.2	V
	VIL		-0.2	---	Vcc×0.3	
Control input current	IIH	VIN=3V	5	15	25	μA
	IIL	VIN=0V	---	---	1	
Standby input voltage	VIH(STB)		Vcc×0.7	---	Vcc+0.2	V
	VIL(STB)		-0.2	---	Vcc×0.3	
Standby input current	IIH(STB)	VIN=3V	5	15	25	μA
	IIL(STB)	VIN=0V	---	---	1	
Output saturating voltage	Vsat(U+L)1	Io=1A,Vcc=VM=5V	---	0.5	(0.7)	V
	Vsat(U+L)2	Io=0.3A,Vcc=VM=5V		0.15	(0.21)	

1.4 Input Low Voltage (VIL)

Definition: The maximum voltage level recognized as a logical "low" state.

Importance: If the input voltage is higher than VIL, the component may falsely interpret the signal as "high."

Recommended Handling: Ensure that input signals are kept below the VIL threshold when they should be logical "low."

Electrical Characteristics (unless otherwise specified, Ta = 25°C, V_{CC}=3V, VM=5V)

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Supply current	Icc(3V)	STBY=Vcc=3V, VM=5V	---	1.1	(1.8)	mA
	Icc(5.5V)	STBY=Vcc=5.5V, VM=5V	---	1.5	2.2	
	Icc(STB)	STBY=0V	---	---	1	μA
	IM(STB)		---	---	1	
Control input voltage	VIH		Vcc×0.7	---	Vcc+0.2	V
	VIL		-0.2	---	Vcc×0.3	
Control input current	IIH	VIN=3V	5	15	25	μA
	IIL	VIN=0V	---	---	1	
Standby input voltage	VIH(STB)		Vcc×0.7	---	Vcc+0.2	V
	VIL(STB)		-0.2	---	Vcc×0.3	
Standby input current	IIH(STB)	VIN=3V	5	15	25	μA
	IIL(STB)	VIN=0V	---	---	1	
Output saturating voltage	Vsat(U+L)1	Io=1A,Vcc=VM=5V	---	0.5	(0.7)	V
	Vsat(U+L)2	Io=0.3A,Vcc=VM=5V		0.15	(0.21)	

1.5 Output High Voltage (VOH)

Definition: The minimum output voltage for a logical "high" state.

Importance: VOH ensures that connected components properly interpret the output as "high." If the voltage is too low, connected devices might misinterpret the signal.

Recommended Handling: Ensure that the component output matches the voltage requirements of the receiving device (e.g., microcontroller, other sensors).

RECOMMENDED DC OPERATING CONDITIONS

(T_A = 0°C to +70°C or T_A = -40°C to +85°C.) (Note 1)

PARAMETER	SYMBOL		CONDITIONS	MIN	TYP	MAX	UNITS
Supply Voltage V_{CC1}, V_{CC2}	V_{CC1}, V_{CC2}		(Notes 2, 10)	2.0	3.3	5.5	V
Logic 1 Input	V_{IH}		(Note 2)	2.0		V_{CC} + 0.3	V
Logic 0 Input	V_{IL}	V_{CC} = 2.0V	(Note 2)	-0.3		+0.3	V
		V_{CC} = 5V		-0.3		+0.8	

DC ELECTRICAL CHARACTERISTICS

(T_A = 0°C to +70°C or T_A = -40°C to +85°C.) (Note 1)

PARAMETER	SYMBOL		CONDITIONS	MIN	TYP	MAX	UNITS
Input Leakage	I_{LI}		(Notes 5, 13)		85	500	μA
I/O Leakage	I_{LO}		(Notes 5, 13)		85	500	μA
Logic 1 Output (I_{OH} = -0.4mA)	V_{OH}	V_{CC} = 2.0V	(Note 2)	1.6			V
Logic 1 Output (I_{OH} = -1.0mA)		V_{CC} = 5V		2.4			
Logic 0 Output (I_{OL} = 1.5mA)	V_{OL}	V_{CC} = 2.0V	(Note 2)			0.4	V
Logic 0 Output (I_{OL} = 4.0mA)		V_{CC} = 5V				0.4	

1.6 Output Low Voltage (VOL)

Definition: The maximum output voltage for a logical "low" state.

Importance: VOL ensures that the output is sufficiently low to be recognized as a logical "low."

Recommended Handling: Ensure VOL is low enough to allow other components to recognize it as a logical "low."

