SSI 78A400/420
Four-Wire Loopback IC

June, 1989

DESCRIPTION

The SSI 78A400 is a low-power CMOS integrated circuit that provides the 2713 and 2913 Hz detector and control circuitry needed to perform remote loopback testing on 4-wire telephone lines. As the major functional block in a Maintenance Terminating Unit (MTU), the SSI 78A400 offers a compact, low-power, high performance alternative to currently available discrete loopback circuitry.

The highly integrated SSI 78A400 incorporates a precise tone detector with guard-band and signal-timing qualification, a programmable fail-safe timer for loopback, and a loopback output for controlling an external relay. A manual-enable feature also allows for on-site loopback testing in the field. The SSI 78A420 has the added feature of two uncommitted operational amplifiers for the purpose of adding gain or loss to the signal path.

The SSI 78A400/420 Loopback Control IC employs advanced CMOS design technology for low power operation (±5 volts, at less than 50mW dissipation). Operation conforms to Bell Publications 43003/43004 specifications.

FEATURES

- **Precise selectable 2713/2913 Hz tone detection.**
- **SSI 78A420 with added gain/loss block.**
- **Integrated tone-detect and timing functions.**
- **Crystal-controlled timers and filters assure high accuracy.**
- **Immune to false activation by voice, data or 2600 Hz tone.**
- **Provision for on-site manual loopback and release.**
- **Adjustable time-out provides for automatic loopback deactivation.**
- **Performs auto reset during start-up.**
- **Compatible with Bell Publications 43003/43004 specifications.**
- **Low power CMOS designs: ±5 volts power at < 50mW dissipation.**
- **Compact 16-pin DIP or 18-pin SOIC packages for 78A400; 22-pin DIP for 78A420.**

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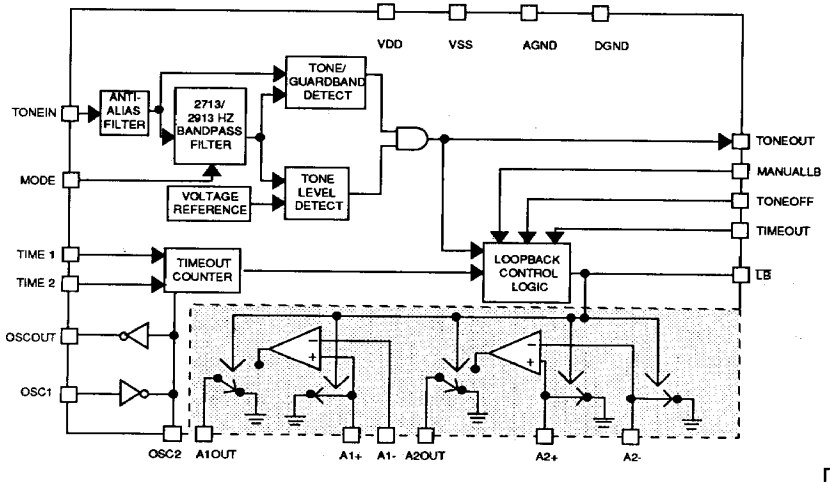
BLOCK DIAGRAM



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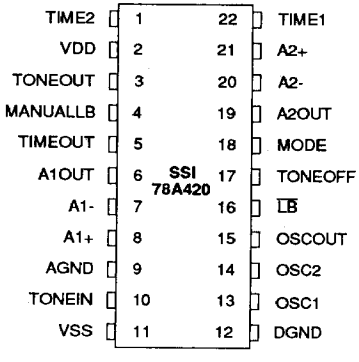
Area enclosed in dotted lines ⬚ applies to SSI 78A420 only.

PIN DIAGRAM



(SSI 78A400 pin-out shown inside)

CAUTION: Use handling procedures necessary for a static sensitive component.

CIRCUIT OPERATION

LOOPBACK AND RELEASE

Functionally, the 78A400 works by receiving a 2713 or 2913 Hz tone sent from the test source, qualifying this tone for a specified time interval, and enabling a loopback-control output that activates a relay to bridge the transmit and receive lines in the 4-wire circuit. A pre-characterized test pattern is then transmitted from the central office, looped back to the receive line, received, and interpreted to determine if there is a problem with line integrity. At the completion of the test, the loopback is terminated by a second qualified 2713 or 2913 Hz command tone, or by a fail-safe timer that responds to a selectable time-out interval preset during installation. (See Table 1.)

