Preliminary Data Sheet

MS1500

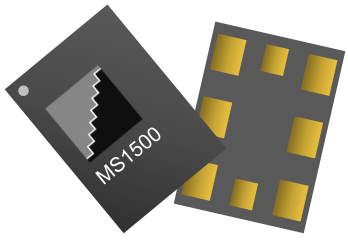
Ultra High-Performance Jitter Attenuator (JA) and Frequency Multiplier (Fx)

Features

- Input frequency from 1 MHz to 750 MHz, gapped clock
- Output frequency from 10 MHz to 1000 MHz
- Ultra-Low Jitter (12 KHz to 20 MHz)
  - 34.9 fs at 156.25 MHz
  - 24.6 fs at 312.50 MHz
  - 26.1 fs at 491.52 MHz
  - 26.8 fs at 625 MHz
- CML/LVDS/LVDS-EXT/LVPECL/HCSL output formats
- Output Enable/Disable Feature
- < 10 ms start-up time
- 3.2X2.5 mm 8-pin LGA package
- Single 1.8V supply with internal regulator
- Superior power supply immunity
- Temperature range: -40°C to 85°C
- Temperature extended range: -40°C to 105°C
- ESD HBM 2000V, CDM 500V
- Lead free / RoHS compliant

Applications

- SATA
- 10 GbE LAN/WAN
- SAS
- Fiber Channel
- Clock and data recovery
- PCI-Express
- Instrumentation



General Description

The MS1500 combines jitter attenuation and frequency multiplication in a single device. It is a digitally synthesized oscillator (DSO) that combines advanced Bulk Acoustic Wave (BAW) resonator technology with high-performance digital frequency synthesis to deliver highly stable, fully programmable multi-GHz clocks with extremely low phase Jitter.

Built-in Adaptive Intelligence continuously monitors operating conditions in the background, using autonomous DSP algorithms to maintain robust and consistent performance across process, voltage, and temperature.

The product can take any input frequency from 1 MHz to 750 MHz and generate any output frequency from 10 MHz to 1000 MHz with <1ppb. The output frequency is synchronized to the input clock. The product is configured using factory programmed NVM.

The MS1500 is manufactured in a high-volume 28 nm CMOS process and represents the most advanced node in the timing industry.

Device Information

Part Number	Package	Description
MS1500	3.2X2.5 mm 8-pin LGA	Jitter Attenuator Frequency Multiplier

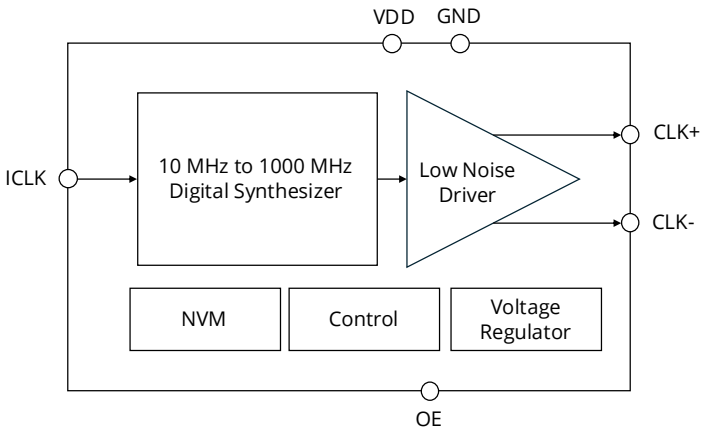


Figure 1. Functional Block Diagram

MS1500

Pin Assignment and Pin Description (TOP VIEW)

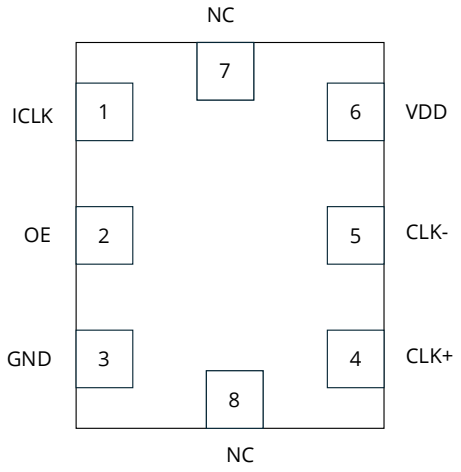


Figure 2. MS1500 Pin Assignments

Table 1. MS1500 Pin Descriptions

Pin No	Name	Description
1	ICLK	Input Clock
2	OE	Output Enable • High/Floating: Output enabled (Internal pull-up of 100kΩ) • Low: Output disabled
3	GND	Ground
4	CLK+	True Clock Output
5	CLK-	Complementary Clock Output
6	VDD	Power Supply – connect bypass capacitor between this pin and pin 3. Keep bypass as close as possible to the pins
7	NC	No Connect
8	NC	No Connect

Part Ordering Information

Figure 3 shows a logic tree for ordering each of the available parts.

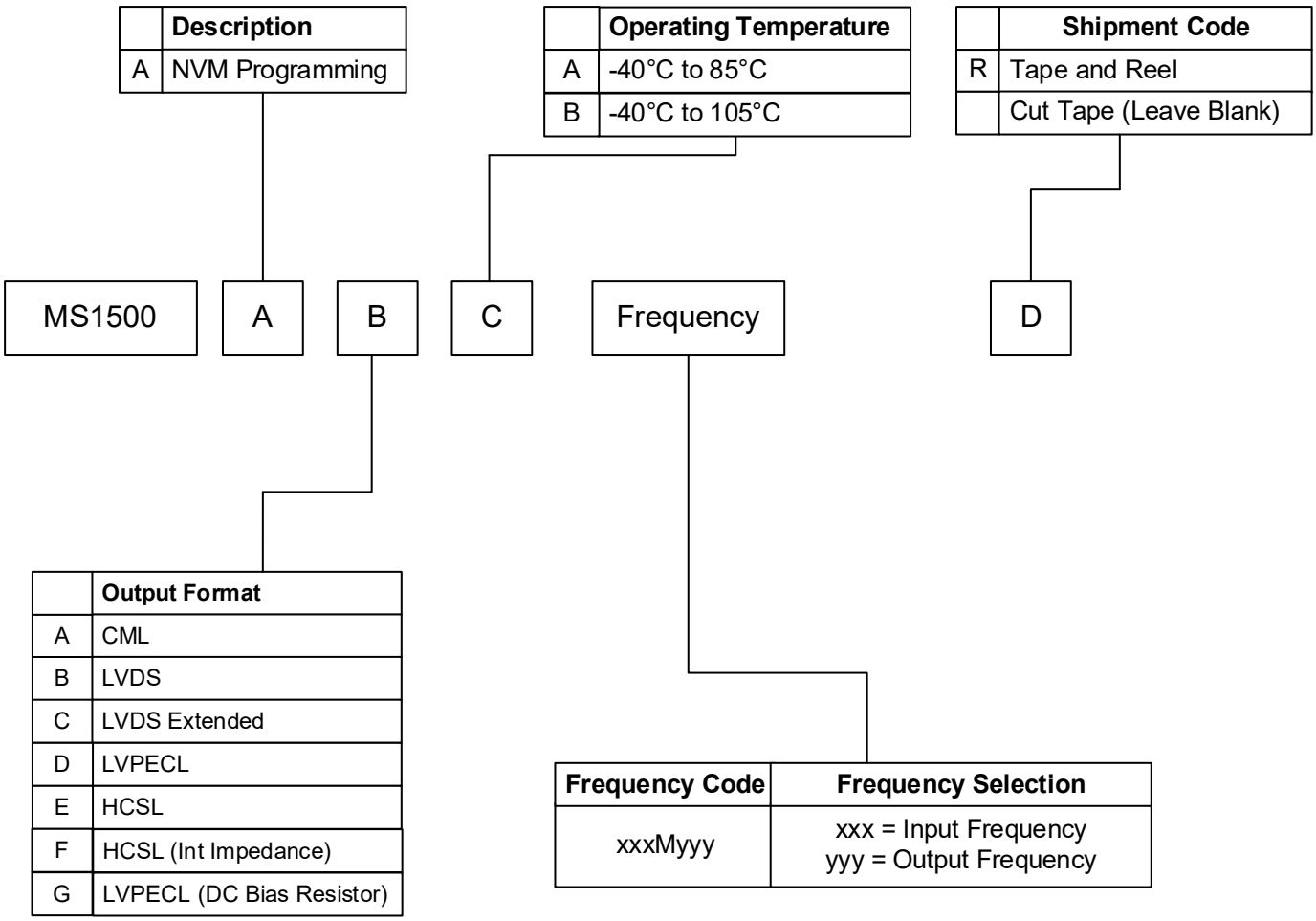


Figure 3. MS1500 Part Ordering Information

Table 2. Example of ordering part number

Base P/N	Output Format	Operating Temperature	Input Frequency	Output Frequency	Shipment Type	**Ordering part number**
MS1500	HCSL	-40°C to 85°C	156 MHz	312.5 MHz	Tape and Reel	**MS1500AEA156M312R**
MS1500	LVPECL	-40°C to 105°C	312.5 MHz	625 MHz	Tape and Reel	**MS1500ADB312M625R**

