APPLICATION NOTE

ABSTRACT

The Data Access Arrangement (DAA) is an amplitude and frequency limiter to protect the telephone network from interference from privately-owned equipment. It also allows devices such as modems and electronic phones to connect to public telephone networks without requiring an acoustic coupler.

There are two types of DAA supported by Philips UCB1300. They are discrete (transformer) DAA and the solid state DAA. The transformer DAA requires more board space for its design. The IC DAA's compact size is the best for portable applications.

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Data access arrangement (DAA)

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INTRODUCTION

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The applications where the UCB1300 with these DAA can be used are in:

- Modems/Voicemail systems
- Telephony applications
- Digital telephone answering machine

Figure 1 shows how the DAA is connected to the UCB1300.

Figure 2 shows a basic DAA (Data Access arrangement) with relay control and ringing detection. Transformer T1 couples the transmit signal from the modem to the phone network, and receive signal from the network to the modem while providing high degree of isolation between the phone network and the modem. When the relay closes, it completes a path between the phone network and the primary side of the transformer. DC current flows from the network through the primary side of the transformer signals the off-hook state of the modem to the network. Diode D2, resistor R3, R4, capacitor C1 and optoisolator ISO1 form a ring detection circuit. When the relay is open and if there is an AC ringing signal present, C1 couples this ringing signal to R4 causing current to flow through D2 and the photo diode inside the optoisolator. During the first half cycle of the ringing signal, when current flows through the photo diode, the transistor inside ISO1 conducts to create a logic Low on the /RING signal. On the next half cycle, current flows through D2. Here, no current flows through the photo diode and the transistor is off to create a logic High on the /RING signal. A microprocessor I/O pin can be used to monitor the /RING signal for the low and high pattern (cadence) of any ringing signals.