Activating the loopback connection ($\overline{LB}$=0) is accomplished on removal of a valid tone that has been present for 1.6 seconds. The loopback is released by a second valid tone that is present for 0.8 seconds. The loopback function can also be controlled manually by the MANUALLB pin. (See Table 2.) A reset during power-on inhibits activation of the loopback by maintaining the $\overline{LB}$ pin in a high state for 2.8 seconds after power is applied.

Prior to tone qualification, a tone dropout of greater than 22ms will be detected as a loss of tone, while a tone dropout of less than 7ms will be ignored. After tone qualification, a tone dropout of greater than 175ms will be detected as a loss of tone, whereas a tone dropout of less than 80 ms will be ignored. (Refer to the Timing Diagram.)

TONE DETECT CIRCUITRY

The 78A400 is capable of detecting either of two tones, centered at 2713 Hz or 2913 Hz. The 2713 Hz (±7 Hz) tone will be detected when the MODE pin is tied high. The 2913 Hz (±7 Hz) tone will be detected when the MODE pin is tied low. Tone energy is required to be between 0 dBm and -32 dBm in order for detection to occur. The tone will not be detected if its energy is less than -40 dBm or if its frequency deviation is greater than ±37 Hz from the center frequency.

TONE-TO-GUARD CIRCUITRY

If guard energy between 300 Hz and 2450 Hz is present, along with a qualified tone (as described under Tone Detect Circuitry), and the ratio between the qualified tone and the guard energy is greater than 18 dB, then a valid tone/guard condition will be detected. A valid tone/guard condition will not be detected for a tone-to-guard ratio of less than 6 dB.

OPERATING STATE SELECTION

Various loopback activation and release states can be selected using the MANUALLB, TONEOFF, and TIMEOUT control inputs. Manual loopback, loopback disable and loopback release options can be selected using these inputs, as noted in Table 2.

GAIN/LOSS BLOCK

In addition to the 4-wire loopback circuitry provided by the SSI 78A400, the SSI 78A420 provides two uncommitted operational amplifiers that can be adjusted by external components as a gain/loss block during loopback. During the loopback inactive condition ($\overline{LB}$ = high), all the operational amplifier inputs and outputs, except A1, are tied to the internal analog ground. The A1 pin is left floating.

TABLE 1

TIME1	TIME2	Timeout Times Normal Mode
Low	Low	1.5 ± 0.1 Minutes
Low	High	2 ± 0.1 Minutes
Low	Open	4 ± 0.1 Minutes
High	Low	6 ± 0.1 Minutes
High	High	9 ± 0.1 Minutes
High	Open	12 ± 0.1 Minutes
Open	Low	15 ± 0.1 Minutes
Open	High	18 ± 0.1 Minutes
Open	Open	20 ± 0.1 Minutes

TABLE 2

MANUALLB	TONEOFF	TIMEOUT	OPERATING STATE
low	low	low	Disables tone activated loopback ($\overline{LB}$ pin high).
low	low	high	Upon loopback activation by tone, circuit returns to loopback release state after time as defined by TIME1 and TIME2 pins.
low	high	low	Upon loopback activation by tone, circuit returns to loopback release state after losing the tone for more than 0.15 seconds and then receiving a second tone of 0.8 seconds duration.
low	high	high	Upon loopback activation by tone, circuit returns to loopback released state by timeout or tone, whichever occurs first.
high	x	x	Circuit is in loopback active ($\overline{LB}$ pin low) condition; tone detect circuitry is deactivated in order for tones not to interfere with this manual state.

PIN DESCRIPTION

I/O	LABEL	PIN NUMBER		DESCRIPTION
		78A400	78A420	
-	VDD	1	2	Positive power supply, 5V +20%, -10%
-	VSS	7	11	Negative power supply, -5V +10%, -20%
-	AGND	5	9	Analog ground
-	DGND	8	12	Digital ground
I I	OSC1 OSC2	9 10	13 14	Connection for a 3.5795 MHz parallel mode crystal. Crystal variation should not exceed a max of ±0.04%. An external CMOS logic level clock may be used to drive OSC2 if the crystal input is not used. OSC1 should then be tied to DGND.
O	OSCOUT	11	15	Oscillator buffered output. Outputs 3.5795 MHz clock in normal mode.
I I	TIME 1 TIME2	15 16	22 1	Timeout time control pins. Controls the loopback timeout sequence as shown in Table 1.
I	MODE	14	18	Tone-detect frequency selection. To detect 2713 Hz tone, tie the MODE pin high. To detect 2913 Hz tone, tie the MODE pin low.

