PRELIMINARY

Integrated Circuit Systems, Inc.

ICS844002I

FEMTOCLOCKS™ CRYSTAL-TO-LVDS FREQUENCY SYNTHESIZER

GENERAL DESCRIPTION

The ICS844002I is a 2 output LVDS Synthesizer optimized to generate Fibre Channel reference clock frequencies and is a member of the HiPerClocks™ family of high performance clock solutions from ICS. Using a 26.5625MHz 18pF parallel resonant crystal, the following frequencies can be generated based on the 2 frequency select pins (F_SEL[1:0]): 212.5MHz, 187.5MHz, 159.375MHz, 106.25MHz and 53.125MHz. The ICS844002I uses ICS' 3rd generation low phase noise VCO technology and can achieve <1ps typical rms phase jitter, easily meeting Fibre Channel jitter requirements. The ICS844002I is packaged in a small 20-pin TSSOP package.

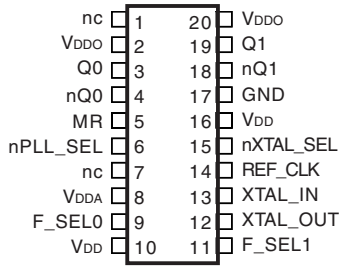
FEATURES

- Two LVDS outputs
- Selectable crystal oscillator interface or LVCMOS/LVTTL single-ended input
- Supports the following output frequencies: 212.5MHz, 187.5MHz, 159.375MHz, 106.25MHz and 53.125MHz
- VCO range: 560MHz - 680MHz
- RMS phase jitter @ 212.5MHz, using a 26.5625MHz crystal (637kHz - 10MHz): 0.65ps (typical)
- Full 3.3V or 2.5V supply modes
- -40°C to 85°C ambient operating temperature
- Available in both standard and lead-free RoHS compliant packages

FREQUENCY SELECT FUNCTION TABLE

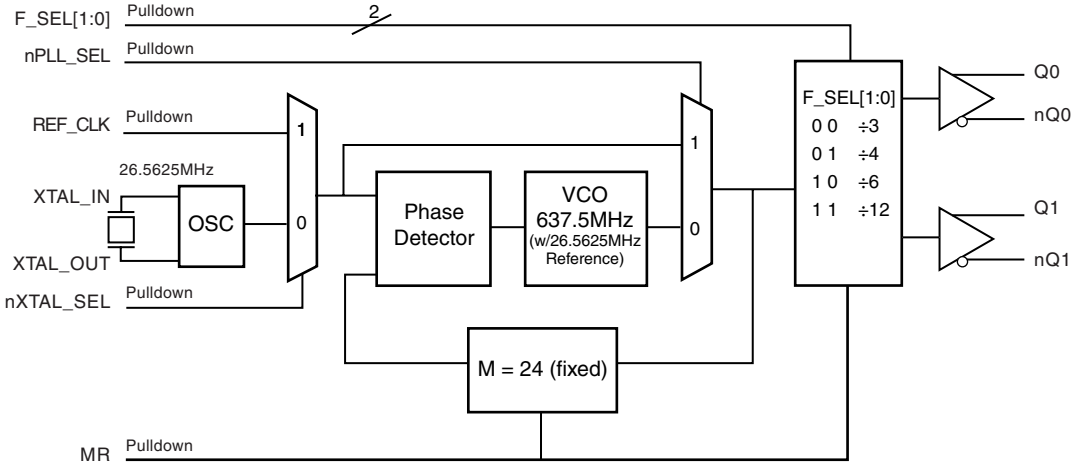
Inputs						Output Frequency (MHz)
Input Frequency (MHz)	F_SEL1	F_SEL0	M Divider Value	N Divider Value	M/N Divider Value	
26.5625	0	0	24	3	8	212.5
26.5625	0	1	24	4	6	159.375
26.5625	1	0	24	6	4	106.25
26.5625	1	1	24	12	2	53.125
23.4375	0	0	24	3	8	187.5

PIN ASSIGNMENT



ICS844002I
20-Lead TSSOP
6.5mm x 4.4mm x 0.92mm package body
G Package
Top View

BLOCK DIAGRAM



The Preliminary Information presented herein represents a product in prototyping or pre-production. The noted characteristics are based on initial product characterization. Integrated Circuit Systems, Incorporated (ICS) reserves the right to change any circuitry or specifications without notice.

