CH1812A, CH1813, CH1815, and CH1818
Telephone Line Interface Components

T-75-37-05

INTRODUCTION

Products that are designed to "direct connect" to the telephone line such as modems, FAX machines, or data terminals, must do so through a circuit called a DAA (Data Access Arrangement) approved by the governmental agencies that control the telephone systems. For the United States this is the FCC (Federal Communications Commission) and for Canada it is the DOC (Department of Communications). These agencies test the product to assure that it meets or exceeds their specifications, thereby protecting their phone system and its users. Unfortunately, passing these tests and waiting for agency approvals can take several months and significantly compromise the timely introduction of a product.

The Cermetek telephone line interface components have been designed and tested to meet these rigorous requirements and thereby speed up the approval process. This does not mean that you can avoid agency approval, but it does mean that if you properly select and then apply one of the components described here, your design time plus the electrical testing portion of the approval process will be minimized.

If even the minimized registration delays for these products are inconsistent with your product introduction schedule, Cermetek offers DAAs which are already FCC registered. This registration may be used by your product and thereby eliminate further delays associated with registration. After product introduction, when cost (not speed to the market) is most critical, the registered DAAs can be replaced with one of these DAAs and a few components. For more information on the registered DAAs, request data sheets from your local Cermetek representative.

These DAAs employ a circuit to provide telephone line coupling and isolation.

An external matching resistor, RM (see Table 2 for values) assures a 600 ohm telephone line impedance match when driven from a low impedance source.

DAA SELECTION

The CH1812A is the basic interface module for U.S. and Canadian use. It is capable of operating over public switched telephone lines or on leased lines with or without current loop.

The CH1815 is a low profile version of the CH1812A for applications where height is restricted to less than ½ inch. In most applications it can readily replace the CH1812A. However, the CH1815 will not operate with leased lines that do not provide loop current (sometimes called dry lines).

The CH1818 is a low cost, small size alternative to the CH1812A and is electrically and functionally identical. The principal differences are in packaging: the CH1818 is square and conformal coated, while the CH1812A is rectangular and is encapsulated. The CH1818 can be used for the North American public switched telephone network dial-up lines only. The CH1812A will support both dial-up and leased lines.

The CH1813 has the same features as the CH1812A and it additionally supports a phone connection port. The CH1813 will provide an indication to the host when an attached phone is off-hook. This feature aids in the implementation of voice/data switching.

FEATURES

- Can be quickly FCC Part 68 approved for switched or leased line operation
- Ringing Detection
- On/Off-Hook Control
- Isolation and Surge Protection as required by FCC Part 68 and DOC
- Small size
- PC board mountable
- Pin compatible
- Compatible with U.S. and Canadian dial-up phone lines
- Off-hook detection (CH1813)

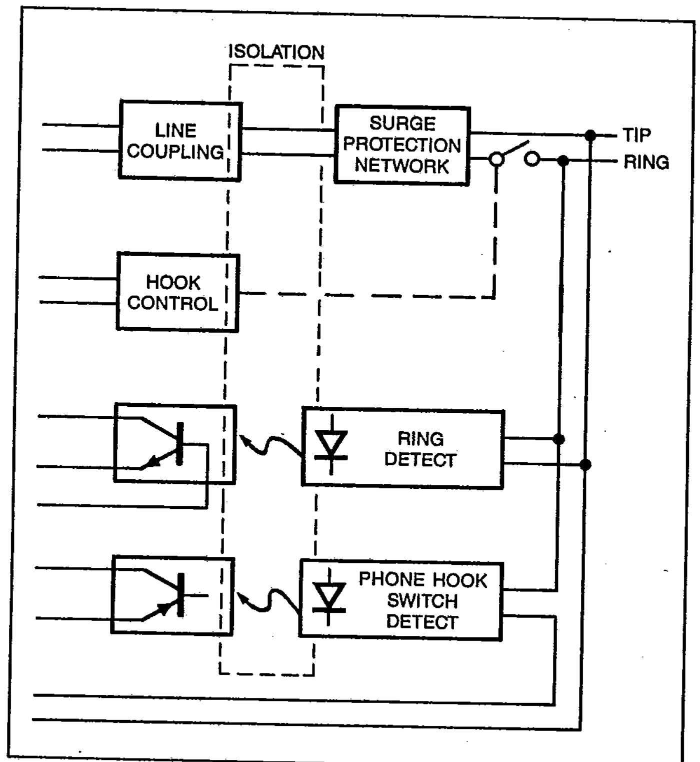


Figure 1. DAA Block Diagram

DESIGN CONSIDERATIONS

The Cermetek DAAs combined with just a few external parts form a complete and approvable telephone line interface. The following guidelines for your product design must be followed to meet the requirements of Part 68 rules.

