# Cybergate™ 20xx Series

## Cybergate™ 20XX Series

IXYS IC Division's Cybergate™ Series Data Access Arrangement (DAA) Module, the Cybergate, combines all of the circuitry necessary to implement a complete telephone line interface solution including:

- Low Distortion Signal Coupling (V.34 compatible)
- 1.5kV$_{PEAK}$ Isolation
- 300V Surge Protection
- Ring Detection
- On/Off Hookswitch Relay
- Compliance to FCC Part 68
- UL1459 and UL1950 Recognized
- Half-Wave or Full-Wave Ring Detection Available
- Products covered in this application note:
  CYG2000/CYG2001
  CYG2010/CYG2011
  CYG2020/CYG2021
  CYG2030/CYG2031

Typical applications for the Cybergate Series include:

- Home Medical Devices
- Plant Monitoring Equipment
- Security/Alarm Systems
- Modems
- Utility Meters
- Voicemail Systems/Telephony Applications
- Vending Machines
- Elevator Control Boxes
- Network Routers
- PBX Systems
- PC Mother Boards
- Digital Telephone Answering Machines
- Set Top Cable Boxes

## Description

The Cybergate DAA Module integrates a complete line interface circuit into a compact 1.07" x 1.07" x 0.4" package. The following is a list of major functions included in the DAA, as shown in the functional diagram in figure 1:

- Hookswitch Circuitry
- Ring Detection Circuitry
- Surge Protection
- Gyrator Circuitry
- Transformer Coupling
- Secondary Transient Protection
- Caller ID Function (optional)
- Loop Current Detection (optional)

A brief description for each of these functions follows:

## Hookswitch Circuitry

The hookswitch asserts the on-hook and off-hook conditions for the phone interface (the difference between being "on-line" and "off-line"). The hookswitch is activated by the host when the host wishes to place a call or answer a call in response to an incoming ring signal. In order to perform this function in the most effective manner, the Cybergate uses a highly reliable solid state relay activated when the OH pin is driven LOW (logic '0').

The current required at the input to operate the relay is 4mA minimum. The solid state relay provides no contact "bounce" and provides up to 350V blocking voltage when on-hook.

### Ring Detection Circuitry

The ring detection circuitry detects the ring signal from the central office, which indicates the presence of an incoming call. This ring signal is a high voltage AC signal superimposed on the central office DC battery, nominally 48VDC. This AC signal can be at any frequency between 15.3 – 68.0Hz and have an RMS voltage between 40 and 150 volts,

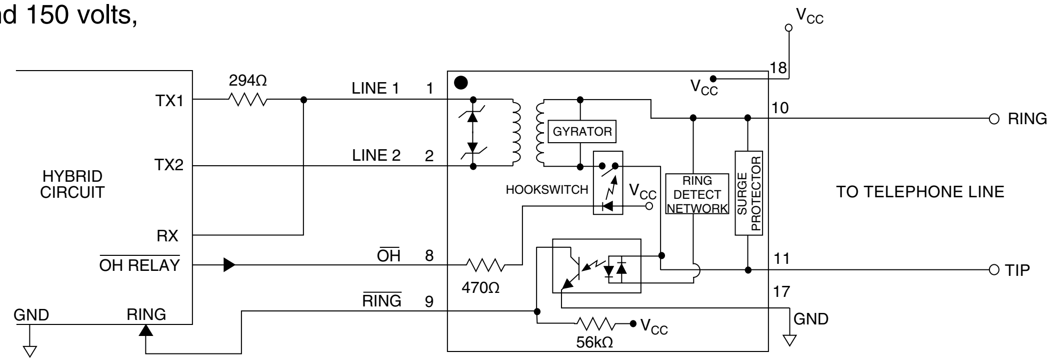



**Figure 1. Functional Block Diagram**

with a typical ring cadence of 2 seconds on and 4 seconds off. The ring detection network includes an LED that emits light on one half cycle (half-wave) or both half cycles (full-wave) of the ring frequency and couples this light to an output phototransistor. The output phototransistor provides pulses from $+V_{CC}$ (via an internal 47K pull-up resistor) to ground, in response to the ring signal. These pulses are presented to the RING pin on the Cybergate module. The duty cycle of these pulses is dependent on the amplitude and frequency of the incoming ring signal. The RING signal is typically connected to an input port on the microcontroller or data pump located on the host system, where it is qualified as a valid ring signal.

### Surge Protection Circuit

Metallic (Tip to Ring) surge protection is another key feature included in the Cybergate. All circuits function per specification under normal conditions.

### Loop Current Detection

On designs requiring loop current detection, a pin, LOOP1 is provided on the Cybergate. When current is placed on the loop, LOOP1 will be driven low.

### Gyrator Circuitry

The gyrator circuit included in the Cybergate™ provides a low DC resistance and a high AC impedance to the telephone line when the Cybergate is in the off-hook state. By doing this, the gyrator is approximating the operation of an inductor (a space saving feature as opposed to using a discrete inductor). The electronic inductor circuitry is required so that the DC current from the telephone line is diverted away from the transformer windings, thus providing the high linearity necessary for V.34 modem performance.

### Transformer Coupling

A low distortion transformer is used to couple voice/data/fax signals to and from the Cybergate. The transformer provides the galvanic isolation of $1500V_{PEAK}$ required by FCC Part 68.302.

### Secondary Transient Protection

Two back to back zeners are connected to the transformer secondary across LINE1 and LINE2 connections on the Cybergate. These zeners clamp any transient voltage above 5V to protect the host circuitry.

### Caller ID Circuitry (optional)

The Cybergate includes two Caller ID signals, CID1 and CID2, for Caller ID applications. These two signals should be connected across a 1-Form-A solid state relay (IXYS IC Division LCA110) which is controlled by the host microprocessor or related circuitry as shown in figure 2.