TABLE 1. PIN DESCRIPTIONS

Number	Name	Type		Description
1, 7	nc	Unused		No connect.
2, 20	V_{DDO}	Power		Output supply pins.
3, 4	Q0, nQ0	Ouput		Differential output pair. LVDS interface levels.
5	MR	Input	Pulldown	Active HIGH Master Reset. When logic HIGH, the internal dividers are reset causing the true outputs Qx to go low and the inverted outputs nQx to go high. When logic LOW, the internal dividers and the outputs are enabled. LVCMOS/LVTTL interface levels.
6	nPLL_SEL	Input	Pulldown	Selects between the PLL and REF_CLK as input to the dividers. When LOW, selects PLL (PLL Enable). When HIGH, deselects the reference clock (PLL Bypass). LVCMOS/LVTTL interface levels.
8	V_{DDA}	Power		Analog supply pin.
9, 11	F_SEL0, F_SEL1	Input	Pulldown	Frequency select pins. LVCMOS/LVTTL interface levels.
10, 16	V_{DD}	Power		Core supply pins.
12, 13	XTAL_OUT, XTAL_IN	Input		Parallel resonant crystal interface. XTAL_OUT is the output, XTAL_IN is the input.
14	REF_CLK	Input	Pulldown	LVCMOS/LVTTL reference clock input.
15	nXTAL_SEL	Input	Pulldown	Selects between crystal or REF_CLK inputs as the the PLL Reference source. Selects XTAL inputs when LOW. Selects REF_CLK when HIGH. LVCMOS/LVTTL interface levels.
17	GND	Power		Power supply ground.
18, 19	nQ1, Q1	Output		Differential output pair. LVDS interface levels.

NOTE: *Pulldown* refers to internal input resistors. See Table 2, Pin Characteristics, for typical values.

TABLE 2. PIN CHARACTERISTICS

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
C_{IN}	Input Capacitance			4		pF
$R_{PULLDOWN}$	Input Pulldown Resistor			51		kΩ

ABSOLUTE MAXIMUM RATINGS

Supply Voltage, V_{DD}	4.6V
Inputs, V_I	-0.5V to V_{DD} + 0.5V
Outputs, I_O	
Continuous Current	10mA
Surge Current	15mA
Package Thermal Impedance, θ_{JA}	73.2°C/W (0 lfpm)
Storage Temperature, T_{STG}	-65°C to 150°C

NOTE: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These ratings are stress specifications only. Functional operation of product at these conditions or any conditions beyond those listed in the *DC Characteristics* or *AC Characteristics* is not implied. Exposure to absolute maximum rating conditions for extended periods may affect product reliability.

TABLE 3A. POWER SUPPLY DC CHARACTERISTICS, $V_{DD} = V_{DDA} = V_{DDO}$ = 3.3V±5%, TA = -40°C TO 85°C

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
V_{DD}	Core Supply Voltage		3.135	3.3	3.465	V
V_{DDA}	Analog Supply Voltage		3.135	3.3	3.465	V
V_{DDO}	Output Supply Voltage		3.135	3.3	3.465	V
I_{DD}	Power Supply Current			TBD		mA
I_{DDA}	Analog Supply Current			TBD		mA
I_{DDO}	Output Supply Current			TBD		mA

TABLE 3B. POWER SUPPLY DC CHARACTERISTICS, $V_{DD} = V_{DDA} = V_{DDO}$ = 2.5V±5%, TA = -40°C TO 85°C

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
V_{DD}	Core Supply Voltage		2.375	2.5	2.625	V
V_{DDA}	Analog Supply Voltage		2.375	2.5	2.625	V
V_{DDO}	Output Supply Voltage		2.375	2.5	2.625	V
I_{DD}	Power Supply Current			TBD		mA
I_{DDA}	Analog Supply Current			TBD		mA
I_{DDO}	Output Supply Current			TBD		mA

