

Features

- 👉 150 Mbps Data Rate
- 👉 5 kV RMS Isolation Rating (WSOP)
- 👉 ± 200 kV/ μ s typ static CMTI, ± 150 kV/ μ s typ dynamic CMTI
- 👉 Low Power Consumption, typ 3 mA/ch @1 Mbps
- 👉 Low Propagation Delay: 12 ns Typical
- 👉 Default Output Low (AL992xF) and High (AL992x)
- 👉 Wide Temperature Range: -40°C to $+125^{\circ}\text{C}$
- 👉 SOP8, WSOP8 and WSOP16 package
- 👉 Robust electromagnetic compatibility (EMC)
 - Low emissions
 - System level ESD, EFT and surge immunity
- 👉 Safety-Related Certifications:
 - VDE Certification according to DIN VDE V 0884-17(IEC60747-17)
 - $5000V_{\text{RMS}}$ (WSOP16, WSOP8), $3750V_{\text{RMS}}$ (SOP8) Isolation Rating per UL 1577
 - CQC Certification per GB 4943.1
 - CAS, TUV and CB certifications
- 👉 Qualified for Automotive Applications with AEC-Q100 Reliability Test (with suffix -S)

Applications

- 👉 Industrial Automation
- 👉 Motor Control
- 👉 Power Supplies
- 👉 Isolated interface and general-purpose isolation

Description

The AL992x devices are high performance, dual channel enhanced digital isolators with $5000 V_{\text{RMS}}$ (WSOP8, WSOP16), $3750 V_{\text{RMS}}$ (SOP8) isolation ratings per UL 1577. These devices are also to be certified by VDE, UL, CSA, TUV, CQC and CB.

The AL992x devices provide high reliability and high performance at low power consumption while isolating digital input and output. Each isolation signal channel is separated by a double capacitive silicon dioxide insulation barrier. The AL9920 device has both channels in the same direction while the AL9921 and AL9922 device has both channels in the opposite direction. In the event of input power or signal loss, the fail-safe default output is low for devices with suffix F and high for devices without suffix F.

The common mode transient immunity (CMTI) and electromagnetic compatibility of the AL992x devices have been significantly enhanced through innovative circuit design and optimized structure.

AL992x family is available in SOP8, WSOP8 and WSOP16 packages, and is characterized from -40°C to $+125^{\circ}\text{C}$. Devices with -S suffix are qualified for Automotive Applications with AEC-Q100 Reliability Test.

Function Block Diagram

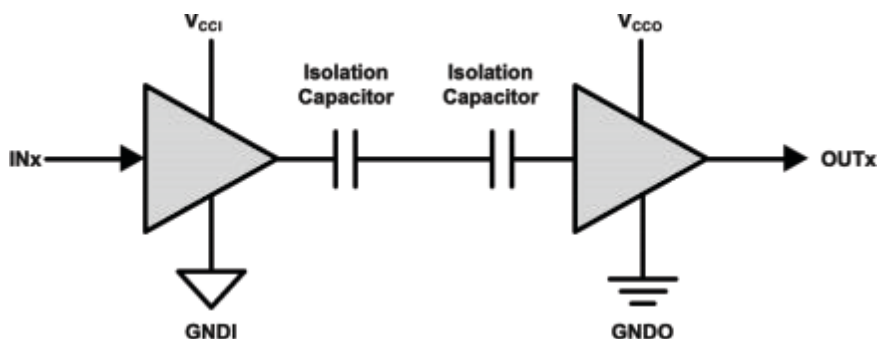
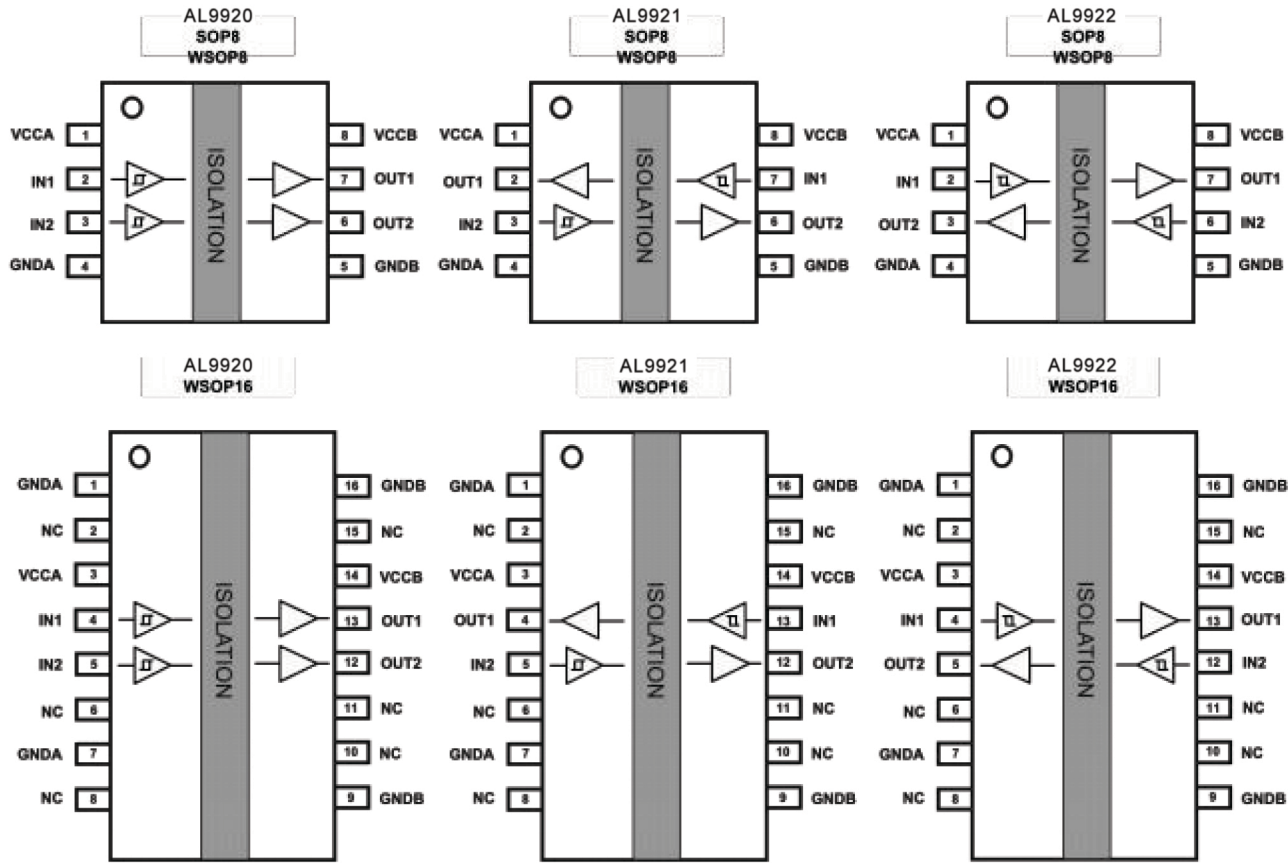


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Pin Configuration and Functions



Pin Functions

	Pin						I/O	Description
Name	SOP8, WSOP8			WSOP16				
	AL9920	AL9921	AL9922	AL9920	AL9921	AL9922		
VCCA	1	1	1	3	3	3	–	Power supply, VCCA
IN1	2	7	2	4	13	4	I	Input, channel 1
IN2	3	3	6	5	5	12	I	Input, channel 2
GNDA	4	4	4	1, 7	1, 7	1, 7	–	Ground connection for VCCA
GNDB	5	5	5	9, 16	9, 16	9, 16	–	Ground connection for VCCB
OUT2	6	6	3	12	12	5	O	Output, channel 2
OUT1	7	2	7	13	4	13	O	Output, channel 1
VCCB	8	8	8	14	14	14	–	Power supply, VCCB
NC	–	–	–	2, 6, 8, 10, 11, 15	2, 6, 8, 10, 11, 15	2, 6, 8, 10, 11, 15	–	No Connect

Specifications

Absolute Maximum Ratings

Parameter		Min	Max	Unit
V _{CC}	Supply voltage, V _{CCA} , V _{CCB}	-0.5	6	V
V _{IO}	Voltage at IN1, IN2, OUT1, OUT2	-0.5	V _{CC} + 0.5	V
I _O	Output current	-15	15	mA
T _J	Operating virtual junction temperature		150	°C
T _{slg}	Storage temperature	-65	150	°C

(1) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

(2) This data was taken with the JEDEC low effective thermal conductivity test board.

(3) This data was taken with the JEDEC standard multilayer test boards.

ESD, Electrostatic Discharge Protection

Parameter	Condition	Value	Unit
HBM, per ANSI/ESDA/JEDEC JS-001/ANSI/ESD STM5.5.1 ⁽¹⁾	All Pin	6	kV
CDM, per ANSI/ESDA/JEDEC JS-002 ⁽²⁾	All Pin	1.5	kV

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

Recommended Operating Conditions

Parameter		Min	Typ	Max	Unit
V _{CCX}	Supply voltage, V _{CCA} , V _{CCB} ⁽¹⁾	2.25		5.5	V
V _{CC(UVLO+)}	UVLO threshold when supply voltage is rising ⁽²⁾		2	2.25	V
V _{CC(UVLO-)}	UVLO threshold when supply voltage is falling ⁽²⁾	1.7	1.85		V
V _{HYS(UVLO)}	Supply voltage UVLO hysteresis	60	150		mV
I _{OH}	High-Level output current	V _{CCB} = 5 V	-4		mA
		V _{CCB} = 3.3 V	-2		mA
		V _{CCB} = 2.5 V	-1		mA
I _{OL}	High-Level output current	V _{CCB} = 5 V		4	mA
		V _{CCB} = 3.3 V		2	mA
		V _{CCB} = 2.5 V		1	mA
V _{IH}	High-level input voltage (data input)	2		V _{CC}	V
V _{IL}	Low-level input voltage (data input)	0		0.8	V
f _{data}	Data rate ⁽³⁾	0		150	Mbps
T _A	Operating ambient temperature	-40	25	125	°C

(1) V_{CCA} is input side V_{CC}; V_{CCB} is output side V_{CC};

(2) V_{CC(UVLO+)}, V_{CC(UVLO-)}, V_{HYS(UVLO)} are same to V_{CCA} and V_{CCB};

(3) 150 Mbps is the maximum specified data rate, although higher data rates are possible.