1) The mounting of the DAA in the final assembly must be made so that it is isolated from exposure to any hazardous voltages within the assembly. Adequate separation and restraint of cables and cords must be provided.
2) The circuitry from the registered unit to the telephone line must be provided in wiring that carries no other circuitry than that specifically allowed in the rules (such as A and A1 leads).
3) Connection to the phone line should be made through a standard RJ-11C jack or equivalent.
4) Circuit board traces from the DAA's TIP and RING pins must exceed 0.1 inch spacing to one another and 0.2 inches spacing from all other traces or other conducting material. Traces should have a nominal width of 0.020 inches or greater.
5) RING and TIP traces should be as short as possible and should be oriented to prevent coupling from other signals on the host circuit card.
6) No additional circuitry should be connected between the DAA and the phone line RJ-11C jack except as shown in Figure 5.
7) The users manual for the host product must provide the user with connection information required by the rules. This includes the Ringer Equivalence Number.
8) See Operating Restrictions for further requirements.

Mounting the DAA

These DAAs can be soldered directly to the host circuit card or installed in sockets. To avoid the problems of flux contamination hand soldering is preferred to wave soldering. Many socket manufacturers offer socket strips that accept the 0.025 inch square pins on 0.10 inch centers. When using sockets, mechanical restraint of the DAA should be provided to keep it seated during shipment. Plastic cablewraps are secure yet easily removed.

Connection to the Host

Connection to the host is made through user supplied circuitry similar to that shown in Figure 2. The interface signals to this circuitry are labeled:

TRXCAR	- Transmit Carrier or Audio
RCVCAR	- Receive Carrier or Audio
RI	- Ring Indication
OH	- On-Hook
POH	- Phone Off-Hook (CH1813 only)
GROUND	- Common for all signals

This interface circuitry implements four separate functions:

1) 2- to 4-wire converter
2) Line On-Hook/Off-Hook Control
3) Ring Detector
4) Phone Hook Switch Detection

