4T/5T Binary Tuning Switch, R_{ON}=0.5Ω, *V*=100 V

Features

- Full integrated solution, single V_{DD}=2.6...5.25 V
- Frequency Range 30 MHz to 1000 MHz
- $R_{ON} = 0.5\,\Omega$
- 50 W CW Power
- $V_{PEAK} = 100$ V
- Highest pulse power in the industry
- No sudden voltage breakdown compared to SOI
- Switch time = 7.2 μs, no power derating
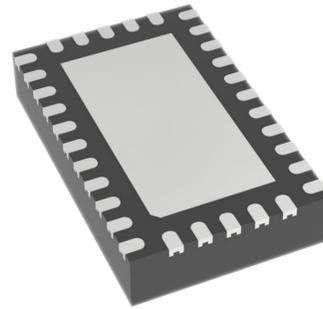- Low power consumption, less than 1 mW
- No need to supply negative voltages

Figure 1: TS63560D in 6.0 x 3.0 mm^2 QFN 32-pin package.

Applications

- Tactical radio
- Tunable filters
- Antenna tuning
- Medical - Ultrasound
- Medical - MRI

General Description

The TS63560D is a HF/VHF/UHF/L-band fully integrated 4/5 throw tuning switch designed for high power tunable antenna and filter applications based on GaN technology. The TS63560D supports applications spanning 30 MHz through 1 GHz, providing low R_{ON} and high linearity within a small package size. The TS63560D is a 50 W CW with peak voltage capability of 100 V, switch suitable for applications requiring low insertion loss, high isolation, and high linearity. TS63560D utilizes standard single V_{DD}, no extra negative voltage needed, neither high voltages.

The TS63560D is packaged into a compact Quad Flat No lead (QFN) 6.0x3.0 mm^2 32 leads plastic package.
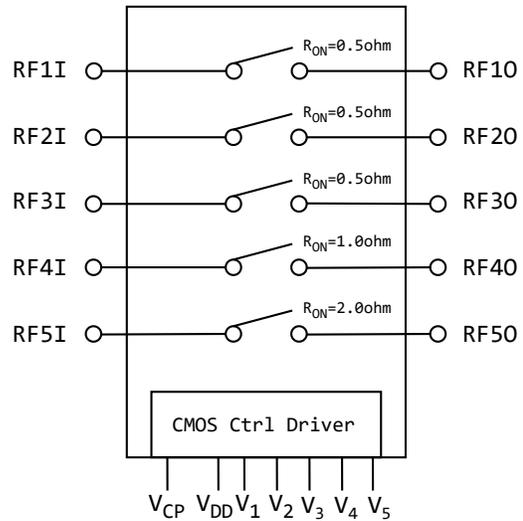

Figure 2: TS63560D functional diagram

RoHS/Reach/Halogen free

Absolute Maximum Ratings

Table 1: Absolute Maximum Ratings $T_A = +25$°C unless otherwise specified[1].

Parameter	Symbol	Value	Unit
Electrical Ratings			
Power Supply Voltage	V_{DD}	5.5	V
Storage Temperature Range	T_{st}	-55...+125	°C
Operating Temperature Range	T_{op}	-40...+85	°C
Maximum Junction Temperature	T_j	+140	°C
Maximum RF CW input power	RFxI/RFxO	49	dBm
Maximum RF peak input power, 1% duty cycle, 10μs pulse	RFxI/RFxO	tbd	dBm
Maximum RF peak voltage	RFxI/RFxO	110	V
Thermal Ratings			
Thermal Resistance (junction-to-case) – Bottom side	$R_{\theta jc}$	tbd	°C/W
Thermal Resistance (junction-to-top)	$R_{\theta jt}$	tbd	°C/W
Soldering Temperature	T_{solder}	+260	°C
ESD Ratings			
Human Body Model (HBM)	Level 1B	500...<1000	V
Charged Device Model (CDM)	Level C3	≥1000	V
Moisture Rating			
Moisture Sensitivity Level	MSL	1	

[1] Maximum ratings are absolute ratings. Exposure to absolute maximum rating conditions for extended periods may affect device reliability and can cause permanent damage to the device. Exceeding one or a combination of the absolute maximum ratings may cause permanent and irreversible damage to the device and/or to surrounding circuit. Functional operation of the device is not implied in any conditions above those indicated in the Electrical Specifications section.

Electrical Specifications

Table 2: Electrical Specifications $T_A = +25°C; V_{DD} = +3.3V; 50\Omega$ Source/Load.

