Table 25: Absolute Maximum Ratings (Die)[1]

Condition	Value
Junction temperature	150°C
Storage temperature range	–65°C to +150°C
Voltage applied to any pad	(V_{SS} – 0.3 V) to (V_{CC} + 0.3 V)
Voltage applied to any pad (Input current limited to ±20 mA)	(V_{SS} – 1.0 V) to (V_{CC} + 1.0 V)
Voltage applied to MOSI, SCLK, and $\overline{SS}$ pins (Input current limited to ±20 mA)	(V_{SS} – 1.0 V) to (V_{CC} + 1.0 V)
V_{CC} – V_{SS}	–0.3 V to +7.0 V

1. *Stresses above those listed may cause permanent damage to the device. Exposure to the absolute maximum ratings may affect device reliability. Functional operation is not implied at these conditions.*

Table 26: Operating Conditions (Die)

Condition	Value
Commercial operating temperature range	0°C to +50°C
Supply voltage (V_{CC})[1]	+2.7 V to +3.3 V
Ground voltage (V_{SS})[2]	0 V

1. $V_{CC} = V_{CCA} = V_{CCD}$
2. $V_{SS} = V_{SSA} = V_{SSD}$.

Table 27: DC Parameters (Die)

Symbol	Parameters	Min[2]	Typ[1]	Max[2]	Units	Conditions
V_{IL}	Input Low Voltage			V_{CC} x 0.2	V	
V_{IH}	Input High Voltage	V_{CC} x 0.8			V	
V_{OL}	Output Low Voltage			0.4	V	I_{OL} = 10 µA
V_{OL1}	RAC, $\overline{INT}$ Output Low Voltage			0.4	V	I_{OL} = 1 mA
V_{OH}	Output High Voltage	V_{CC} – 0.4			V	I_{OH} = –10 µA
I_{CC}	V_{CC} Current (Operating) — Playback — Record		 15 25	 30 40	 mA mA	 $R_{EXT} = \infty$ [3] $R_{EXT} = \infty$ [3]
I_{SB}	V_{CC} Current (Standby)		1	10	µA	[3] [4]
I_{IL}	Input Leakage Current			±1	µA	
I_{HZ}	MISO Tristate Current		1	10	µA	
R_{EXT}	Output Load Impedance	5			KΩ	

Table 27: DC Parameters (Die)

Symbol	Parameters	Min[2]	Typ[1]	Max[2]	Units	Conditions
$R_{ANA\ IN+}$	ANA IN+ Input Resistance	2.2	3.0	3.8	KΩ	
$R_{ANA\ IN-}$	ANA IN– Input Resistance	40	56	71	KΩ	
A_{ARP}	ANA IN+ or ANA IN– to AUDOUT Gain		25		dB	(5)

1. *Typical values: T_A = 25°C and 3.0 V.*
2. *All min/max limits are guaranteed by ISD via electrical testing or characterization. Not all specifications are 100 percent tested.*
3. *V_{CCA} and V_{CCD} connected together.*
4. *$\overline{SS}$ = V_{CCA}= V_{CCD}, XCLK = MOSI = V_{SSA} = V_{SSD} and all other pins floating.*
5. *Measured with AutoMute feature disabled.*

Table 28: AC Parameters (Die)

Symbol	Characteristic		Min[2]	Typ[1]	Max[2]	Units	Conditions
F_S	Sampling Frequency	ISD4002-120		8.0		KHz	(5)
		ISD4002-150		6.4		KHz	(5)
		ISD4002-180		5.3		KHz	(5)
		ISD4002-240		4.0		KHz	(5)
F_{CF}	Filter Pass Band	ISD4002-120		3.4		KHz	3dB Roll-Off Point (3) (6)
		ISD4002-150		2.7		KHz	3dB Roll-Off Point (3) (6)
		ISD4002-180		2.3		KHz	3dB Roll-Off Point (3) (6)
		ISD4002-240		1.7		KHz	3dB Roll-Off Point (3) (6)
T_{REC}	Record Duration	ISD4002-120		120		sec	(5)
		ISD4002-150		150		sec	(5)
		ISD4002-180		180		sec	(5)
		ISD4002-240		240		sec	(5)
T_{PLAY}	Playback Duration	ISD4002-120		120		sec	(5)
		ISD4002-150		150		sec	(5)
		ISD4002-180		180		sec	(5)
		ISD4002-240		240		sec	(5)
T_{PUD}	Power-Up Delay	ISD4002-120		25		msec	
		ISD4002-150		31.25		msec	
		ISD4002-180		37.5		msec	
		ISD4002-240		50		msec	
T_{STOP} or T_{PAUSE}	Stop or Pause in Record or Play	ISD4002-120		50		msec	
		ISD4002-150		62.5		msec	
		ISD4002-180		75		msec	
		ISD4002-240		100		msec	