Input/Output Frequency codes for ordering

Code (xxx)	Frequency (MHz)	Code (yyy)	Frequency (MHz)
001	1	050	50
100	100	100	100
106	106.25	106	106.25
122	122.88	122	122.88
153	153.6	153	153.6
156	156.25	156	156.25
212	212.5	212	212.5
245	245.76	245	245.76
250	250	250	250
307	307.2	307	307.2
312	312.5	312	312.5
322	322.2656525	322	322.2656525
491	491.52	491	491.52
500	500	500	500
614	614.4	614	614.4
625	625	625	625
644	644.53125	644	644.53125
750	750	983	983.05

Please contact Mixed-Signal Devices for additional frequency codes

Specifications

Table 3. Electrical Specifications

Typical values are specified at T_A= 25°C, V_{DD}=1.8V unless otherwise specified. All Min and Max limits are specified over the operating temperature range and voltage range with standard output terminations (See Figure 9-15). A 0.1uF and 10uF bypass capacitors should be connected between VDD and GND pins located close to the device.

Parameter	Symbol	Test Condition/Comment	Min	Typ	Max	Unit
Frequency Range						
Input Frequency Range	I_{CLK}		1		750	MHz
Input Voltage Swing	I_{SWG}	AC-coupled	0.1		1.8	Vpp-SE
Output Frequency Range	F_{CLK}	All Output Formats	10		1000	MHz
Clock Output Jitter Characteristics						
RMS Phase Jitter (12 KHz – 20 MHz integration band)	Φ_{JITTER}	Frequency=312.5 MHz		25	37	fs
		Frequency=625 MHz		27	40	fs
Note: Phase jitter measured on Agilent 5052B Signal Source Analyzer						
Operating Voltage/Temperature Range						
Supply Voltage	V_{DD}		1.71 (-5%)	1.8	1.89 (+5%)	V
Temperature Range	T_A	Industrial Temperature	-40	25	85	°C
		Extended Industrial Temperature	-40	25	105	°C

Current Consumption

Supply Current Consumption	I_{DD}	LVDS Output (Output Enabled)		80	100	mA
		All Other Outputs (Output Enabled)		90	110	mA
		Tristate Hi-Z (Output Disabled. OE=0)		50	60	mA

Input Characteristics

Digital Input Levels(OE)	V_{IH}		$0.7XV_{DD}$			V
	V_{IL}				$0.3XV_{DD}$	V
Output Enable (OE)	T_D	Output Disable Time			3	µs
	T_E	Output Enable Time			20	µs
Input Signal Powerup Time	T_{SIG}	Time required from 0.9xVDD until input signal	10			ms
Output Lock Time	T_{LOCK}	Time from input signal to a stable output			10	ms

PSRR Characteristics

Power Supply-Induced Phase Noise	PSPN	Spurs induced by 50mV power supply ripples (1) (Center Frequency is 312.5MHz)		-110		dBc
Power Supply-Jitter Sensitivity	PSJS			0.2		fs/mV

Note:

(1) Measured with 50 mVpp ripple from 500 KHz to 10 MHz applied on VDD Pin

Output Characteristics

Output Duty Cycle	DC	All Output Formats	48		52	%
Output Rise/Fall Time (20% to 80% V_{PP})	T_R / T_F	All Output Formats		60	80	ps
CML Output (AC-Coupled)	Vpp	Differential Pk-Pk See Figure 11, Figure 12	0.6	0.8	1	V
LVDS Output (AC-Coupled)	Vpp	Differential Pk-Pk See Figure 13	0.5	0.7	0.9	V
LVDS-EXT Output (AC-Coupled)	Vpp	Differential Pk-Pk See Figure 13	0.8	1.2	1.6	V
LVPECL Output (AC-Coupled)	Vpp	Differential Pk-Pk See Figure 14, Figure 14	1.2	1.4	1.6	V
HCSL Output (AC or DC-Coupled)	Vpp	Differential Pk-Pk See Figure 15, Figure 16	1.1	1.35	1.6	V
HCSL Output Voltage (DC- Coupled)	V_{CM}	Common Mode Voltage	340	350	360	mV

Unless otherwise specified, all differential output amplitudes are measured across a 100 Ω differential load or the termination network shown in the referenced output driver figures on the following pages

Table 4. Absolute Maximum Ratings

Parameter	Min	Max	Unit
1.8V Supply Voltage	-0.3	1.98	V
Digital I/O (OE)	-0.3	1.98	V
Maximum Operating Temperature		105	°C
Storage Temperature	-55	150	°C
Junction Temperature		150	°C
Note: Stresses that exceed what is listed in this table may cause permanent damage to the device. Exposure to conditions above the recommendations for extended periods of time may affect device reliability.			

Table 5. Environmental Compliance

Parameter	Test Condition	Value	Unit
Moisture Sensitivity Level (MSL)	MSL3 @260°C		
Soldering Temperature	MIL-STD-883, Method 2003	260	°C
Electrostatic Discharge (HBM)	JEDEC JS-001	2000	V
Charge-Device Model (CDM)	JEDEC JESD22-C101	500	V
Latch-up Compliance	JESD78 Compliant		

Table 6. Package Thermal Information

Package	Parameter	Symbol	Value	Unit
3.2mmX2.5mm 8 pin LGA	Maximum Board Temperature	T_B	125	°C
	Thermal Resistance, Junction to Ambient	$ø_{JA}$	80	°C/W
	Thermal Resistance, Junction to Board	$ø_{JB}$	40	°C/W
	Air Flow Condition		0	mps
	Maximum Junction Temperature	T_J	125	°C

Note: The thermal resistance information stated in this table is based on a standard JEDEC PCB condition. The actual thermal resistance varies depending on the customer PCB design.

Table 7. Typical Output Phase Noise Characteristics
VDD= 1.8V, T_A = 25°C, Output Type = LVDS-EXT

Offset frequency	156.25 MHz	312.50 MHz	491.52 MHz	625 MHz	Unit
1 KHz	-106	-103	-100	-98	dBc/Hz
10 KHz	-138	-133	-128	-127	dBc/Hz
100 KHz	-157	-154	-149	-147	dBc/Hz
1 MHz	-167	-163	-158	-156	dBc/Hz
10 MHz	-168	-164	-160	-148	dBc/Hz
20 MHz	-168	-164	-159	-158	dBc/Hz
RMS Jitter (12 KHz – 20 MHz)	35	25	26	27	fs

Typical Output Measured Phase Noise Plots

This section shows MS1500 performance plots.

Measurement parameters are: VDD = 1.8 V, TA = 25°C, Output Type = LVDS-EXT.

The plots were captured using an Agilent E5052B Signal Source Analyzer.

