

**FXO/DAA Design  
Using IXYS Integrated Circuits Division  
OptoMOS<sup>®</sup> Components**

## 1. Introduction

IXYS Integrated Circuits Division OptoMOS components can be applied to a variety of DAA telephone line interface designs suitable for many applications.

This application note includes a collection of DAA circuits that use IXYS Integrated Circuits Division OptoMOS components. It also includes a primer on DAA circuit fundamentals and listings of OptoMOS DAA design resources.

These circuits show the versatility of the OptoMOS line of components. You can select just the portions of a DAA you need to use, and select the level of integration required to minimize component count, cost, and printed-circuit board space.

Note: Circuits presented in this application note assume a +5 Vdc power supply.

## 2. DAA Fundamentals

### 2.1 Telephone Network Connection

Devices that connect to telephone networks generally require a data access arrangement circuit (DAA). The DAA provides the physical connection between the telephone line and the device, while, at the same time, providing the necessary electrical isolation that allows devices designed with it to meet the requirements of applicable regulatory agencies. Examples of some common devices are telephones and modems found in set-top boxes, point-of-sale terminals, answering machines, vending equipment, and metering equipment.

Isolation of host equipment from the telephone network assures that no harm to the network occurs due to a device malfunction in the customer premises equipment (CPE). Without isolation, a device connected to the network could damage central office equipment and endanger telephone company personnel if it failed. Additionally, if a high voltage transient is applied to the telephone line from an outside source (a lightning-induced transient, for example), the device and user are generally protected by the high electrical isolation that a DAA provides.

### 2.2 DAA Functions

In addition to the primary function of isolation, a DAA circuit must also provide the following functions while meeting stringent regulatory requirements:

1. Line termination
2. 2-to-4 wire conversion (hybrid function)
3. Ring detection
4. Signal coupling
5. Monitoring on-hook transmissions (display functions like caller-ID)
6. Surge/transient protection

#### 2.2.1 Surge Protection

The surge protection block protects the CPE from damage, most likely lightning induced transients or power-cross events. Protection circuit topology varies and is determined by the system's reliability criteria.

#### 2.2.2 Switchhook

The switchhook controls the off-hook and on-hook condition. When the switchhook is closed, the device is off-hook and current flows from the central office battery through the switchhook and DC termination circuit. This current is known as the loop current.

#### 2.2.3 DC Termination

The DC termination presents a low DC resistance across tip and ring when the DAA is off-hook, but maintains a very high AC impedance that will not interfere with the AC termination of the DAA. The DC termination also has a bridge rectifier that allows the circuit to operate even if the tip and ring leads are inadvertently reversed.

#### 2.2.4 Ring Detection

The ring detection block connects across the tip and ring terminals and is used to monitor the line for an incoming ring signal. The circuit is AC coupled in order to meet low on-hook current draw requirements. The ring detection circuit requires an isolation barrier to isolate the telephone line from the CPE power supply.

#### 2.2.5 Isolation and Signal Coupling

The isolation and signal coupling block couples the AC signal to and from the host system while maintaining linearity and providing electrical isolation in excess of 1500 V<sub>RMS</sub>.

## 2.2.6 Hybrid

The hybrid network is also known as the 2-to-4 wire converter. Since both transmit and receive signals are on the same telephone line pair at the same time (full duplex), a mechanism is required such that the transmitted signal from the device is removed or minimized at the device receive path. In a voice application, poor rejection of the transmit signal into the receive path is apparent as “talker echo.” For data applications, poor rejection of the transmit signal in the receive path can cause poor data throughput. The loss from transmit path to receive path is known as transhybrid loss, measured in decibels.

## 2.3 Optional DAA Circuits

In addition to the basic functions described above, DAA circuits may be required to perform one or more of these optional functions:

### 2.3.1 Loop Current Detection

Some PBX systems require reading the current being drawn from the phone line. Using a DAA to detect loop current is shown in the Loop Current Detection section ([Section 4.1 on page 10](#)).

### 2.3.2 Display Services (Caller ID)

Display services such as caller ID require monitoring the telephone line in the on-hook state. The establishment of an on-hook AC path for display services signals is shown in the Caller ID Detection section ([Section 4.2 on page 12](#)).

### 2.3.3 Line Use Detection

Managing the use of the telephone line in either the on-hook or off-hook states can be a DAA requirement for some CPE devices. See the 911 Function section ([Section 5.1 on page 14](#)), and the APOH Function section ([Section 5.2 on page 16](#)) for more information.

### 2.3.4 Reverse Battery Condition

Some telephone networks, especially private ones, use reverse-battery type signalling for direct-inward-dialing (DID). A reverse battery detection circuit is shown in the Detecting Loop Reverse-Battery Condition on a Telephone Line section ([Section 7 on page 20](#)).

## 2.4 DAA Circuits

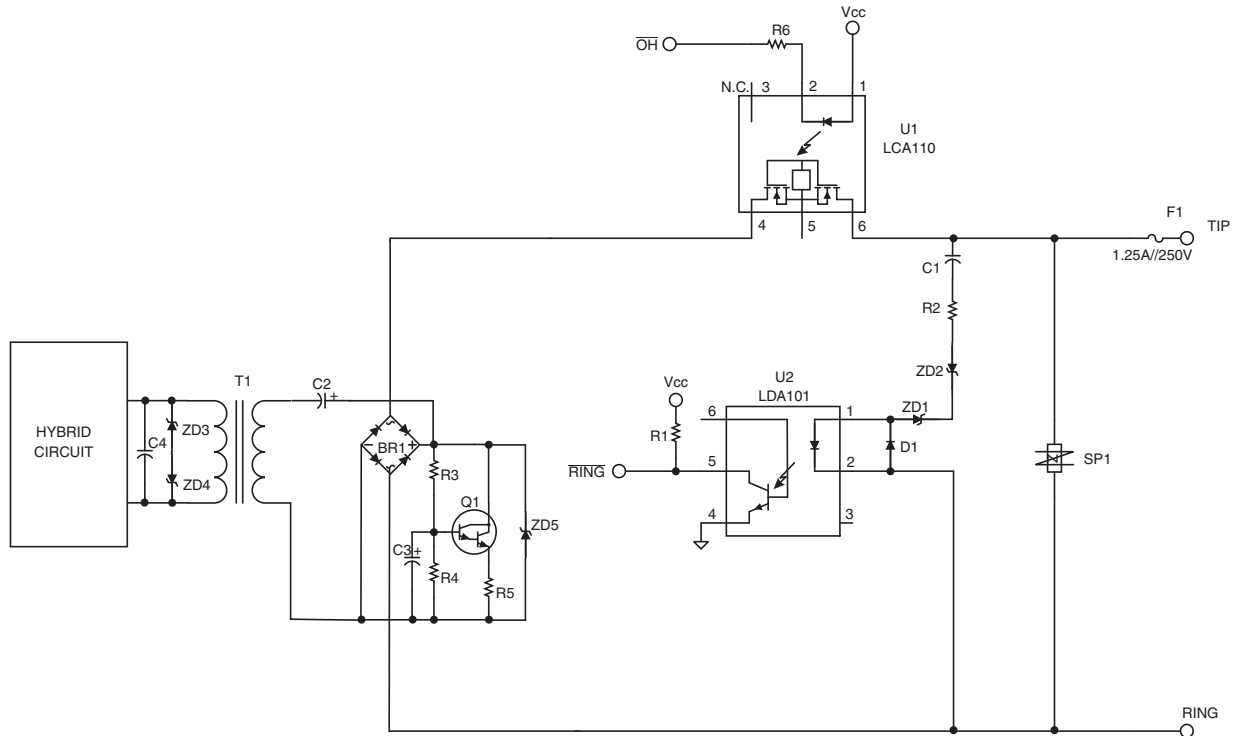
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## 3. North American/JATE DAAs

### 3.1 Using 1-Form-A Switchhook - LCA110 and LDA101

Figure 1 shows a basic DAA implementation using IXYS Integrated Circuits Division's LCA110 (or CPC1035) as the switchhook and LDA101 as the ring detector.

**Figure 1. North American/JATE DAA Using OptoMOS LDA101 and LCA110**



On asserting  $\overline{\text{OH}}$ , loop current flows through the solid-state relay and the electronic gyrator circuit consisting of BR1, Q1, R3, R4, R5, ZD5, and C3. The gyrator presents a high AC impedance while providing a low DC resistance so that DC loop current can flow. Signals are AC coupled through C2 and T1 to the hybrid circuit.

U2, an LDA101, and its associated components provide half-wave ring detection. The LDA101 has one internal LED that emits light during one-half of the ringing AC sine wave. Full-wave ring detection can be used by substituting an LDA100 for U2 and removing D1. The LDA100 has back-to-back LEDs that emit light on both halves of the sine wave.