Table 28: AC Parameters (Die)

Symbol	Characteristic		Min[2]	Typ[1]	Max[2]	Units	Conditions
T_{RAC}	RAC Clock Period	ISD4002-120		200		msec	
		ISD4002-150		250		msec	
		ISD4002-180		300		msec	
		ISD4002-240		400		msec	
T_{RACLO}	RAC Clock Low Time	ISD4002-120		25		msec	(9)
		ISD4002-150		31.25		msec	(9)
		ISD4002-180		37.5		msec	(9)
		ISD4002-240		50		msec	(9)
T_{RACM}	RAC Clock Period in Message Cueing Mode	ISD4002-120		125		µsec	
		ISD4002-150		156.3		µsec	
		ISD4002-180		187.5		µsec	
		ISD4002-240		250		µsec	
T_{RACML}	RAC Clock Low Time in Message Cueing Mode	ISD4002-120		15.63		µsec	
		ISD4002-150		19.53		µsec	
		ISD4002-180		23.44		µsec	
		ISD4002-240		31.25		µsec	
THD	Total Harmonic Distortion			1	2	%	@ 1 KHz
V_{IN}	ANA IN Input Voltage				32	mV	Peak-to-Peak[4] [7] [8]

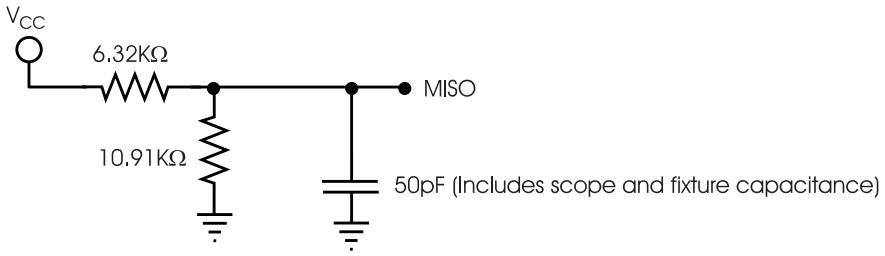
1. *Typical values: T_A = 25°C and 3.0 V.*
2. *All min/max limits are guaranteed by ISD via electrical testing or characterization. Not all specifications are 100 percent tested.*
3. *Low-frequency cut off depends upon the value of external capacitors (see Pin Descriptions).*
4. *Single-ended input mode. In the differential input mode, V_{IN} maximum for ANA IN+ and ANA IN– is 16 mV peak-to-peak.*
5. *Sampling Frequency and Duration can vary as much as ±2.25 percent over the commercial temperature and voltage ranges. For greater stability, an external clock can be utilized (see Pin Descriptions).*
6. *Filter specification applies to the anti-aliasing filter and to the smoothing filter.*
7. *The typical output voltage will be approximately 570 mV peak-to-peak with V_{IN} at 32 mV peak-to-peak.*
8. *For optimal signal quality, this maximum limit is recommended.*
9. *When a record command is sent, $T_{RAC} = T_{RAC} + T_{RACLO}$ on the first row addressed.*

Table 29: SPI AC Parameters(1)

Symbol	Characteristics	Min	Max	Units	Conditions
T_{SSS}	$\overline{SS}$ Setup Time	500		nsec	
T_{SSH}	$\overline{SS}$ Hold Time	500		nsec	
T_{DIS}	Data in Setup Time	200		nsec	
T_{DIH}	Data in Hold Time	200		nsec	
T_{PD}	Output Delay		500	nsec	
T_{DF}(2)	Output Delay to hiZ		500	nsec	
T_{SSmin}	$\overline{SS}$ HIGH	1		µsec	
T_{SCKhi}	SCLK High Time	400		nsec	
T_{SCKlow}	SCLK Low Time	400		nsec	
F_0	CLK Frequency		1,000	KHz	

1. *Typical values: T_A= 25°C and 3.0 V. Timing measured at 50 percent of the V_{CC} level.*

