STP Cheat Sheet — Reference Tables

STP Variants & Overview

IEEE 802.1D	Classic STP — original standard
IEEE 802.1W	RSTP — Rapid Spanning Tree Protocol
IEEE 802.1S	MSTP — Multiple Spanning Tree Protocol
Cisco PVST+	Per-VLAN STP (one instance per VLAN)
Rapid PVST+	Cisco RSTP per VLAN (default on modern IOS)
Purpose	Prevents Layer 2 loops / broadcast storms
Algorithm	Spanning Tree Algorithm (STA) — IEEE
Protocol	Bridge Protocol Data Units (BPDUs)
Convergence	Classic: ~50s | RSTP: <1s

Bridge ID & Root Election

Bridge Priority	0–61440 in steps of 4096 (default 32768)
System ID Ext	VLAN ID added to priority field
MAC Address	Lowest MAC = tiebreaker
Bridge ID	Priority (2B) + MAC Address (6B) = 8 bytes
Root Bridge	Lowest Bridge ID wins election
Default priority	32768 (set lower to make root)

STP Timers

Hello Time	2 seconds — BPDU send interval
Forward Delay	15 seconds — Listening & Learning timer
Max Age	20 seconds — BPDU timeout
Total STP conv.	~50 seconds (802.1D)
RSTP conv.	<1 second (802.1W / Rapid PVST+)

STP & RSTP Path Cost

10 Mbps	STP: 100 | RSTP: 2,000,000
100 Mbps	STP: 19 | RSTP: 200,000
1 Gbps	STP: 4 | RSTP: 20,000
10 Gbps	STP: 2 | RSTP: 2,000
100 Gbps	STP: 1 | RSTP: 200
Formula	STP: 10^8/bps | RSTP: 20*10^12/bps

STP Port Roles

Root Port (RP)	Best path to Root Bridge — one per non-root switch
Designated (DP)	Best port on each segment — forwards traffic
Non-Designated	Blocking — prevents loops (802.1D)
Alternate (AP)	RSTP — backup to Root Port
Backup (BP)	RSTP — backup to Designated Port
Disabled	Administratively shut down

STP Port States

Blocking	802.1D — receives BPDUs only — no forwarding
Listening	802.1D — 15s — processes BPDUs, no MAC learning
Learning	802.1D — 15s — learns MACs, no forwarding
Forwarding	802.1D — full operation — forward + learn
Disabled	802.1D — admin down
Discarding	RSTP — replaces Blocking + Listening

STP Election Process (in order)

1. All switches claim to be Root — send BPDUs
2. Compare Bridge IDs — lowest wins Root Bridge
3. Non-root switches elect Root Port (best path to root)
4. Each segment elects Designated Port (best BPDU on link)
5. Remaining ports become Non-Designated (Blocking)
6. Topology stable — periodic Hello BPDUs every 2s

BPDU Types & Fields

BPDU Type 0x00	Config BPDU — sent by root every Hello Time
BPDU Type 0x80	TCN BPDU — Topology Change Notification
BPDU fields	Root ID, Path Cost, Bridge ID, Port ID, Flags
RSTP BPDU	Single type — carries role + state flags
Proposal/Agree	RSTP handshake — replaces 30s transition
TC flag	Triggers MAC table flush on all bridges

STP Enhancements / Protection

PortFast	Skips Listening/Learning — access ports only
BPDU Guard	err-disable if BPDU received on PortFast port
BPDU Filter	Stops sending/receiving BPDUs on port
Root Guard	Prevents external root bridge takeover
Loop Guard	Blocks port if BPDUs stop (prevents loops)
UplinkFast	Faster failover for access layer (802.1D only)
BackboneFast	Faster indirect failure recovery (802.1D only)
RSTP Edge	Equivalent to PortFast in RSTP

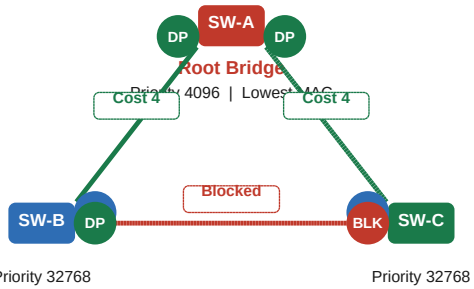
Key Cisco IOS Commands

```
spanning-tree mode pvst | rapid-pvst | mst
spanning-tree vlan <id> priority <0-61440>
spanning-tree vlan <id> root primary
spanning-tree vlan <id> root secondary
interface <intf>
  spanning-tree portfast
  spanning-tree portfast trunk
  spanning-tree bpduguard enable
  spanning-tree bpdufilter enable
  spanning-tree guard root
  spanning-tree guard loop
  spanning-tree cost <value>
  spanning-tree port-priority <0-240>
  spanning-tree vlan <id> cost <value>
spanning-tree portfast default
spanning-tree portfast bpduguard default
show spanning-tree
show spanning-tree vlan <id>
```