Thermal Information

Package Type	θ_{JA}	θ_{JC}	Unit
8-Pin SOP	130	48	$^{\circ}\text{C/W}$
8-Pin WSOP	85	43	$^{\circ}\text{C/W}$
16-Pin WSOP	93	52	$^{\circ}\text{C/W}$

Insulation Specifications

Symbol	Parameter	Conditions	Value			Unit
			SOP8	WSOP8	WSOP16	
CLR	External clearance	Shortest terminal-to-terminal distance through air	> 4.0	> 8.0	> 8.0	mm
CPG	External creepage	Shortest terminal-to-terminal distance across the package surface	> 4.0	> 8.0	> 8.0	mm
DTI	Distance through the insulation	Minimum internal gap (internal clearance)	> 22	> 22	> 22	μm
DTC	Distance through the Molding compound	Minimum internal distance across the conductors inside the package	0.45	0.8	0.8	mm
CTI	Comparative tracking index	DIN EN 60112 (VDE 0303-11); IEC 60112; UL 746A	> 600	> 600	> 600	V
	Material group	According to IEC 60664-1	I	I	I	
	Over-voltage category	For Rated Mains Voltage $\leq 150 \text{ V}_{\text{RMS}}$	I-IV	I-IV	I-IV	
		For Rated Mains Voltage $\leq 300 \text{ V}_{\text{RMS}}$	I-III	I-IV	I-IV	
		For Rated Mains Voltage $\leq 600 \text{ V}_{\text{RMS}}$	I-II	I-IV	I-IV	
		For Rated Mains Voltage $\leq 1000 \text{ V}_{\text{RMS}}$	I	I-III	I-III	
	Climatic category		40/125/21	40/125/21	40/125/21	
	Pollution degree		2	2	2	
DIN V VDE V 0884-17 (1)(2)						
V_{IORM}	Maximum repetitive isolation voltage	AC voltage	637	1414	1414	V_{PK}
V_{IOWM}	Maximum working isolation voltage	AC voltage; TDDB Test	450	1000	1000	V_{RMS}
		DC voltage	637	1414	1414	V_{DC}
V_{IOTM}	Maximum transient isolation voltage	$V_{\text{TEST}} = V_{\text{IOTM}}$, $t = 60 \text{ s}$ (qualification); $V_{\text{TEST}} = 1.2 \times V_{\text{IOTM}}$, $t = 1 \text{ s}$ (100% production)	5300	7000	7000	V_{PK}
V_{IOSM}	Maximum surge isolation voltage (3)	Test method per IEC 62368-1, 1.2/50 μs waveform, $V_{\text{TEST}} = 1.3 \times V_{\text{IOSM}}$ (qualification)	5980	6500	6500	V_{PK}
q_{pd}	Apparent charge	Method a, After Input/Output safety test subgroup 2/3, $V_{\text{ini}} = V_{\text{IOTM}}$, $t_{\text{ini}} = 60 \text{ s}$; $V_{\text{pd(m)}} = 1.2 \times V_{\text{IORM}}$,	≤ 5	≤ 5	≤ 5	pC

		$t_m = 10\text{ s}$				
		Method a, After environmental tests subgroup 1, $V_{ini} = V_{IOTM}$, $t_{ini} = 60\text{ s}$; $V_{pd(m)} = 1.6 \times V_{IORM}$, $t_m = 10\text{ s}$	≤ 5	≤ 5	≤ 5	
		Method b1; At routine test (100% production) and preconditioning (type test), $V_{ini} = 1.2 \times V_{IOTM}$, $t_{ini} = 1\text{ s}$; $V_{pd(m)} = 1.875 \times V_{IORM}$, $t_m = 1\text{ s}$	≤ 5	≤ 5	≤ 5	
C_{IO}	Isolation capacitance	$V_{IO} = 0.4 \times \sin (2\pi f t)$, $f = 1\text{ MHz}$	~ 0.5	~ 0.5	~ 0.5	pF
R_{IO}	Isolation resistance	$V_{IO} = 500\text{ V}$, $TA= 25^{\circ}C$	$> 10^{12}$	$> 10^{12}$	$> 10^{12}$	Ω
		$V_{IO} = 500\text{ V}$, $100. ^{\circ}C \leq TA \leq 125. ^{\circ}C$	$> 10^{11}$	$> 10^{11}$	$> 10^{11}$	Ω
		$V_{IO} = 500\text{ V}$ at $T S= 150^{\circ}C$	$> 10^9$	$> 10^9$	$> 10^9$	Ω
UL 1577						
V_{ISO}	Withstanding isolation voltage	$V_{TEST} = V_{ISO}$, $t = 60\text{ s}$ (qualification); $V_{TEST} = 1.2 \times V_{ISO}$, $t = 1\text{ s}$ (100% production)	3750	5000	5000	V_{RMS}

(1) All pins on each side of the barrier tied together creating a two-terminal device.

(2) This coupler is suitable for safe electrical insulation only within the safety operating ratings. Compliance with the safety ratings shall be ensured by means of suitable protective circuits.

(3) Testing must be carried out in oil.

Safety-Related Certifications

VDE	UL	TUV	CQC	CSA	CB
Certified according to DIN VDE V 0884-17	Certified according to UL 1577 and CSA Component Acceptance Notice 5A	Certified according to EN IEC 62368-1 and EN IEC 61010-1	Certified according to GB 4943.1	Certified CSA C22.2 No. 62368-1 and CAN/CSA-C22.2 No. 60601-1	Certified according to EN IEC 62368-1
Basic insulation (WSOP) $V_{IORM} = 1414$ $V_{IOSM} = 6500$ (SOP) $V_{IORM} = 637$ $V_{IOSM} = 5500$	(WSOP)Single protection, 5000Vrms (SOP)Single protection, 3750Vrms	5000Vrms reinforced insulation (WSOP), 800Vrms maximum work voltage. 3750Vrms basic insulation (SOP), 400V rms maximum work voltage.	Reinforced insulation (WSOP), Altitude $\leq 5000\text{m}$, 800V rms maximum work voltage. Basic insulation (SOP), Altitude $\leq 5000\text{m}$, 400V rms maximum work voltage.	400Vrms basic insulation (SOP) and 600V rms reinforced insulation (WSOP) working voltage per CSA C22.2 No. 62368-1:19 3rd, IEC 62368-1:2018 Ed. 3(in pollution degree 2, material group I) 2 MOPP (Means of Patient Protection) insulation requirements for 250Vrms (WSOP) in CAN/CSA-C22.2 No. 60601-1:14, IEC 60601-1:2005 + AMD1:2012	Reinforced insulation (WSOP), Altitude $\leq 5000\text{m}$, 800V rms maximum work voltage. Basic insulation (SOP), Altitude $\leq 5000\text{m}$, 400V rms maximum work voltage.
Certificate No.	Report Reference	Registration No. AK 50524505 0001	Certificate No. CQC21001303701	Master contract: 302375	Ref. Certif. No. CN54369

40054570	E524241	AK 50524506 0001 AK 50550847 0001 AK 50550849 0001	CQC22001332218 CQC22001332219		CN56354 CN56355
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Safety Limiting Values

Parameter	Conditions ⁽¹⁾	Min	Typ	Max	Unit
Safety supply current	$R_{\theta JA} = 130^{\circ}\text{C/W}$, $V_I = 5\text{ V}$, $T_J = 150^{\circ}\text{C}$, $T_A = 25^{\circ}\text{C}$ (SOP8)			192.3	mA
	$R_{\theta JA} = 85^{\circ}\text{C/W}$, $V_I = 5\text{ V}$, $T_J = 150^{\circ}\text{C}$, $T_A = 25^{\circ}\text{C}$ (WSOP8)			294.1	
	$R_{\theta JA} = 93^{\circ}\text{C/W}$, $V_I = 5\text{ V}$, $T_J = 150^{\circ}\text{C}$, $T_A = 25^{\circ}\text{C}$ (WSOP16)			268.8	
Safety total power	$R_{\theta JA} = 130^{\circ}\text{C/W}$, $T_J = 150^{\circ}\text{C}$, $T_A = 25^{\circ}\text{C}$ (SOP8)			961.5	mW
	$R_{\theta JA} = 85^{\circ}\text{C/W}$, $T_J = 150^{\circ}\text{C}$, $T_A = 25^{\circ}\text{C}$ (WSOP8)			1470.5	
	$R_{\theta JA} = 93^{\circ}\text{C/W}$, $T_J = 150^{\circ}\text{C}$, $T_A = 25^{\circ}\text{C}$ (WSOP16)			1344	
Maximum safety temperature				150	$^{\circ}\text{C}$

(1) The assumed junction-to-air thermal resistance in the Thermal Information is that of a device installed on a high-K test board for leaded surface-mount packages.