In this circuit, D1 prevents high reverse voltages from damaging the LED in U2. C1 AC couples the ringing signal to the ring detector. ZD1 and ZD2 prevent in-band signals (modem tones or speech) from falsely triggering RING. SP1 and the optional fuse provide circuit protection.

This DAA design, while simple, can support high modem throughput rates up to V.90 with proper selection of discrete components and good printed-circuit board design practices.

**Table 1: Part List for Figure 1**

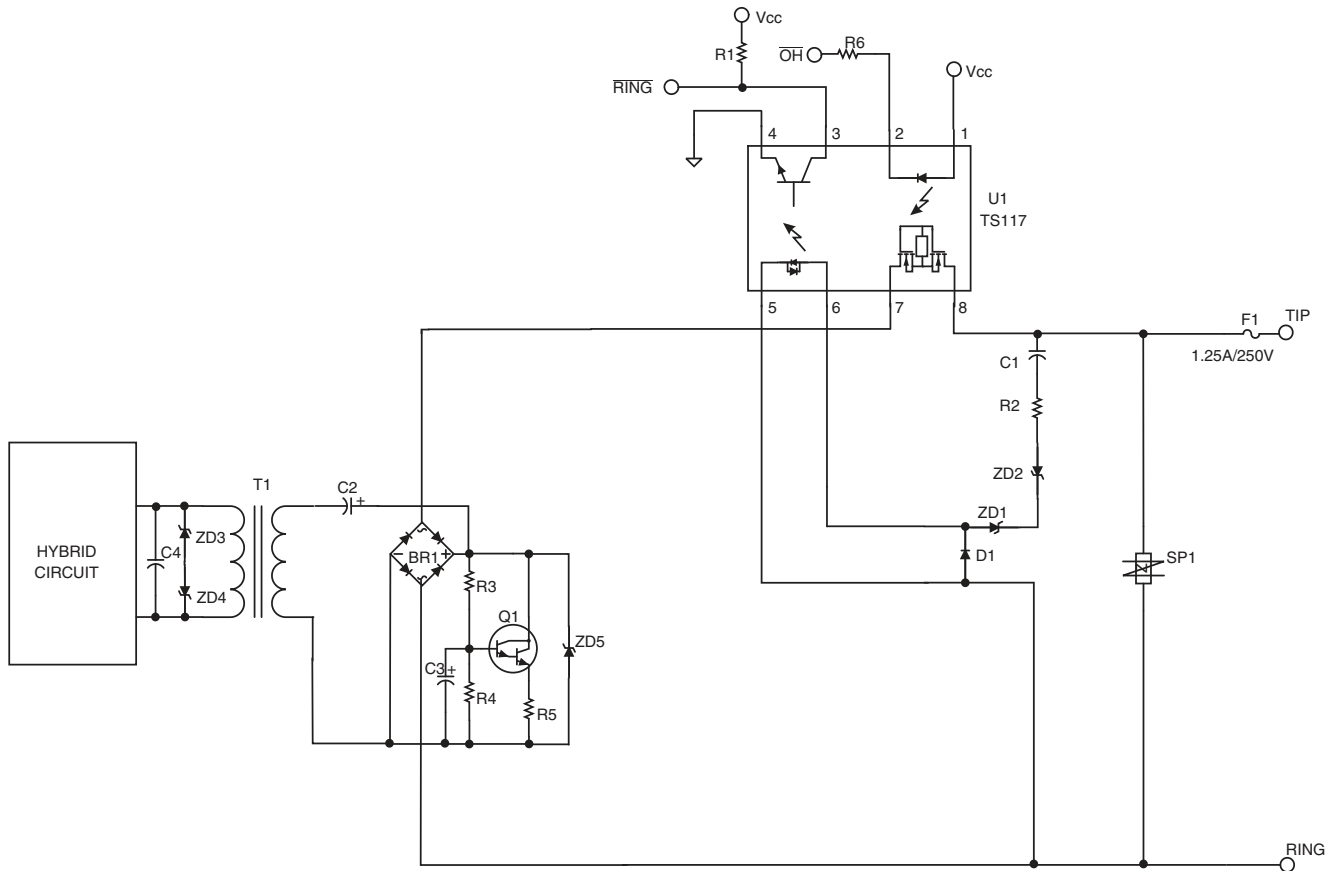
| Quantity | Reference Designator | Description                                  |
|----------|----------------------|--|
| 1        | R1                   | 47 k $\Omega$ , 1/8 W                        |
| 1        | R2                   | 8.2 k $\Omega$ , 1/4 W                       |
| 1        | R3                   | 68 k $\Omega$ , 1/4 W                        |
| 1        | R4                   | 100 k $\Omega$ , 1/4 W                       |
| 1        | R5                   | 10 $\Omega$ , 1/4 W                          |
| 1        | R6                   | 470 $\Omega$ , 1/4 W                         |
| 1        | C1                   | 0.47 $\mu$ F, 250 V                          |
| 1        | C2                   | 10 $\mu$ F, 50 V, Tantalum                   |
| 1        | C3                   | 10 $\mu$ F, 25 V, Tantalum                   |
| 1        | C4                   | optional ( <i>see Section 6 on page 18</i> ) |
| 1        | T1                   | Midcom 82096 transformer                     |
| 1        | BR1                  | 400 PIV bridge rectifier                     |
| 1        | U1                   | IXYS Integrated Circuits Division LCA110     |
| 1        | U2                   | IXYS Integrated Circuits Division LDA101     |
| 2        | ZD1, ZD2             | 18 V Zener diode                             |
| 2        | ZD3, ZD4             | 5.1 V Zener diode                            |
| 1        | ZD5                  | 18 V, 1/2 W Zener diode                      |
| 1        | Q1                   | FZT605 Zetex Darlington                      |
| 1        | SP1                  | P3100SB Teccor surge suppressor              |
| 1        | F1                   | 1.25 A, 250 V fuse                           |
| 1        | D1                   | 1N4001                                       |

## 3.2 Using TS117 for Switchhook and Ring Detect

Figure 2 shows a higher level of integration, where an IXYS Integrated Circuits Division TS117 takes the place of the LCA110 and LDA101 in Figure 1. The TS117 provides switchhook and ring detect functions with the same external components used in Figure 1.

The TS117 has two back-to-back LEDs for use in the ring detector. With D1 installed the circuit provides half-wave ring detection. With D1 removed the circuit provides full-wave ring detection.

Figure 2. North American/JATE DAA Using OptoMOS TS117



**Table 2: Part List for Figure 2**

| Quantity | Reference Designator | Description                                  |
|----------|----------------------|--|
| 1        | R1                   | 47 k $\Omega$ , 1/8 W                        |
| 1        | R2                   | 8.2 k $\Omega$ , 1/4 W                       |
| 1        | R3                   | 68 k $\Omega$ , 1/4 W                        |
| 1        | R4                   | 100 k $\Omega$ , 1/4 W                       |
| 1        | R5                   | 10 $\Omega$ , 1/4 W                          |
| 1        | R6                   | 470 $\Omega$ , 1/4 W                         |
| 1        | C1                   | 0.47 $\mu$ F, 250 V                          |
| 1        | C2                   | 10 $\mu$ F, 50 V, Tantalum                   |
| 1        | C3                   | 10 $\mu$ F, 25 V, Tantalum                   |
| 1        | C4                   | optional ( <i>see Section 6 on page 18</i> ) |
| 1        | T1                   | Midcom 82096 transformer                     |
| 1        | BR1                  | 400 PIV bridge rectifier                     |
| 1        | U1                   | IXYS Integrated Circuits Division TS117      |
| 2        | ZD1, ZD2             | 18 V Zener diode                             |
| 2        | ZD3, ZD4             | 5.1 V Zener diode                            |
| 1        | ZD5                  | 18 V, 1/2 W Zener diode                      |
| 1        | Q1                   | FZT605 Zetex Darlington                      |
| 1        | SP1                  | P3100SB Teccor surge suppressor              |
| 1        | F1                   | 1.25 A, 250 V fuse                           |
| 1        | D1                   | 1N4001                                       |