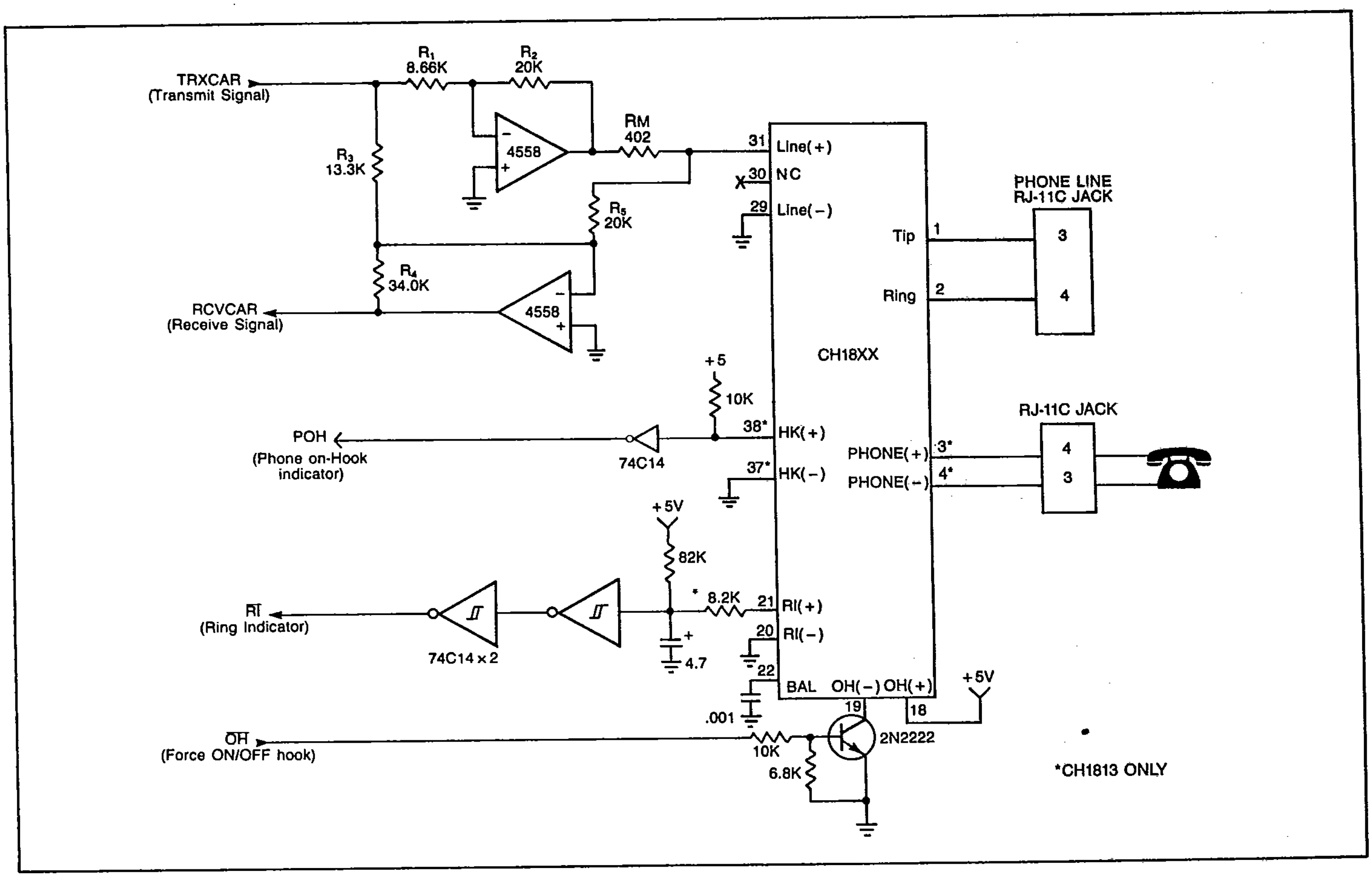


Figure 2. Typical Application

2- To 4-Wire Converter

In most applications it is necessary to have separate transmit and receive audio paths. On the telephone line and at LINE(+)/LINE(−) of the DAA the transmit and receive audio appear simultaneously. A circuit called a 2- to 4-Wire Converter is used to separate the two. The two op-amps and associated resistors at TRXCAR and RCVCAR provide this function.

The transmit signal (TRXCAR) level is adjusted by the top op-amp and applied to the line matching resistor RM. (The optimum value of RM for 600 ohm phone lines is given in Table 2.) The DAA couples this signal to the phone line. The combined transmit and receive signals appear at LINE(+). The lower op-amp subtracts the transmitted signal from the combined signals to leave the received signal at RCVCAR. The accuracy of this subtraction process depends on how close to 600 ohms the phone line actually is. Generally a small amount of the TRXCAR signal will appear at RCVCAR. The ratio of the signal applied to the signal returned is called trans-hybrid rejection. For phone lines that are 600 ohms ±30%, this circuit will yield a rejection of at least 10 dB.

The 2- to 4-wire converter performance is defined by resistors R_1 through R_5. By correctly choosing these values, the transmit and receive path gain can be controlled in addition to its primary function which is transmit signal subtraction. The three equations shown below apply to the CH1812A, CH1813 and the CH1818. They assume RM equals 402 ohms and also compensate for the DAA's inherent transmit and receive insertion loss.

CH1812A, CH1813, and CH1818

Transmit Path Gain

$$\frac{VTIP/RING}{VTRXCAR} = \frac{R_2}{2.3 \bullet R_1} = Gtx$$

Receive Path Gain

$$\frac{VRCVCAR}{VTIP/RING} = \frac{R_4}{1.7 \bullet R_5} = Rtx$$

Transmit Signal Rejection

$$\frac{R_2\ R_3}{R_1\ R_5} = 1.53$$

The following equations apply to the CH1815 and assume RM equals 402 ohms. NOTE: The CH1815 requires slightly different values for R_1 through R_5. If you are upgrading from the CH1812A to the low profile CH1815 you should also change the resistor values.