Electrical Characteristics

$V_{CCA} = V_{CCB} = 2.25\text{ V} \sim 5.5\text{ V}$, $T_A = -40^{\circ}\text{C} \sim +125^{\circ}\text{C}$, Typical value is in $V_{CC} = 3.3\text{ V}$, $T_A = +25^{\circ}\text{C}$.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Input Electrical Specifications						
V_{IH}	Logic Input High Voltage	Input signal, IN1, IN2	2.0			V
V_{IL}	Logic Input Low Voltage	Input signal, IN1, IN2			0.8	V
V_{IT+}	Rising input threshold voltage	Input signal, IN1, IN2		1.6	2	V
V_{IT-}	Falling input threshold voltage	Input signal, IN1, IN2	0.8	1.2		V
V_{HYS}	Input threshold voltage hysteresis			0.4		V
I_{IH}	High-level input current	$V_{IH} = V_{CCA}$ at IN1, IN2 ⁽¹⁾		2.5	10	μA
I_{IL}	Low-level input current	$V_{IL} = 0\text{ V}$ at IN1, IN2 ⁽¹⁾	-10	-2.5		μA
I_{OH}	High-level output current	$V_{CCB} = 5\text{ V} \pm 10\%$	-4			mA
		$V_{CCB} = 3.3\text{ V} \pm 10\%$	-2			
		$V_{CCB} = 2.5\text{ V} \pm 10\%$	-1			
I_{OL}	Low-level output current	$V_{CCB} = 5\text{ V} \pm 10\%$			4	mA
		$V_{CCB} = 3.3\text{ V} \pm 10\%$			2	
		$V_{CCB} = 2.5\text{ V} \pm 10\%$			1	
V_{OH}	High-level output voltage	$V_{CCB} = 5\text{ V} \pm 10\%$, $I_{OH} = -4\text{ mA}$;	$V_{CCB} -$	$V_{CCB} -$		mV

		Test OUT1, OUT2, Figure 9	0.4	0.2		
		$V_{CCB} = 3.3\text{ V} \pm 10\%$, $I_{OH} = -2\text{ mA}$; Test OUT1, OUT2, Figure 9	$V_{CCB} - 0.3$	$V_{CCB} - 0.15$		
		$V_{CCB} = 2.5\text{ V} \pm 10\%$, $I_{OH} = -1\text{ mA}$; Test OUT1, OUT2, Figure 9	$V_{CCB} - 0.2$	$V_{CCB} - 0.1$		
V_{OL}	Low-level output voltage	$V_{CCB} = 5\text{ V} \pm 10\%$, $I_{OL} = 4\text{ mA}$; Test OUT1, OUT2, Figure 9		0.2	0.4	V
		$V_{CCB} = 3.3\text{ V} \pm 10\%$, $I_{OL} = 2\text{ mA}$; Test OUT1, OUT2, Figure 9		0.15	0.3	
		$V_{CCB} = 2.5\text{ V} \pm 10\%$, $I_{OL} = 1\text{ mA}$; Test OUT1, OUT2, Figure 9		0.1	0.2	
CMTI	Common-mode transient immunity	Static CMTI, See Figure 11	150	200		kV/ μs
		Dynamic CMTI, See Figure 11	100	150		kV/ μs
C_i	Input capacitance ⁽¹⁾			2		pF

(1) Provided by bench test and design simulation

Timing Specifications-5 V Supply

$V_{CCA} = V_{CCB} = 5\text{ V} \pm 10\%$, $T_A = -40^\circ\text{C} \sim +125^\circ\text{C}$. Typical value is in $V_{CC} = 5\text{ V}$, $T_A = +25^\circ\text{C}$, $C_L = 15\text{ pF}$ to GND.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
f_{data}	Translation data rate				150	Mbps
t_{PLH}	Propagation delay time	See Figure 9		11.5	18	ns
t_{PHL}	Propagation delay time	See Figure 9		12	18	ns
PWD	Pulse width distortion ⁽¹⁾ $ t_{\text{PHL}} - t_{\text{PLH}} $			0.5	5	ns
$t_{\text{sk(CC)}}$	Channel-to-channel output skew time ⁽²⁾	Same direction channels			2.5	ns
$t_{\text{sk(PP)}}$	Channel-to-channel output skew time ⁽²⁾	Same direction channels			4.5	ns
t_r	Output signal rise time ⁽¹⁾	See Figure 9		0.7	4	ns
t_f	Output signal fall time ⁽¹⁾	See Figure 9		0.7	4	ns
Jitter	Eye jitter p-p ⁽¹⁾	$f_{\text{data}} = 100\text{ Mbps}$		800		ps
t_{DO}	Default output delay time from input power loss	Measured from the time V_{CC} goes below 1.7 V. See Figure 15		30	52	ns
t_{SU}	Setup time			28	60	us
t_{IE}	Time interval error ⁽¹⁾	$2^{16} - 1$ PRBS data at 100 Mbps ⁽¹⁾		2.4		ns

(1) Provided by bench test and design simulation.

(2) $t_{\text{sk(CC)}}$ & $t_{\text{sk(PP)}}$ is the skew of delay time between different channel of a single device or different devices switching in the same direction while operating at identical supply voltages, temperature, input signals and loads.

Supply Current Characteristics-5 V Supply

$V_{CCA} = V_{CCB} = 5\text{ V} \pm 10\%$, $T_A = -40^\circ\text{C} \sim +125^\circ\text{C}$. Typical value is in $V_{CC} = 5\text{ V}$, $T_A = +25^\circ\text{C}$, $C_L = 15\text{ pF}$ to GND.

Parameter	Description		Supply current	Min	Typ	Max	Unit
AL9920							
Supply current - DC signal	$V_I = 0\text{ V}$ (AL9920F), $V_I = V_{CC_I}$ (AL9920)		I_{CCA}		0.95	1.5	mA
			I_{CCB}		2.4	4.4	
	$V_I = V_{CC_I}$ (AL9920F), $V_I = 0\text{ V}$ (AL9920)		I_{CCA}		8.2	10.9	
			I_{CCB}		2.1	3.8	
Supply current - AC signal	All channels switching with square wave clock input; $C_L = 15\text{ pF}$	1 Mbps	I_{CCA}		4.4	5.9	
			I_{CCB}		2.4	4.3	
		10 Mbps	I_{CCA}		4.6	6	
			I_{CCB}		3.7	6.2	
		100 Mbps	I_{CCA}		6.3	8.4	
			I_{CCB}		16.4	22	
AL9921							
Supply current - DC signal	$V_I = 0\text{ V}$ (AL9921F), $V_I = V_{CC_I}$ (AL9921)		I_{CCA}, I_{CCB}		1.9	2.9	mA
	$V_I = V_{CC_I}$ (AL9921F), $V_I = 0\text{ V}$ (AL9921)		I_{CCA}, I_{CCB}		5.2	7.5	
Supply current - AC signal	All channels switching with square wave clock input; $C_L = 15\text{ pF}$	1 Mbps	I_{CCA}, I_{CCB}		3.6	5.5	
		10 Mbps	I_{CCA}, I_{CCB}		4.3	6.6	
		100 Mbps	I_{CCA}, I_{CCB}		11.6	19	
AL9922							
Supply current - DC signal	$V_I = 0\text{ V}$ (AL9922F), $V_I = V_{CC_I}$ (AL9922)		I_{CCA}, I_{CCB}		1.9	2.9	mA
	$V_I = V_{CC_I}$ (AL9922F), $V_I = 0\text{ V}$ (AL9922)		I_{CCA}, I_{CCB}		5.2	7.5	
Supply current - AC signal	All channels switching with square wave clock input; $C_L = 15\text{ pF}$	1 Mbps	I_{CCA}, I_{CCB}		3.6	5.5	
		10 Mbps	I_{CCA}, I_{CCB}		4.3	6.6	
		100 Mbps	I_{CCA}, I_{CCB}		11.6	19	

(1) Provided by bench test and design simulation.

(2) V_{CC_I} is the VCC of V_I .

Timing Specifications-3.3 V Supply

$V_{CCA} = V_{CCB} = 3.3 \text{ V} \pm 10\%$, $T_A = -40^\circ\text{C} \sim +125^\circ\text{C}$. Typical value is in $V_{CC} = 3.3 \text{ V}$, $T_A = +25^\circ\text{C}$, $C_L = 15 \text{ pF}$ to GND.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
f_{data}	Translation data rate				150	Mpbs
t_{PLH}	Propagation delay time	See Figure 9		12.5	18	ns
t_{PHL}	Propagation delay time	See Figure 9		12.2	18	ns
PWD	Pulse width distortion ⁽¹⁾ $ t_{\text{PHL}} - t_{\text{PLH}} $			0.3	5	ns
$t_{\text{sk(CC)}}$	Channel-to-channel output skew time ⁽²⁾	Same direction channels			2.5	ns
$t_{\text{sk(PP)}}$	Channel-to-channel output skew time ⁽²⁾	Same direction channels			4.5	ns
t_r	Output signal rise time ⁽¹⁾	See Figure 9		0.7	4	ns
t_f	Output signal fall time ⁽¹⁾	See Figure 9		0.7	4	ns
Jitter	Eye jitter p-p ⁽¹⁾	$f_{\text{data}} = 100 \text{ Mbps}$		800		ps
t_{DO}	Default output delay time from input power loss	Measured from the time VCC goes below 1.7 V. See Figure 15		30	52	ns
t_{su}	Setup time			28	60	μs
t_{ie}	Time interval error ⁽¹⁾	$2^{16} - 1$ PRBS data at 100 Mbps		2.4		ns

(1) Provided by bench test and design simulation.

(2) $t_{\text{sk(CC)}}$ & $t_{\text{sk(PP)}}$ is the shew of delay time between different channel of a single device or different devices switching in the same direction while operating at identical supply voltages, temperature, input signals and loads.

Supply Current Characteristics-3.3 V Supply

$V_{CCA} = V_{CCB} = 3.3 \text{ V} \pm 10\%$, $T_A = -40^\circ\text{C} \sim +125^\circ\text{C}$. Typical value is in $V_{CC} = 3.3 \text{ V}$, $T_A = +25^\circ\text{C}$, $C_L = 15 \text{ pF}$ to GND.