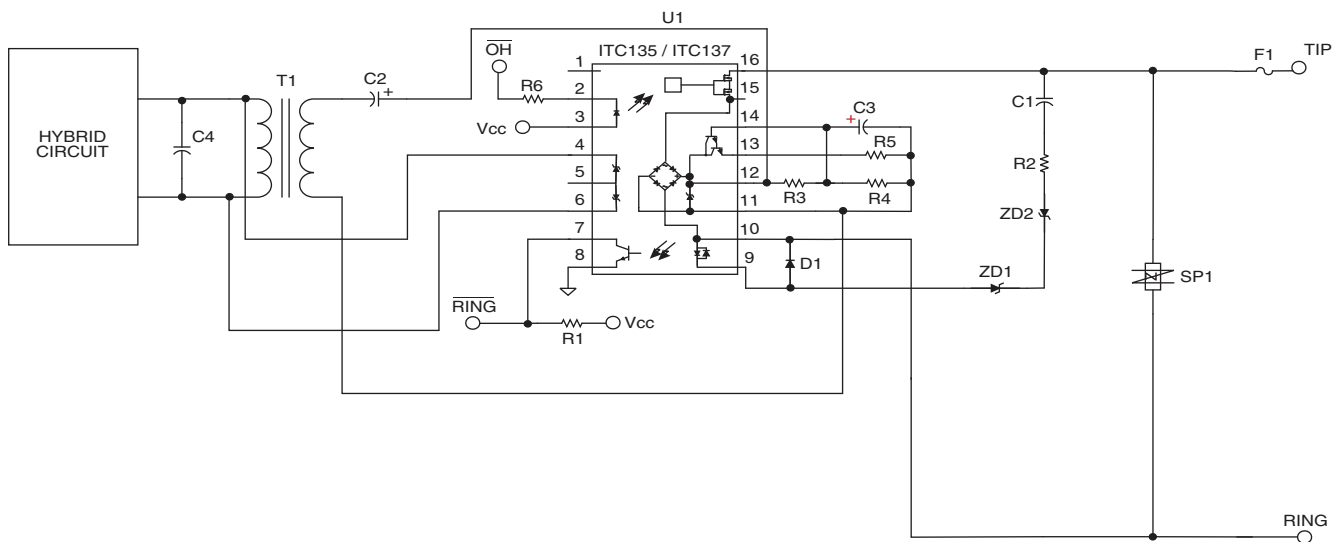
### 3.3 Using ITC135 or ITC137

Figure 3 shows even more integration, using the IXYS Integrated Circuits Division ITC135 or ITC137.

The ITC135 and ITC137 include the switchhook function, a Darlington transistor for the gyrator circuit, an optocoupler for ring detect, and transient protection zener diodes. The ITC135 offers half-wave ring detect, while the ITC137 offers full-wave ring detect. All the discrete components function as described previously.

This DAA design saves printed-circuit real estate.

**Figure 3. North American/JATE DAA Using OptoMOS ITC135 or ITC137**





**Table 3: Part List for Figure 3**

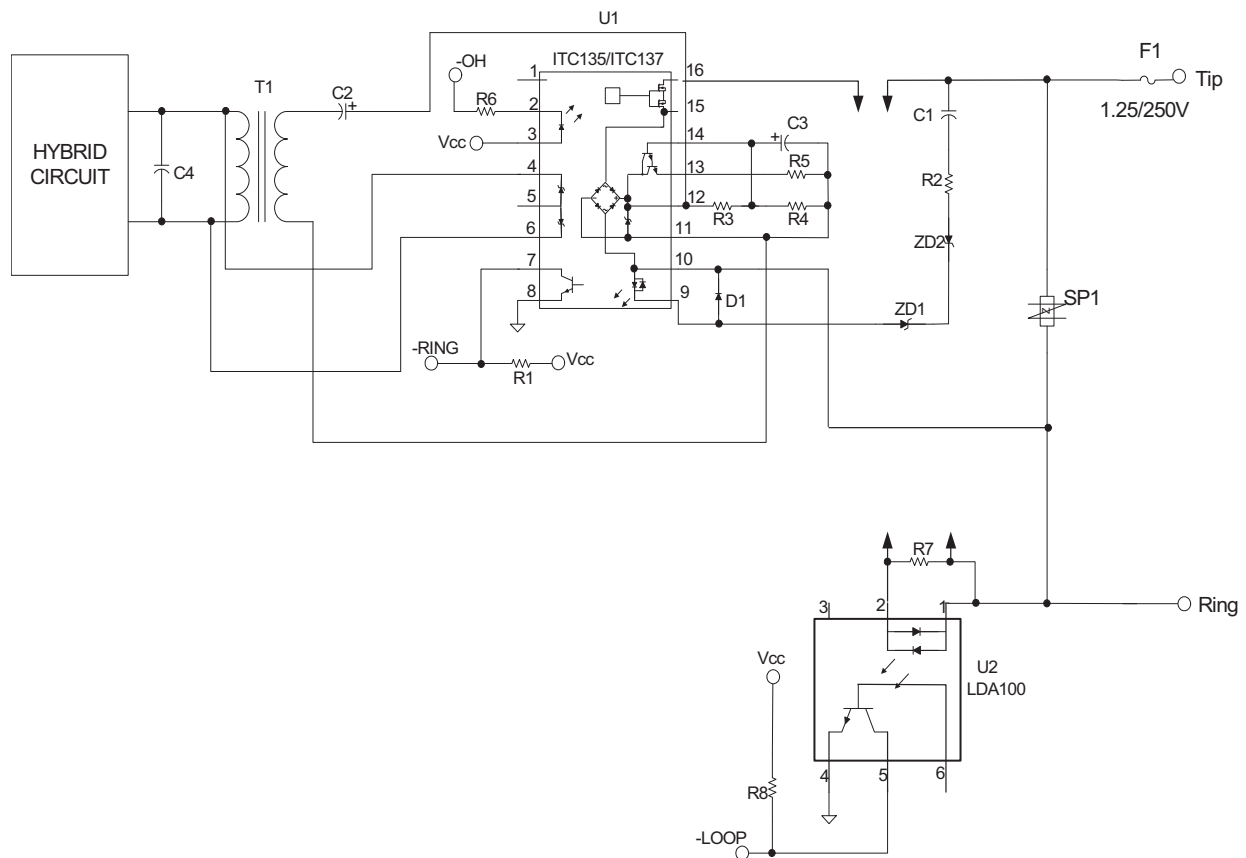
| Quantity | Reference Designator | Description  |
|----------|----------------------|--|
| 1        | R1                   | 47 k $\Omega$ , 1/8 W                              |
| 1        | R2                   | 8.2 k $\Omega$ , 1/4 W                             |
| 1        | R3                   | 51 k $\Omega$ , 1/4 W                              |
| 1        | R4                   | 22 k $\Omega$ , 1/4 W                              |
| 1        | R5                   | 10 $\Omega$ , 1/4 W                                |
| 1        | R6                   | 470 $\Omega$ , 1/4 W                               |
| 1        | C1                   | 0.47 $\mu$ F, 250 V                                |
| 1        | C2                   | 10 $\mu$ F, 50 V, Tantalum                         |
| 1        | C3                   | 10 $\mu$ F, 25 V, Tantalum                         |
| 1        | C4                   | optional ( <i>see Section 6 on page 18</i> )       |
| 1        | T1                   | Midcom 82096 transformer                           |
| 1        | U1                   | IXYS Integrated Circuits Division ITC135 or ITC137 |
| 2        | ZD1, ZD2             | 18 V Zener diode                                   |
| 1        | SP1                  | P3100SB Teccor surge suppressor                    |
| 1        | F1                   | 1.25 A, 250 V fuse                                 |

## 4. DAA Options

### 4.1 Loop Current Detection

Loop current detection can be implemented with any of the DAA circuits presented previously. Figure 4 shows a loop current detection circuit using the DAA circuit shown in Figure 3.

**Figure 4. Loop Current Detection Using LDA100**



In this circuit, an IXYS Integrated Circuits Division LDA100 optocoupler (U2) is connected in series with the RING lead after the surge protector. When the DAA goes off hook, current flows through one of the LEDs in the LDA100. The LDA100 was chosen because it can be used to sense loop current regardless of the direction of loop current flow.

Select the value of R7 to match your requirement for the minimum loop current to detect. The minimum forward voltage of the LEDs in the LDA100 is 0.9 V. To set the value of R7 for 15 mA, use:

$$R7 = \frac{V_F}{15mA} = 60\Omega$$

In this circuit it is important to size R8 according to the current transfer ratio information given in the LDA100 data sheet. The part list in Table 4 shows component values for a typical loop current detection of 15 mA.