2. *Tristate test condition.*



TIMING DIAGRAMS

Figure 6: Timing Diagram

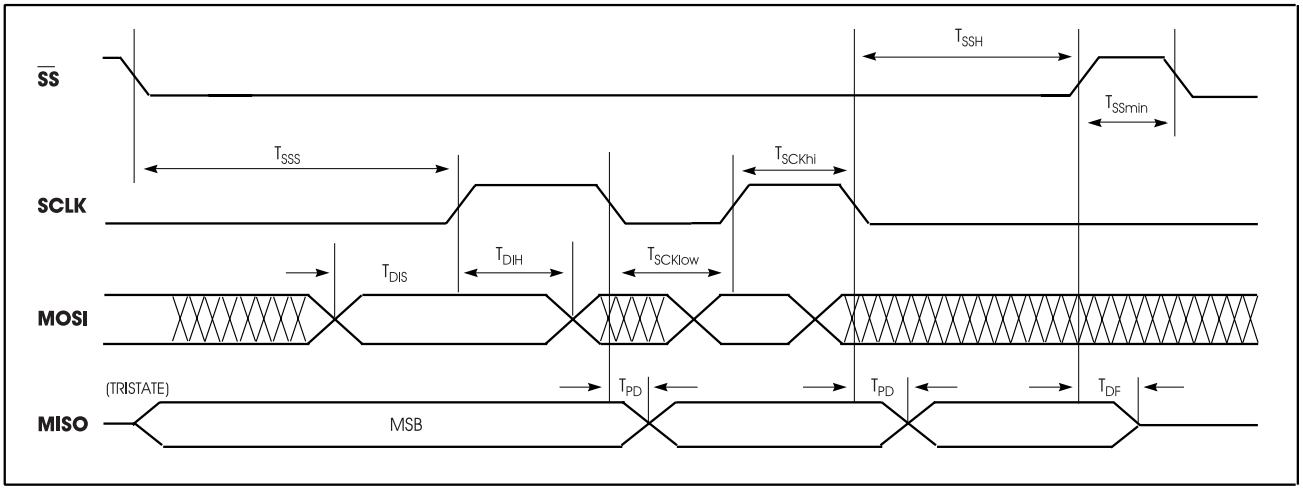


Figure 7: 8-Bit Command Format