RECOMMENDED DC OPERATING CONDITIONS

(T_A = 0°C to +70°C or T_A = -40°C to +85°C.) (Note 1)

PARAMETER	SYMBOL		CONDITIONS	MIN	TYP	MAX	UNITS
Supply Voltage V_{CC1}, V_{CC2}	V_{CC1}, V_{CC2}		(Notes 2, 10)	2.0	3.3	5.5	V
Logic 1 Input	V_{IH}		(Note 2)	2.0		V_{CC} + 0.3	V
Logic 0 Input	V_{IL}	V_{CC} = 2.0V	(Note 2)	-0.3		+0.3	V
		V_{CC} = 5V		-0.3		+0.8	

DC ELECTRICAL CHARACTERISTICS

(T_A = 0°C to +70°C or T_A = -40°C to +85°C.) (Note 1)

PARAMETER	SYMBOL		CONDITIONS	MIN	TYP	MAX	UNITS
Input Leakage	I_{LI}		(Notes 5, 13)		85	500	µA
I/O Leakage	I_{LO}		(Notes 5, 13)		85	500	µA
Logic 1 Output (I_{OH} = -0.4mA)	V_{OH}	V_{CC} = 2.0V	(Note 2)	1.6			V
Logic 1 Output (I_{OH} = -1.0mA)		V_{CC} = 5V		2.4			
Logic 0 Output (I_{OL} = 1.5mA)	V_{OL}	V_{CC} = 2.0V	(Note 2)			0.4	V
Logic 0 Output (I_{OL} = 4.0mA)		V_{CC} = 5V				0.4	

1.7 Temperature Rating (Operating and Storage Temperature)

Definition: The range of temperatures within which the component can function properly.

Importance: Components have a temperature range in which they are designed to work. Exceeding these limits can lead to component degradation, failure, or even fires.

Recommended Handling: Always check the specified temperature range for the component and ensure it is used within the limits. Use heatsinks, fans, or thermal pads when necessary.

Absolute Maximum Ratings (Ta = 25°C)

Characteristics	Symbol	Rating	Unit	Remarks
Supply voltage	VM	15	V	
	Vcc	6		
Input voltage	VIN	-0.2～6	V	IN1, IN2, STBY, PWM pins
Output voltage	Vout	15	V	01, 02 pins
Output current	Iout	1.2	A	Per 1ch
	Iout (peak)	2		tw=20ms Continuous pulse, Duty≦20%
		3.2		tw=10ms Single pulse
Power dissipation	PD	0.78	W	IC only
		0.89		50×50 t=1.6(mm) Cu≧40% in PCB mounting
		1.36		76.2×114.3 t=1.6(mm) Cu≧30% in PCB monting
Operating temperature	Topr	-20～85	°C	
Storage temperature	Tstg	-55～150	°C	

1.8 Maximum Power Dissipation

Definition: The maximum amount of power the component can dissipate as heat.

Importance: Exceeding the maximum power dissipation can lead to overheating and failure of the component.

Recommended Handling: Use heat management techniques like heat sinks or thermal pads, especially for components with high power dissipation (e.g., power transistors, voltage regulators).

Absolute Maximum Ratings (Ta = 25°C)

Characteristics	Symbol	Rating	Unit	Remarks
Supply voltage	VM	15	V	
	Vcc	6		
Input voltage	VIN	-0.2～6	V	IN1, IN2, STBY, PWM pins
Output voltage	Vout	15	V	01, 02 pins
Output current	Iout	1.2	A	Per 1ch
	Iout (peak)	2		tw=20ms Continuous pulse, Duty≦20%
		3.2		tw=10ms Single pulse
Power dissipation	PD	0.78	W	IC only
		0.89		50×50 t=1.6(mm) Cu≧40% in PCB mounting
		1.36		76.2×114.3 t=1.6(mm) Cu≧30% in PCB monting
Operating temperature	Topr	-20～85	℃	
Storage temperature	Tstg	-55～150	℃	

1.9 Maximum Input/Output Current

Definition: The maximum current the component can handle through its input/output pins.

Importance: Overcurrent can cause permanent damage to the component, such as burning out transistors, ICs, or capacitors.

Recommended Handling: Always use current-limiting resistors or protection circuitry (e.g., diodes, fuses) when handling I/O connections.