CH1815

Transmit Path Gain

$$\frac{VTIP/RING}{VTRXCAR} = \frac{R_2}{2.57 \bullet R_1} = Gtx$$

Receive Path Gain

$$\frac{VRCVCAR}{VTIP/RING} = \frac{R_4}{1.45 \bullet R_5} = Rtx$$

Transmit Signal Rejection

$$\frac{R_2\ R_3}{R_1\ R_5} = 1.81$$

To demonstrate the method we will solve the CH1812A/13/18 equations assuming a requirement for both transmit gain (Gtx) and receive gain (Grx) equal to 1.

Table 1A. Pin Description - CH1812A, CH1813, CH1815

Pin	Name	Function
1 2	TIP RING	TIP and RING directly connect to the telephone line
3 4	PHONE (+) PHONE (−)	PHONE (+) and PHONE (−) couple a standard phone set to the telephone line. (CH1813 only)
38 37	HK (+) HK (−)	HK (+) and HK (−) outputs indicate the state of the hook switch of a phone set connected to PHONE (+) and PHONE (−). An off-hook state is indicated by a LOW impedance between HK (+) to HK (−). An on-hook state is indicated by a HIGH impedance between HK (+) to HK (−). (CH1813 only)
18 19	OH (+) OH (−)	OH(+) and OH (−) are on-hook inputs. Applying 4 to 6 volts from OH(−) to OH (+) causes the DAA to take the telephone line off-hook.
20 21	RI (−) RI (+)	RI (+) and RI (−) are Ring Indicate outputs. During phone line ringing, a LOW and HIGH impedance results from RI (+) to RI (−) .
22	BAL	Balance for the ring indicator. A 0.001 μF ceramic disc capacitor should be connected from BAL to ground.
29 31	LINE (−) LINE (+)	Audio coupling path for the telephone line.
30	—	Reserved — Do not connect.

Table 1B. Pin Description - CH1818

Pin	Name	Function
1 2	TIP RING	TIP and RING directly connect to the telephone line.
3 4	OH (+) OH (−)	OH (+) and (−) are on-hook inputs. Applying 4 to 6 volts from OH (−) to OH (+) causes the DAA to take the telephone line off-hook.
5	BAL	Balance for the ring indicator. A 0.001 μF ceramic disc capacitor should be connected from BAL to ground.
6 7	RI (−) RI (+)	RI (+) and RI (−) are Ring Indicate outputs. During phone line ringing, a LOW and HIGH impedance results from RI (+) to RI (−) .
8 9	LINE (−) LINE (+)	Audio coupling path for the telephone line.

Table 2

Product	Impedance Matching Resistor (RM), Ohms
CH1812A/CH1818	402
CH1813	402
CH1815	536

This still leaves us with five unknowns and three equations. So we arbitrarily select values for R_2 and R_5.

$$R_2 = 20K \text{ ohms}$$
$$R_5 = 20K \text{ ohms}$$

Substituting these values into equations 1.0 and 2.0 and solving for R_1 and R_4 yields:

$$R_1 = 8.66K$$
$$R_4 = 34.0K$$

Rearranging equation 3 gives:

$$R_3 = \frac{1.53 \bullet R_1 \bullet R_5}{R_2}$$

or $R_3 = 13.3K$

It is recommended that these resistor values be rounded to the nearest 1% tolerance resistor value.

Operating Restrictions

Cermetek DAAs provide all required surge, hazardous voltage and isolation requirements. In addition to these functions, however, the user must typically incorporate the following additional requirements to satisfy such governmental registration agencies as FCC and DOC.

Transmit Level

For data equipment there are two different direct connect applications:

1) Leased Line
2) Dial-up Line

In each case the transmit level applied to the telephone line must be regulated to a different maximum level.

In the leased line arrangement, the TIP/RING audio must be limited to 0 dBM maximum.

For dial-up lines, the audio placed on TIP and RING should not exceed −9 dBM.

Part 68 of the FCC rules places restrictions on the power transmitted to the phone line. Under most circumstances the limit is −9 dB below 1mW or, since the phone line is nominally 600 ohms, less than 0.275 V_{rms}. One exception to this rule allows DTMF tones for network signaling to be transmitted at up to 0 dBM (0.774 V_{rms}). These restrictions must be considered when selecting the Transmit Path Gain.