TABLE 3C. LVCMOS / LVTTL DC CHARACTERISTICS, $V_{DD} = V_{DDA} = V_{DDO}$ = 3.3V±5% OR 2.5V±5%, TA = -40°C TO 85°C

Symbol	Parameter		Test Conditions	Minimum	Typical	Maximum	Units
V_{IH}	Input High Voltage		V_{DD} = 3.3V	2		V_{DD} + 0.3	V
			V_{DD} = 2.5V	1.7		V_{DD} + 0.3	V
V_{IL}	Input Low Voltage		V_{DD} = 3.3V	-0.3		0.8	V
			V_{DD} = 2.5V	-0.3		0.7	V
I_{IH}	Input High Current	REF_CLK, MR, F_SEL0, F_SEL1, nPLL_SEL, nXTAL_SEL,	$V_{DD} = V_{IN}$ = 3.465 or 2.5V			150	µA
I_{IL}	Input Low Current	REF_CLK, MR, F_SEL0, F_SEL1, nPLL_SEL, nXTAL_SEL,	V_{DD} = 3.465V or 2.5V, V_{IN} = 0V	-150			µA

TABLE 3D. LVDS DC CHARACTERISTICS, $V_{DD} = V_{DDA} = V_{DDO}$ = 3.3V±5%, TA = -40°C TO 85°C

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
V_{OD}	Differential Output Voltage			350		mV
ΔV_{OD}	V_{OD} Magnitude Change			40		mV
V_{OS}	Offset Voltage			1.45		V
ΔV_{OS}	V_{OS} Magnitude Change			50		mV

TABLE 3E. LVDS DC CHARACTERISTICS, $V_{DD} = V_{DDA} = V_{DDO}$ = 2.5V±5%, TA = -40°C TO 85°C

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
V_{OD}	Differential Output Voltage			350		mV
ΔV_{OD}	V_{OD} Magnitude Change			40		mV
V_{OS}	Offset Voltage			1.2		V
ΔV_{OS}	V_{OS} Magnitude Change			50		mV

TABLE 4. CRYSTAL CHARACTERISTICS

Parameter	Test Conditions	Minimum	Typical	Maximum	Units
Mode of Oscillation			Fundamental		
Frequency		23.33	26.5625	28.33	MHz
Equivalent Series Resistance (ESR)				50	Ω
Shunt Capacitance				7	pF
Drive Level				1	mW

NOTE: Characterized using an 18pF parallel resonant crystal.

TABLE 5A. AC CHARACTERISTICS, $V_{DD} = V_{DDA} = V_{DDO}$ = 3.3V±5%, TA = -40°C TO 85°C

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
f_{OUT}	Output Frequency	F_SEL[1:0] = 00	186.67		226.66	MHz
		F_SEL[1:0] = 01	140		170	MHz
		F_SEL[1:0] = 10	93.33		113.33	MHz
		F_SEL[1:0] = 11	46.67		56.66	MHz
*t*sk(o)	Output Skew; NOTE 1, 2			TBD		ps
*t*jit(Ø)	RMS Phase Jitter (Random); NOTE 3	212.5MHz, (637kHz - 10MHz)		0.65		ps
		159.375MHz, (637kHz - 10MHz)		0.61		ps
		106.25MHz, (637kHz -10MHz)		0.74		ps
		53.125MHz, (637kHz - 10MHz)		0.64		ps
		187.5MHz, (637kHz - 10MHz)		0.80		ps
t_R / t_F	Output Rise/Fall Time	20% to 80%		400		ps
odc	Output Duty Cycle			50		%