Parameter	Description		Supply current	Min	Typ	Max	Unit
AL9920							
Supply current - DC signal	$V_I = 0\text{ V}$ (AL9920F), $V_I = V_{CC_I}$ (AL9920)		I_{CCA}		0.92	1.5	mA
			I_{CCB}		2.4	4.4	
	$V_I = V_{CC_I}$ (AL9920F), $V_I = 0\text{ V}$ (AL9920)		I_{CCA}		8.2	10.8	
			I_{CCB}		2.1	4	
Supply current - AC signal	All channels switching with square wave clock input; $C_L = 15\text{ pF}$	1 Mbps	I_{CCA}		4.3	6.4	
			I_{CCB}		2.3	4.3	
		10 Mbps	I_{CCA}		4.4	6.5	
			I_{CCB}		3.2	6.2	
		100 Mbps	I_{CCA}		5.5	8.2	
			I_{CCB}		11	18	
AL9921							
Supply current - DC signal	$V_I = 0\text{ V}$ (AL9921F), $V_I = V_{CC_I}$ (AL9921)		I_{CCA}, I_{CCB}		1.9	2.9	mA
	$V_I = V_{CC_I}$ (AL9921F), $V_I = 0\text{ V}$ (AL9921)		I_{CCA}, I_{CCB}		5.2	7.5	
Supply current - AC signal	All channels switching with square wave clock input; $C_L = 15\text{ pF}$	1 Mbps	I_{CCA}, I_{CCB}		3.5	5	
		10 Mbps	I_{CCA}, I_{CCB}		3.9	5.5	
		100 Mbps	I_{CCA}, I_{CCB}		8.6	15.5	
AL9922							
Supply current - DC signal	$V_I = 0\text{ V}$ (AL9922F), $V_I = V_{CC_I}$ (AL9922)		I_{CCA}, I_{CCB}		1.9	2.9	mA
	$V_I = V_{CC_I}$ (AL9922F), $V_I = 0\text{ V}$ (AL9922)		I_{CCA}, I_{CCB}		5.2	7.5	
Supply current - AC signal	All channels switching with square wave clock input; $C_L = 15\text{ pF}$	1 Mbps	I_{CCA}, I_{CCB}		3.5	5	
		10 Mbps	I_{CCA}, I_{CCB}		3.9	5.5	
		100 Mbps	I_{CCA}, I_{CCB}		8.6	15.5	

(1) Provided by bench test and design simulation

(2) V_{CC_I} is the VCC of V_I

Timing Specifications-2.5 V Supply

$V_{CCA} = V_{CCB} = 2.5 \text{ V} \pm 10\%$, $T_A = -40^\circ\text{C} \sim +125^\circ\text{C}$. Typical value is in $V_{CC} = 2.5 \text{ V}$, $T_A = +25^\circ\text{C}$, $C_L = 15 \text{ pF}$ to GND.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
f_{data}	Translation data rate				150	Mpbs
t_{PLH}	Propagation delay time	See Figure 9		13.5	20	ns
t_{PHL}	Propagation delay time	See Figure 9		12.2	20	ns
PWD	Pulse width distortion ⁽¹⁾ $ t_{\text{PHL}} - t_{\text{PLH}} $			1.3	5	ns
$t_{\text{sk(CC)}}$	Channel-to-channel output skew time ⁽²⁾	Same direction channels			2.5	ns
$t_{\text{sk(PP)}}$	Channel-to-channel output skew time ⁽²⁾	Same direction channels			4.5	ns
t_r	Output signal rise time ⁽¹⁾	See Figure 9		0.7	4	ns
t_f	Output signal fall time ⁽¹⁾	See Figure 9		0.7	4	ns
Jitter	Eye jitter p-p ⁽¹⁾	$f_{\text{data}} = 100 \text{ Mbps}$		800		ps
t_{DO}	Default output delay time from input power loss	Measured from the time VCC goes below 1.7 V. See Figure 15		30	52	ns
t_{su}	Setup time			28	60	μs
t_{ie}	Time interval error ⁽¹⁾	$2^{16} - 1$ PRBS data at 100 Mbps		2.4		ns

(1) Provided by bench test and design simulation.

(2) $t_{\text{sk(CC)}}$ & $t_{\text{sk(PP)}}$ is the shew of delay time between different channel of a single device or different devices switching in the same direction while operating at identical supply voltages, temperature, input signals and loads.

Supply Current Characteristics-2.5 V Supply

$V_{CCA} = V_{CCB} = 2.5 \text{ V} \pm 10\%$, $T_A = -40^\circ\text{C} \sim +125^\circ\text{C}$. Typical value is in $V_{CC} = 2.5 \text{ V}$, $T_A = +25^\circ\text{C}$, $C_L = 15 \text{ pF}$ to GND.

Parameter	Description		Supply current	Min	Typ	Max	Unit
AL9920							
Supply current - DC signal	$V_I = 0\text{ V}$ (AL9920F), $V_I = V_{CC_I}$ (AL9920)		I_{CCA}		0.9	1.5	mA
			I_{CCB}		2.4	4.4	
	$V_I = V_{CC_I}$ (AL9920F), $V_I = 0\text{ V}$ (AL9920)		I_{CCA}		8.2	10.8	
			I_{CCB}		2.1	4	
Supply current - AC signal	All channels switching with square wave clock input; $C_L = 15\text{ pF}$	1 Mbps	I_{CCA}		4.3	5.9	
			I_{CCB}		2.3	4.3	
		10 Mbps	I_{CCA}		4.3	6.1	
			I_{CCB}		3	6.2	
		100 Mbps	I_{CCA}		4.6	6.2	
			I_{CCB}		8.9	12.5	
AL9921							
Supply current - DC signal	$V_I = 0\text{ V}$ (AL9921F) $V_I = V_{CC_I}$ (AL9921)		I_{CCA}, I_{CCB}		1.9	2.9	mA
	$V_I = V_{CC_I}$ (AL9921F) $V_I = 0\text{ V}$ (AL9921)		I_{CCA}, I_{CCB}		5.2	7.5	
Supply current - AC signal	All channels switching with square wave clock input; $C_L = 15\text{ pF}$	1 Mbps	I_{CCA}, I_{CCB}		3.5	5	
		10 Mbps	I_{CCA}, I_{CCB}		3.8	5.5	
		100 Mbps	I_{CCA}, I_{CCB}		7	10.5	
AL9922							
Supply current - DC signal	$V_I = 0\text{ V}$ (AL9922F) $V_I = V_{CC_I}$ (AL9922)		I_{CCA}, I_{CCB}		1.9	2.9	mA
	$V_I = V_{CC_I}$ (AL9922F) $V_I = 0\text{ V}$ (AL9922)		I_{CCA}, I_{CCB}		5.2	7.5	
Supply current - AC signal	All channels switching with square wave clock input; $C_L = 15\text{ pF}$	1 Mbps	I_{CCA}, I_{CCB}		3.5	5	
		10 Mbps	I_{CCA}, I_{CCB}		3.8	5.5	
		100 Mbps	I_{CCA}, I_{CCB}		7	10.5	

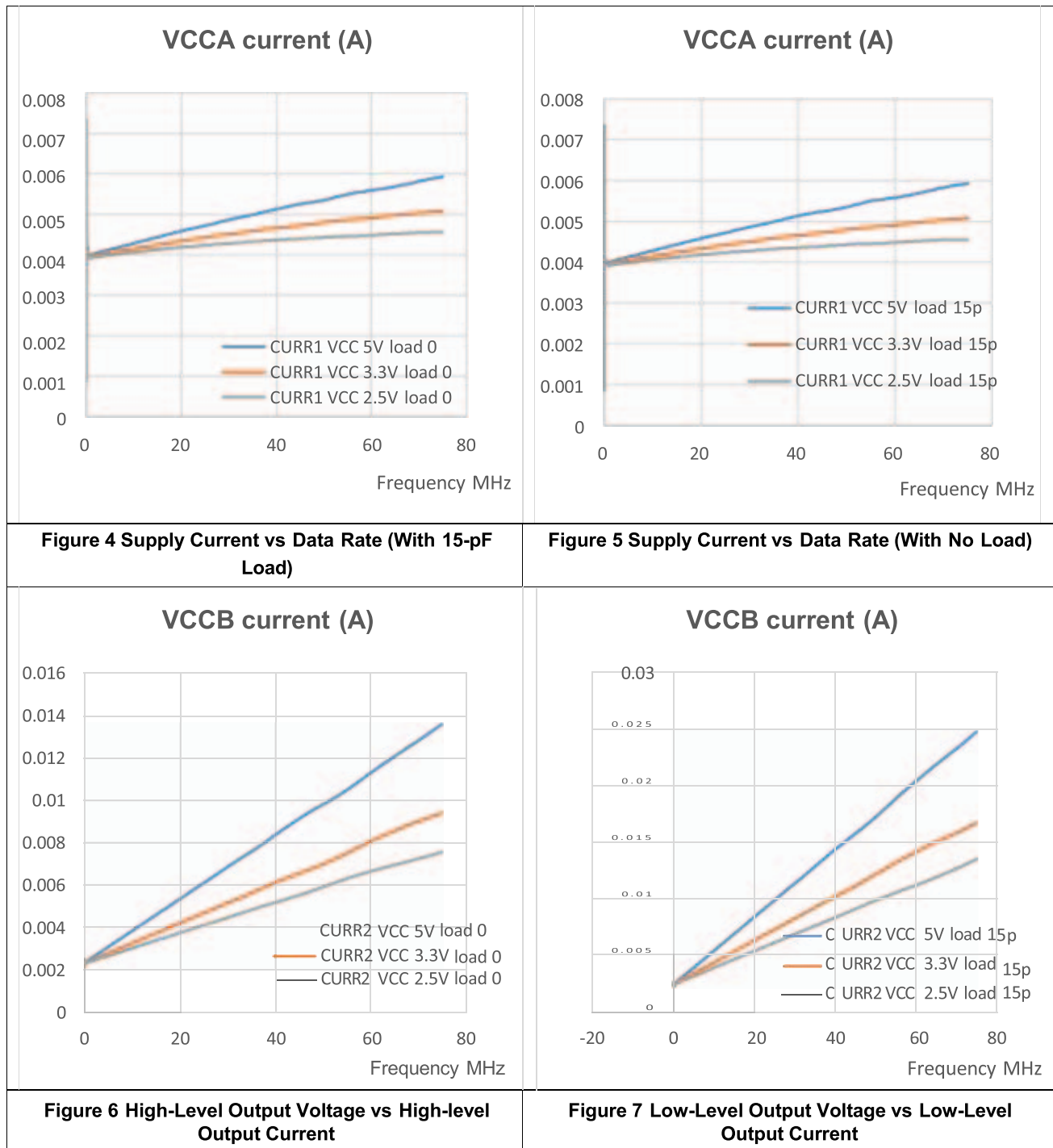
(1) Provided by bench test and design simulation

(2) V_{CC_I} is the VCC of V_I

Typical Performance Characteristics

	voltage(v) UVLO curve Figure 1 UVLO characterization by temperature	
	delay(ns) t_{PLH} delay timing Figure 2 t_{PLH} delay timing	
	delay(ns) t_{PHL} delay timing Figure 3 t_{PHL} delay timing	