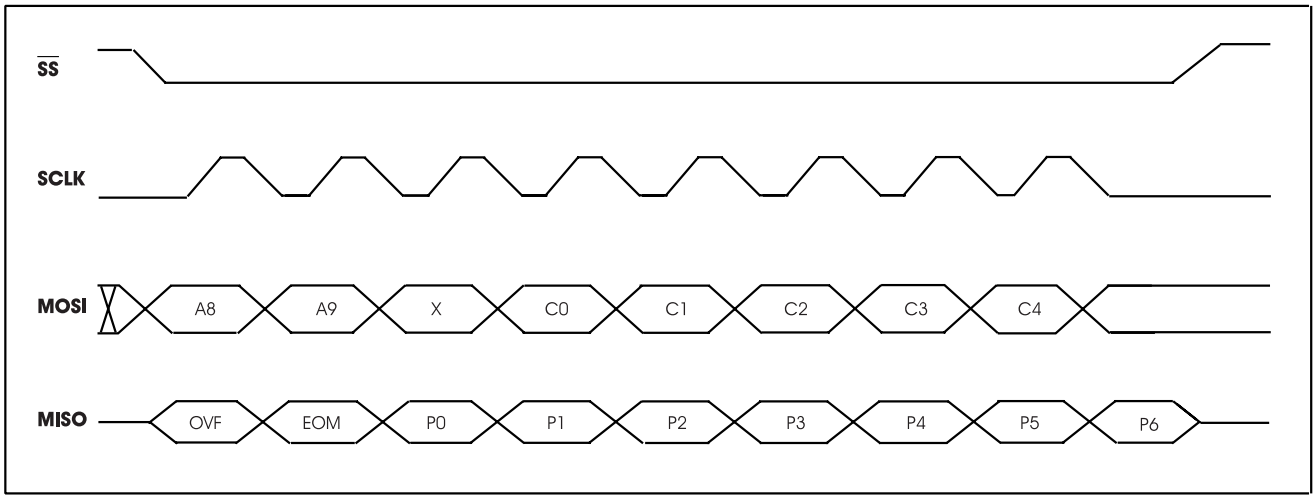


Figure 8: 16-Bit Command Format

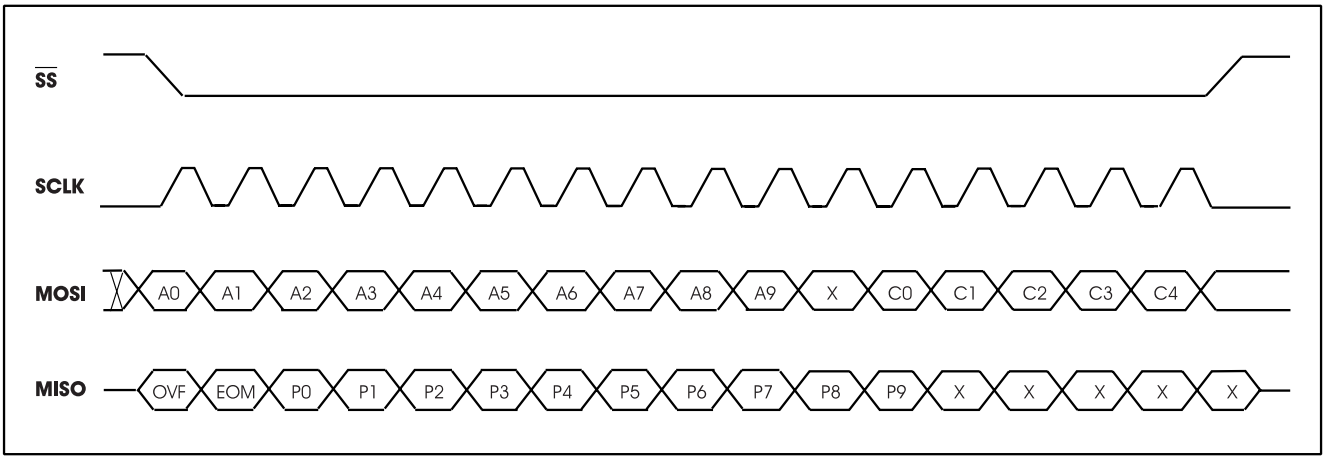


Figure 9: Playback/Record and Stop Cycle