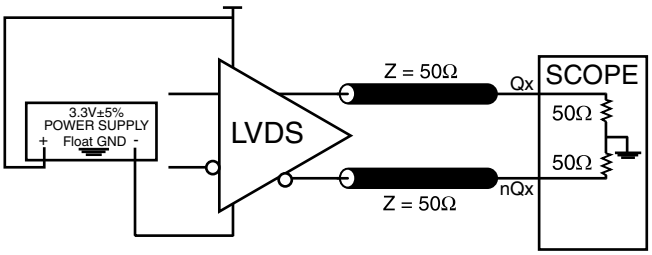
NOTE 1: Defined as skew between outputs at the same supply voltages and with equal load conditions. Measured at V_{DDO}/2.
NOTE 2: This parameter is defined in accordance with JEDEC Standard 65.
NOTE 3: Please refer to the Phase Noise Plot.

TABLE 5B. AC CHARACTERISTICS, $V_{DD} = V_{DDA} = V_{DDO}$ = 2.5V±5%, TA = -40°C TO 85°C

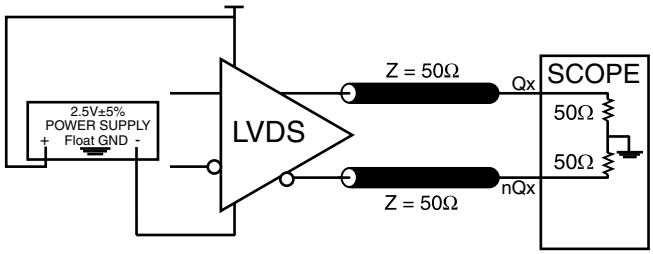
Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
f_{OUT}	Output Frequency	F_SEL[1:0] = 00	186.67		226.66	MHz
		F_SEL[1:0] = 01	140		170	MHz
		F_SEL[1:0] = 10	93.33		113.33	MHz
		F_SEL[1:0] = 11	46.67		56.66	MHz
*t*sk(o)	Output Skew; NOTE 2, 4			TBD		ps
*t*jit(Ø)	RMS Phase Jitter (Random); NOTE 3	212.5MHz, (637kHz - 10MHz)		0.65		ps
		159.375MHz, (637kHz - 10MHz)		0.61		ps
		106.25MHz, (637kHz -10MHz)		0.74		ps
		53.125MHz, (637kHz - 10MHz)		0.64		ps
		187.5MHz, (637kHz - 10MHz)		0.80		ps
t_R / t_F	Output Rise/Fall Time	20% to 80%		430		ps
odc	Output Duty Cycle			50		%

NOTE 1: Defined as skew between outputs at the same supply voltages and with equal load conditions. Measured at V_{DDO}/2.
NOTE 2: This parameter is defined in accordance with JEDEC Standard 65.
NOTE 3: Please refer to the Phase Noise Plot.

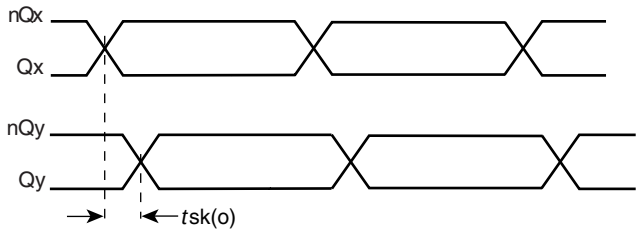
PARAMETER MEASUREMENT INFORMATION



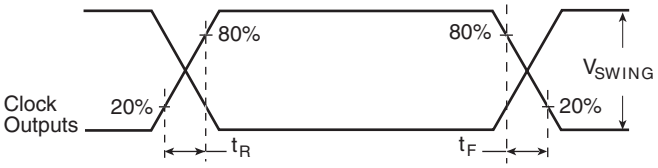
3.3V CORE/3.3V OUTPUT LOAD AC TEST CIRCUIT