**Table 4: Part List for Figure 4**

| Quantity | Reference Designator | Description  |
|----------|----------------------|--|
| 2        | R1, R8               | 47 k $\Omega$ , 1/8 W                              |
| 1        | R2                   | 8.2 k $\Omega$ , 1/4 W                             |
| 1        | R3                   | 51 k $\Omega$ , 1/4 W                              |
| 1        | R4                   | 22 k $\Omega$ , 1/4 W                              |
| 1        | R5                   | 10 $\Omega$ , 1/4 W                                |
| 1        | R6                   | 470 $\Omega$ , 1/4 W                               |
| 1        | R7                   | 60 $\Omega$ , 1/4 W                                |
| 1        | C1                   | 0.47 $\mu$ F, 250 V                                |
| 1        | C2                   | 10 $\mu$ F, 50 V, Tantalum                         |
| 1        | C3                   | 10 $\mu$ F, 25 V, Tantalum                         |
| 1        | C4                   | optional ( <i>see Section 6 on page 18</i> )       |
| 1        | T1                   | Midcom 82096 transformer                           |
| 1        | U1                   | IXYS Integrated Circuits Division ITC135 or ITC137 |
| 1        | U2                   | IXYS Integrated Circuits Division LDA100           |
| 2        | ZD1, ZD2             | 18 V Zener diode                                   |
| 1        | SP1                  | P3100SB Teccor surge suppressor                    |
| 1        | F1                   | 1.25 A, 250 V fuse                                 |

## 4.2 Caller ID Detection

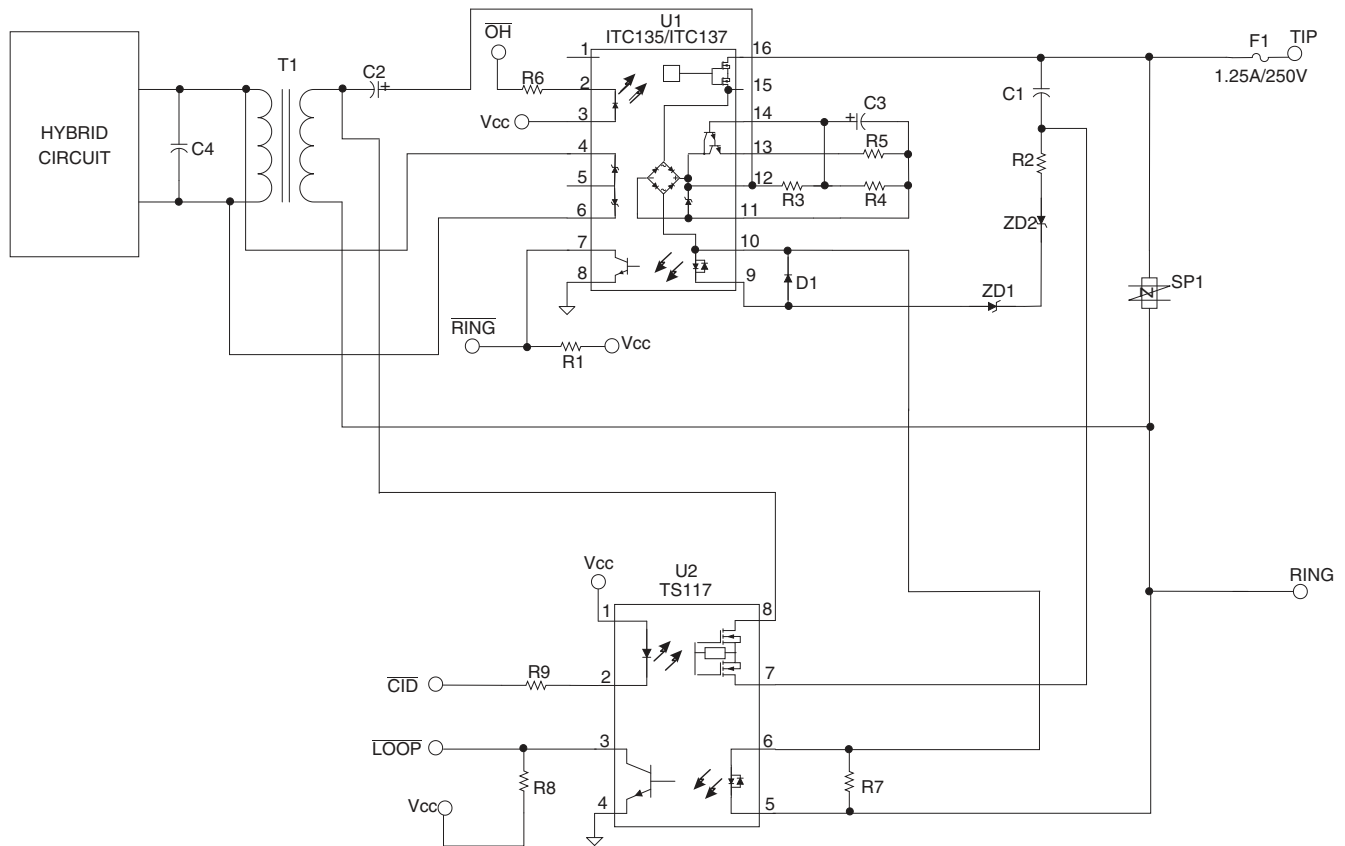
Figure 5 shows an ITC135/ITC137-based DAA like the one in figure 3 with the addition of a TS117 to handle loop current detection and caller ID (CID) signal processing. For CID processing without loop current detection, substitute CPC1035 or LCA110 for the TS117.

CID signals must be passed by the DAA while the DAA is on-hook. Voice-band FSK CID signals are included after the first ring burst.

This circuit uses the relay portion of the TS117 to pass CID signals as follows:

1. The host processor detects the first ring burst from the  $\overline{\text{RING}}$  output of the ITC135/ITC137.
2. The host processor asserts  $\overline{\text{CID}}$  after the first ring, completing an AC signal path from C1 through the relay in the TS117, and coupling the CID signal through the transformer and hybrid to the CODEC or data pump.
3. After receiving the CID signal, the host processor de-asserts  $\overline{\text{CID}}$ , preserving on-hook telephone line characteristics.

**Figure 5. Caller ID Detection Using TS117**



**Table 5: Part List for Figure 5**

| Quantity | Reference Designator | Description                                     |
|----------|----------------------|---|
| 2        | R1, R8               | 47 k $\Omega$ , 1/8 W                           |
| 1        | R2                   | 8.2 k $\Omega$ , 1/4 W                          |
| 1        | R3                   | 51 k $\Omega$ , 1/4 W                           |
| 1        | R4                   | 22 k $\Omega$ , 1/4 W                           |
| 1        | R5                   | 10 $\Omega$ , 1/4 W                             |
| 1        | R6                   | 470 $\Omega$ , 1/4 W                            |
| 1        | R7                   | 60 $\Omega$ , 1/4 W                             |
| 1        | C1                   | 2.2 $\mu$ F, 50 V                               |
| 1        | C2                   | 10 $\mu$ F, 50 V, Tantalum                      |
| 1        | C3                   | 10 $\mu$ F, 25 V, Tantalum                      |
| 1        | C4                   | optional ( <i>see Section 6 on page 18</i> )    |
| 1        | T1                   | Midcom 82096 transformer                        |
| 1        | U1                   | IXYS Integrated Circuits Division ITC117P       |
| 1        | U2                   | IXYS Integrated Circuits Division ITC135/ITC137 |
| 2        | ZD1, ZD2             | 18 V Zener diode                                |
| 1        | SP1                  | P3100SB Teccor surge suppressor                 |
| 1        | F1                   | 1.25 A, 250 V fuse                              |

## 5. Phone Line Use Detection

DAA circuits may need help managing the use of the telephone line to which they are connected by monitoring for another parallel-connected telephone off-hook while the modem is in either the off-hook or on-hook states. These functions are often called the 911 function (monitoring for another telephone going off-hook while the DAA is off-hook) and another phone off-hook or APOH (monitoring for another phone using the line while the DAA is on-hook).

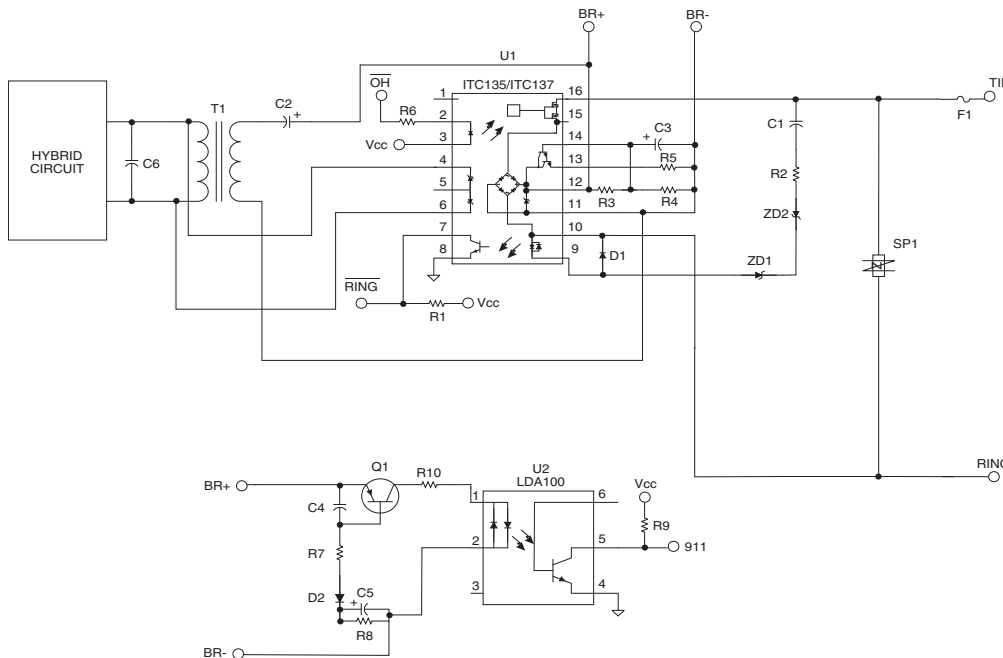
Bear in mind that these are two similar but different situations that must be handled differently in the DAA.