Typical Performance Characteristics (Continued)



Test Circuits and Waveforms

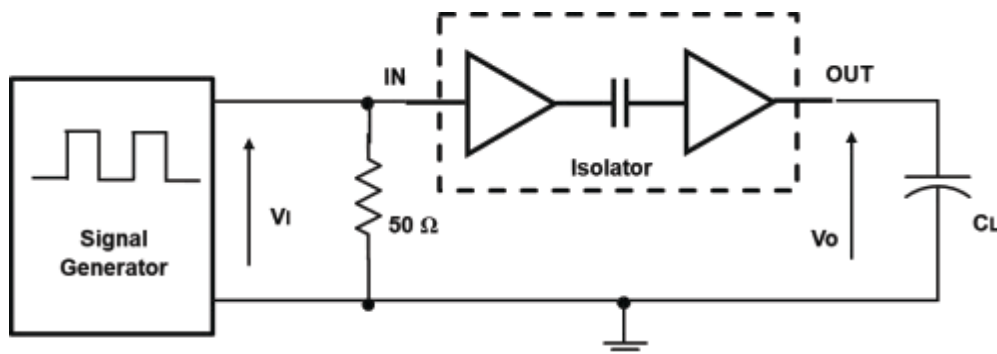


Figure 8 AC Characteristics Test Circuit

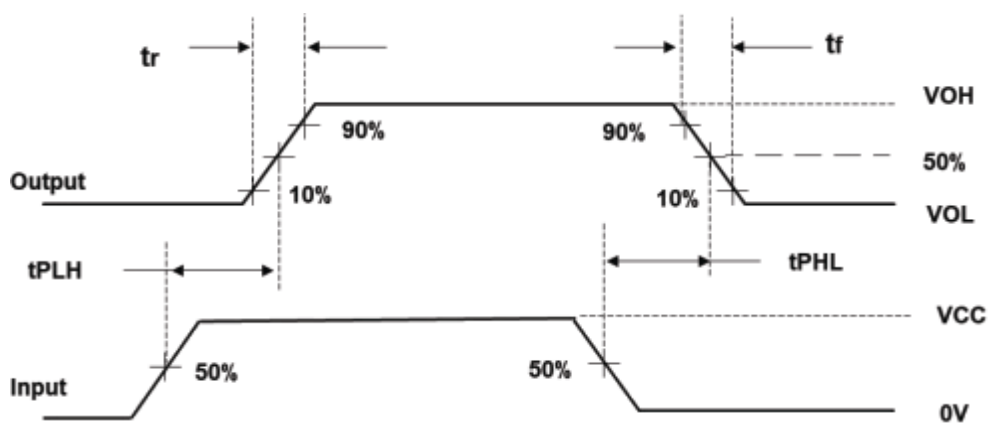


Figure 9 Timing Characteristics Voltage Waveforms

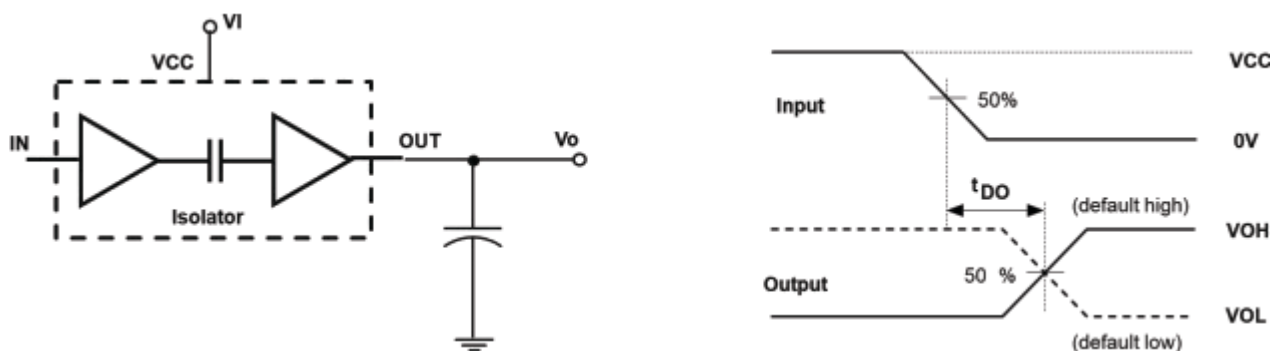


Figure 10 Default Output Delay Time Test Circuit and Voltage Waveforms

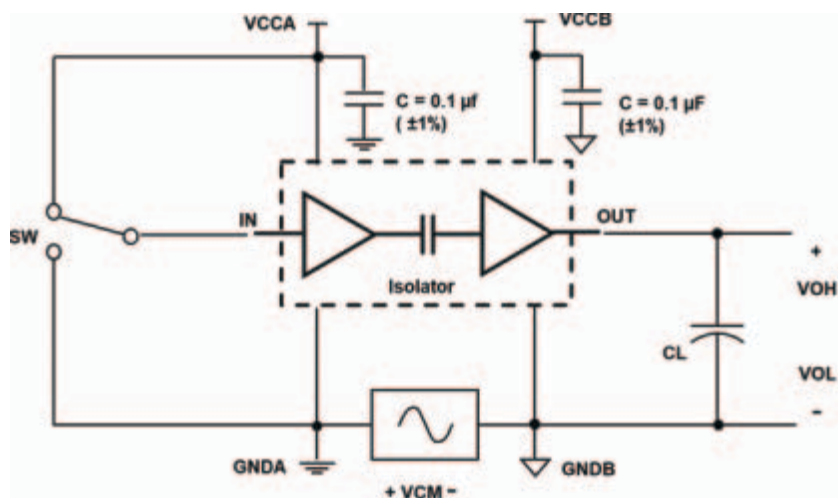


Figure 11 Common-Mode Transient Immunity Test Circuit

Detailed Description

Overview

The AL992x family design an ON-OFF keying (OOK) modulation circuit to transmit the digital data by the isolation barrier. The transmitter sends a high frequency carrier across the barrier to represent one digital state and sends no signal to represent the other digital state. The receiver demodulates the signal after advanced signal conditioning and produces the output through a buffer stage, which builds in an H-CMTI (High-performance Common-mode transient immunity) circuit to protect the normal signal transmission and minimize the radiated emissions due to the high-frequency carrier and IO buffer switching. The block diagram of a digital capacitive isolator shows a functional block diagram of a typical channel in Figure 12.

Function Block Diagram

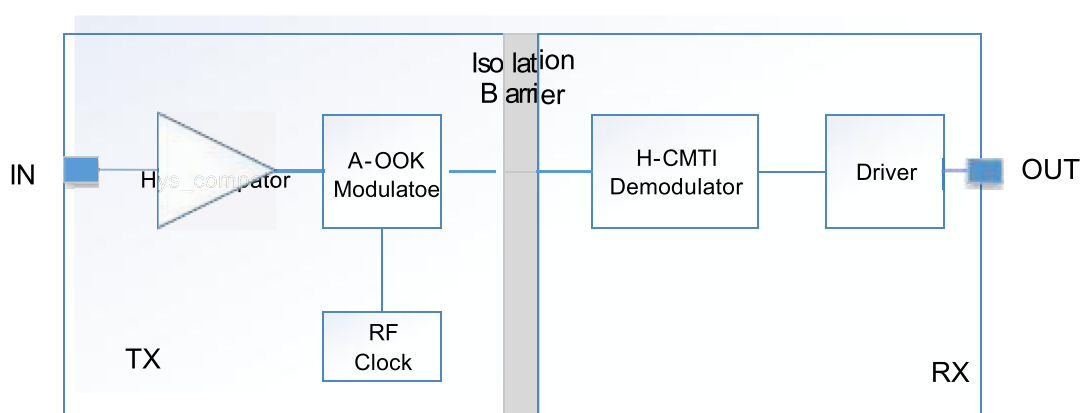


Figure 12 Conceptual Block Diagram of a Digital Capacitive Isolator

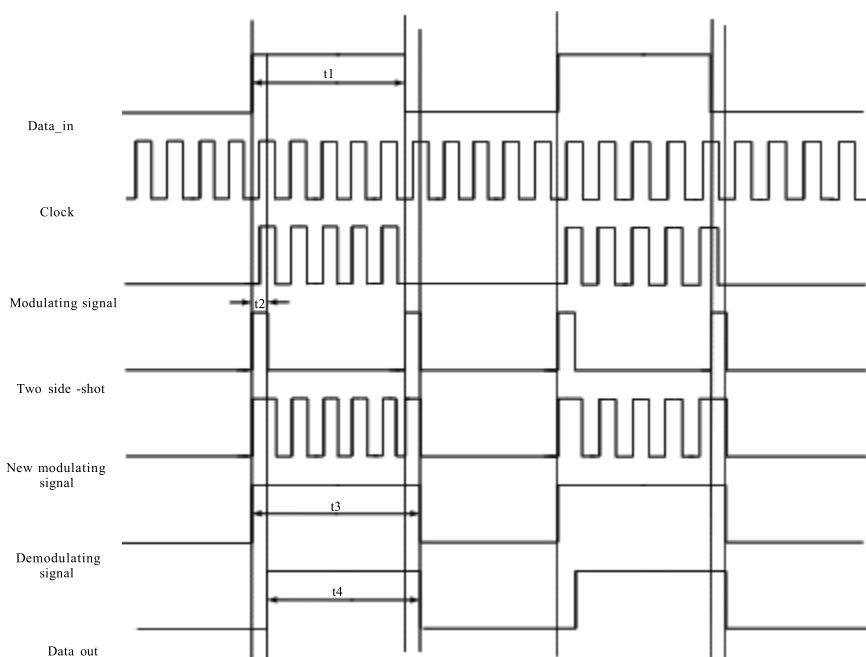


Figure 13 On-Off Keying (OOK) Based Modulation Scheme

Feature Description

The AL992x family of devices is available in two channel configurations and default output state options to enable a variety of application uses. Table 1 lists the device features of the AL992x devices.