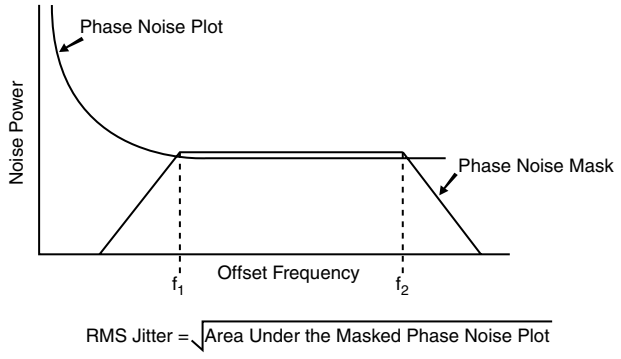
2.5V CORE/2.5V OUTPUT LOAD AC TEST CIRCUIT



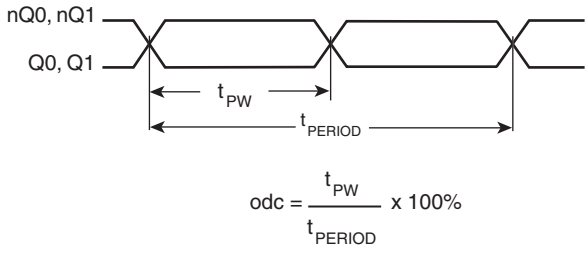
OUTPUT SKEW



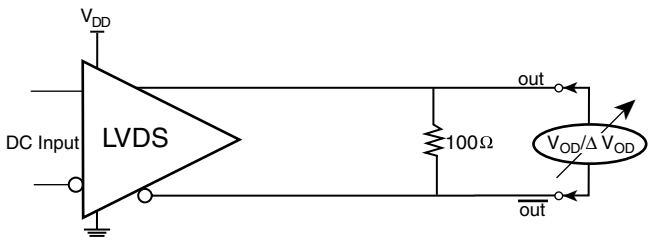
OUTPUT RISE/FALL TIME



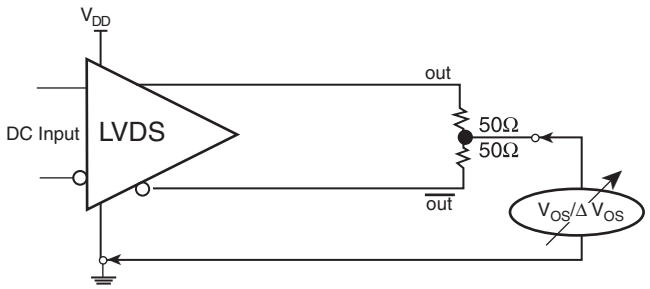
RMS PHASE JITTER



OUTPUT DUTY CYCLE/PULSE WIDTH/PERIOD



DIFFERENTIAL OUTPUT VOLTAGE SETUP



OFFSET VOLTAGE SETUP

APPLICATION INFORMATION

POWER SUPPLY FILTERING TECHNIQUES

As in any high speed analog circuitry, the power supply pins are vulnerable to random noise. The ICS844002I provides separate power supplies to isolate any high switching noise from the outputs to the internal PLL. V_{DD}, V_{DDA}, and V_{DDO} should be individually connected to the power supply plane through vias, and bypass capacitors should be used for each pin. To achieve optimum jitter performance, power supply isolation is required. *Figure 1* illustrates how a 10Ω resistor along with a 10µF and a .01µF bypass capacitor should be connected to each V_{DDA}.

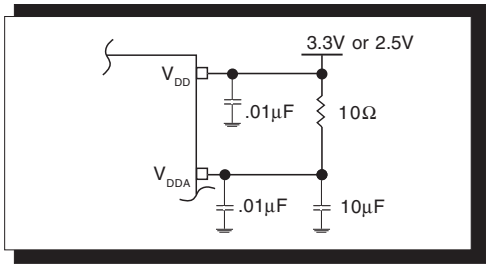


FIGURE 1. POWER SUPPLY FILTERING

CRYSTAL INPUT INTERFACE

The ICS844002I has been characterized with 18pF parallel resonant crystals. The capacitor values shown in *Figure 2* below were determined using a 26.5625MHz 18pF parallel resonant crystal and were chosen to minimize the ppm error.