### 5.1 911 Function

Consider the case of the satellite set-top box. The STB periodically dials out to transfer information with the service provider. During this call, other devices (like telephones) connected to the telephone line cannot be used until the information transfer concludes and the DAA in the STB hangs up. This leads to the potentially dangerous situation where an emergency occurs during this period where the user needs to dial “911.” The DAA in the STB must have the capability to detect when another phone or device tries to use the telephone line while the STB is already using the line.

Figure 6 shows an IXYS Integrated Circuits Division OptoMOS DAA with a 911 function detector.

**Figure 6. 911 Function**



With the DAA off-hook, capacitor C5 charges through the PN emitter-base junction of transistor Q1. With Q1 on, current flows through the LED in U2, holding the 911 output off.

When another phone tries to use the telephone line, the tip to ring voltage drops, causing the base and emitter voltages of Q1 to drop. With D2 now reverse-biased, the charge in capacitor C5 maintains the previous off-hook voltage level on the cathode of D2 momentarily. Q1 turns off, shutting off the LED in U2, and causing a logic high pulse at the 911 output. After C5 discharges through R8, Q1 conducts, the LED in U2 turns on, and the 911 output returns low. The width of the output pulse is determined by the time constant of C5 and R8.

The system controller must detect this pulse and tell the DAA to release the telephone line (go on-hook).

**Table 6: Part List for Figure 6**

| Quantity | Reference Designator | Description                                     |
|----------|----------------------|---|
| 2        | R1, R9               | 47 k $\Omega$ , 1/8 W                           |
| 1        | R2                   | 8.2 k $\Omega$ , 1/4 W                          |
| 1        | R3                   | 51 k $\Omega$ , 1/4 W                           |
| 1        | R4                   | 22 k $\Omega$ , 1/4 W                           |
| 1        | R5                   | 10 $\Omega$ , 1/4 W                             |
| 1        | R6                   | 470 $\Omega$ , 1/4 W                            |
| 1        | R7                   | 1 k $\Omega$ , 1/4 W                            |
| 2        | R8, R10              | 10 k $\Omega$ , 1/4 W                           |
| 1        | C1                   | 0.47 $\mu$ F, 50 V                              |
| 1        | C2                   | 10 $\mu$ F, 50 V, Tantalum                      |
| 1        | C3                   | 10 $\mu$ F, 25 V, Tantalum                      |
| 1        | C4                   | 0.1 $\mu$ F, 50 V                               |
| 1        | C5                   | 10 $\mu$ F, 16 V                                |
| 1        | C6                   | optional ( <i>see Section 6 on page 18</i> )    |
| 1        | T1                   | Midcom 82096 transformer                        |
| 1        | U1                   | IXYS Integrated Circuits Division ITC135/ITC137 |
| 1        | U2                   | IXYS Integrated Circuits Division LDA100        |
| 1        | D1                   | 1N4001  |
| 2        | ZD1, ZD2             | 18 V Zener diode                                |
| 1        | SP1                  | P3100SB Teccor surge suppressor                 |
| 1        | F1                   | 1.25 A, 250 V fuse                              |

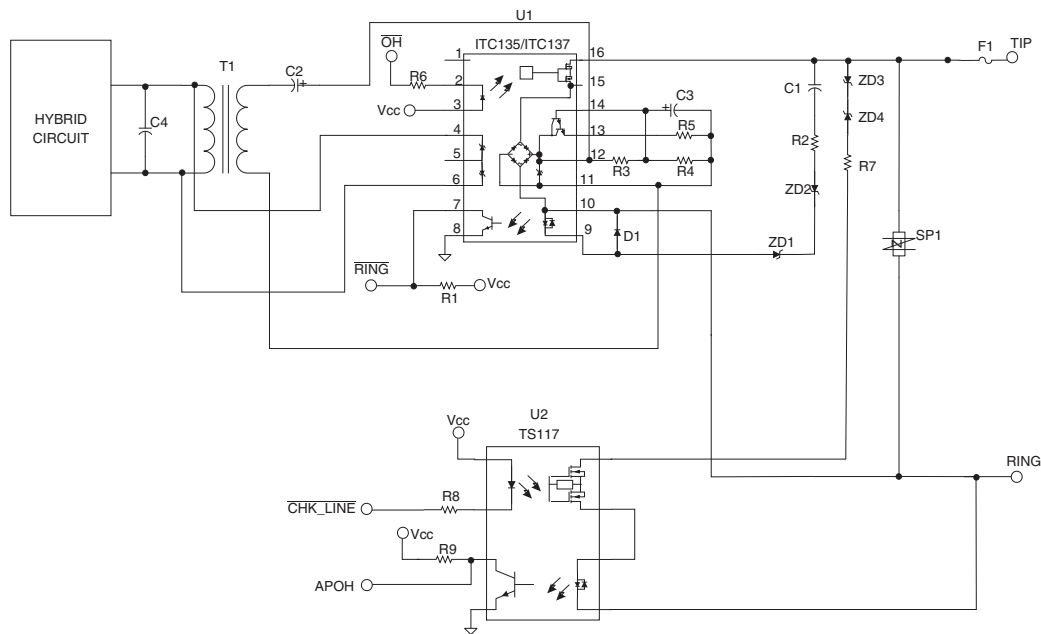
## 5.2 APOH Function

While the 911 DAA function allows for release of a phone line when a parallel-connected phone is taken off-hook (see Section 5.1 on page 14), another circuit is required to see if another device has taken the phone line off-hook before the DAA tries to connect. This function is often called APOH (another phone off-hook).

An APOH circuit can take advantage of the voltage drop that occurs on a telephone line when any parallel-connected device takes the line off-hook. In North America, for instance, the tip to ring voltage difference is usually greater than 40 Vdc when the telephone is not in use, but, when the line is in use, the tip to ring voltage is somewhere between 4 to 11 Vdc.

Figure 7 shows an IXYS Integrated Circuits Division OptoMOS DAA with an APOH detector.

**Figure 7. APOH Detection Using TS117**



To check whether or not the line is in use, the system controller asserts  $\overline{\text{CHK\_LINE}}$ , closing the relay portion of U2, an IXYS Integrated Circuits Division TS117. ZD3 and ZD4 prevent current flow in this part of the circuit when the tip to ring voltage drops between 4 to 11 Vdc. Two 18 V Zener diodes prevent current flow and make the circuit insensitive to telephone line polarity.

With another telephone device offhook, no current flows through the APOH branch of the circuit, turning the optocoupler in U2 off. This sets the APOH output high, indicating an APOH condition. With no external telephone devices off-hook the Zeners conduct. Current in the APOH detector circuit causes APOH to go low. With APOH low, the host device can assert  $\overline{\text{OH}}$  and use the telephone line.

Selecting the value of R7 is critical. R7 must be a high enough value to reduce telephone line loop current below the threshold normally considered as an off-hook condition by the central office equipment. Yet R7 must also be a low enough value to provide sufficient current to the optocoupler in U2 to keep it on when there is not another parallel-connected telephone off-hook.

After checking the line for APOH, the system controller must de-assert  $\overline{\text{CHK\_LINE}}$  for normal DAA operation. See IXYS Integrated Circuits Division's application note AN-123, *Using CYG2911 and TS117 in APOH (911) Circuits* for more information on component value selection.