PIN DESCRIPTION (continued)

I/O	LABEL	PIN NUMBER		DESCRIPTION
		78A400	78A420	
O	TONEOUT	2	3	Output from the tone detect section used for monitoring internal signals in test mode only.
I	TONEIN	6	10	Input for 2713 Hz tone detector.
O	$\overline{LB}$	12	16	Loopback digital output. A low state indicates a loopback activate condition. A high state indicates a loopback release condition. TTL compatible.
I	MANUALLB	3	4	Input to manually set chip into loopback active condition. See Table 2.
I	TONEOFF	13	17	Input to incorporate tone disable of loopback. See Table 2.
I	TIMEOUT	4	5	Input to incorporate timeout disable of loopback. See Table 2.
I	A1–	NA	7	Inverting gain/loss block input.
I	A1+	NA	8	Non-inverting gain/loss block input.
O	A1OUT	NA	6	Gain/loss block output.
I	A2–	NA	20	Inverting gain/loss block input.
I	A2+	NA	21	Non-inverting gain/loss block input.
O	A2OUT	NA	19	Gain/loss block output.

ABSOLUTE MAXIMUM RATINGS

PARAMETER		RATING	UNIT
Supply Voltage	VDD	6.5	V
Supply Voltage	VSS	-6.5	V
Storage Temperature		-65 to 150	°C
Soldering Temperature (10 sec.)		260	°C
Applied Voltage, All Inputs		VSS-0.3 to VDD+0.3 or 50mA	V
Output Voltage, All outputs		DGND-0.3 to VDD+0.3 or 50mA	V

NOTE: All inputs and outputs are protected from static charge using built-in, industry standard protection devices and all outputs are short-circuit protected.

RECOMMENDED OPERATING CONDITIONS

PARAMETER		CONDITIONS	MIN	MAX	UNITS
Ambient Temperature			–40	85	°C
Positive Power Supply	VDD		4.5	6	V
Negative Power Supply	VSS		–6	–4.5	V
Supply Variation	VDD – | VSS |		–1	1	V
Digital Ground (DGND)			VSS–0.1	AGND+0.1	V
Crystal Frequency Variation		3.5795 MHz	–0.04	+0.04	%
Digital Inputs, Low	MANUALLB TONEOFF		DGND–0.3	DGND+0.8	V
Digital Inputs, High			DGND+3	VDD+0.3	V
Input Low Voltage	TIME1, TIME2		DGND	DGND+0.3	V
Input Medium Voltage	TIME1, TIME2	Pin open			
Input High Voltage	TIME1, TIME2		VDD–0.4	VDD	V
Input Low Voltage	MODE	Test mode	VDD–1.7	VDD–1.5	V
Input High Voltage	MODE	Normal mode	VDD–0.1	VDD	V
Input Current	(All Inputs)	DGND≤VIN≤VDD	–100	100	µA
Input Low Voltage	OSC2	External Frequency	DGND–0.3	DGND+0.4	V
Input High Volyage	OSC2	Source; OSC1 at DGND	DGND+3	VDD+0.3	V

DC ELECTRICAL CHARACTERISTICS

PARAMETER		CONDITIONS	MIN	MAX	UNITS
Positive Supply Current	IDD				
In Loopback		Outputs unloaded		9	mA
Not In Loopback		Outputs unloaded		8	mA
Negative Supply Current	ISS				
In Loopback		Outputs unloaded		–9	mA
Not In Loopback		Outputs unloaded		–8	mA
Analog Ground (AGND) Supply Current			–250	+250	µA
Output High Voltage	$\overline{LB}$, OSCOUT	IOUT = –0.4mA	DGND+2.4	VDD	V
Output Low Voltage	$\overline{LB}$, OSCOUT	IOUT = 4mA		DGND+0.4	V
Output High Voltage	TONEOUT	IOUT = –40µA	VDD–0.5		V
Output Low Voltage	TONEOUT	IOUT = 40µA		VSS+0.5	V