Out-of-Band Energy

Data equipment must not place Out-of-Band energy on the telephone line that exceeds the limits (see Table 3). On modems, this function is generally performed by the transmit filter.

Table 3. Out-of-Band Limits

Frequency Band (Hz)	Maximum Power (dB with respect to 1 mW)
4005 to 10K	−16
10K to 25K	−24
25K to 40K	−36
40K to 1M	−50

Billing Silence

After the start (or specifically answering) of a call, no audio shall be transmitted for at least 2 seconds.

This ensures the unhampered exchange between telephone central offices of tone encoded billing information.

Most modems already have this feature built-in. For equipment that does not already support this function, it may be easily added by triggering a 2-second "one shot" on the On- to Off-Hook transition of $\overline{OH}$ which squelches the transmit audio path.

Ring Detector

The RI (+) and RI (−) are outputs from an opto-isolator as shown in Figure 3a. The RI (+), RI (−) and BAL present the raw ring detect indication. The circuitry shown converts this raw output to a signal called $\overline{RI}$. $\overline{RI}$ is normally HIGH. When the telephone company central office applies a ringing signal to the phone line, $\overline{RI}$ will go LOW for the nominally 2-second ring period and HIGH for the nominally 4-seconds between rings. This circuit also helps prevent false ring indication from noise on the phone line.

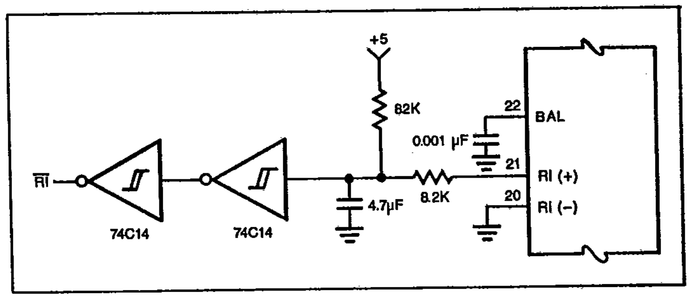


Figure 3a. Ring Envelope Detect

To reduce the component count, the circuit shown in Figure 3b can feed directly to a microprocessor input port and the signal debouncing can be done in software. The pulse frequency during the ring is twice that of the signal from the phone company central office (CO). The phone company's signal is usually 20 Hz but older systems may range from 15.3 to 68 Hz.

With either of these circuits a potential exists for false ring indications during pulse dialing of the DAA or by an extension phone on the same line. The Ring Detect signal should be ignored any time the DAA is Off-Hook and especially when pulse dialing.

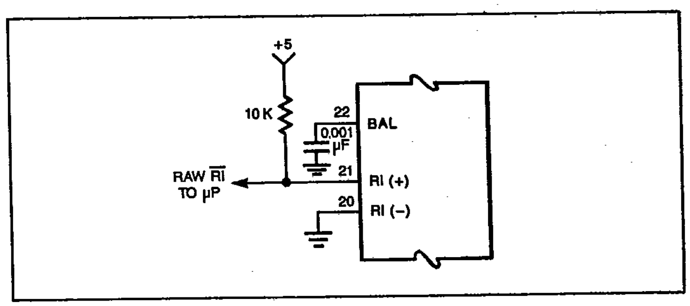


Figure 3b. Simple Ring Detect

Hook Control

The DAA will seize the two-wire telephone line (go Off-Hook) when 4 to 6 volts are applied from OH (−) to OH (+). This allows On/Off-Hook control from a single 5-volt supply via an inexpensive 2N2222 transistor, as can be seen in Figure 3c.

Operation from supplies higher than +5 volts can be accommodated by adding a current limiting resistor from OH (+) to the supply voltage. A +12 volt supply configuration would require a 680 ohms limiting resistor.

Asserting OH (On Hook) HIGH takes the telephone line Off-Hook while asserting a LOW places the line On-Hook.