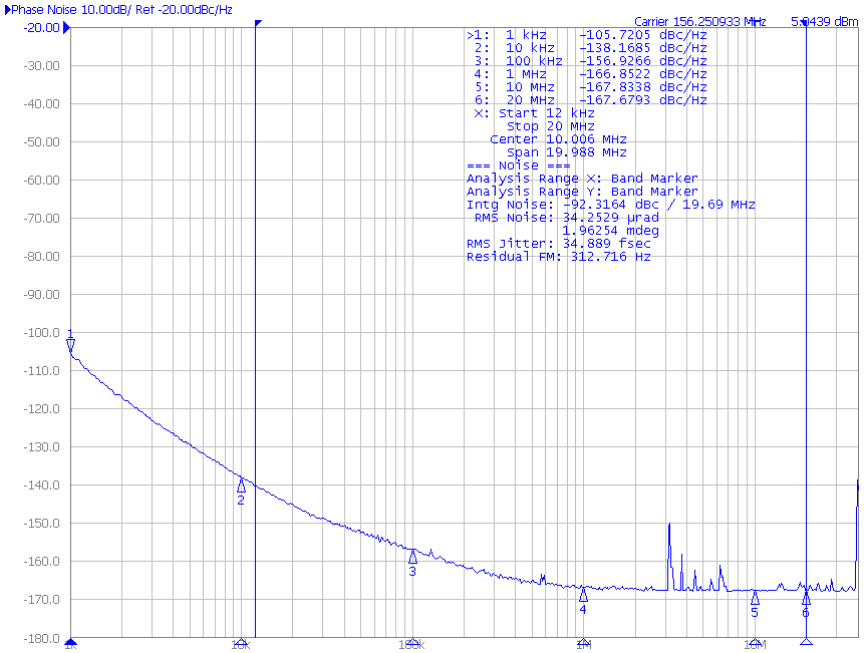


Figure 4. Center Frequency: 156.25 MHz

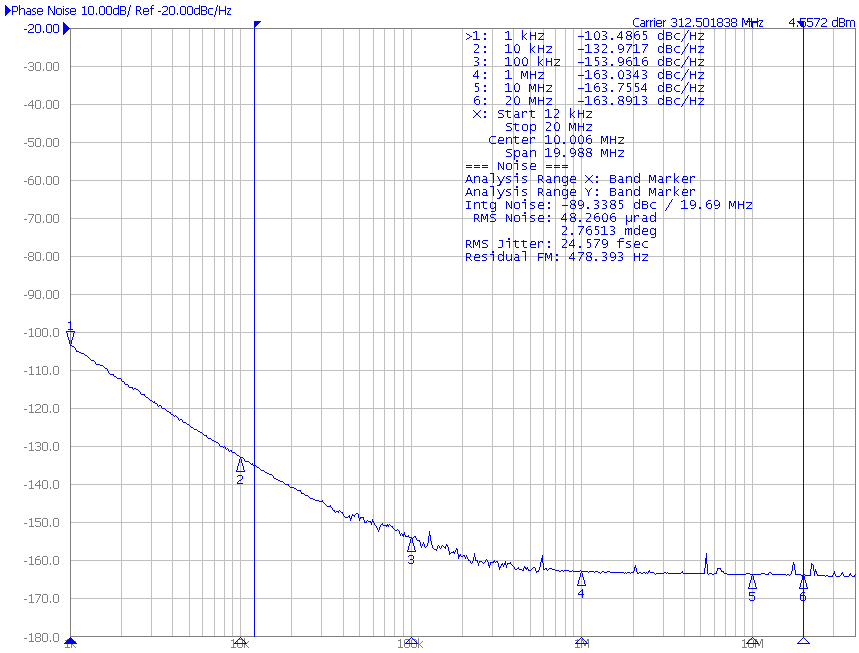


Figure 5. Center Frequency: 312.5 MHz

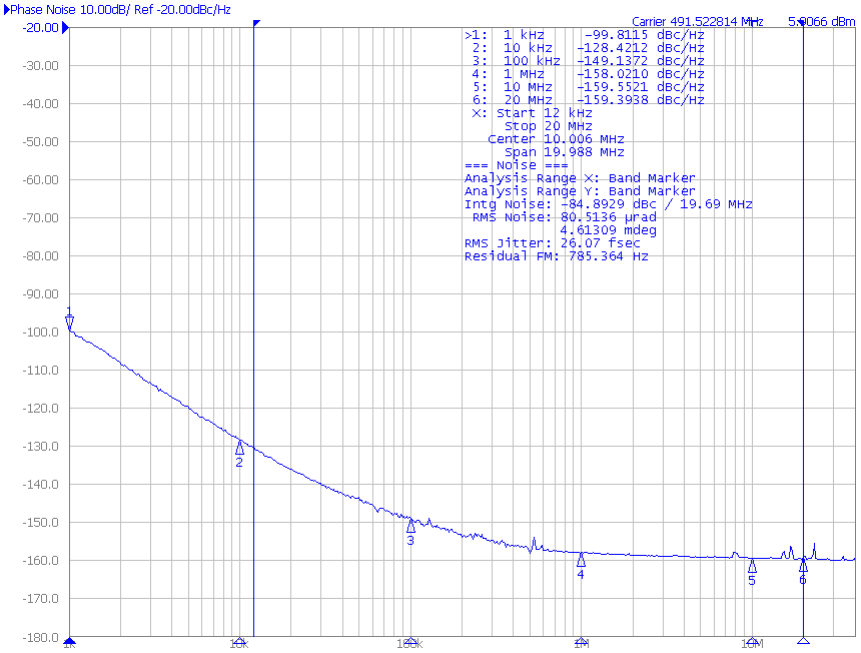


Figure 6. Center Frequency: 491.52 MHz

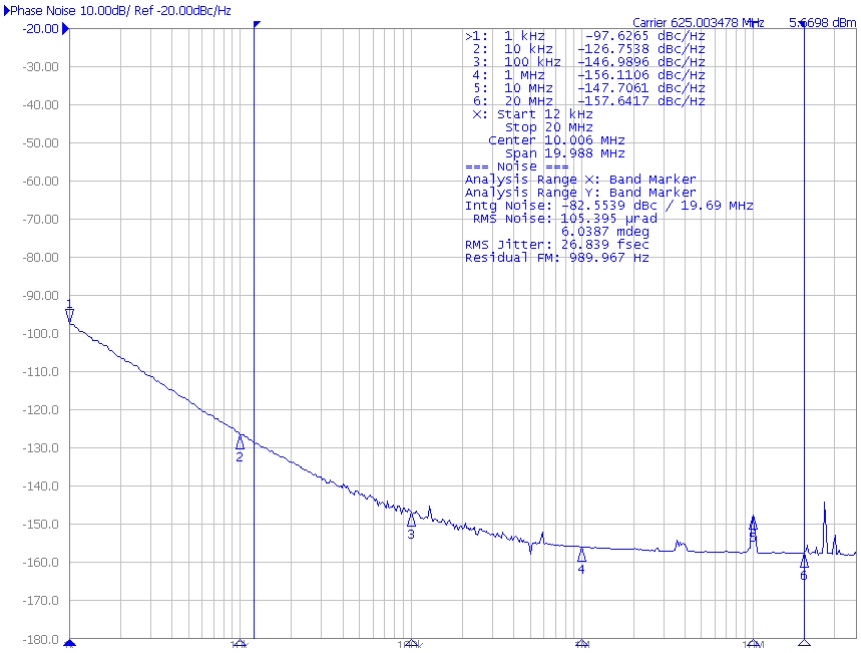


Figure 7. Center Frequency: 625 MHz

Overview

The MS1500 is a single channel high-performance Jitter Attenuator that offers exceptional capabilities in the generation of an ultra-low phase noise clock, making it an ideal solution for next-generation communication systems and base stations. This device can produce one differential output clock synchronized to the reference clock input with input frequency ranging from 1MHz to 750MHz single-ended, and gapped clock support. The MS1500 boasts an output frequency range of 10MHz to 1GHz and a remarkably low RMS jitter of 20fs (12KHz to 20MHz), making it one of the most reliable and precise devices available.

The device's programmability is configured by on-chip non-volatile memory (NVM). This attribute permits the MS1500 to provide great flexibility and ease of use in a broad range of applications, including telecommunications, networking, and test and measurement equipment.