DYNAMIC CHARACTERISTICS AND TIMING

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNITS
Tone Detection						
Frequency	2713 Hz	Mode = high	2706		2720	Hz
Frequency	2913 Hz	Mode = low	2906		2920	Hz
Amplitude			–32		0	dBm
Tone To Guard Band Ratio		300–2450 Hz Guard Energy	18			dB
Tone Dropout Reject	T_{TDB}	Before Qualification			7	ms
Tone Dropout Detect	T_{TDB}	Before Qualification	22			ms
Tone Dropout Reject	T_{TDA}	After Qualification			80	ms
Tone Dropout Detect	T_{TDA}	After Qualification	175			ms
Tone Detect Qualification Time						
Loopback Activate			1.5	1.6	1.7	s
Loopback Release			0.7	0.8	0.9	s
Tone Rejection						
Frequency	2713 Hz	Mode = high	$F_0 \leq 2676$; $F_0 \geq 2750$Hz			
Frequency	2913 Hz	Mode = low	$F_0 \leq 2876$; $F_0 \geq 2950$Hz			
Amplitude			–40			dBm
Tone To Guard Band Ratio					6	dB
Alias Energy Detect		Energy > 90KHz	–36			dBm
Input Impedance At Tone In				100		KΩ
Power On Reset Delay Time				2.8		s

GAIN/LOSS CHARACTERISTICS

PARAMETERS	CONDITION	MIN	NOM	MAX	UNITS
Input Offset Voltage	$\overline{LB}$ = Low			20	mV
Unity Gain Bandwidth	$\overline{LB}$ = Low	0.8			MHz
Max. Output Voltage Swing	$\overline{LB}$ = Low, RL = 5K CL ≤30 pF, THD ≤1%	4.0			Vpp
Input Referred Noise Voltage	$\overline{LB}$ = Low			0.16	$\mu V/\sqrt{Hz}$
Input Common Mode Voltage	$\overline{LB}$ = Low	VSS+2.0		VDD–2.0	V
Open Loop DC Gain	$\overline{LB}$ = Low	80			dB
(Loopback inactive) Shorting Pin To GND Resistance	$\overline{LB}$ = High			200	Ω

APPLICATION

The 78A400 would typically reside in a 4-wire telephone line Maintenance Terminating Unit (MTU), as shown in Figure 1. In this application, the 78A400 monitors the receiver side of the 4-wire telephone circuit for a loopback command signal (a 2713 Hz tone) to be sent from testing equipment in the telephone company's central office.

When the loopback command tone is received, the 78A400 qualifies the tone for frequency, amplitude, and adequate level above other energy in the guard band frequency range of 300-2450 Hz. Additional to these qualifications, the tone must also be continuous for 1.6 seconds. After this timed interval, termination of the qualified tone will activate the $\overline{LB}$ output (logic "0"). This extensive command-tone qualification prevents false loopback activation, which could cause an interruption of normal line communications.

Activation of the $\overline{LB}$ output drives a loopback relay that bridges the transmit and receive signal paths, disconnecting the customer premises equipment from the phone line. Once this loopback is in place, the central office test equipment can transmit known test signals on the transmit line and receive these signals back on the receive line. A comparison of these test results with predetermined line-characterization data allows verification of the integrity of the network, without the need for a service call. Upon completion of the testing sequence, the MTU is returned to its operational state by transmitting a second qualified tone from the central office to deactivate the loopback connection. As a backup, a fail-safe timer, adjusted during MTU setup, will also cause release of the loopback after a pre-set time interval.