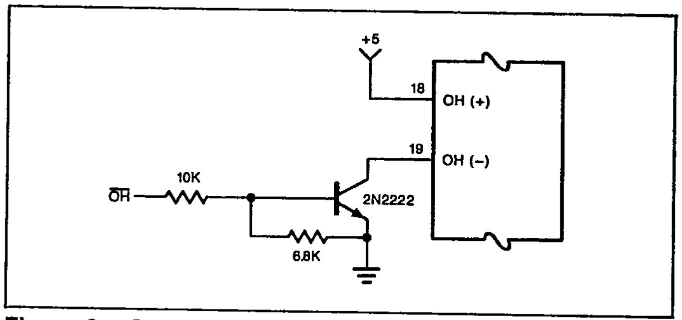


Figure 3c. Off-Hook Control

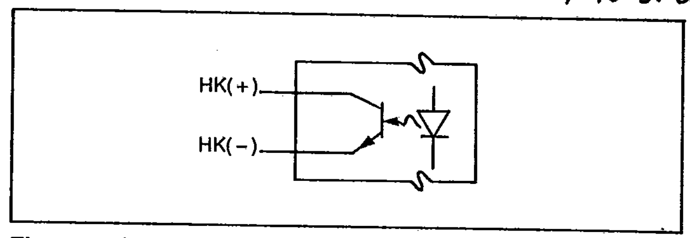


Figure 4. Hook Switch Detection Equivalent Output Circuit

Phone Hook Switch Detection

Connected as shown in Figure 3d, the CH1813 provides a logic high indication on P_{OH} when a connected phone is taken Off-Hook. The CH1813 provides a low impedance path from HK (+) to HK (−) when the phone is Off-Hook and a high impedance path when the phone is On-Hook. The hook switch detection equivalent output circuit is shown in Figure 4.

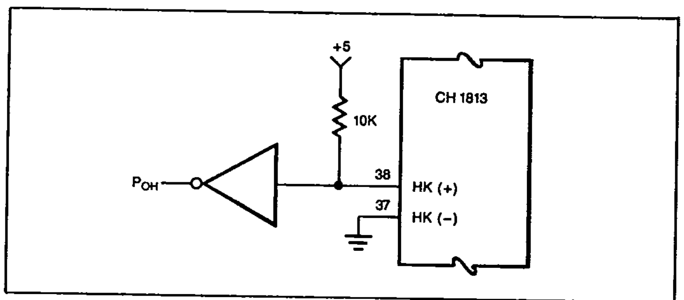


Figure 3d. Hook Detect

Canadian Approval

The DAA can additionally be approved for Canadian telephone connection. This must be done, however, after the DAA is installed in the host. The entire host system must then be submitted to Canada's DOC, Department of Communications, for approval. Because the DOC requires additional protection, the following additional telephone line interface circuitry, shown in the dotted box, is needed. This circuitry is optional for FCC Part 68 registration in the U.S.A.