RSTP vs STP Key Differences

RSTP has only 3 states: Discarding, Learning, Forwarding.
RSTP adds Alternate + Backup port roles for fast failover.
RSTP convergence <1s using Proposal/Agreement handshake.
RSTP backward-compatible with 802.1D switches.

STP Topology — Root Bridge Election & Port Roles



Blocked link (loop prevention)

BLK Blocking — prevents loop

DP Designated Port — forwarding

Active / forwarding link

RP Root Port — best path to root

Root Bridge Election — Step by Step

1. All switches start believing THEY are the Root Bridge.
2. Switches exchange Config BPDUs every Hello Time (2s).
3. Switch with lowest Bridge ID becomes Root Bridge.
4. Non-root: elect Root Port (lowest cost path to root).
5. Each segment: elect Designated Port (best BPDU wins).
6. All other ports go Blocking — loop-free topology achieved.

STP Port States & RSTP Comparison

802.1D STP Port States (up to 50 seconds total)

BLOCKING	LISTENING	LEARNING	FORWARDING	DISABLED
Receives BPDUs only	15s Process BPDUs	15s Learn MACs	Full Forwarding	Admin Down
Max Age 20s	Fwd Delay 15s	Fwd Delay 15s	Stable	

■■■ 802.1W RSTP Port States ■■■

DISCARDING	LEARNING	FORWARDING
Replaces Blocking+Listening	Learns MACs no forwarding	Full Operation

Convergence < 1 second (Proposal / Agreement handshake)

STP vs RSTP — Key Differences

Feature	802.1D STP	802.1W RSTP
States	5 states	3 states
Convergence	~50 seconds	<1 second
Port roles	3 roles	5 roles (adds Alt+Backup)
BPDUs	Root sends only	All switches send
Topology change	Slow flooding	Rapid per-port
Backward compat.	N/A	Yes — falls back to STP

RSTP Proposal / Agreement — How Fast Convergence Works

New link comes up → sends Proposal BPDU with Sync flag.
Downstream switch blocks all non-edge ports → sends Agreement.
Upstream port moves immediately to Forwarding (no 30s wait).
Edge ports (PortFast) skip Discarding/Learning entirely.

BPDU Frame Structure & STP Enhancements

Ethernet Frame (carrying STP BPDU)

Dst MAC	Src MAC	LLC Header	BPDU	FCS
01:80:C2:00:00:00 (STP Multic	Switch MAC 6B	DSAP SSAP Ctrl 3B	STP Data Variable	4B

STP Config BPDU (Type 0x00 — 35 bytes)

Proto ID	Version	Type	Flags	Root ID	Root Cost	Bridge ID	Port ID
2B 0x0000	1B 0x00	1B 0x00	1B TC+TC	8B Bridge ID	4B Path Cost	8B Sender	2B

BPDU Flags Byte (1 byte — key bits)

TC	P	Port Role	Port Role	L	F	A	TCA
Topology Change bit 0	Proposal RSTP bit 1	Port Role bits 2-3		Learning bit 4	Forwarding bit 5	Agreement bit 6	TC Ack bit 7

STP Enhancements & Protection Features

PortFast	Skips L/L — access ports only — never on trunks
BPDU Guard	err-disable port if BPDU received on PortFast port
BPDU Filter	Suppresses BPDU send/receive — use carefully
Root Guard	Prevents superior BPDU from changing root bridge
Loop Guard	Alternate/backup port if BPDUs stop arriving
UplinkFast	Instant failover access→uplink (802.1D only)
BackboneFast	Faster indirect failure (802.1D) — 30s saved
RSTP Edge	Equivalent to PortFast in RSTP / Rapid PVST+

Bridge Priority — Valid Values & Root Placement

Priority must be a multiple of 4096 (0, 4096, 8192 … 61440).
Default: 32768. To make root: priority 4096 or root primary.
root primary = current lowest - 4096 (min 4096).
root secondary = current lowest - 4096 after primary.
Extended System ID adds VLAN ID to priority field.