Functional Description

MS1500 is an all-digital clock generation device that incorporates a range of features to enable jitter attenuation and programmable multiplication of input frequency. It receives one reference clock input and generates any multiplication of the input clock using fractional multipliers and high-speed output divider. The device can output various formats, such as LVDS, LVDS EXT, CML, LVPECL, and HCSL.

1. Frequency Configuration
   The frequency configuration is defined through non-volatile memory (NVM). Device settings are programmed during manufacturing and are automatically loaded at power-up. A combination of fractional frequency synthesis (M/N) and integer output division (Rn) allows generation of a wide range of output frequencies across all outputs. Frequency planning parameters are calculated using the EZ-Cleaner™ GUI utility, which generates the required configuration values for NVM programming. Contact Mixed-Signal for the EZ-Cleaner™ GUI utility.

2. Jitter Attenuation Bandwidth Control
   The MS1500 provides digitally programmable jitter attenuation bandwidth control, which defines the degree of input reference jitter filtering. Bandwidth options from 0.01 Hz to 4 kHz are selectable during configuration and stored in NVM.
   Because jitter filtering and frequency synthesis are implemented entirely in the digital domain, the device maintains inherent stability across all supported bandwidth settings, with less than 0.1 dB of peaking, independent of the selected bandwidth.

Operation Modes

Free Running Mode (Default Mode)

After initialization, MS1500 will enter free running mode. In this mode, the device generates an output clock using multiplication factor stored in the on-chip NVM. The frequency accuracy of the generated output clock tracks the frequency accuracy of the input reference. For example, if the input frequency is 156.25 MHz (+/- 10ppm) and the stored multiplication factor is 33/32, the output frequency would be 161.1328125 MHz (+/- 10ppm).

Frequency Translation Example
For example, if the input frequency is 15.625 MHz (±10ppm) and the stored multiplication factor is 33/32, the resulting output frequency is:

$$F_{OUT} = F_{IN} \times (M/N)$$
$$Fout = 156.25\ MHz \times (33/32) = 161.1328125\ MHz$$

The output frequency tolerance directly tracks the input reference tolerance:

$$\Delta F_{OUT} = \Delta F_{IN}$$

Lock Acquisition Mode.

Upon completion of the configuration process, the MS1500 will transition into the lock acquisition mode. This mode comprises two stages: fast acquisition and narrow acquisition. In the first stage, the loop bandwidth is widened to facilitate a speedy initial acquisition process. Following this, the bandwidth is narrowed as the device completes the lock.

Output

MS1500 supports CML, LVDS, LVDS-EXT, LVPECL, and HCSL output formats. The output enable, OE, is active HI. When OE is LOW, MS1500 output will be High Z but the loop will stay locked.

Input Terminations

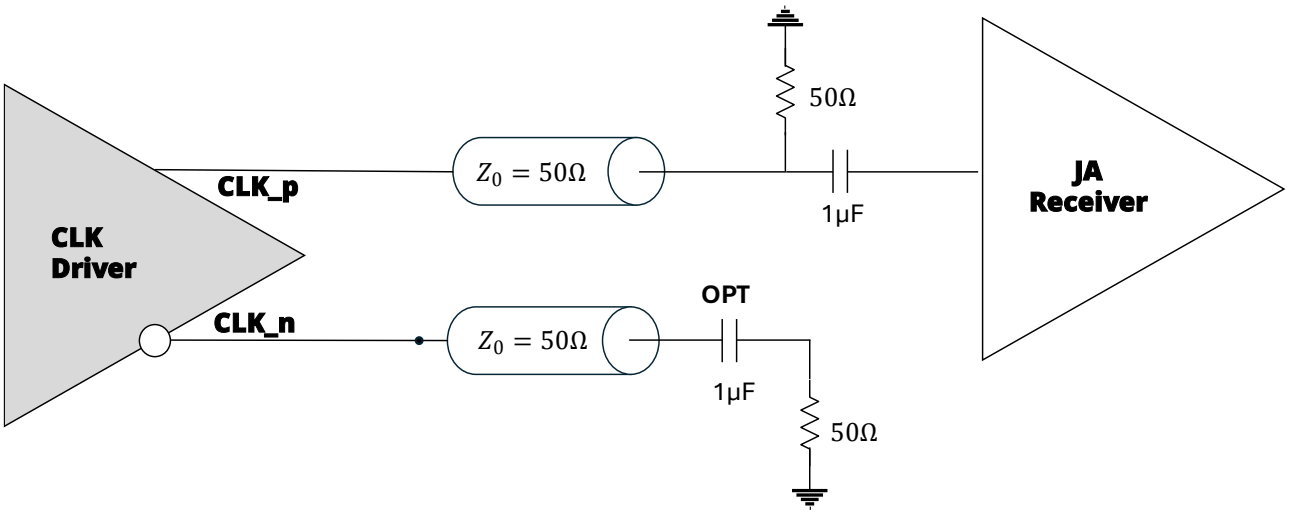


Figure 8. Differential Input Interface

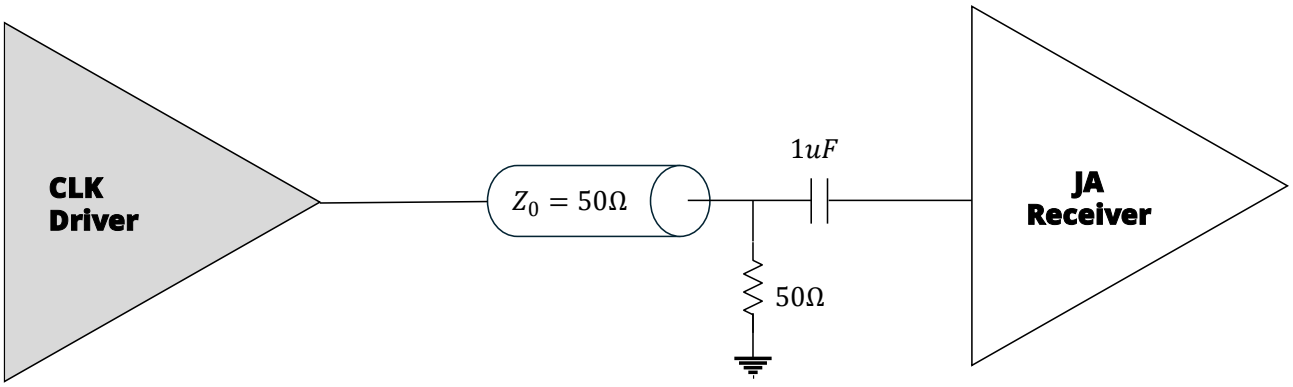


Figure 9. Single-Ended Input Interface

Output Terminations

Output Type	Differential Output Swing Vpp (Typ)	Coupling	Termination
CML	0.8V	AC	100 Ω diff
LVDS	0.7V	AC	100 Ω diff
LVDS-EXT	1.2V	AC	100 Ω diff
LVPECL	1.4V	AC	50 Ω to VT
LVPECL (DC Bias Resistor)	1.4V	AC	150 Ω to 250 Ω to GND, 50 Ω to VT
HCSL (Int Term)	1.35V	AC or DC	None
HCSL	1.35V	DC	50 Ω to GND