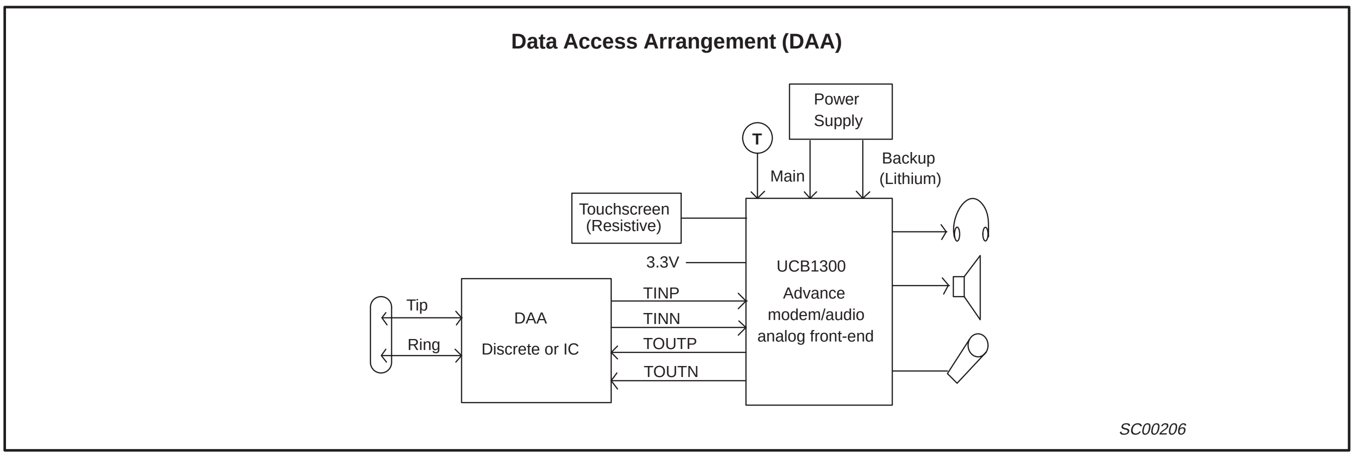

Figure 1. System block diagram of UCB1300 with DAA connection

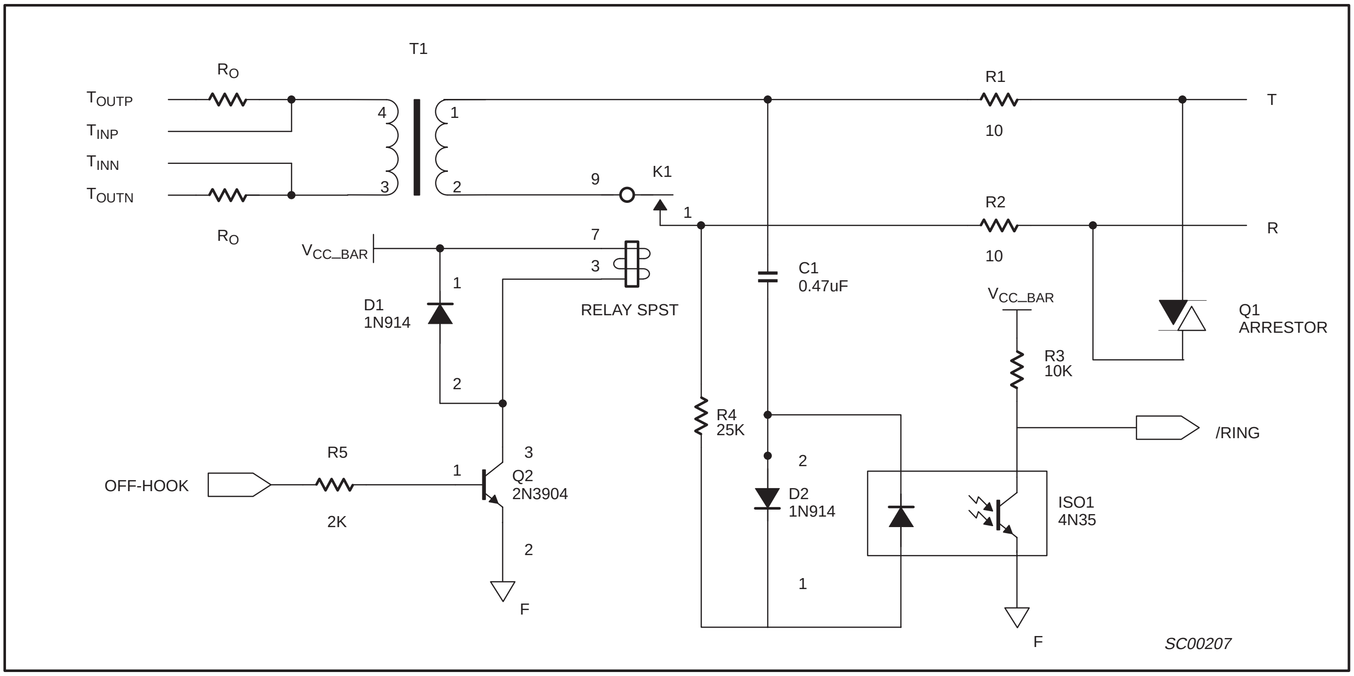

Figure 2. Basic DAA with relay control and ringing detection

CHOOSING A TRANSFORMER

Flatness of the frequency response and low harmonic distortion are very important and must be maintained across a wide range of loop current and voltages. The isolation between the primary (network side) and secondary (modem side) must be able to withstand a large differential voltage up to 1500 V.

The transformer's primary winding, of the above DAA, is also being used to carry the loop current required to keep the modem in the off-hook state. The winding must be able to carry large loop current without altering the frequency response or introducing harmonic distortion. Loop current varies between 20 mA and 80 mA, although it can go up to 100 mA in rare cases. Loading the secondary side of the transformer is crucial and necessary so that it will terminate the network with correct impedance load (600 ohms is typical for U.S. local loops). The value for this resistor can be obtained from the transformer data sheet. The insertion loss value of the transformer needs to be calculated in order to adjust the signal that you are sending to the network without violating FCC part 68.

The transformer used in Figure 2 is a "wet" type transformer. It does not include a blocking capacitor along the transmit line. This type of transformer allows DC current to flow through its primary winding and is mostly used in modems with baud rates below 9600bps. For higher speed, a transformer with lower THD (Total Harmonic Distortion) and better frequency response is used.

CHOOSING A RELAY

Relay K1 in Figure 2 is used to seize the line. When it closes, current flows from the network through the primary side of the transformer. The network equipment monitors this current and if a certain amount is drawn (more than 20 mA), the network knows that the modem has gone off-hook and it will send out a dial tone. As soon as the modem receives the dial tone it starts to dial the calling number, although in the United States the modem can not dial the number for two seconds after it has received the dial tone.

Since the relay is on the network side it must be able to withstand the high surge voltage. Use a relay that has wide separation between line contact and contact, and contact and coil. The relay that you select must be approved for use by safety organizations (FCC for the United States). Most relay companies make relays for telephone line interface purposes, and these relays meet FCC, UL and CSA approval for use both in the U.S. and in Canada.

Mechanical relays require large amount of current to operate. They must be powered from a supply of 4 V and higher. Although they vary between manufacturers, most of the mechanical relays need about 20 to 30 mA of coil current to turn the relay ON.

It is possible to use solid state relays but they have to be the bi-directional type because the loop current can be any polarity. The on-hook resistance must be large to meet FCC requirements and the off-hook resistance must be small compared to the 600 ohm line impedance. Solid state relays can be operated from a 3V power supply and they typically draw only about 5 mA in off-hook condition. They also come in small surface mount packages, but these cost more than mechanical relays. In most handheld applications, the solid state relays are recommended because of the limited board space for the device.