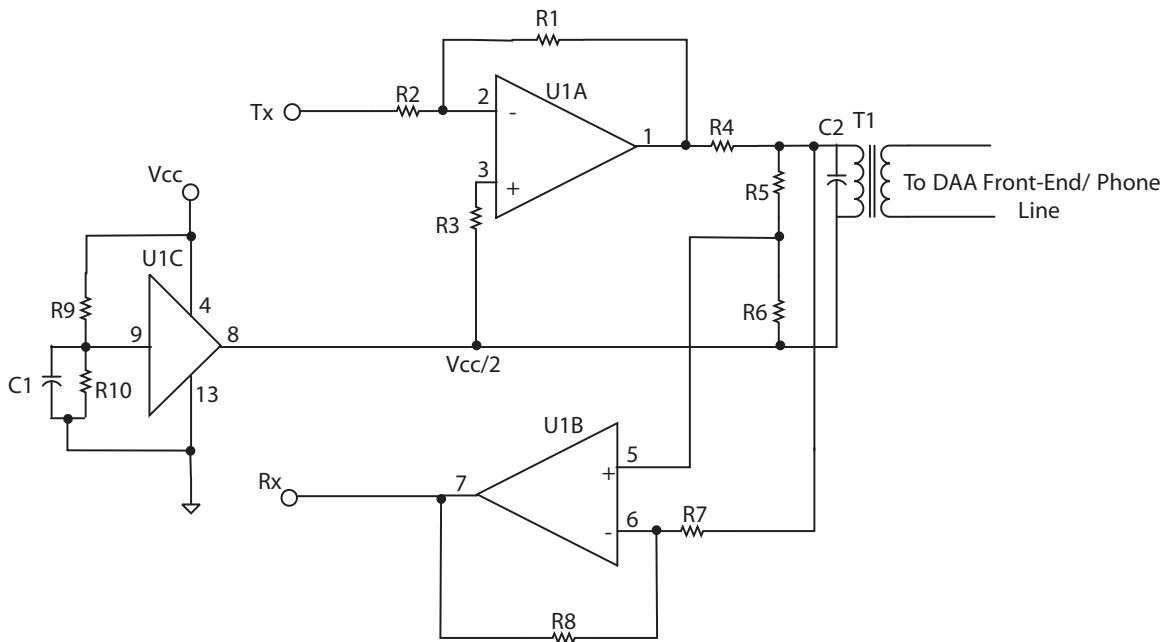
**Table 7: Part List for Figure 7**

| Quantity | Reference Designator | Description                                     |
|----------|----------------------|---|
| 2        | R1, R9               | 47 k $\Omega$ , 1/8 W                           |
| 1        | R2                   | 8.2 k $\Omega$ , 1/4 W                          |
| 1        | R3                   | 51 k $\Omega$ , 1/4 W                           |
| 1        | R4                   | 22 k $\Omega$ , 1/4 W                           |
| 1        | R5                   | 10 $\Omega$ , 1/4 W                             |
| 1        | R6                   | 470 $\Omega$ , 1/4 W                            |
| 1        | R7                   | 51 k $\Omega$ , 1/4 W                           |
| 1        | R8                   | 470 $\Omega$ , 1/4 W                            |
| 1        | C1                   | 0.47 $\mu$ F, 250 V                             |
| 1        | C2                   | 10 $\mu$ F, 50 V, Tantalum                      |
| 1        | C3                   | 10 $\mu$ F, 25 V, Tantalum                      |
| 1        | C4                   | 0.1 $\mu$ F, 50 V                               |
| 1        | C5                   | 10 $\mu$ F, 16 V                                |
| 1        | C6                   | optional ( <i>see Section 6 on page 18</i> )    |
| 1        | T1                   | Midcom 82096 transformer                        |
| 1        | U1                   | IXYS Integrated Circuits Division ITC135/ITC137 |
| 1        | U2                   | IXYS Integrated Circuits Division TS117         |
| 2        | ZD1, ZD2, ZD3, ZD4   | 18 V Zener diode                                |
| 1        | SP1                  | P3100SB Teccor surge suppressor                 |
| 1        | F1                   | 1.25 A, 250 V fuse                              |
| 1        | D1                   | 1N4001  |

## 6. DAA Hybrid Circuit

Figure 8 shows a typical hybrid (two-wire to four-wire conversion) circuit. The signal labelled TX in the diagram is the signal transmitted from the CODEC or modem data pump to the telephone line.

**Figure 8. Typical Hybrid Circuit**



The signal is amplified by U1A to account for the transducer loss incurred through R4 and T1, typically 6 dB when connected to a properly matched 600  $\Omega$  line. The value of R4 is determined by the specific transformer in use and often specified by the transformer manufacturer.

U1C is a low output-impedance buffer that reproduces the voltage at pin 9. R8 and R9 are matched so that the reference Voltage  $V_{CC}/2$  allows hybrid operation from a single supply.

U1 is specified as a rail-to-rail amplifier to accommodate large signal swings.

R5 and R6 present part of the transmit signal to U1B. This signal cancels the transmit signal (V1) from the receive path in U1B as follows:

$$V_{RX} = \left(\frac{R7 + R8}{R5 + R6}\right)\left(\frac{R6}{R7}\right)V1 - \left(\frac{R8}{R7}\right)V2$$

Using the values from the part list for the circuit in figure 8, where R7 = 20 k $\Omega$ , R8 = 40 k $\Omega$ , R5 = 15 k $\Omega$ , and R6 = 15 k $\Omega$ , the formula becomes:

$$V_{RX} = (1.5)(V1) - (2)(V2)$$

Setting  $V_{RX}$  for 0, with no transmitted signal appearing at RX yields:

$$0 = (1.5)(V1) - (2)(V2)$$

Solving for V2 in terms of V1 yields:

$$V_2 = \left(\frac{1.5}{2}\right)(V_1)$$

Substituting into the original equation yields:

$$V_{RX} = (1.5)(V_1) - (2)\left(\frac{1.5}{2}\right)(V_1) = 0$$

While this equation shows complete cancellation of the transmit signal in the receive path, practical considerations, such as component tolerances and variations in telephone line length, suggest a real-world cancellation of between 15 dB to 30 dB.

Capacitor C2 compensates for leakage inductance effects from the transformer at high frequencies. This capacitor may improve or degrade transhybrid loss, depending on the transformer. Test the circuit to optimize the value for C2 for transhybrid loss.

**Table 8: Part List for Figure 8**

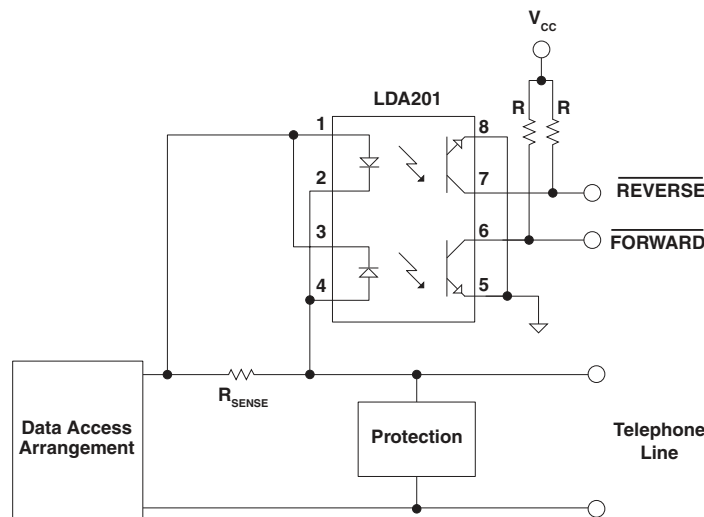
| Quantity | Reference Designator | Description                                   |
|----------|----------------------|---|
| 1        | R1                   | 20 kΩ, 1/8 W                                  |
| 1        | R2                   | 10 kΩ, 1/4 W                                  |
| 1        | R3                   | 6.8 kΩ, 1/4 W                                 |
| 1        | R4                   | 530 Ω, 1/4 W                                  |
| 2        | R5, R6               | 15 kΩ, 1/4 W                                  |
| 1        | R7                   | 20 kΩ, 1/4 W                                  |
| 1        | R8                   | 40 kΩ, 1/4 W                                  |
| 2        | R9, R10              | 47 kΩ, 1/4 W                                  |
| 1        | C1                   | 0.1 μF, 50 V                                  |
| 1        | C2                   | see text                                      |
| 1        | U1                   | TS 925 op amp, ST Microelectronics or similar |

## 7. Detecting Loop Reverse-Battery Condition on a Telephone Line

Some equipment connected to telephone networks must be able to detect reversal of the battery feed voltage. Some direct-inward-dialing (DID) systems use loop reverse-battery signalling. See ANSI T1.405-1996 for more information.

One requirement of loop reverse-battery condition detectors is the ability to distinguish the direction of battery current. Figure 9 shows a loop reverse-battery detection circuit using an IXYS Integrated Circuits Division LDA201 that provides forward and reverse output signals.

**Figure 9. Loop Reverse-Battery Detection Using LDA201**



Tip is normally positive with respect to ring in telephone loops. The nominal open voltage from the telephone network is -48 Vdc. In this circuit, the value of  $R_{SENSE}$  allows a threshold current before forward or reverse sensing.

Given the nominal forward voltage of the LEDs in the LDA201 of 1.2 V, a value of  $120\ \Omega$  for  $R_{SENSE}$  provides a 10 mA threshold value, where

$$R_{SENSE} = \frac{V_F}{I}$$

or,

$$R_{SENSE} = \frac{1.2}{10mA} = 120\ \Omega$$

When loop current exceeds 10 mA with normal polarity,  $\overline{FORWARD}$  is asserted. When the loop current exceeds 10 mA with reversed polarity,  $\overline{REVERSE}$  is asserted. The forward voltage specification for the LDA201 varies from 0.9 V to 1.4 V and is affected by temperature. With  $R_{SENSE}$  at  $120\ \Omega$ , detection threshold currents will vary from 7.5 mA to 11.7 mA.