Part Number	Max Data rate	Channel Direction	Default Output State	Package	Rating Isolation
AL9920	150 Mbps	2 Forward, 0 Reverse	High	WSOP16	5000 V _{RMS} / 8000 V _{PK}
				WSOP8	5000 V _{RMS} / 7071 V _{PK}
				SOP8	3750 V _{RMS} / 5250 V _{PK}
AL9920F	150 Mbps	2 Forward, 0 Reverse	Low	WSOP16	5000 V _{RMS} / 8000 V _{PK}
				WSOP8	5000 V _{RMS} / 7071 V _{PK}
				SOP8	3750 V _{RMS} / 5250 V _{PK}
AL9921	150 Mbps	1 Forward, 1 Reverse	High	WSOP16	5000 V _{RMS} / 8000 V _{PK}
				WSOP8	5000 V _{RMS} / 7071 V _{PK}
				SOP8	3750 V _{RMS} / 5250 V _{PK}
AL9921F	150 Mbps	1 Forward, 1 Reverse	Low	WSOP16	5000 V _{RMS} / 8000 V _{PK}
				WSOP8	5000 V _{RMS} / 7071 V _{PK}
				SOP8	3750 V _{RMS} / 5250 V _{PK}
AL9922	150 Mbps	1 Forward, 1 Reverse	High	WSOP16	5000 V _{RMS} / 8000 V _{PK}
				WSOP8	5000 V _{RMS} / 7071 V _{PK}
				SOP8	3750 V _{RMS} / 5250 V _{PK}
AL9922F	150 Mbps	1 Forward, 1 Reverse	Low	WSOP16	5000 V _{RMS} / 8000 V _{PK}
				WSOP8	5000 V _{RMS} / 7071 V _{PK}
				SOP8	3750 V _{RMS} / 5250 V _{PK}

Electromagnetic Compatibility (EMC) Considerations

Many applications in a harsh industrial environment are sensitive to disturbances such as electrostatic discharge (ESD), electrical fast transient (EFT), surge and electromagnetic emissions. These electromagnetic disturbances are regulated by international standards such as IEC 61000-4-x and CISPR 32 (new EMC standard). Although system-level performance and reliability depend on the application board design and layout, the AL992x family integrates many chip-level design improvements and helps to build a robust system.

Some of these improvements include:

-  Robust ESD protection cells for input and output signal pins and chip-level bond pads.
-  Low resistance connectivity of ESD cells for power supply and ground pins.
-  Enhanced performance of high voltage capacitor isolation for better tolerance of ESD, EFT and surge events.

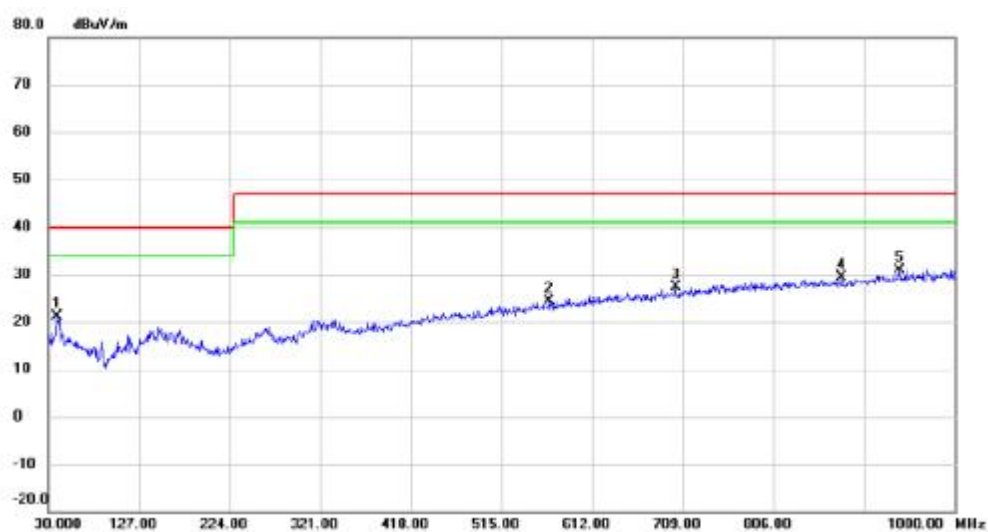


Figure 14 Radiated Emission Measurement per CISPR32 Class-B - Vertical

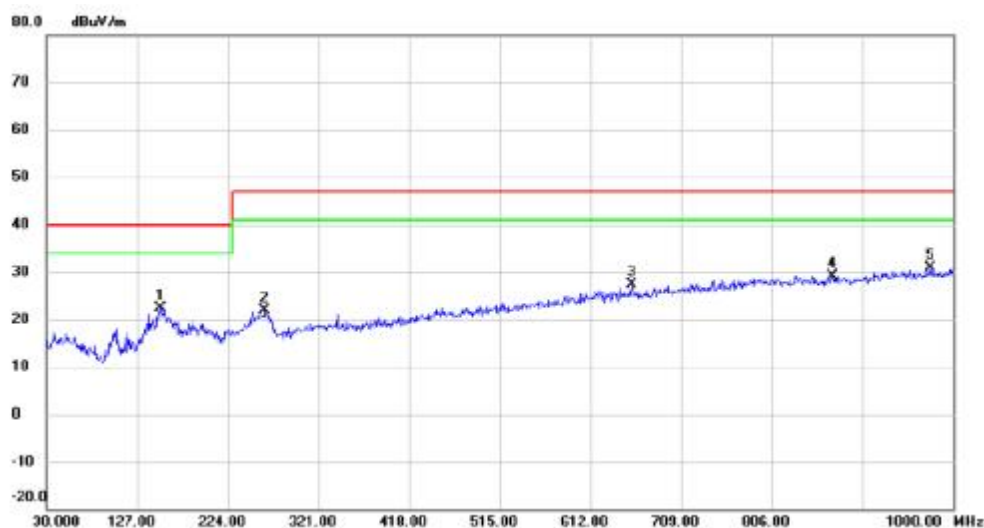


Figure 15 Radiated Emission Measurement per CISPR32 Class-B - Horizontal

Device Functional Modes

The below table lists the functional modes for the AL992x devices.

VCC _I	VCC _O	Input (IN1, IN2)	Output (OUT1, OUT2)	Comments
PU	PU	H	H	Normal Operation: A channel output assumes the logic state of the input.
		L	L	
		Open	Default	Default mode: When INx is open, the corresponding channel output goes to the default logic state. The default is Low for AL992xF
PD	PU	X	Default	Default mode: When VCC _I is unpowered, the default is Low for AL992xF When VCC _I transitions from unpowered to powered-up, a channel output assumes the logic state of the input. When VCC _I transitions from powered-up to unpowered, channel output assumes the selected default state.
X	PD	X	Undetermined	When VCC _O is unpowered, a channel output is undetermined. When VCC _O transitions from unpowered to powered-up, a channel output assumes the logic state of the input

(1) VCC_I = Input-side V_{CCA}; VCC_O = Output-side V_{CCB}; PU = Powered up (V_{CC} ≥ 2.25 V); PD = Powered down (V_{CC} ≤ 1.7 V); X = Irrelevant; H = High level; L = Low level

(2) The outputs are in the undetermined state when 1.7 V < VCC_I, VCC_O < 2.25 V.

Application and Implementation

The following typical eye diagrams of the AL992x device indicate low jitter and wide-open eye at data rate of 100 Mbps, and typical jitter is 736 ps in lab test @5 V and 25°C.