DESIGNING THE RING DETECTION CIRCUIT

As mentioned before, C1 is used to couple the ringing signal to the optoisolator, and together with R1 it sets the REN (ring equivalent number) and the operating ringing frequency ranges. Although the ringing frequency can vary, the most common frequency is between 15.8 and 68 Hz, and the voltage ranges from 40 Vrms to 150 Vrms. The REN number specifies how many of the same devices can be connected in parallel without affecting the device operation. FCC requires that the REN must be less than 1.

Choosing the optoisolator

Since the optoisolator couples the ringing signal from the network side to the modem side it must be able to withstand a high surge voltage, and must be approved for use by safety agencies. When the transistor is turned on, it will cause the /RING signal to go Logic Low. To ensure a good logic low, avoid using optoisolators that have a Darlington transistor output since the saturation voltage on the collector can be as high as 1 V, while a normal transistor is only 0.2 V. Choose parts with high current transfer ratio (ratio of current flows in the transistor to the current flows in the photo diode) which allows you to use higher impedance for C1 and R4 to achieve a lower ring equivalent number. Optoisolators with industry part numbers such as 4N35 and 4N37 are widely used for ring detection purposes since they have high current transfer ratio, high isolation voltage and are approved by UL.

Diode D2 is used to limit the voltage across the photo diode to a diode drop when it is not conducting during ringing. Without D2, the photo diode would experience the high voltage of the ringing signal across its terminals (up to 150 Vrms) and would probably breakdown. Any general purpose diode can be used for D2, and it is important that D2 not be omitted.

As noted earlier, C1 is used to couple the AC ringing signal and block the loop DC voltage. Since the ringing can be as high as 210 V, the peak the rating of C1 must be at least equal to this voltage. A typical capacitor used in this circuit is a 0.47 µF with 250 VAC rating, metal film type. Metal film capacitors are “self-healing”, meaning they can withstand momentary surges without being damaged. R4 is used to limit the current flow through the photo diode inside the optoisolator. Its value has to be such that at minimum ringing signal amplitude there would be enough current flow through the photo diode to turn on the transistor. For example, if we choose R4 to be 25 K, at lowest ringing signal of 15.8 Hz C1 has an impedance of 21.5 K, and together with R1 they have an equivalent impedance of 33 K $\left(\sqrt{(25K)^2 + (21.5K)^2}\right)$. At a minimum ringing amplitude of 40 V we have 40/33 K = 1.2 mA flowing through the photo diode, which is enough to turn on the transistor.

At the other end of the ringing frequency, 68 Hz, the impedance of C1 would be about 5 K, and together with R4, their equivalent impedance is 25.5 K. The REN can be calculated using the following formula:

REN = 8000 / total impedance

For the example above the REN is 8000/25.5 K = 0.31, which is less than one, a requirement of FCC part 68.

DAA USING “DRY” TRANSFORMER

Figure 3 shows another example in DAA design. Here a different type of transformer is used to couple the transmit and receive signal from the network to the modem and vice versa. This type of transformer, “dry type”, cannot have any significant DC current flow through its windings, therefore, C2 is used to block the loop DC voltage and the DC current is routed through another circuit. The advantage of dry transformers over other types is its frequency transfer characteristics are far more constant, both at the high and low ends of the pass band. DC current is now handled by Q1, R1, R2, R3, and C1. These components formed what is called a “line holding circuit”. Its purpose is to draw loop DC current while reflecting a high impedance path to AC signal.

Since the polarities of loop DC voltage on Tip and Ring can be in any direction, diodes D1 and D2, D3 and D4 serve to rectify the correct polarities, on the line holding circuit. R1 and R2 form a voltage divider to bias the base of Q1. Resistor R3 and Q1 draw current from the network and behave as a current sink. C1 offers a low impedance path for the AC signal; without it AC signal would flow through the base of Q1 upsetting the DC bias. Q1 is a Darlington transistor because with a high h_{fe} we can use higher values for R1 and R2. This is desirable because the AC impedance of this circuit is approximately equal to R1.

PROTECTION AGAINST HIGH VOLTAGE

Lightning might cause a high voltage surge on the tip and ring wires of the network with respect to earth ground. Any component that crosses from the network side to the modem side must be able to withstand this high surge voltage. Components that are not rated for this voltage will be destroyed and its could cause excessive current flow through other parts of the system. The transformer, the relay and the optoisolator must be able to withstand this high voltage or the unit will fail during part 68 qualification tests. Care must be taken during the layout process; do not route any traces from the modem side close to or crossing over the network side. A barrier should be established between the network and the system side of at least 100 mil (4 mm), or arc-over may occur.