Set the values of the pull-up resistors (R) based on the minimum current transfer ratio of the LDA201 and the minimum LED current for the application according to the specifications in the LDA201 data sheet.

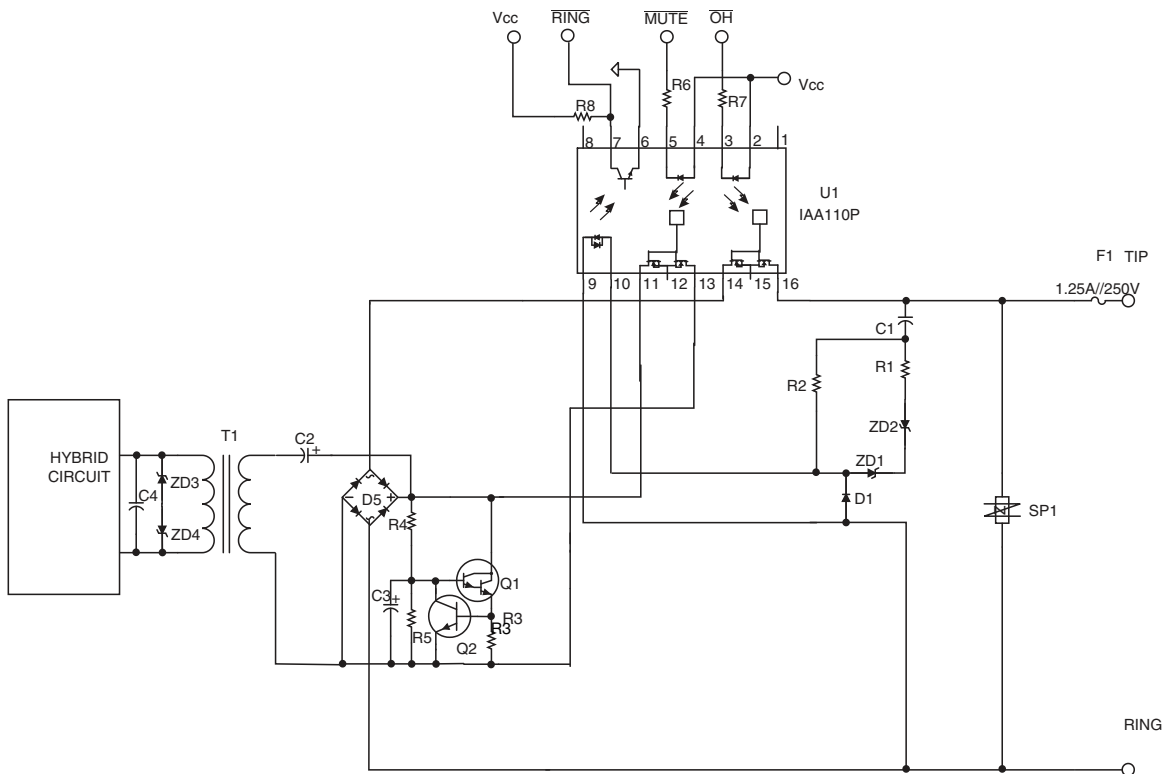
The LEDs in the LDA201 are rated for 100 mA maximum current, so current limited resistors in series with the LEDs are not needed.

## 8. European Type DAA Circuits

The circuit in Figure 10 can be populated for many of the telephone systems that require compliance to European Directive 1999/5/EC from March 9, 1999 and the now obsolete TBR-21. Diagrams are also included here for specific implementations required in certain areas.

The IAA110P was chosen for this design because it can function as the switchhook, ring detector, and as a mute relay.

**Figure 10. European Type DAA Using IAA110P**



The mute relay can be used both for low-impedance (fast) pulse dialing and to meet the transient off-hook requirements of some systems. Typically, MUTE is asserted in conjunction with OH and held for 50 milliseconds.

One important functional difference between this circuit and the circuits described earlier is telephone line loop-current limiting. Many European systems require limiting the loop current to 60 mA.

Loop current limiting is accomplished with Q2 and R3 in this circuit. With R3 set to 10  $\Omega$  and the  $V_{BE}$  of Q2 of 0.6 V, line current is limited to 60 mA.

Limiting the current in this way leads to the possibility of tip to ring voltages as high as 40 V, which infers that power dissipation in Q1 could be as high as 2.4 Watts. Q1 requires adequate heat sinking to account for this high power level.

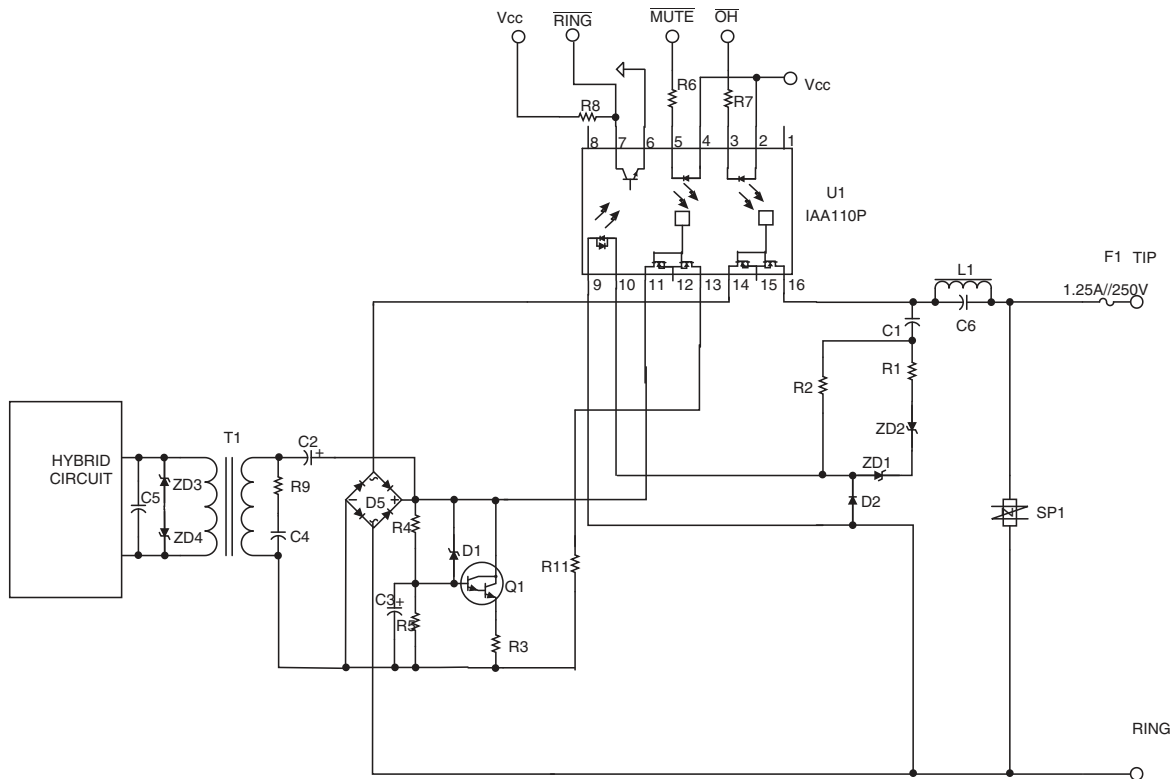
**Table 9: Part List for Figure 10**

| Quantity | Reference Designator | Description                                  |
|----------|----------------------|--|
| 1        | R1                   | 20 k $\Omega$ , 1/4 W                        |
| 1        | R2                   | 100 k $\Omega$ , 1/8 W                       |
| 1        | R3                   | 10 $\Omega$ , 1/8 W                          |
| 1        | R4                   | 47 k $\Omega$ , 1/8 W                        |
| 1        | R5                   | 68 k $\Omega$ , 1/8 W                        |
| 2        | R6, R7               | 470 $\Omega$ , 1/8 W                         |
| 1        | R8                   | 47 k $\Omega$ , 1/8 W                        |
| 1        | C1                   | 0.33 $\mu$ F, 250 V                          |
| 1        | C2                   | 10 $\mu$ F, 50 V Tantalum                    |
| 1        | C3                   | 10 $\mu$ F, 25 V Tantalum                    |
| 1        | C5                   | optional ( <i>see Section 6 on page 18</i> ) |
| 1        | T1                   | Midcom 82096 transformer                     |
| 1        | U1                   | IXYS Integrated Circuits Division IAA110P    |
| 2        | ZD1, ZD2             | 33 V Zener                                   |
| 1        | SP1                  | P3100SB Teccor surge suppressor              |
| 1        | F1                   | 1.25 A, 250 V fuse                           |
| 1        | D2                   | 1N4001                                       |
| 1        | BR1                  | 400 V bridge rectifier                       |
| 1        | Q1                   | FZT604 NPN Darlington, Zetex                 |
| 1        | Q2                   | BC846 NPN Transistor, 65 V                   |

## 8.1 European Type DAA with Metering Filter

Some areas, like Germany, use telephone service metering signals to collect billing information. The circuit in Figure 11 is similar to the one in Figure 10, but adds an LC tank circuit at the tip connection to filter out the metering signal (16 kHz in the case of Germany) and preserve DAA DC characteristics while off-hook.