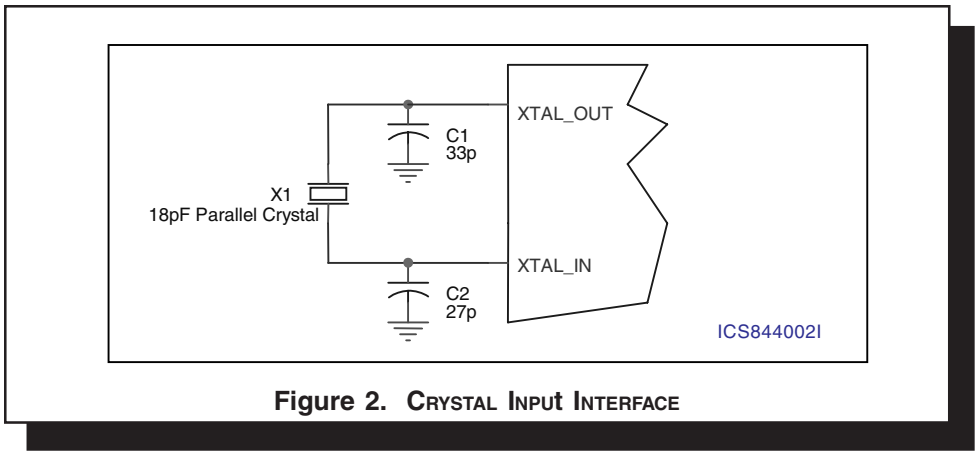


Figure 2. CRYSTAL INPUT INTERFACE

RECOMMENDATIONS FOR UNUSED INPUT AND OUTPUT PINS

INPUTS:

CRYSTAL INPUT:
For applications not requiring the use of the crystal oscillator input, both XTAL_IN and XTAL_OUT can be left floating. Though not required, but for additional protection, a 1kΩ resistor can be tied from XTAL_IN to ground.

REF_CLK INPUT:
For applications not requiring the use of the reference clock, it can be left floating. Though not required, but for additional protection, a 1kΩ resistor can be tied from the REF_CLK to ground.

LVCMOS CONTROL PINS:
All control pins have internal pull-ups or pull-downs; additional resistance is not required but can be added for additional protection. A 1kΩ resistor can be used.

OUTPUTS:

LVDS
All unused LVDS output pairs can be either left floating or terminated with 100Ω across. If they are left floating, we recommend that there is no trace attached.

3.3V, 2.5V LVDS DRIVER TERMINATION

A general LVDS interface is shown in *Figure 3.* In a 100Ω differential transmission line environment, LVDS drivers require a matched load termination of 100Ω across near the receiver input. For a multiple LVDS outputs buffer, if only partial outputs are used, it is recommended to terminate the un-used outputs.

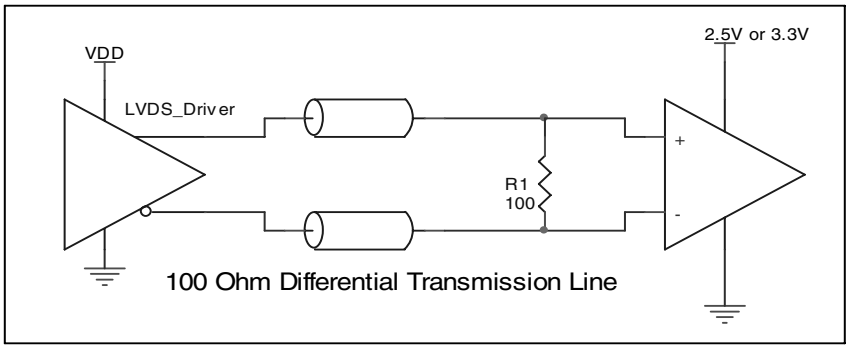


FIGURE 3. TYPICAL LVDS DRIVER TERMINATION

RELIABILITY INFORMATION

TABLE 6. θ_{JA} VS. AIR FLOW TABLE FOR 20 LEAD TSSOP

θ_{JA} by Velocity (Meters per Second)	0	200	500
Single-Layer PCB, JEDEC Standard Test Boards	114.5°C/W	98.0°C/W	88.0°C/W
Multi-Layer PCB, JEDEC Standard Test Boards	73.2°C/W	66.6°C/W	63.5°C/W

NOTE: Most modern PCB designs use multi-layered boards. The data in the second row pertains to most designs.