Electrical Characteristics

(V_{DD} = 1.8V, V_{LED+} = 5.0V, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
POWER SUPPLY						
Power-Supply Voltage	V_{DD}	Guaranteed by RED and IR count tolerance	1.7	1.8	2.0	V
LED Supply Voltage V_{LED+} to PGND	V_{LED+}	Guaranteed by PSRR of LED driver	3.1	3.3	5.0	V
Supply Current	I_{DD}	SpO_2 and HR mode, PW = 215µs, 50sps		600	1200	µA
		IR only mode, PW = 215µS, 50sps		600	1200	
Supply Current in Shutdown	I_{SHDN}	T_A = +25°C, MODE = 0x80		0.7	10	µA

1.10 Voltage Tolerance

Definition: The range of voltages a component can tolerate without risk of failure.

Importance: Applying voltage beyond this range can cause irreversible damage or even permanent failure of the component.

Recommended Handling: Always adhere strictly to the component's voltage ratings, use voltage regulators when needed, and employ over-voltage protection.

2 Handling and Safety Precautions

2.1 Avoiding Overheating

Importance: Overheating can destroy components, affect their performance, or cause fire hazards.

Best Practices:

- Ensure adequate heat dissipation (e.g., using heat sinks or fans).
- Monitor the temperature of critical components.
- Avoid running components at their maximum ratings for extended periods.

2.2 Preventing Short Circuits

What is a Short Circuit?: A short circuit occurs when two conductors are unintentionally connected, often leading to excessive current flow.

How to Avoid:

- Double-check connections before powering on the circuit.
- Use fuses and circuit breakers for overcurrent protection.
- Inspect the circuit for any possible shorts, especially when working with breadboards.

2.3 Correct Component Orientation

Importance: Many components (e.g., diodes, electrolytic capacitors) are polarized, meaning they must be connected in a specific orientation to function correctly.

Best Practices:

- Double-check the component's datasheet for the correct polarity.
- Ensure that polarized components are correctly placed on the PCB or breadboard.

3 Understand Voltage levels and Logic voltage levels.

3.1 Supply Voltage Levels (V_{DD}, V_{CC}, V_{IN})

Definition:

Supply Voltage refers to the voltage provided to power the internal circuitry of an electronic component (e.g., microcontroller, sensor, IC). Without this supply, the component will not function.

Key Terms:

V_{CC} or V_{DD}: Positive power supply voltage (e.g., +5V or +3.3V).

V_{SS} or GND: Ground or 0V reference.

Examples:

Component	Supply Voltage Range
ATmega328P (Arduino Uno)	1.8V – 5.5V (typically 5V)
STM32F103C8T6 (Blue Pill)	2.0V – 3.6V (typically 3.3V)
DHT11 Sensor	3.3V – 5V
HC-SR04 Ultrasonic Sensor	5V only

Note: Supplying a higher voltage than allowed can permanently damage the component.

Important Care Tips:

- Always check the datasheet for maximum and recommended supply voltage.
- Use a regulated power supply or voltage regulator (e.g., LM7805 for 5V).
- Never connect a 5V component directly to a 3.3V-only microcontroller without level shifting.

3.2 Logic Level Voltage (Input/Output Voltage Thresholds)

Definition:

Logic levels are the voltage ranges that define digital HIGH (1) and LOW (0) states at the input or output pins of a digital component.

Key Parameters:

VIH = Minimum input voltage recognized as HIGH

VIL = Maximum input voltage recognized as LOW

VOH = Minimum output voltage for HIGH

VOL = Maximum output voltage for LOW

Example – STM32F103 (3.3V Operation):

Logic Parameter	Value
VIH	≥ 2.0V
VIL	≤ 0.8V
VOH	≥ 2.4V
VOL	≤ 0.4V

IMPORTANT: Even though supply voltage is 3.3V, logic HIGH may only be guaranteed at 2.4V+, NOT 3.3V.

3.3 Relationship between Supply Voltage and Logic Levels:

Supply Voltage	Logic Level Range (Typical)
5V	LOW = 0–0.8V HIGH = 2–5V
3.3V	LOW = 0–0.6V HIGH = 2–3.3V
1.8V	LOW = 0–0.3V HIGH = 1.2–1.8V

*These ranges vary by manufacturer; always refer to the datasheet.

Why This Matters in Real Projects

Common Scenarios:

Interfacing 5V sensor to 3.3V microcontroller:

- Problem: Sensor output might be too high for the MCU.
- Solution: Use a logic level shifter or voltage divider.

Using a 3.3V output with a 5V input device:

- Problem: The 5V input might not recognize 3.3V as HIGH.
- Solution: Check if VIH threshold of 5V device is low enough to accept 3.3V; if not, use buffer/amplifier.

How to Test Logic Levels

Using a Multimeter :

Measure the output pin voltage when HIGH or LOW.

Confirm it meets the receiving component’s logic threshold.