**Figure 11. TBR-21 Type DAA With Metering Filter Using IAA110P**



**Table 10: Part List for Figure 11**

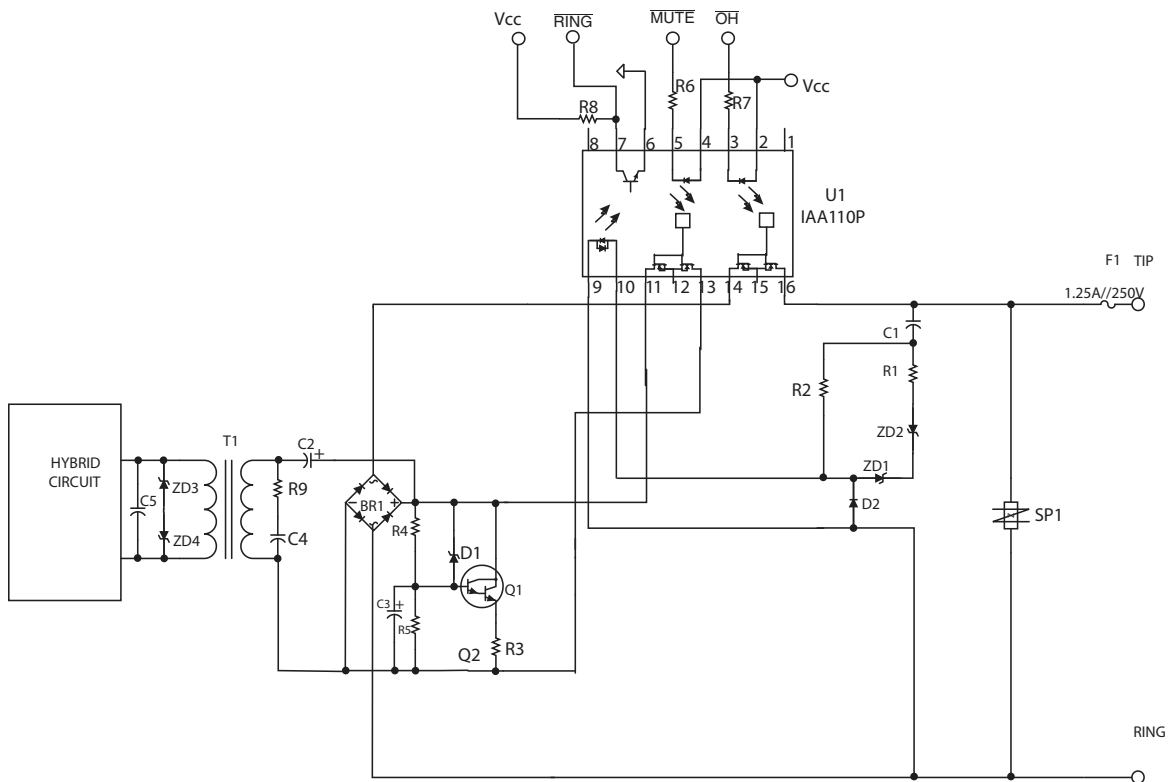
| Quantity | Reference Designator | Description                                  |
|----------|----------------------|--|
| 1        | R1                   | 20 k $\Omega$ , 1/4 W                        |
| 1        | R2                   | 100 k $\Omega$ , 1/8 W                       |
| 1        | R3                   | 10 $\Omega$ , 1/8 W                          |
| 1        | R4                   | 120 k $\Omega$ , 1/8 W                       |
| 1        | R5                   | 68 k $\Omega$ , 1/8 W                        |
| 2        | R6, R7               | 470 $\Omega$ , 1/8 W                         |
| 1        | R8                   | 47 k $\Omega$ , 1/8 W                        |
| 1        | R9                   | 180 $\Omega$ , 1/4 W                         |
| 1        | R11                  | 68 $\Omega$ , 1/4 W                          |
| 1        | C1                   | 0.47 $\mu$ F, 250 V                          |
| 1        | C2                   | 10 $\mu$ F, 50 V Tantalum                    |
| 1        | C3                   | 10 $\mu$ F, 25 V Tantalum                    |
| 1        | C4                   | 0.082 $\mu$ F, 50 V                          |
| 1        | C5                   | optional ( <i>see Section 6 on page 18</i> ) |
| 1        | C6                   | 0.29 $\mu$ F, 50 V                           |
| 1        | T1                   | Midcom 82096 transformer                     |
| 1        | U1                   | IXYS Integrated Circuits Division IAA110P    |
| 1        | L1                   | 3.3 mH inductor, 100 mA dc current           |
| 2        | ZD1, ZD2             | 20 V Zener                                   |
| 1        | SP1                  | P3100SB Teccor surge suppressor              |
| 1        | F1                   | 1.25 A, 250 V fuse                           |
| 1        | L1                   | 3.3 mH inductor, 100 mA                      |
| 1        | D1                   | 8.2 V Zener, 1/4 W                           |
| 1        | D2                   | 1N4001                                       |
| 1        | BR1                  | 400 V bridge rectifier                       |
| 1        | Q1                   | FZT604 NPN Darlington, Zetex                 |



## 8.2 DAA for Spain

Figure 12 uses a circuit similar to Figure 11, but includes components needed for regulatory compliance in Spain as of the date of publication.

**Figure 12. DAA for Spain Using IAA110P**



**Table 11: Part List for Figure 12**

| Quantity | Reference Designator | Description                                  |
|----------|----------------------|--|
| 1        | R1                   | 10 k $\Omega$ , 1/4 W                        |
| 1        | R2                   | 100 k $\Omega$ , 1/8 W                       |
| 1        | R3                   | 10 $\Omega$ , 1/8 W                          |
| 1        | R4                   | 68 k $\Omega$ , 1/8 W                        |
| 1        | R5                   | 100 k $\Omega$ , 1/8 W                       |
| 2        | R6, R7               | 470 $\Omega$ , 1/8 W                         |
| 1        | R8                   | 47 k $\Omega$ , 1/8 W                        |
| 1        | R9                   | 820 $\Omega$ , 1/8 W                         |
| 1        | C1                   | 0.47 $\mu$ F, 250 V                          |
| 1        | C2                   | 10 $\mu$ F, 50 V Tantalum                    |
| 1        | C3                   | 10 $\mu$ F, 25 V Tantalum                    |
| 1        | C4                   | 0.056 $\mu$ F, 50 V                          |
| 1        | C5                   | optional ( <i>see Section 6 on page 18</i> ) |
| 1        | T1                   | Midcom 82096 transformer                     |
| 1        | U1                   | IXYS Integrated Circuits Division IAA110P    |
| 2        | ZD1, ZD2             | 33 V Zener                                   |
| 1        | SP1                  | P3100SB Teccor surge suppressor              |
| 1        | F1                   | 1.25 A, 250 V fuse                           |
| 1        | D1                   | 8.2 V Zener, 1/4 W                           |
| 1        | D2                   | 1N4001                                       |
| 1        | BR1                  | 400 V bridge rectifier                       |
| 1        | Q1                   | FZT604 NPN Darlington, Zetex                 |

## 9. Circuit Layout Considerations

IXYS Integrated Circuits Division strongly recommends that engineers designing a DAA circuit using OptoMOS components become familiar with all regulatory and safety requirements for such devices. In particular, IEC950 and UL1950 contain relevant and useful information. FCC part 68.3, TBR-21, and ETSI EG201 121 also provide useful information.

Although written specifically for IXYS Integrated Circuits Division's LITELINK™ products, application note AN-146, *Guidelines for Effective LITELINK Designs*, contains information useful to the OptoMOS DAA designer.

Remember that component placement and printed-circuit board layout are critical to building compliant, safe products.

## 10. OptoMOS Design Resources

IXYS Integrated Circuits Division's web site has a wealth of information useful for designing with its products, including application notes and reference designs. Product data sheets also contain additional application and design information. See the following links:

Application Note AN-114: *IITC117P Integrated Telecom Circuit*.

**For additional information please visit our web site at: [www.ixysic.com](http://www.ixysic.com)**

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