TRANSISTOR COUNT

The transistor count for ICS844002I is: 2914

PACKAGE OUTLINE - G SUFFIX FOR 20 LEAD TSSOP

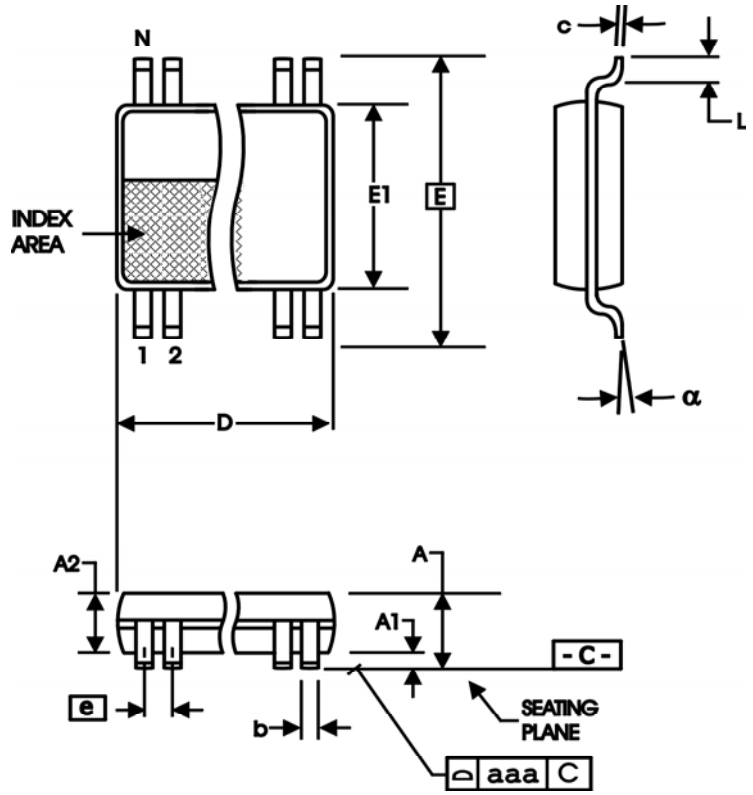


TABLE 7. PACKAGE DIMENSIONS

SYMBOL	Millimeters	
	MIN	MAX
N	20	
A	--	1.20
A1	0.05	0.15
A2	0.80	1.05
b	0.19	0.30
c	0.09	0.20
D	6.40	6.60
E	6.40 BASIC	
E1	4.30	4.50
e	0.65 BASIC	
L	0.45	0.75
α	0°	8°
aaa	--	0.10

Reference Document: JEDEC Publication 95, MO-153

TABLE 9. ORDERING INFORMATION

Part/Order Number	Marking	Package	Shipping Packaging	Temperature
ICS844002AGI	ICS844002AGI	20 Lead TSSOP	tube	-40°C to 85°C
ICS844002AGIT	ICS844002AGI	20 Lead TSSOP	2500 tape & reel	-40°C to 85°C
ICS844002AGILF	ICS844002AIL	20 Lead "Lead-Free" TSSOP	tube	-40°C to 85°C
ICS844002AGILFT	ICS844002AIL	20 Lead "Lead-Free" TSSOP	2500 tape & reel	-40°C to 85°C

NOTE: Parts that are ordered with an "LF" suffix to the part number are the Pb-Free configuration and are RoHS compliant.