Example:

You measure 2.9V output from a sensor (logic HIGH).

If your microcontroller requires VIH ≥ 3.0V, it may not register this as HIGH.

Best Practices to Prevent Damage

Practice	Description
Use level shifters	For cross-voltage communication
Check datasheets	Always read "Electrical Characteristics" section
Use clamping diodes	To protect inputs from overvoltage
Add pull-up/pull-down resistors	To stabilize input voltage levels
Don’t assume compatibility	Even if it "works" in a quick test, it may not be reliable

4 Introduction to Pull-up and Pull-down Resistors

4.1 Definition:

Pull-up and Pull-down resistors are used to set a known voltage level on a pin when no active device (such as a switch or IC) is connected to it.

Pull-up resistors connect the pin to the supply voltage (V_{CC}), ensuring the pin reads a logical HIGH when the switch is open.

Pull-down resistors connect the pin to ground (GND), ensuring the pin reads a logical LOW when the switch is open.

Why Are Pull-up and Pull-down Resistors Needed?

Floating Inputs:

When an input pin (e.g., on a microcontroller or sensor) is not connected to a voltage source, it is floating. This means it can pick up noise from the surrounding environment and lead to unpredictable readings (high impedance).

To avoid floating states, pull-up or pull-down resistors are added to ensure the pin always has a known state when the switch or input device is not actively driven.

4.2 Pull-up Resistor

Definition:

A pull-up resistor is a resistor connected between the input pin and positive voltage (V_{CC}), ensuring the pin reads a HIGH state (1) when the switch is open (not connected to ground).

How It Works:

When the switch is open, the pull-up resistor pulls the pin up to V_{CC}, ensuring a logical HIGH (1).

When the switch is closed (connected to ground), the pin is pulled LOW (0), overriding the pull-up.

Example: Push Button with Pull-up Resistor

Component	Connection
Button	One side to input pin, other side to GND.
Pull-up Resistor	Between input pin and V_{CC}.

Typical Pull-up Resistor Value:

Common values for pull-up resistors range from 1kΩ to 10kΩ, but 4.7kΩ and 10kΩ are the most widely used.

The value should be high enough to avoid excessive current but low enough to pull the input voltage reliably to V_{CC} when the switch is open.

4.3 Pull-down Resistor

Definition:

A pull-down resistor is a resistor connected between the input pin and ground (GND), ensuring the pin reads a LOW state (0) when the switch is open.

How It Works:

When the switch is open, the pull-down resistor pulls the pin to GND (0V), ensuring a logical LOW (0).

When the switch is closed, the pin is pulled up to V_{CC}, overriding the pull-down resistor.

Example: Push Button with Pull-down Resistor

Component	Connection
Button	One side to input pin, other side to V_{CC}.
Pull-down Resistor	Between input pin and GND.

Typical Pull-down Resistor Value:

Like pull-up resistors, pull-down resistors typically range from 1kΩ to 10kΩ.

10kΩ is the most common value for pull-down resistors.

4.4 Internal Pull-up/Pull-down Resistors

Microcontroller Built-in Pull-up/Pull-down:

Many microcontrollers (e.g., Arduino, STM32, ESP32) have internal pull-up and pull-down resistors that can be enabled via software.

These resistors save space and eliminate the need for external components.

4.5 Difference between Pull-up and Pull-down Resistors

Feature	Pull-up Resistor	Pull-down Resistor
Connection	Connected between input pin and V_{CC}	Connected between input pin and GND
Default State	Pin is HIGH when switch is open	Pin is LOW when switch is open
Use Case	Used when you need the pin to read HIGH by default	Used when you need the pin to read LOW by default
Common Application	Button input, open/close switches	Button input, open/close switches

4.6 Practical Applications of Pull-up and Pull-down Resistors

Common Use Cases:

A. Button Press Detection

Pull-up Resistor: Typically used for buttons connected to GND to detect button presses.

Pull-down Resistor: Typically used for buttons connected to V_{CC} to detect button presses.

B.I2C Communication (SDA, SCL Lines)

Pull-up resistors are commonly used on the I2C bus (SDA and SCL lines) to ensure proper communication between the master and slave devices.

Example: In an Arduino I2C setup, 4.7kΩ pull-up resistors are used on both the SDA and SCL lines.

C. Open-Collector / Open-Drain Outputs

Open-drain outputs require pull-up resistors to function properly. These outputs are typically used for I2C, SPI, or interrupt signals where the output transistor connects to ground when active, and the pull-up resistor pulls it to V_{CC} when inactive.

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