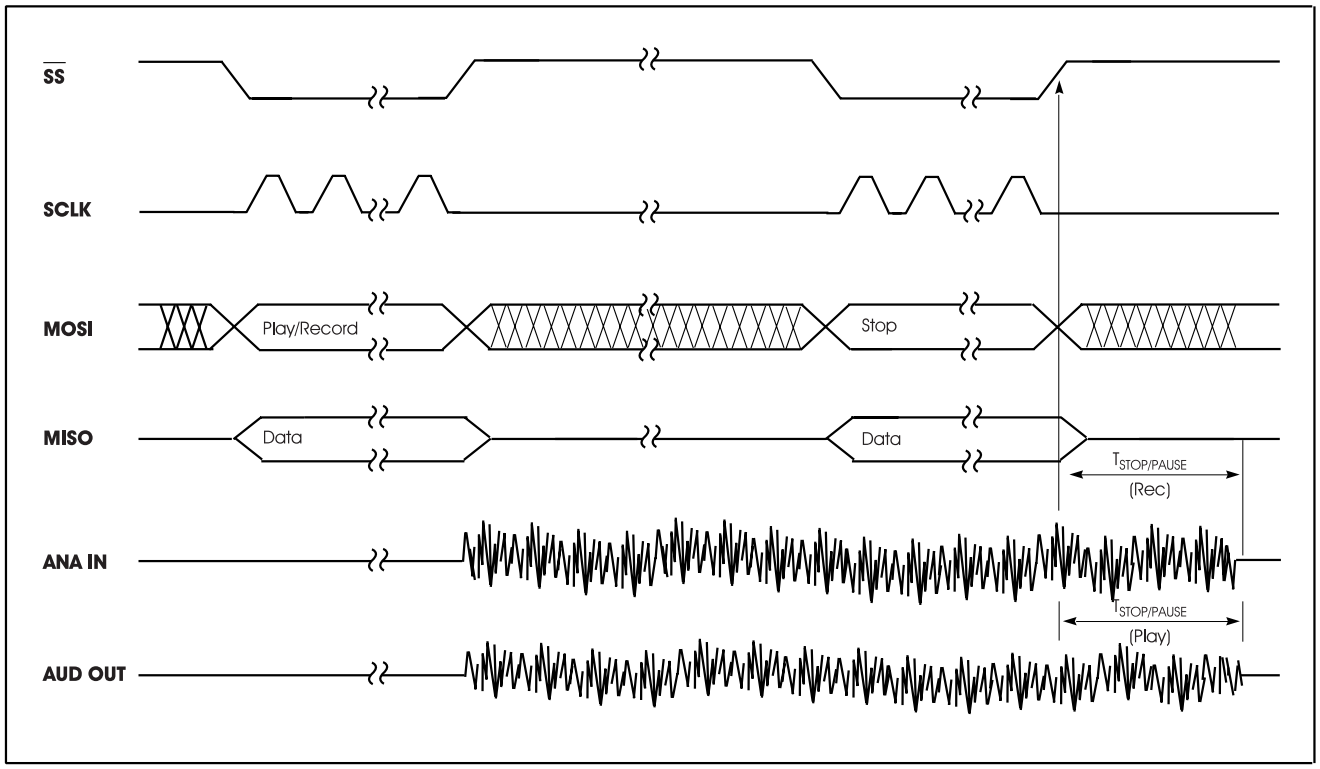
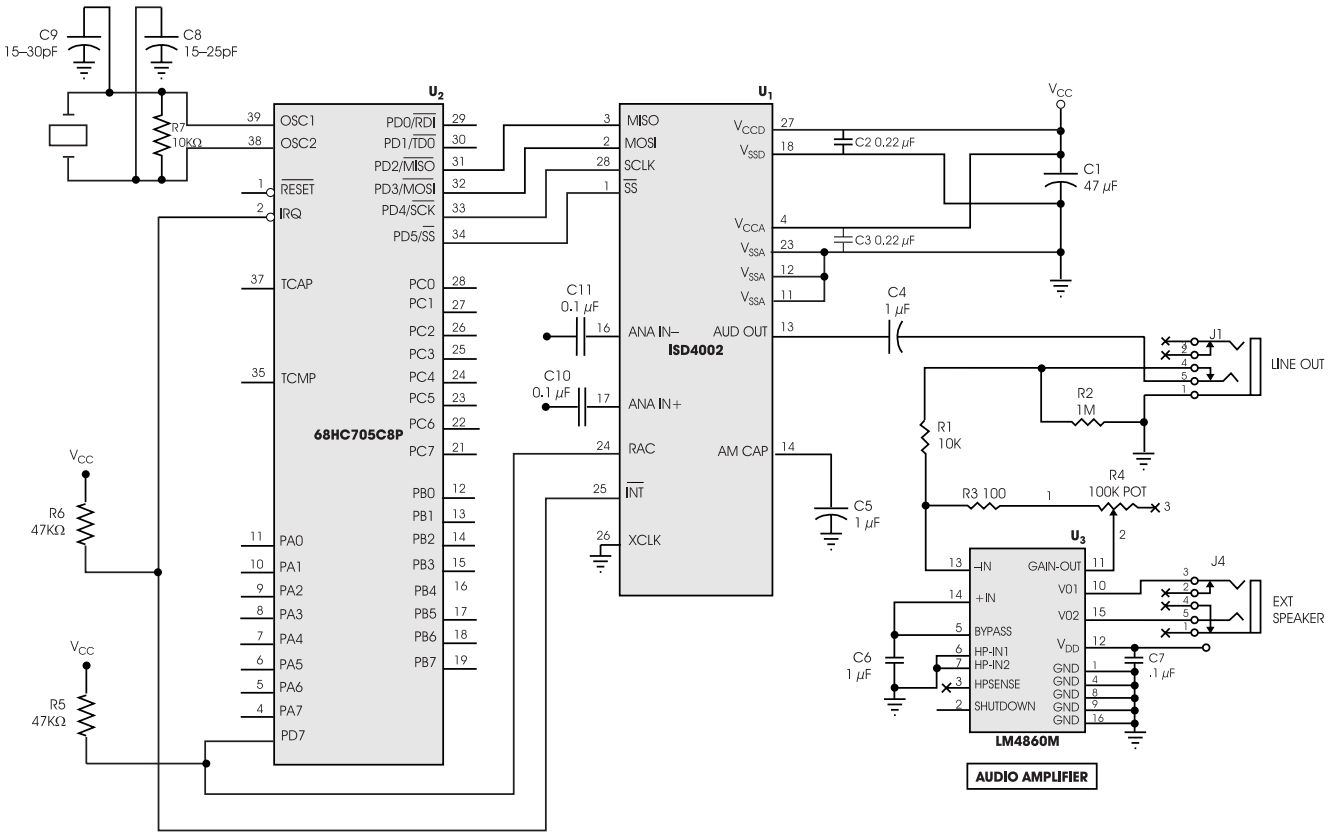
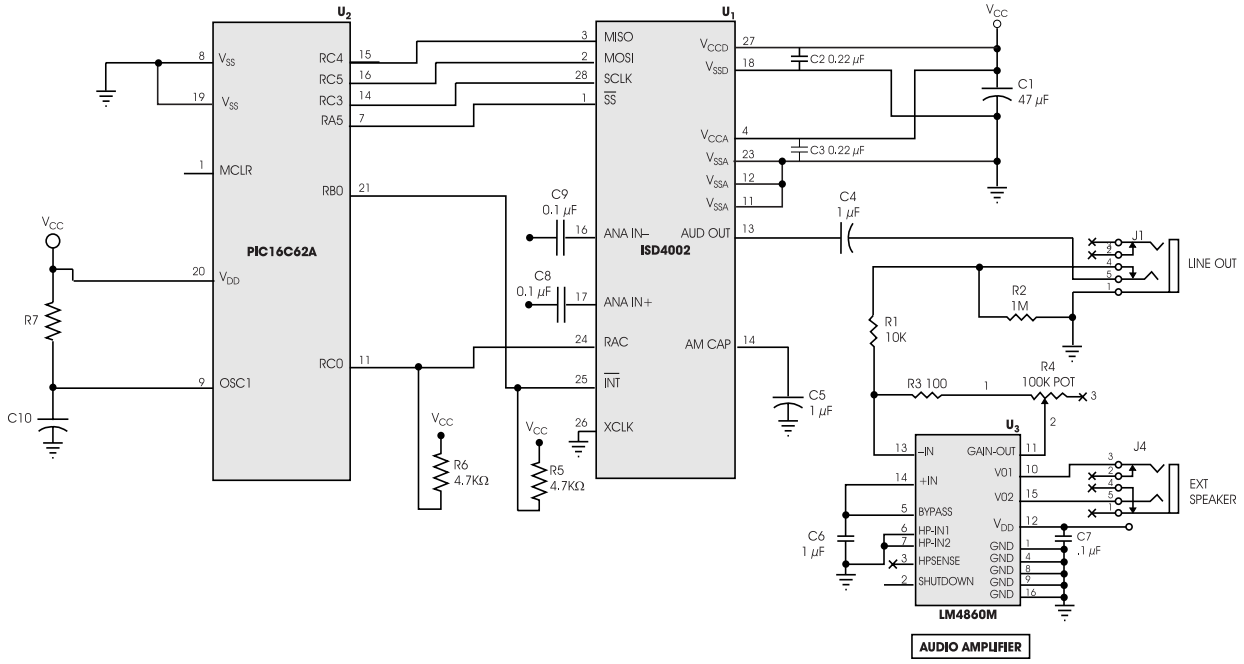