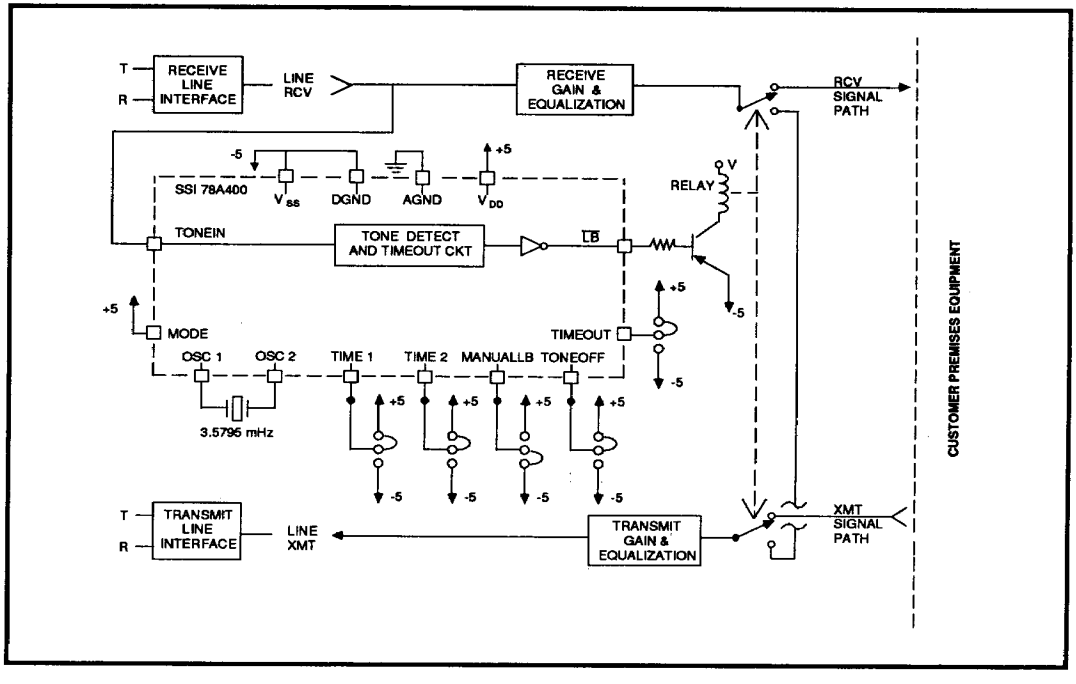


FIGURE 1: SSI 78A400 4-Wire Loopback Controller Typical MTU Application

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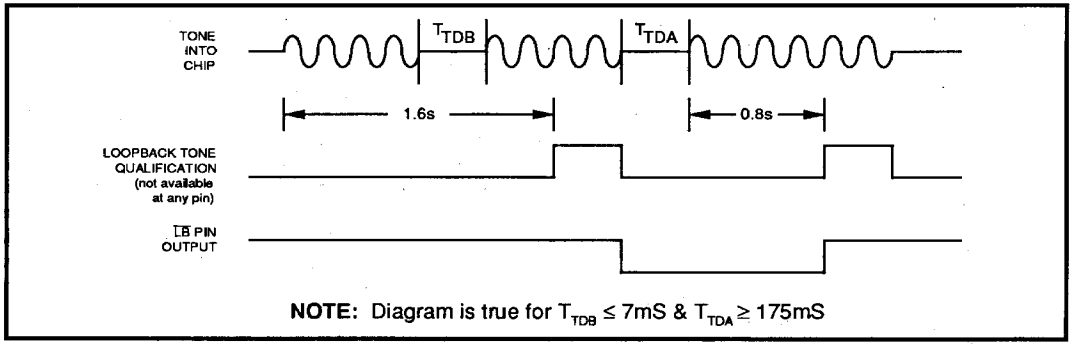
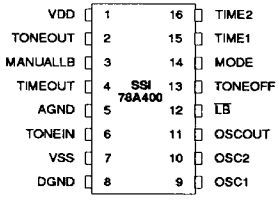
SSI 78A400/420
Four-Wire Loopback IC

TIMING DIAGRAM

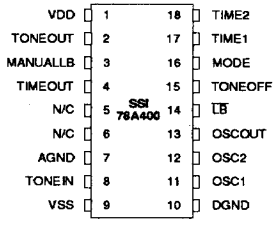


NOTE: Diagram is true for $T_{TDB} \leq 7mS$ & $T_{TDA} \geq 175mS$

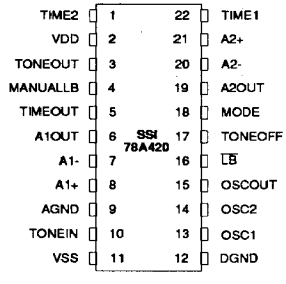
PACKAGE PIN DESIGNATIONS



16-PIN DIP



18-PIN SMALL OUTLINE



22-PIN DIP

ORDERING INFORMATION

PART DESCRIPTION	ORDER NO.	PKG. MARK
SSI 78A400 16-Pin Plastic Dual-in-line	SSI 78A400-IP	78A400-IP
SSI 78A400 18-Pin Small Outline	SSI 78A400-IL	78A400-IL
SSI 78A420 22-Pin with Gain/Loss Block Plastic Dual-in-line	SSI 78A420-IP	78A420-IP