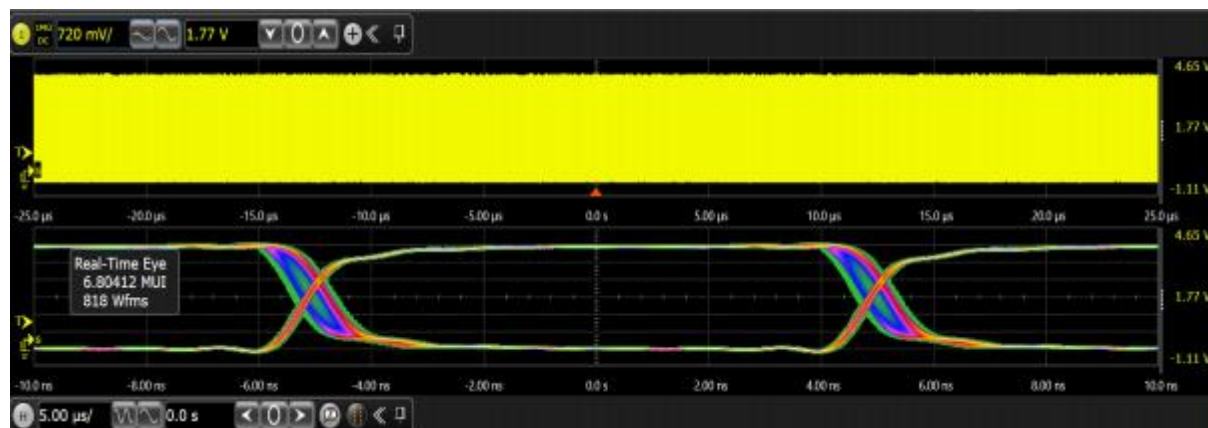
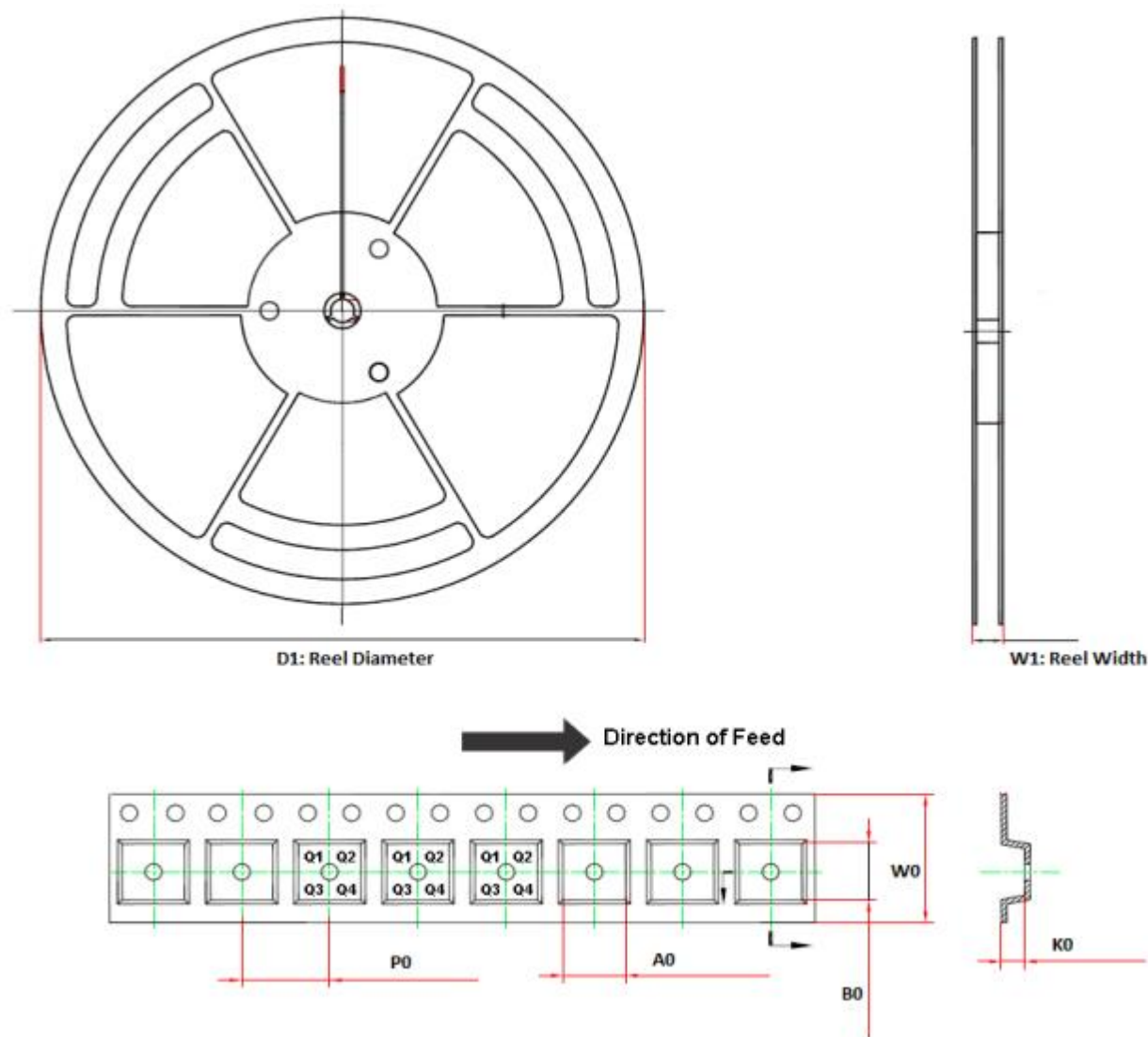


Figure 16 AL9920 Eye Diagram at 100 Mbps PRBS, 5 V Supplies and 25°C

Tape and Reel Information

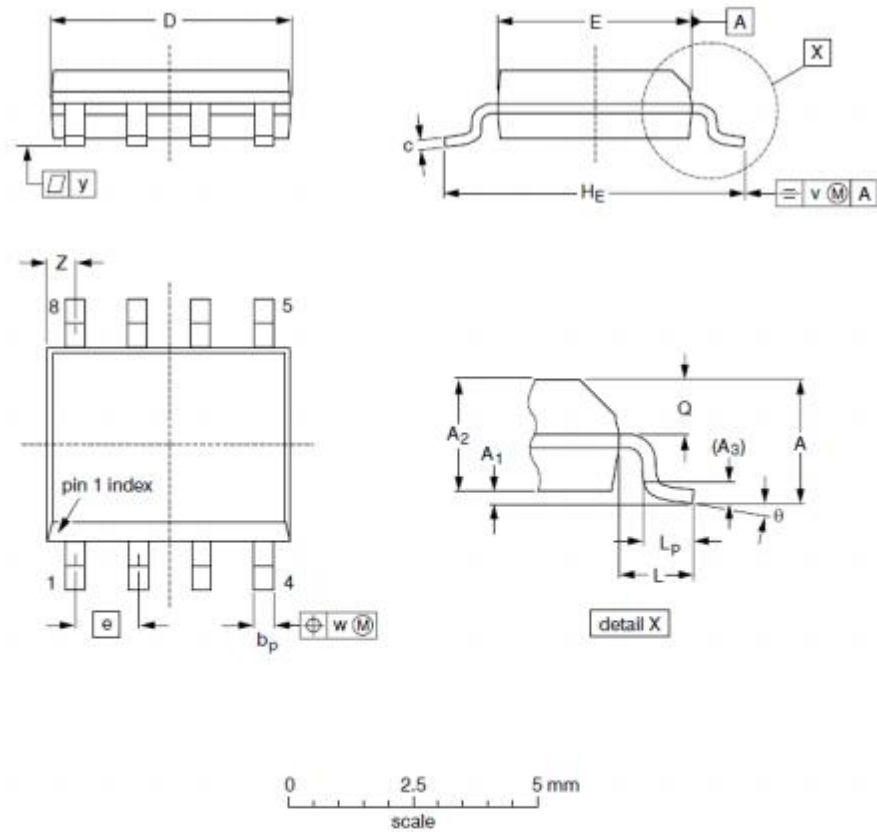


Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
AL9920-SO1R	8-Pin SOP	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
AL9920F-SO1R	8-Pin SOP	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
AL9921-SO1R	8-Pin SOP	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
AL9921F-SO1R	8-Pin SOP	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
AL9922-SO1R	8-Pin SOP	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
AL9922F-SO1R	8-Pin SOP	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
AL9920-SOAR	8-Pin WSOP	330	16.4	11.95	6.2	3.0	16.0	16.0	Q1
AL9920F-SOAR	8-Pin WSOP	330	16.4	11.95	6.2	3.0	16.0	16.0	Q1
AL9921-SOAR	8-Pin WSOP	330	16.4	11.95	6.2	3.0	16.0	16.0	Q1

AL9921F-SOAR	8-Pin WSOP	330	16.4	11.95	6.2	3.0	16.0	16.0	Q1
AL9922-SOAR	8-Pin WSOP	330	16.4	11.95	6.2	3.0	16.0	16.0	Q1
AL9922F-SOAR	8-Pin WSOP	330	16.4	11.95	6.2	3.0	16.0	16.0	Q1
AL9920-SOBR	16-Pin WSOP	330.0	22.4	10.9	10.8	3.0	12.0	16.0	Q1
AL9920F-SOBR	16-Pin WSOP	330.0	22.4	10.9	10.8	3.0	12.0	16.0	Q1
AL9921-SOBR	16-Pin WSOP	330.0	22.4	10.9	10.8	3.0	12.0	16.0	Q1
AL9921F-SOBR	16-Pin WSOP	330.0	22.4	10.9	10.8	3.0	12.0	16.0	Q1
AL9922-SOBR	16-Pin WSOP	330.0	22.4	10.9	10.8	3.0	12.0	16.0	Q1
AL9922F-SOBR	16-Pin WSOP	330.0	22.4	10.9	10.8	3.0	12.0	16.0	Q1
AL9920-SO1R-S	8-Pin SOP	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
AL9920F-SO1R-S	8-Pin SOP	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
AL9921-SO1R-S	8-Pin SOP	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
AL9921F-SO1R-S	8-Pin SOP	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
AL9922-SO1R-S	8-Pin SOP	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
AL9922F-SO1R-S	8-Pin SOP	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
AL9920-SOAR-S	8-Pin WSOP	330	16.4	11.95	6.2	3.0	16.0	16.0	Q1
AL9920F-SOAR-S	8-Pin WSOP	330	16.4	11.95	6.2	3.0	16.0	16.0	Q1
AL9921-SOAR-S	8-Pin WSOP	330	16.4	11.95	6.2	3.0	16.0	16.0	Q1
AL9921F-SOAR-S	8-Pin WSOP	330	16.4	11.95	6.2	3.0	16.0	16.0	Q1
AL9922-SOAR-S	8-Pin WSOP	330	16.4	11.95	6.2	3.0	16.0	16.0	Q1
AL9922F-SOAR-S	8-Pin WSOP	330	16.4	11.95	6.2	3.0	16.0	16.0	Q1
AL9920-SOBR-S	16-Pin WSOP	330.0	22.4	10.9	10.8	3.0	12.0	16.0	Q1
AL9920F-SOBR-S	16-Pin WSOP	330.0	22.4	10.9	10.8	3.0	12.0	16.0	Q1
AL9921-SOBR-S	16-Pin WSOP	330.0	22.4	10.9	10.8	3.0	12.0	16.0	Q1
AL9921F-SOBR-S	16-Pin WSOP	330.0	22.4	10.9	10.8	3.0	12.0	16.0	Q1
AL9922-SOBR-S	16-Pin WSOP	330.0	22.4	10.9	10.8	3.0	12.0	16.0	Q1
AL9922F-SOBR-S	16-Pin WSOP	330.0	22.4	10.9	10.8	3.0	12.0	16.0	Q1