Parameter	Condition	Minimum	Typical	Maximum	Unit
Operating frequency	f	30		1000	MHz
RF1, RF2, RF3, ON Resistance	R_{ON}		0.50		Ω
RF1, RF2, RF3, OFF Capacitance	C_{OFF}		500		fF
RF4, ON Resistance	R_{ON}		1.0		Ω
RF4, OFF Capacitance	C_{OFF}		250		fF
RF5, ON Resistance	R_{ON}		2.0		Ω
RF5, OFF Capacitance	C_{OFF}		125		fF
Insertion loss	50 MHz		0.08		dB
	500 MHz		0.10		dB
$RF1I - RF1O, RF2I - RF2O, RF3I - RF3O$	1000 MHz		0.13		dB
Insertion loss	50 MHz		0.12		dB
	500 MHz		0.16		dB
$RF4I - RF4O$	1000 MHz		0.20		dB
Insertion loss	50 MHz		0.25		dB
	500 MHz		0.30		dB
$RF5I - RF5O$	1000 MHz		0.32		dB
Isolation	50 MHz		36		dB
	500 MHz		17		dB
$RF1I - RF1O, RF2I - RF2O, RF3I - RF3O$	1000 MHz		11		dB
Isolation	50 MHz		44		dB
	500 MHz		24		dB
$RF4I - RF4O$	1000 MHz		18		dB
Isolation	50 MHz		49		dB
	500 MHz		29		dB
$RF5I - RF5O$	1000 MHz		24		dB
Return Loss	50 MHz		-42		dB
	500 MHz		-37		dB
$RF1I - RF1O, RF2I - RF2O, RF3I - RF3O$	1000 MHz		-36		dB
Return Loss	50 MHz		-36		dB
	500 MHz		-29		dB
$RF4I - RF4O$	1000 MHz		-27		dB
Return Loss	50 MHz		-31		dB
	500 MHz		-24		dB
$RF5I - RF5O$	1000 MHz		-23		dB

Table 3: Electrical Specifications $T_A = +25°\mathrm{C}; \mathrm{V_{DD}} = +3.3\mathrm{V}; 50\Omega$ Source/Load.

Parameter	Condition	Minimum	Typical	Maximum	Unit
Operating frequency	f	30		1000	MHz
Harmonic Distortion					
H_2 RF1, RF2, RF3	800MHz, P_{in} =35dBm		118		dBc
H_3 RF1, RF2, RF3	800MHz, P_{in} =35dBm		110		dBc
IIP3 RF1, RF2, RF3	800MHz		75		dBm
Power and Compression point					
P_{maxCW}	Max RF CW Power		48		dBm
P_{maxpeak}	Max RF Peak Power 1% duty cycle		tbd		dBm
Noise					
CP switching noise	RBW=1kHz		-140		dBm
Switching Time					
t_{ON}[1] RF1, RF2, RF3	Switch ON time		7.6		μs
t_{OFF}[1] RF1, RF2, RF3	Switch OFF time		7.6		μs
t_{RISE}	Switch RISE time		tbd		μs
t_{FALL}	Switch FALL time		tbd		μs
t_{startup}, $\mathrm{C_{VCP}} = 1\mathrm{nF}$	startup time		0.8		ms
Power Supply, DC					
Control voltage	Power Supply $\mathrm{V_{DD}}$	2.6	3.3	5.25	V
	All control pins high, $\mathrm{V_{ih}}$	1.0	3.3	5.25	V
	All control pins low, $\mathrm{V_{il}}$	-0.3	0	0.5	V
Control current	All control pins high, $\mathrm{I_{ih}}$			7.5	μA
	All control pins low, $\mathrm{I_{il}}$		0		μA
Current consumption	$\mathrm{I_{DD}}$, active mode ($\mathrm{V_{DD}}$ on)		220		μA

[1] This switching time is complete switching time. Many industry solutions require external biasing and control circuitry, which is not taken into account in switching time. TS63560D switching time definition includes time of the internal biasing and control circuitry.

4T Full Binary Weighted Application Example

TS63560D Tuning switch can be also used in fully binary configuration. This requires combined connection of RF1 and RF2 together, resulting $R_{\text{ON}} = 0.25\Omega$. This is helpful when designing tunable capacitor circuitry with constant Q. In case of series resonance circuitry, which is case here, Q can be written

$$Q = \frac{1}{\omega_0 RC}. \tag{1}$$

Therefore to have constant Q tunable capacitor with binary weighted capacitance values, switch can be used as a 4T tuning switch with binary weighted series resistance. Assuming that C_1 is largest capacitance, we can create for example following capacitor values

Table 4: Constant Q Example

RF Port	Capacitance C	Resistance R	RC Product
RF1+RF2	16 pF	0.25 Ω	4 pFΩ
RF3	8 pF	0.50 Ω	4 pFΩ
RF4	4 pF	1.00 Ω	4 pFΩ
RF5	2 pF	2.00 Ω	4 pFΩ

With this example, one has 0 stage with small C_P capacitance and all values from 2 pF to 30 pF with the step size of 2 pF. Tagore is currently working to provide exact parameters, including minimum capacitance of C_P,
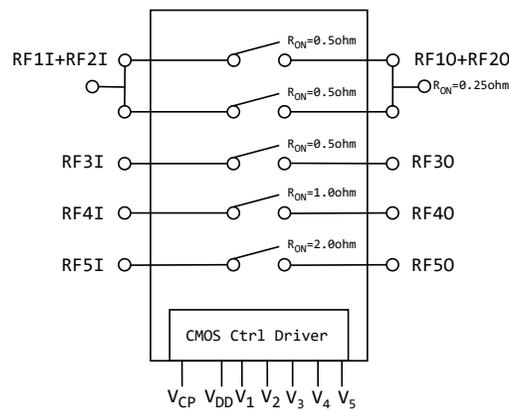

Figure 3: TS63560D functional diagram in Full Binary Weighted 4T configuration.

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Changelog

Table 5: Changelog

Date	Revision	Notes
09/20/2025	0.1	Product Brief Published