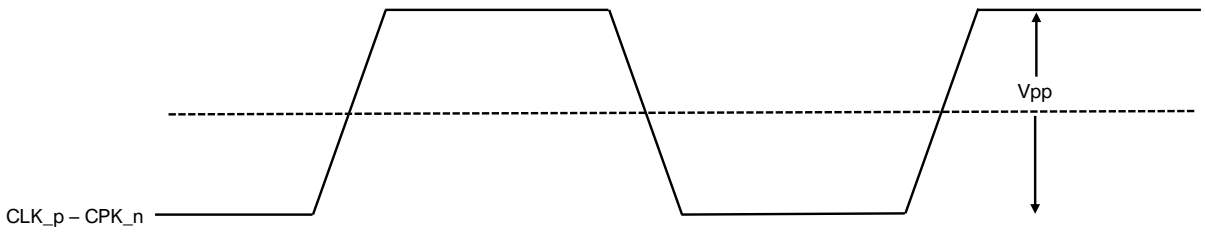


Figure 10. Differential Output Swing

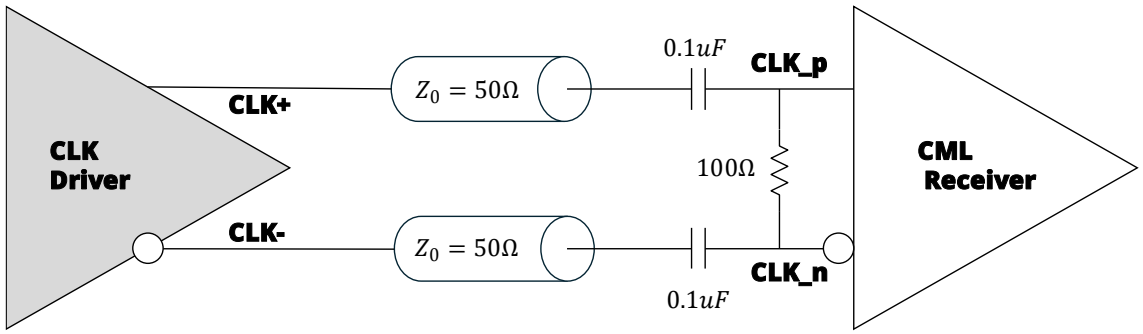


Figure 11. CML Output Driver with 100 Ω Differential Receiver Termination

Output Type	Differential Output Swing Vpp (Typ)	Coupling	Termination
CML	0.8V	AC	100 Ω diff

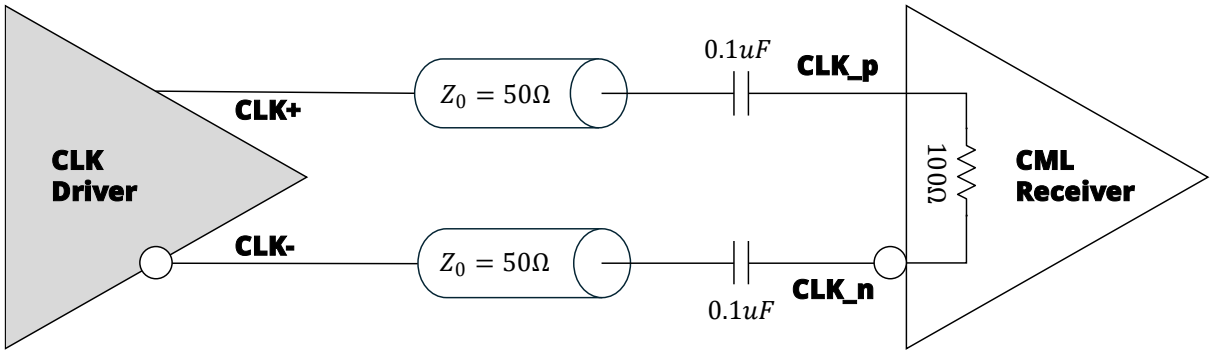


Figure 12. CML Output Driver with 100 Ω Differential Receiver Termination

Output Type	Differential Output Swing Vpp (Typ)	Coupling	Termination
CML	0.8V	AC	100 Ω diff

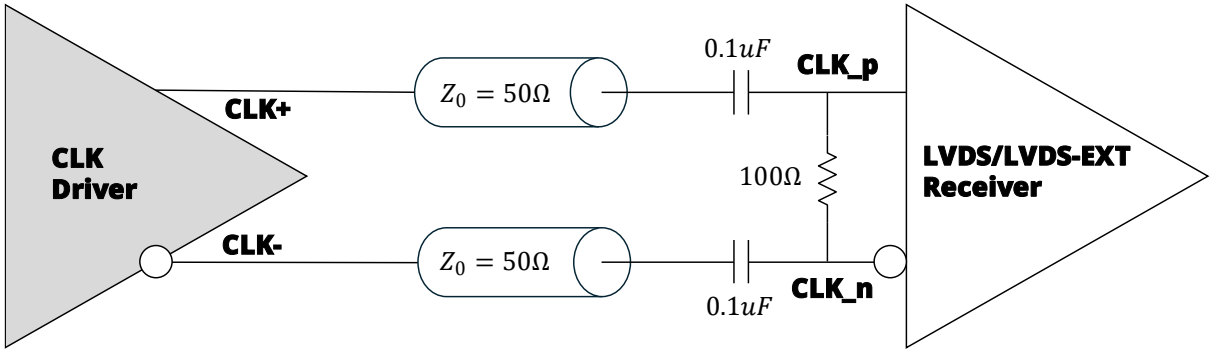


Figure 13. LVDS/LVDS-EXT Output Driver with 100 Ω Differential Termination

Output Type	Differential Output Swing Vpp (Typ)	Coupling	Termination
LVDS/LVDS-EXT	0.7V/1.2V	AC	100 Ω diff

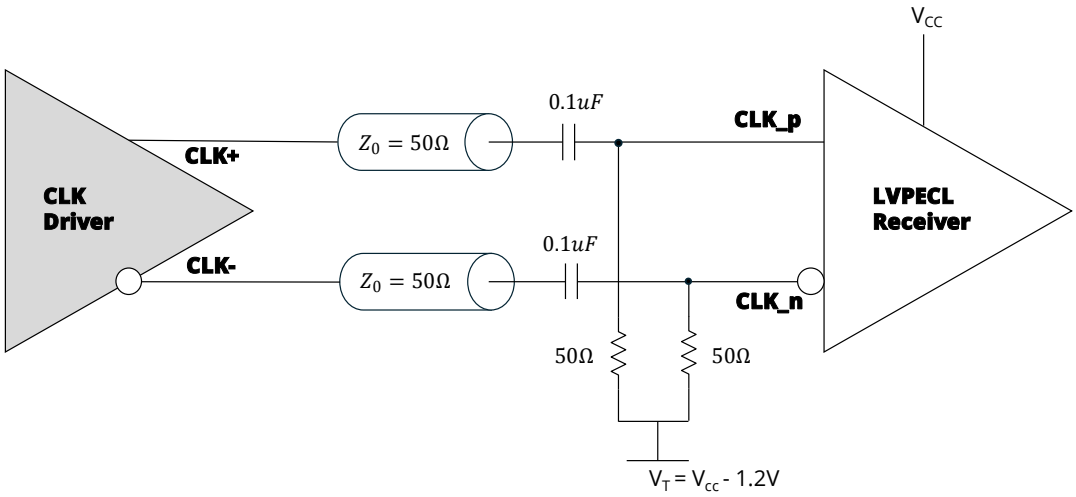


Figure 14. LVPECL Output Driver with External VT Bias Termination

Output Type	Differential Output Swing Vpp (Typ)	Coupling	Termination
LVPECL	1.4V	AC	50Ω to VT

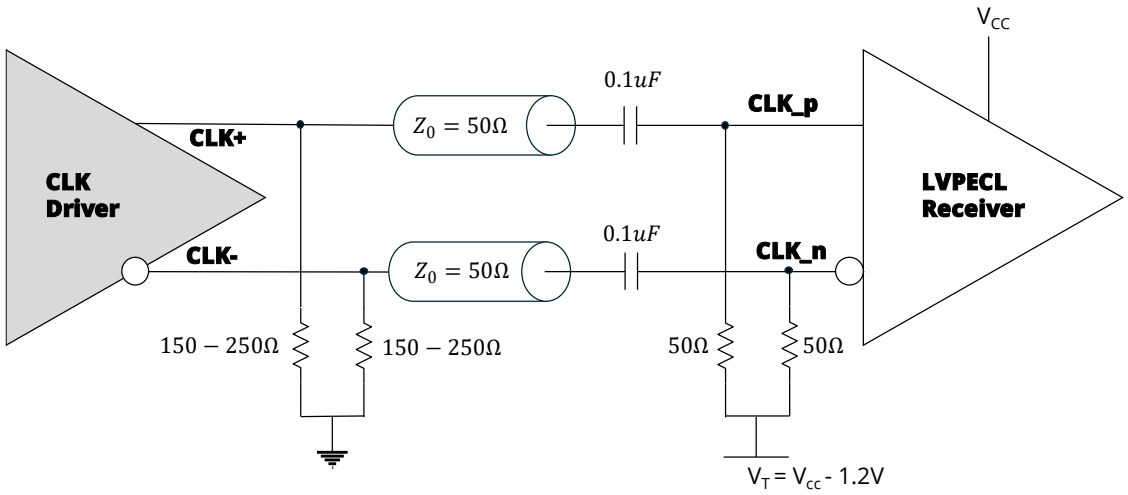


Figure 15. LVPECL Output Driver with Source Bias Resistors and External VT Bias Termination