Package Outline Dimensions

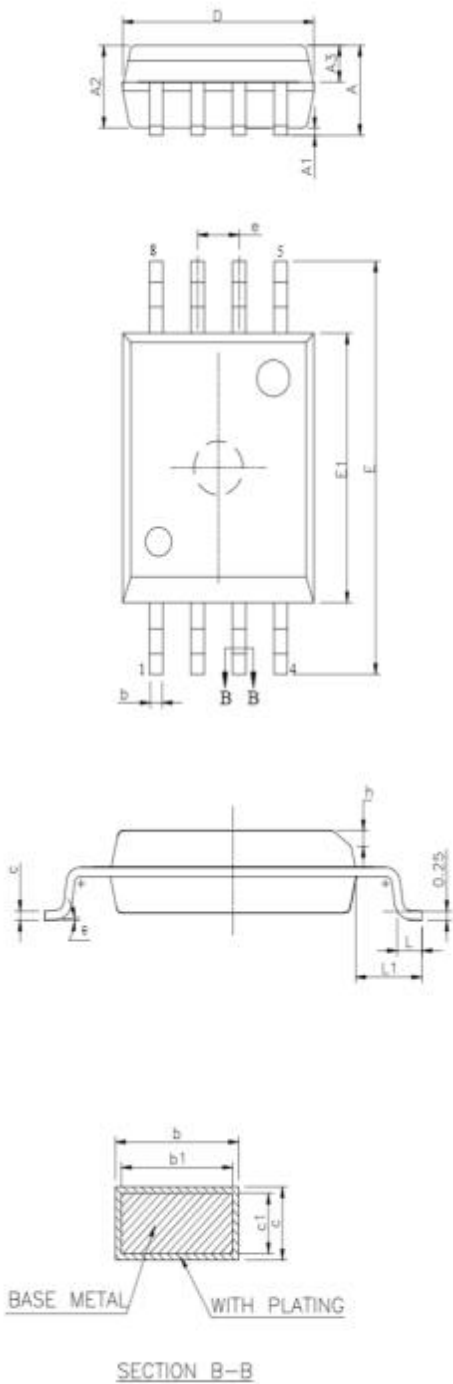
SO1R (SOP)



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

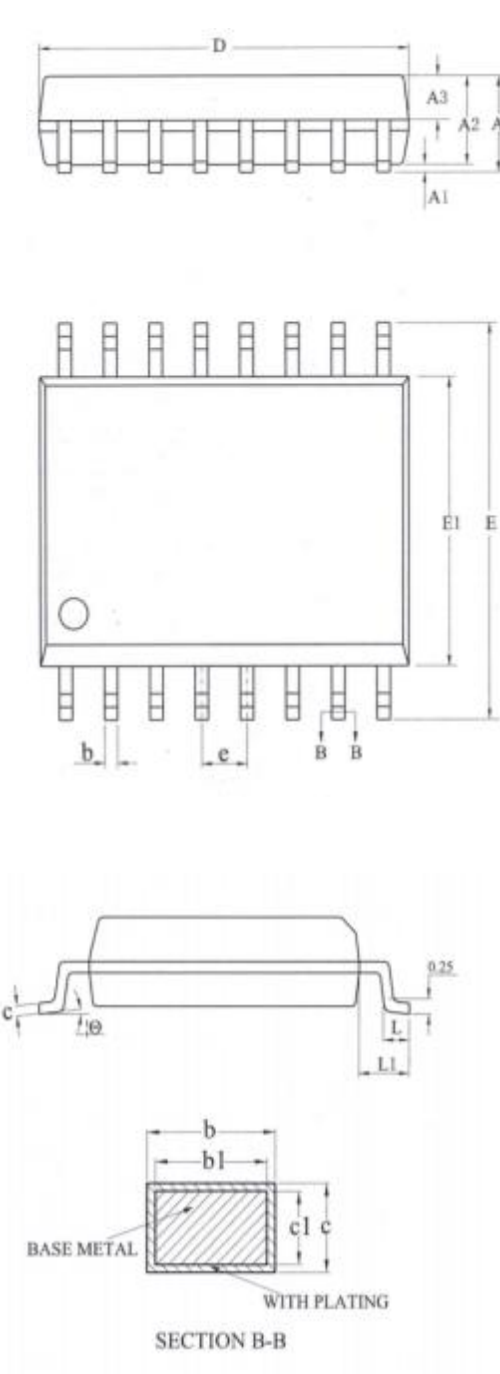
UNIT	A _{max.}	A ₁	A ₂	A ₃	b _p	c	D ⁽¹⁾	E ⁽²⁾	e	H _E	L	L _p	Q	v	w	y	Z ⁽¹⁾	θ
mm	1.75	0.25 0.10	1.45 1.25	0.25	0.49 0.36	0.25 0.19	5.0 4.8	4.0 3.8	1.27	6.2 5.8	1.05	1.0 0.4	0.7 0.6	0.25	0.25	0.1	0.7 0.3	8° 0°
inches	0.069	0.010 0.004	0.057 0.049	0.01	0.019 0.014	0.0100 0.0075	0.20 0.19	0.16 0.15	0.05	0.244 0.228	0.041	0.039 0.016	0.028 0.024	0.01	0.01	0.004	0.028 0.012	

SOAR (WSOP8)



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	—	—	2.65
A1	0.10	—	0.30
A2	2.25	2.30	2.35
A3	0.97	1.02	1.07
b	0.39	—	0.47
b1	0.38	0.41	0.44
c	0.25	—	0.29
c1	0.24	0.25	0.26
D	5.75	5.85	5.95
E	11.30	11.50	11.70
E1	7.40	7.50	7.60
e	1.27BSC		
h	0.25	—	0.50
L	0.50	—	1.00
L1	2.00REF		
θ	0	—	8°

SOBR (WSOP16)



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	—	—	2.65
A1	0.10	—	0.30
A2	2.25	2.30	2.35
A3	0.97	1.02	1.07
b	0.35	—	0.44
b1	0.34	0.37	0.39
c	0.25	—	0.31
c1	0.24	0.25	0.26
D	10.10	10.30	10.50
E	10.26	10.41	10.60
E1	7.30	7.50	7.70
e	1.27BSC		
L	0.55	—	0.85
L1	1.40BSC		
θ	0	—	8°

△ △

△

Order Information

Order Number	Operating Temperature Range	Package	MSL	Transport Media, Quantity	Eco Plan
AL9920-SO1R	-40 to 125°C	8-Pin SOP	MSL3	Tape and Reel, 4000	Green
AL9920F-SO1R	-40 to 125°C	8-Pin SOP	MSL3	Tape and Reel, 4000	Green
AL9921-SO1R	-40 to 125°C	8-Pin SOP	MSL3	Tape and Reel, 4000	Green
AL9921F-SO1R	-40 to 125°C	8-Pin SOP	MSL3	Tape and Reel, 4000	Green
AL9922-SO1R ⁽¹⁾	-40 to 125°C	8-Pin SOP	MSL3	Tape and Reel, 4000	Green
AL9922F-SO1R ⁽¹⁾	-40 to 125°C	8-Pin SOP	MSL3	Tape and Reel, 4000	Green
AL9920-SOAR	-40 to 125°C	8-Pin WSOP	MSL3	Tape and Reel, 1000	Green
AL9920F-SOAR	-40 to 125°C	8-Pin WSOP	MSL3	Tape and Reel, 1000	Green
AL9921-SOAR	-40 to 125°C	8-Pin WSOP	MSL3	Tape and Reel, 1000	Green
AL9921F-SOAR	-40 to 125°C	8-Pin WSOP	MSL3	Tape and Reel, 1000	Green
AL9922-SOAR ⁽¹⁾	-40 to 125°C	8-Pin WSOP	MSL3	Tape and Reel, 1000	Green
AL9922F-SOAR ⁽¹⁾	-40 to 125°C	8-Pin WSOP	MSL3	Tape and Reel, 1000	Green
AL9920-SOBR	-40 to 125°C	16-Pin WSOP	MSL3	Tape and Reel, 1500	Green
AL9920F-SOBR	-40 to 125°C	16-Pin WSOP	MSL3	Tape and Reel, 1500	Green
AL9921-SOBR	-40 to 125°C	16-Pin WSOP	MSL3	Tape and Reel, 1500	Green
AL9921F-SOBR	-40 to 125°C	16-Pin WSOP	MSL3	Tape and Reel, 1500	Green
AL9922-SOBR ⁽¹⁾	-40 to 125°C	16-Pin WSOP	MSL3	Tape and Reel, 1500	Green
AL9922F-SOBR ⁽¹⁾	-40 to 125°C	16-Pin WSOP	MSL3	Tape and Reel, 1500	Green
AL9920-SO1R-S	-40 to 125°C	8-Pin SOP	MSL3	Tape and Reel, 4000	
AL9920F-SO1R-S	-40 to 125°C	8-Pin SOP	MSL3	Tape and Reel, 4000	
AL9921-SO1R-S	-40 to 125°C	8-Pin SOP	MSL3	Tape and Reel, 4000	
AL9921F-SO1R-S	-40 to 125°C	8-Pin SOP	MSL3	Tape and Reel, 4000	

AL9922-SO1R-S ⁽¹⁾	-40 to 125°C	8-Pin SOP	MSL3	Tape and Reel, 4000	
AL9922F-SO1R-S ⁽¹⁾	-40 to 125°C	8-Pin SOP	MSL3	Tape and Reel, 4000	
AL9920-SOAR-S	-40 to 125°C	8-Pin WSOP	MSL3	Tape and Reel, 1000	
AL9920F-SOAR-S	-40 to 125°C	8-Pin WSOP	MSL3	Tape and Reel, 1000	
AL9921-SOAR-S	-40 to 125°C	8-Pin WSOP	MSL3	Tape and Reel, 1000	
AL9921F-SOAR-S	-40 to 125°C	8-Pin WSOP	MSL3	Tape and Reel, 1000	
AL9922-SOAR-S ⁽¹⁾	-40 to 125°C	8-Pin WSOP	MSL3	Tape and Reel, 1000	
AL9922F-SOAR-S ⁽¹⁾	-40 to 125°C	8-Pin WSOP	MSL3	Tape and Reel, 1000	
AL9920-SOBR-S	-40 to 125°C	16-Pin WSOP	MSL3	Tape and Reel, 1500	
AL9920F-SOBR-S	-40 to 125°C	16-Pin WSOP	MSL3	Tape and Reel, 1500	
AL9921-SOBR-S	-40 to 125°C	16-Pin WSOP	MSL3	Tape and Reel, 1500	
AL9921F-SOBR-S	-40 to 125°C	16-Pin WSOP	MSL3	Tape and Reel, 1500	
AL9922-SOBR-S ⁽¹⁾	-40 to 125°C	16-Pin WSOP	MSL3	Tape and Reel, 1500	
AL9922F-SOBR-S ⁽¹⁾	-40 to 125°C	16-Pin WSOP	MSL3	Tape and Reel, 1500	