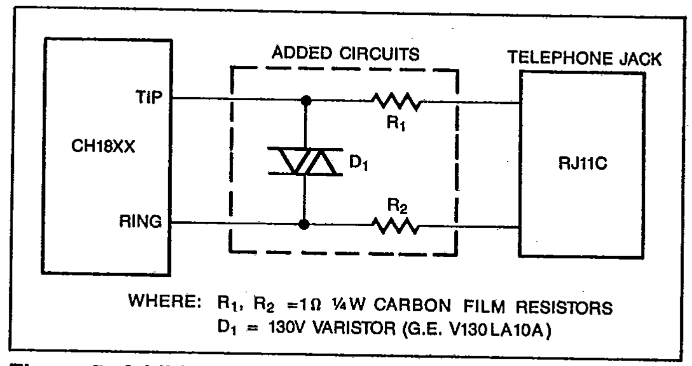
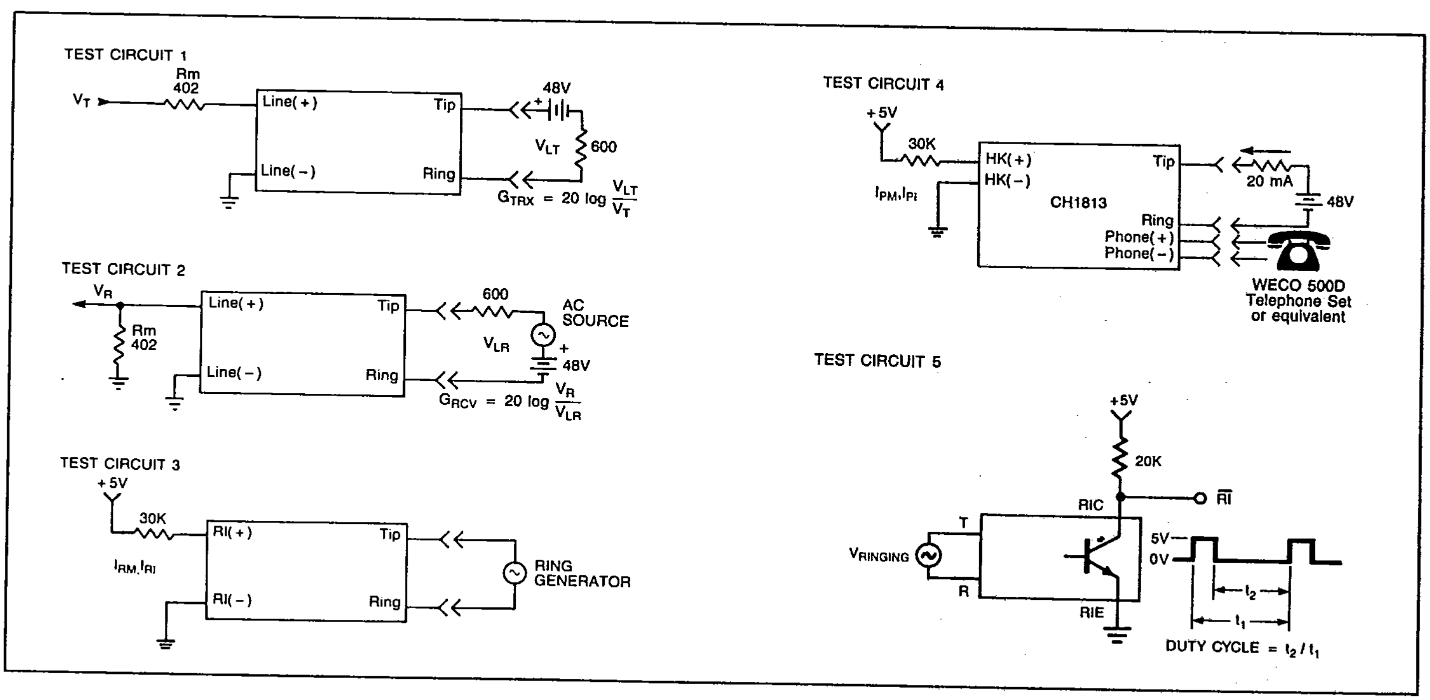


Figure 5. Additional Circuitry Needed for Canadian DOC Registration



Electrical Specifications
CH1812A, CH1813, CH1815, CH1818
T_A = 0°C to +55°C

Parameter	Symbol	Conditions	CH1812A/1813/1818 Min.	CH1812A/1813/1818 Typ.	CH1812A/1813/1818 Max.	CH1815 Min.	CH1815 Typ.	CH1815 Max.	Units
Transmit Insertion Loss	G_t	Z_{line} = 600Ω R_M = 402Ω (CH1812A/13/18) R_M = 536Ω (CH1815) Test Circuit 1	6.0	7.2	8.4	7.2	8.2	9.2	dB
Receive Insertion Loss	G_r	R_M = 402Ω (CH1812A/13/18) R_M = 536Ω (CH1815)	3.4	4.6	5.8	2.2	3.2	4.2	dB
On-Hook Impedance	Z_{onhk}		10 M			10M			Ohms
Off-Hook Loop Current	I_{loop}		20		100	20		100	mA
Line Match Resistor	R_M			402			536		Ohms
Hook Switch Control Impedance				500 ±10%			500 ±10%		Ohms
On-Hook Voltage		Measured between OH (+) and OH (−)	0		0.5	−0.5		0.5	V
Off-Hook Voltage		Measured between OH (+) and OH (−)	4.0		6.0	4.0		6.0	V
Ring Detect Output Leakage	I_{Sat} V_{Sat}	V_{CE} = 10V V_{CE} = 30V I = 0.5 mA			50 100 0.3			50 100 0.3	nA mA V
Duty Cycle		15.3 to 68 Hz	50	75		50	75		% On
Detect Threshold		15.3 to 68 Hz	40		130	40		130	V_{rms}
Ringer Equivalence Number	REN				0.5A			0.5A	
Hook Detect Output Leakage Current (CH1813 only)	V_{Sat}	On-Hook Test Circuit 5 I_{CE} = 0.5 mA			50 0.3				nA V
Surge Protection FCC Part 68		68.302(d) metallic 68.302(e) Longitudinal 68.304 60 Hz	800 1000 1000			800 1000 1000			V_{peak} V_{peak} V_{RMS}