Figure 10: Application Example Using SPI(1)



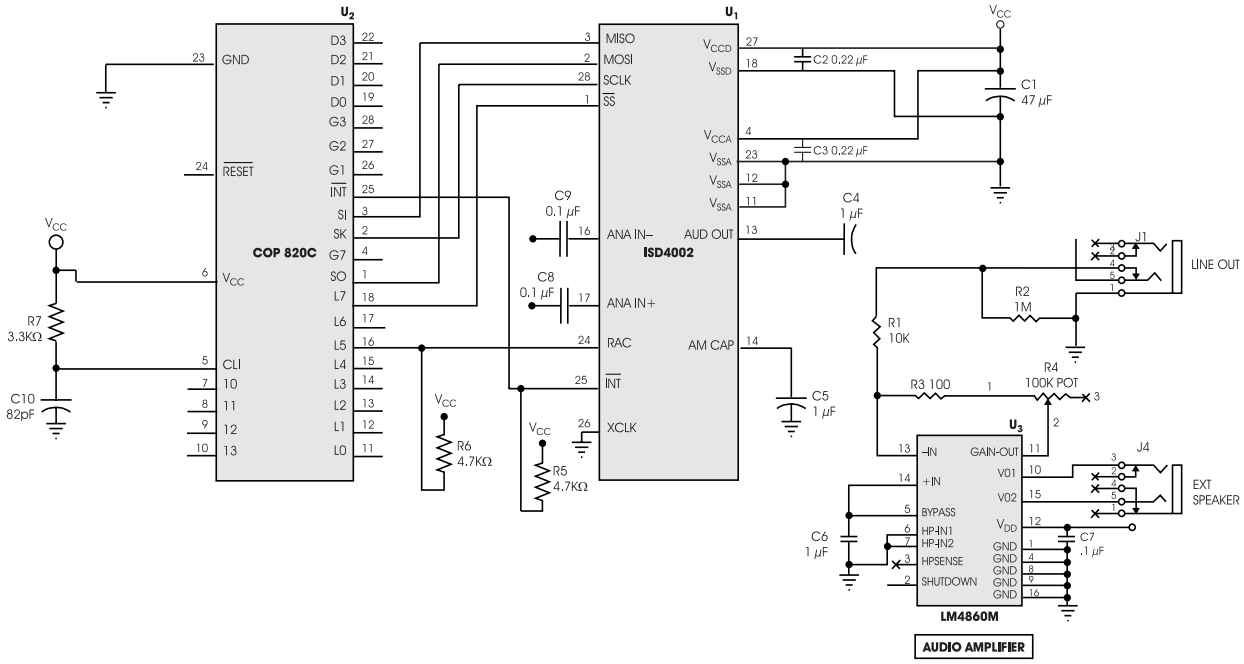
1. *This application example is for illustration purposes only. ISD makes no representation or warranty that such application will be suitable for production.*
2. *Please make sure the bypass capacitor C2 is as close as possible to the package.*

