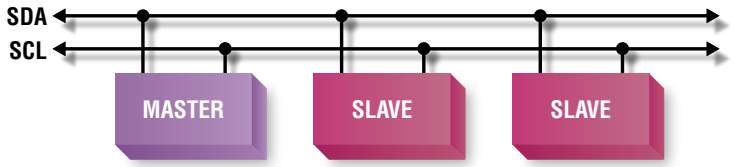
I²C Quick Guide



I²C Standard

The I²C (inter-IC) bus is a 2-wire, multi-drop, digital communications link for ICs that has become the defacto standard for many embedded applications. Serial, 8-bit, bidirectional data transfer can occur at speeds up to 3.4Mbps, though 400kHz is usually sufficient. Since only two bus lines are required, a serial data line (SDA) and serial clock line (SCL), building a system with multiple master or slave devices is relatively simple. The number of I²C devices that can be connected to a single I²C bus segment is limited only by a maximum bus capacitance (400pF) and address space.

I²C vs SMBus vs PMBus

Specification		I²C	SMBus		PMBus
			High Power	Low Power	
Signaling	Packet Error Checking (Optional)	–	•		
	$\overline{\text{SMBALERT}}$ (Optional)	–	•		
	Block Size Limit	–	32 bytes		255 bytes
Timing	Data Rate (Standard Mode)	100kbps			
	Data Rate (Fast Mode)	400kbps	–	–	400kbps
	Data Rate (Fast Mode Plus)	1Mbps	–	–	–
	Data Rate (High Speed Mode)	3.4Mbps	–	–	–
	Clock Speed	0Hz to 3.4MHz	10kHz to 100kHz		10kHz to 400kHz
	Bus Timeout	–	25ms to 35ms		
	Bus Master Request Delay (Min)	–	50µs		
	SCL Hold Time (Max)	–	2ms		
	Data Hold Time (Min)	–	300ns		
Electrical	Capacitance Load per Bus Segment (Max)	400pF		–	400pF
	Rise Time (Max)	1µs at 100kHz, 300ns at 400kHz	1µs		1µs at 100kHz, 300ns at 400kHz
	Pull-Up Current at 0.4V (Max)	3mA (Standard Mode and Fast Mode)	4mA	350µA	4mA
	Leakage Current per Device (Max)	±10µA		±5µA	±10µA
	V_{IL} Input Logic Low Threshold (Max)	$0.3V_{DD}$ or 1.5V	0.8V		
	V_{IH} Input Logic High Threshold (Min)	$0.7V_{DD}$ or 3V	2.1V		
	V_{OL} Output Logic Low Threshold (Max)	0.4V			

Frequently Asked Questions

Q1) How are I²C, SMBus and PMBus related?

Answer: Originally developed to facilitate battery management systems, SMBus uses I²C hardware but adds second-level software, which ultimately allows devices to be hot swapped without restarting the system. PMBus extends SMBus by defining a set of device commands specifically designed to manage power converters, exposing device attributes such as measured voltage, current, temperature and more. In general, I²C, SMBus and PMBus devices can share a bus without any major issues.

Q2) How do I build a large system and still meet bus capacitance and rise time specifications?

Answer: Linear Technology's bus buffers resolve common electrical limitations posed by specifications, thereby allowing more devices to be added to the bus. These devices break up large busses into several smaller I²C compliant (<400pF) pieces, while still providing simultaneous communications to all bus segments and optionally injecting a boosted pull-up current during positive bus transitions to quickly slew large bus capacitances.

Q3) How do I resolve a stuck bus?

Answer: Other than having a host try to manually fix a bus stuck low, Linear Technology's bus buffers provide stuck bus protection which recovers a stuck bus by automatically generating pulses on SCLOUT in an attempt to unstick the bus. Otherwise, a hard reset is required.

Q4) How do I increase the number of I²C addresses available?

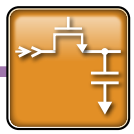
Answer: Linear Technology's address translators and software or hardware controlled I²C multiplexers provide the ability to address one of multiple identical devices or simply increase fan-out, thus resolving address conflict issues, while also providing Hot Swap™ capabilities, bus buffering, rise time acceleration and stuck bus protection.

LINEAR TECHNOLOGY

I²C Checklist ☑

Linear Technology provides a comprehensive family of I²C-enabled devices for a variety of applications. From Hot Swap™ controllers to bus isolators, these devices provide on-the-fly adjustability, enhance I²C performance or simply enable designers to easily manage key system parameters.

I²C Bus



Hot Swap Controller

- Control inrush current on a live backplane, while monitoring current, voltage, power and energy
- Record past and present fault conditions and configure latchoff or auto-restart

Power Supply/LED Driver

- Control power-on/-off or dimming and configure mode of operation, output voltage, sequencing and slew rate for single- or multi-topology converters

Power System Management Controller

- Control, monitor, supervise, sequence and margin multiple power supplies
- Access EEPROM for user configuration, fault logging and telemetry

Power/Energy Monitor

- Monitor current, voltage, average power, charge and energy, while minimizing software polling with min/max registers and configurable alerts

Temperature Monitor

- Measure combinations of voltage, current and internal or external temperature
- Trigger single or repeated measurements and change formats (Celsius or Kelvin)

Bus Buffer/Multiplexer/Address Translator/Rise Time Accelerator

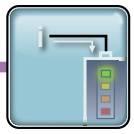
- Break up bus capacitance, increase fan-out, level shift busses, decrease rise times and nest addresses while providing Hot Swap capabilities and stuck bus protection

Bus Isolator

- Break ground loops and isolate logic level interfaces, while also providing Hot Swap capabilities or adjustable isolated power to neighboring components

Power over Ethernet Power Sourcing Equipment (PSE)

- Efficiently source up to 90W of power, while configuring PSE mode of operation and monitoring per port status, current, MOSFET health and die temperature



Battery Charger/Gas Gauge

- Adjust charge current, float voltage and charge termination, while monitoring status, charge, current, voltage or temperature of battery, USB or wall sources

ADC/DAC

- Write to or read from data converters with no latency, and select input or output data formats and use of internal or external reference

Silicon Oscillator

- Enable and program clock frequency with 0.1% resolution, as well as instantaneously change octaves using DACs with 10-bit monotonicity and less than 1% nonlinearity