To protect against high voltage surge between tip and ring, a surge suppressor or a spark-gap is usually used. A rating of at least 260 V is typical because if the rating is lower, a high ringing signal might turn on the surge suppressor and fail FCC part 68 tests. Two 10 ohm resistors can also be placed in series of tip and ring. These two resistors act as fuses if there is excessive current flow through them.

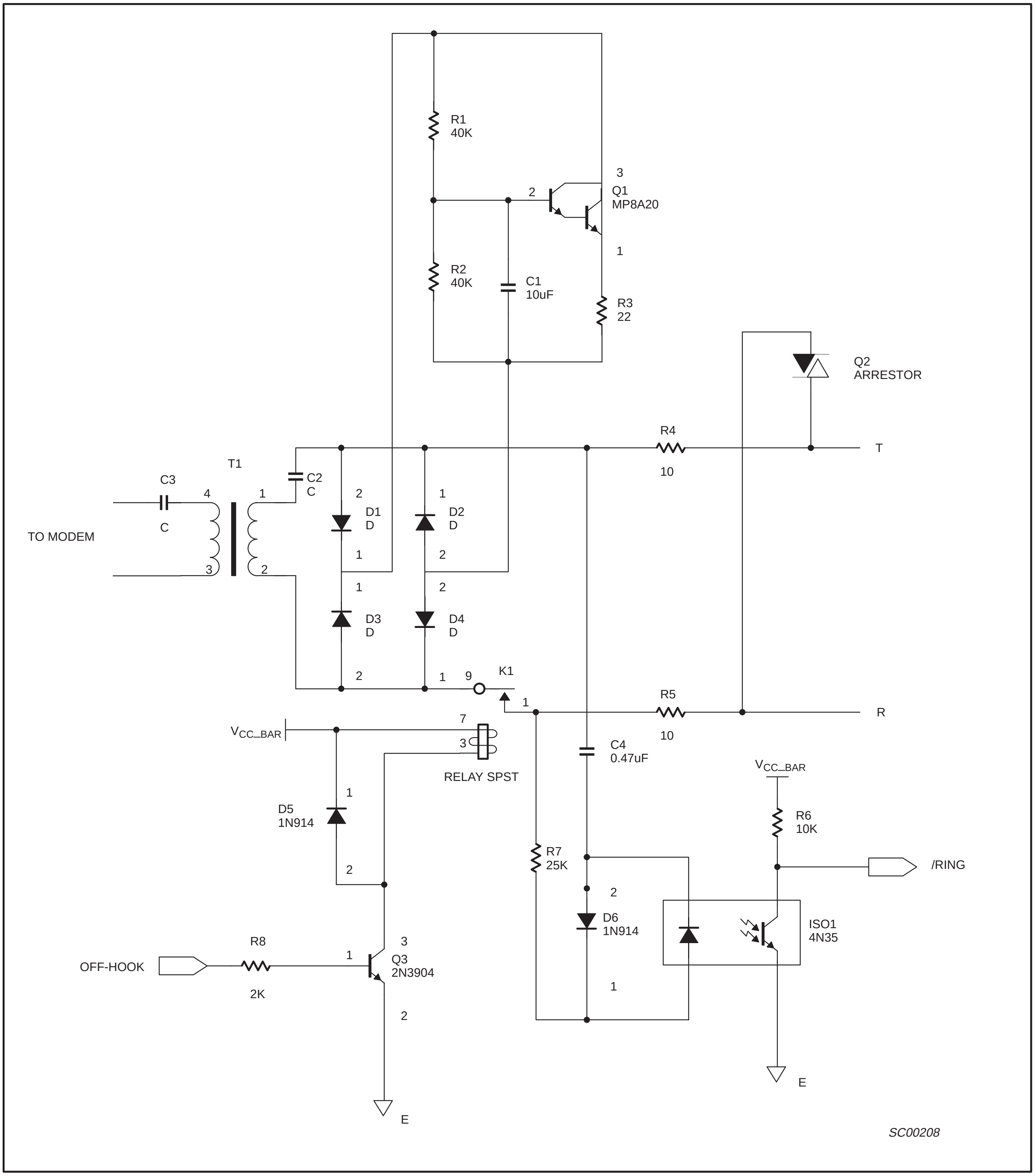

Figure 3. Another example in DAA design

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Data sheet status

Data sheet status	Product status	Definition [1]
Objective specification	Development	This data sheet contains the design target or goal specifications for product development. Specification may change in any manner without notice.
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[1] Please consult the most recently issued datasheet before initiating or completing a design.

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Limiting values definition — Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.

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Philips Semiconductors
811 East Arques Avenue
P.O. Box 3409
Sunnyvale, California 94088–3409
Telephone 800-234-7381

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