Figure 11: Application Example Using Microwire(1)



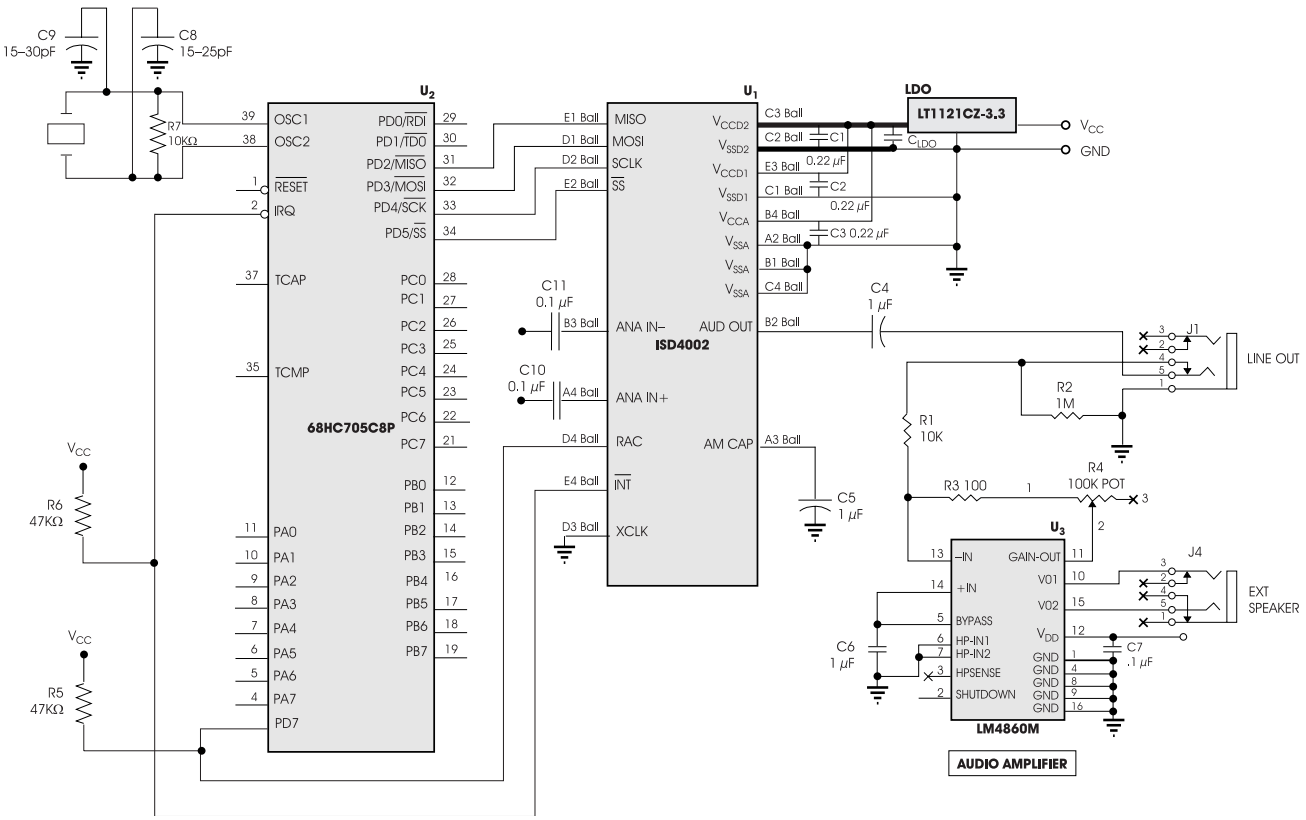
1. *This application example is for illustration purposes only. ISD makes no representation or warranty that such application will be suitable for production.*
2. *Please make sure the bypass capacitor C2 is as close as possible to the package.*

Figure 12: Application Example Using SPI Port on Microcontroller(1)