Output Type	Differential Output Swing Vpp (Typ)	Coupling	Termination
LVPECL (DC Bias Resistor)	1.4V	AC	150 Ω to 250 Ω to GND, 50 Ω to VT

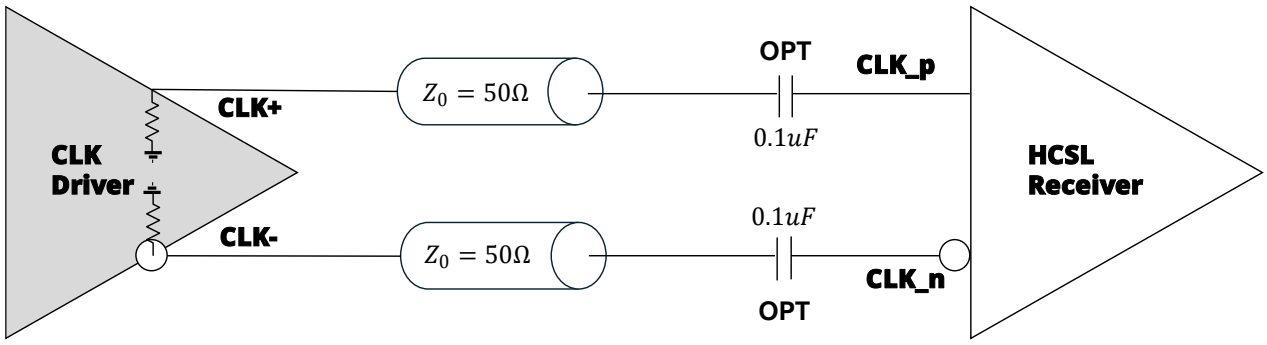


Figure 16. HCSL Output Driver with Integrated Termination to Ground

Output Type	Differential Output Swing Vpp (Typ)	Coupling	Termination
HCSL (Int Term)	1.35V	AC/DC	None

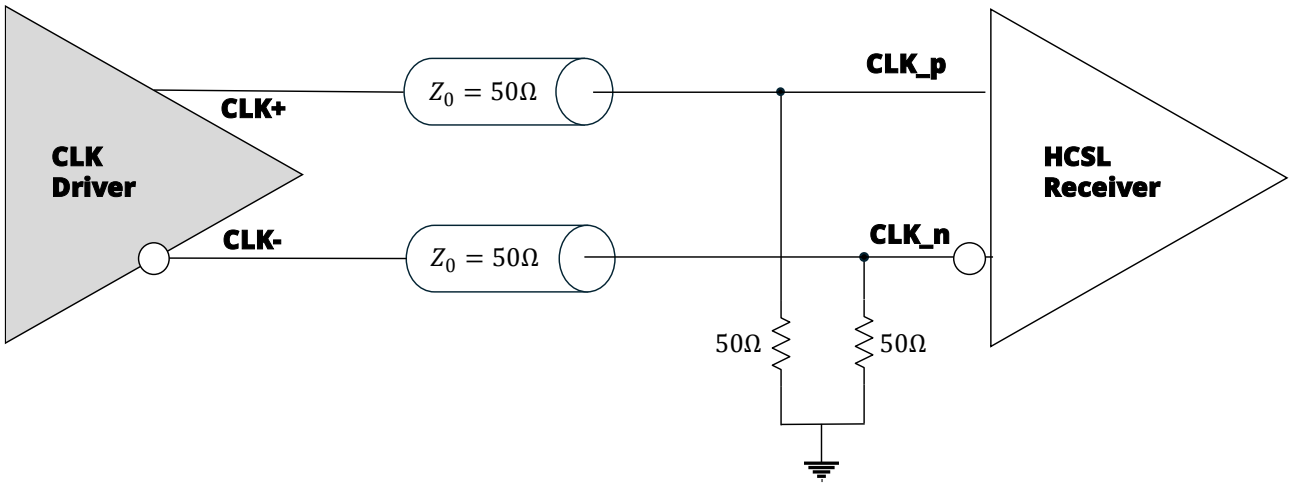


Figure 17. HCSL Output Driver with 50 Ω Receiver Termination to Ground

Output Type	Differential Output Swing Vpp (Typ)	Coupling	Termination
HCSL	1.35V	DC	50 Ω to GND

Output Timing

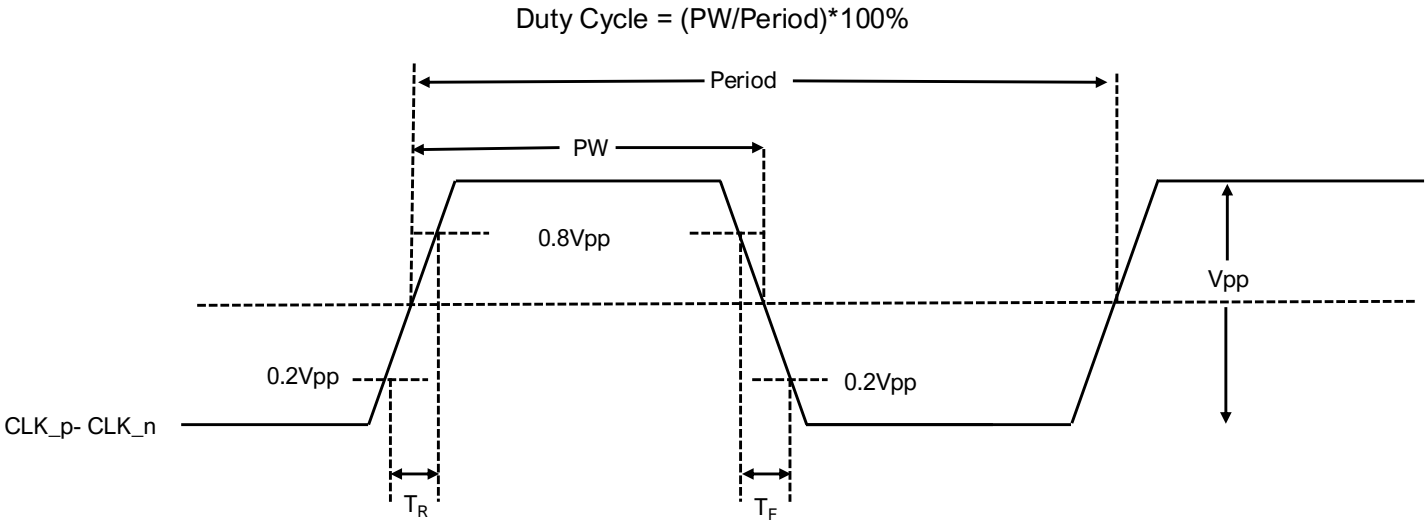


Figure 18. Output Timing across differential pair (CLK_p - CLK_n)

Parameter	Symbol	Test Condition/Comment	Min	Typ	Max	Unit
Output Duty Cycle	DC	All Output Formats	48		52	%
Output Rise/Fall Time (20% to 80% V_{PP})	T_R / T_F	All Output Formats		60	80	ps