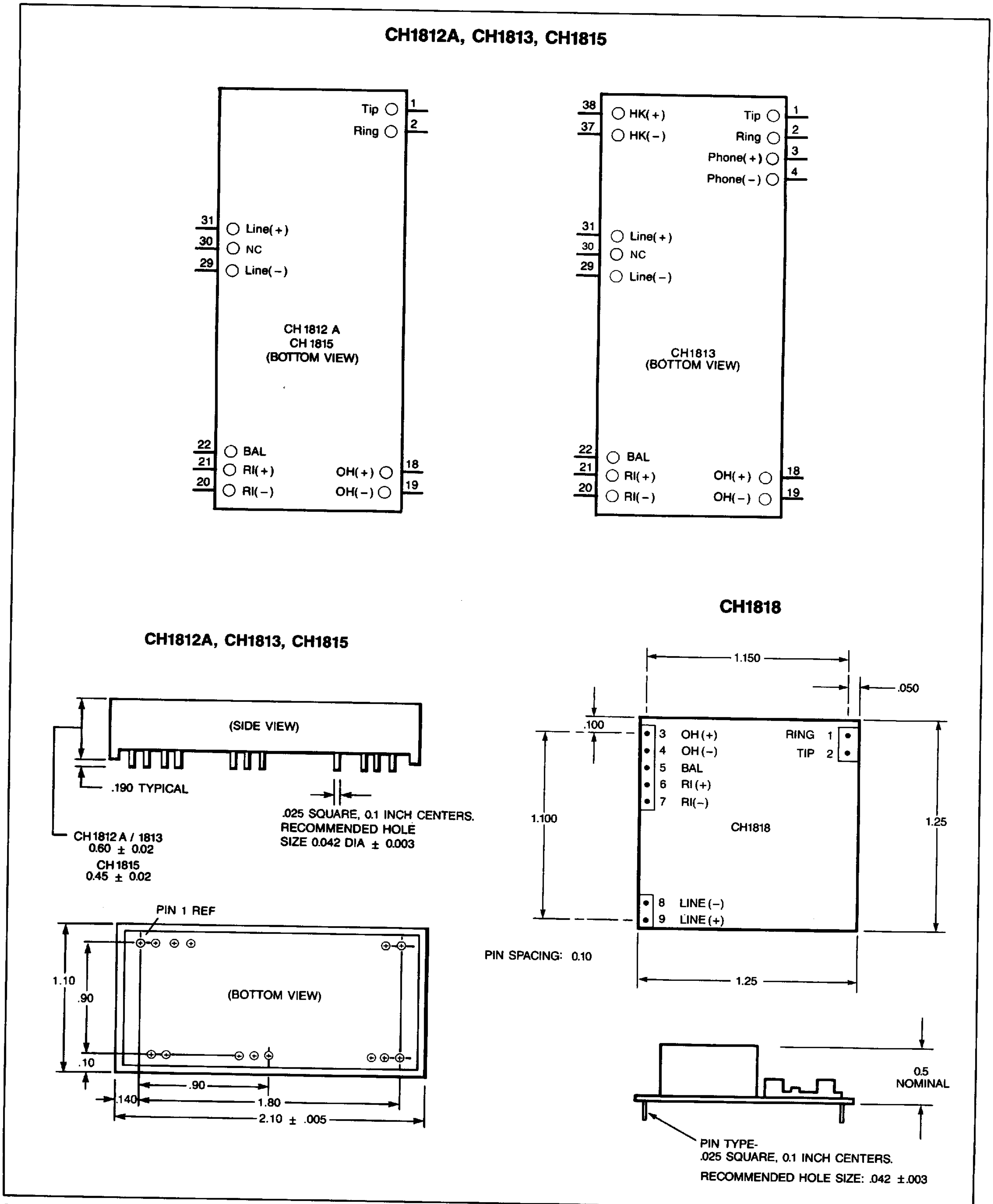


Figure 6. Pin Configurations and Physical Dimensions