1. *This application example is for illustration purposes only. ISD makes no representation or warranty that such application will be suitable for production.*
2. *Please make sure the bypass capacitor C2 is as close as possible to the package.*

Figure 13: Application Example Using SPI with a Chip Scale Packaged Device



1. *This application example is for illustration purposes only. ISD makes no representation or warranty that such application will be suitable for production.*
2. *Please make sure all bypass capacitors are as close as possible to the package.*
3. *Ground plane must be used to connect all V_{SSA} pins together. If a ground plane is not available then a short and low impedance path is necessary.*
4. *Route ANA IN+ and ANA IN– away from V_{CCD} and V_{SSD} return paths.*
5. *Biasing for electret microphone must come from V_{CCA} and V_{SSA}.*
6. *AM CAP must return to V_{SSA}.*
7. *Traces from V_{CCD2} to the LDO (Low Dropout regulator) and from V_{SSD2} to the LDO ground should be as thick as possible. The distance between these two traces should be as short as possible.*

DEVICE PHYSICAL DIMENSIONS

Figure 14: 28-Lead 8x13.4 mm Plastic Thin Small Outline Package (TSOP) Type I (E)

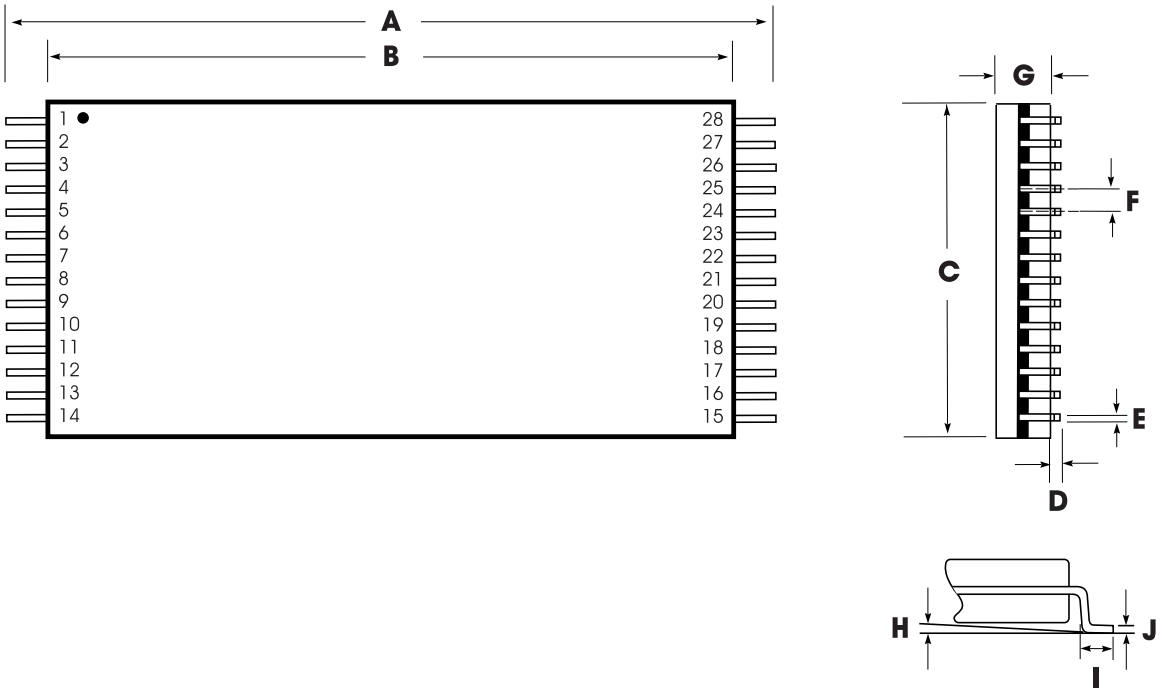


Table 30: Plastic Thin Small Outline Package (TSOP) Type I (E) Dimensions

	INCHES			MILLIMETERS		
	Min	Nom	Max	Min	Nom	Max
A	0.520	0.528	0.535	13.20	13.40	13.60
B	0.461	0.465	0.469	11.70	11.80	11.90
C	0.311	0.315	0.319	7.90	8.00	8.10
D	0.002		0.006	0.05		0.15
E	0.007	0.009	0.011	0.17	0.22	0.27
F		0.0217			0.55	
G	0.037	0.039	0.041	0.95	1.00	1.05
H	0°	3°	6°	0°	3°	6°
I	0.020	0.022	0.028	0.50	0.55	0.70
J	0.004		0.008	0.10		0.21

NOTE: *Lead coplanarity to be within 0.004 inches.*