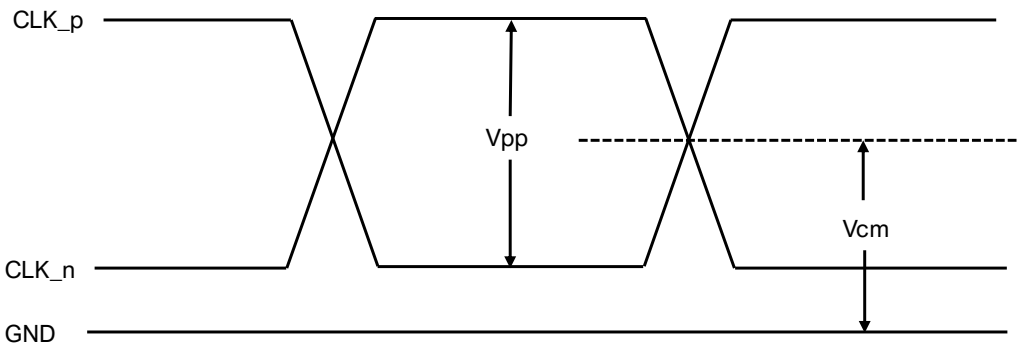


Figure 19. HCSL Output Level across differential pair (CLK_p - CLK_n)

Parameter	Symbol	Test Condition/Comment	Min	Typ	Max	Unit
HCSL Output Voltage (DC- Coupled)	V_{CM}	Common Mode Voltage	340	350	360	mV

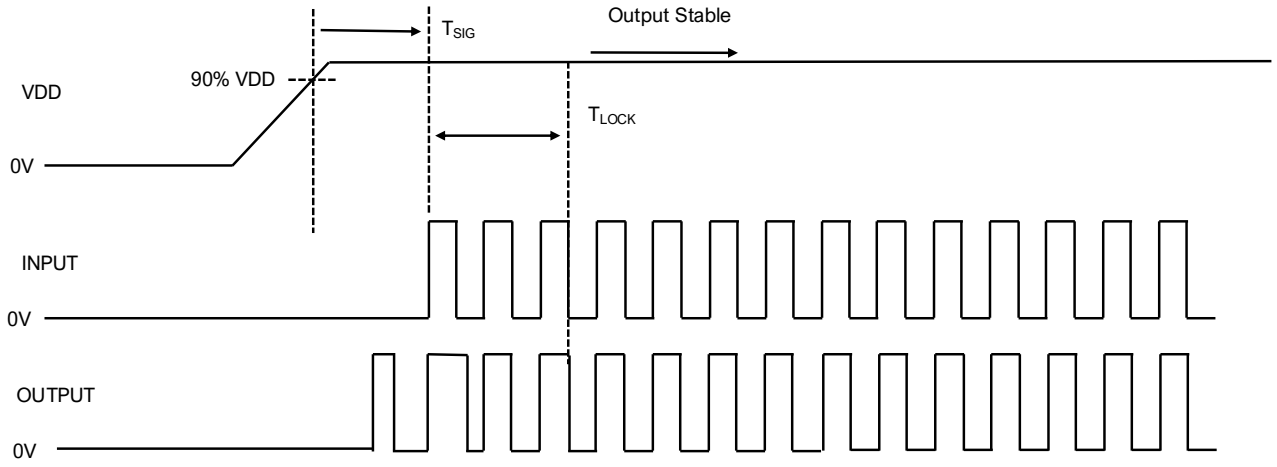


Figure 20. Powerup Timing

Parameter	Symbol	Test Condition/Comment	Min	Typ	Max	Unit
Input Signal Powerup Time	T_{SIG}	Time required from 0.9xVDD until input signal	10			ms
Output Lock Time	T_{LOCK}	Time from input signal to a stable output			10	ms

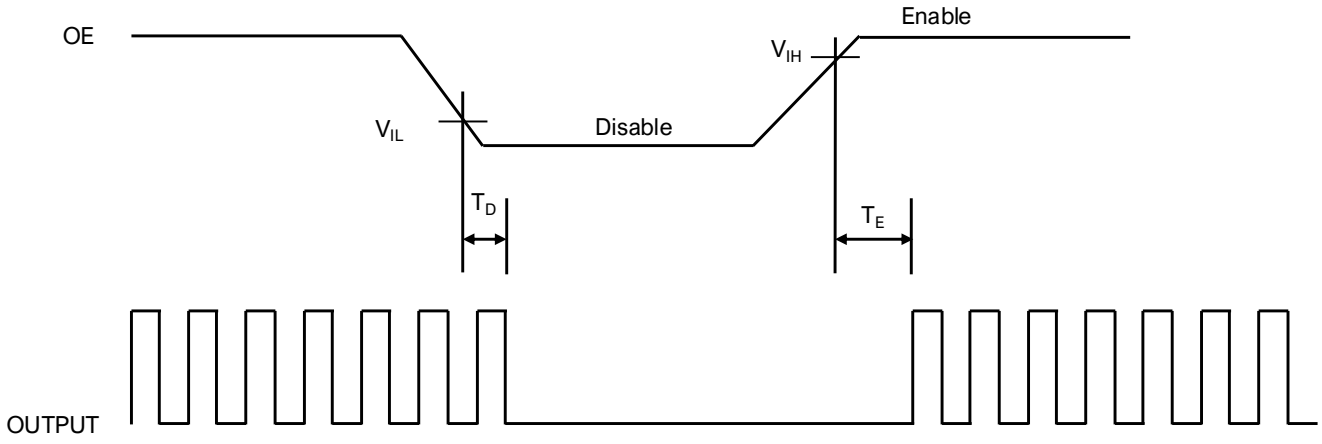


Figure 21. OE Enable/Disable Timing

Parameter	Symbol	Test Condition/Comment	Min	Typ	Max	Unit
Output Enable (OE)	T_D	Output Disable Time			3	µs
	T_E	Output Enable Time			20	µs

Packaging Information

Figure 22 shows the MS1500 packaging drawing.

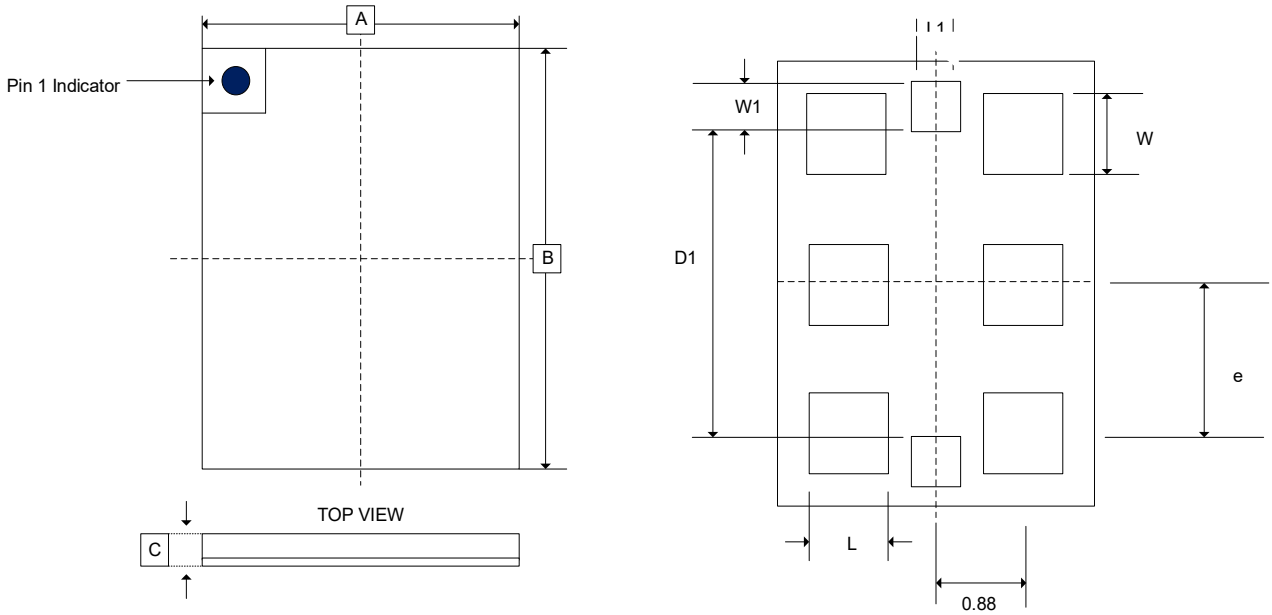


Figure 22. MS1500 Packaging Drawing (3.2mm x 2.5 mm)

Table 8. MS1500 Packaging Dimensions

Dimensions	Min	Nom	Max
A		2.5 BSC	
B		3.2 BSC	
C	1.246	1.346	1.446
W	0.55	0.6	0.65
L	0.5	0.55	0.6
W1	0.35	0.4	0.45
L1	0.35	0.4	0.45
e		1.1 BSC	
D1		2.2 BSC	
Package Edge Tolerance		0.1	
Mold Flatness		0.1	
Coplanarity		0.08	

Note: All dimensions are in millimeters

Packaging Land Pattern

Figure 23 shows the MS1500 PCB land pattern.

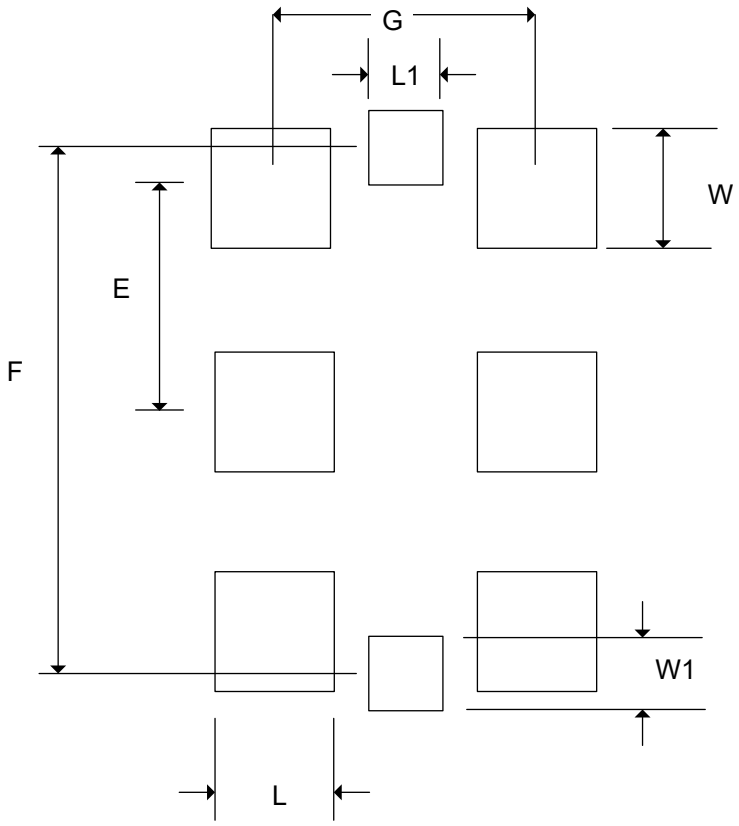


Figure 23. MS1500 Packaging Land Pattern Drawing (3.2mm x 2.5mm)

Table 9. MS1500 Packaging Land Pattern Dimensions

Dimensions	In mm
L	0.7
W	0.7
L1	0.5
W1	0.55
E	1.1
F	2.6
G	1.76

Note: All dimensions are in millimeters

Device Top Marking

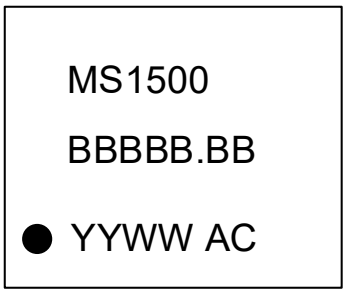


Figure 24. MS1500 Device Top Marking Showing Pin 1

Table 10. MS1500 Device Marking Legend

Line	Position	Description
1	1	Part Number
2	1-5	Wafer Lot Number
	6-7	Wafer #
3	Lot Traceability	
	1	Pin 1 Orientation Mark (Dot),
	2-3	Year (last two digits of the year)
	4-5	Calendar Work Week Number (1-53)
	6-7	Assembly Code

Reflow Profile (IPC/JEDEC-STD-020)

Figure 25 shows the reflow profile for MS1500

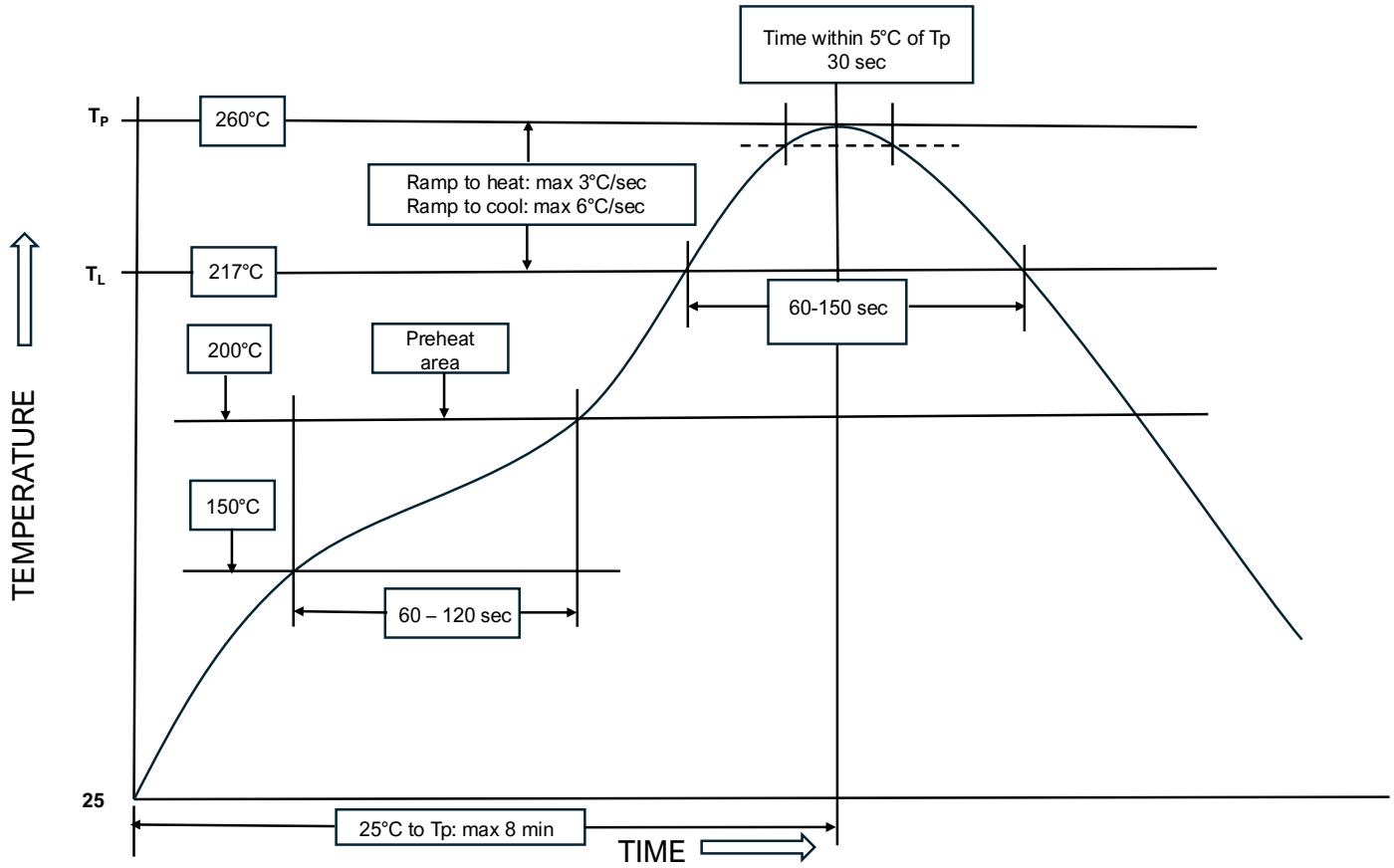


Figure 25. MS1500 Reflow Profile

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