### Power Consumption

The Cybergate consumes very little power from the host system. This power is mainly limited to the hookswitch relay which consumes about 25mW with a $+V_{CC}$ of 5V and corresponding LED current of 4mA. $+V_{CC}$ can be greater than +5V if desired as there is an internal 470Ω LED current limiting resistor in the Cybergate. The following boundary equation should be observed, however, when selecting a $+V_{CC}$ operating voltage:

$$\{V_{CC} - 1.4V\}/470\Omega \leq 22mA$$

It is also important to note that $+V_{CC}$ should be no higher than 20V. This is because the ring detect output transistor's collector is pulled to $+V_{CC}$ via a 47K resistor. The maximum $V_{CEO}$ of the transistor is 20V and should therefore not be exceeded.

The Cybergate module is designed to dissipate about 1.5W of power from the telephone line at a maximum ambient temperature of 70°C.

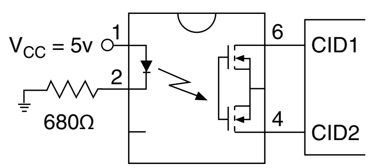
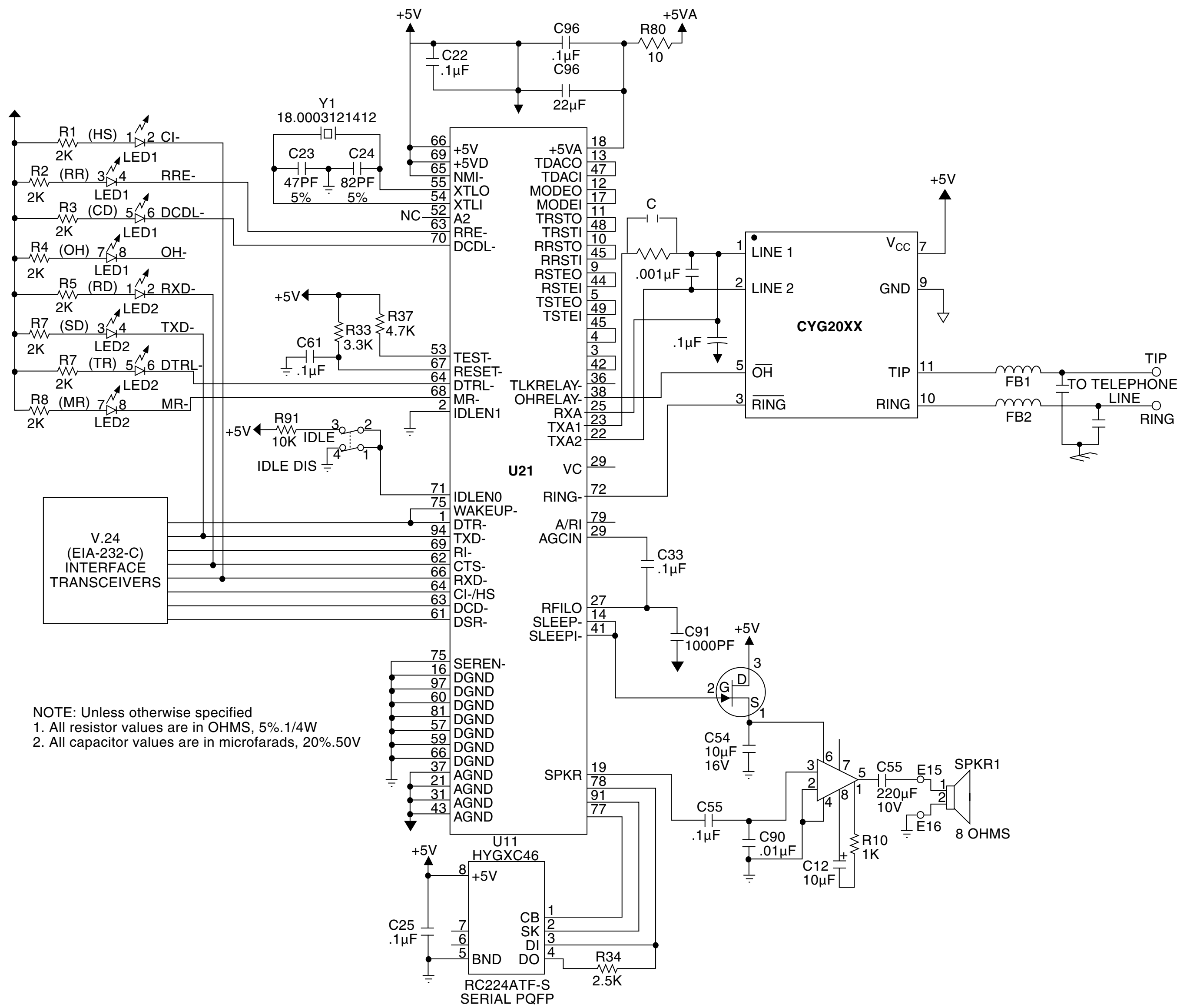



**Figure 2. Caller ID Connection**

### Interfacing the Cybergate to a Modern Chip

Figure 3 shows a CYG20XX connected to a Rockwell 224ATF Fax/Data modem. The 224ATF has an internal 2-4 wire hybrid that eliminates the need for an external hybrid circuit. The modem circuit shown is a 2400 bps data modem with 9600 bps fax capability. The TXA1 and TXA2 pins from the 224ATF represent the differentially driven transmit signal and the RXA is the single-ended signal from the telephone line to the modem. The 294Ω resistor from TXA1 was selected for optimum return loss by reflecting a nominal 600Ω impedance to the telephone line.

**Figure 3. Rockwell 224ATF Fax/Data Modem**



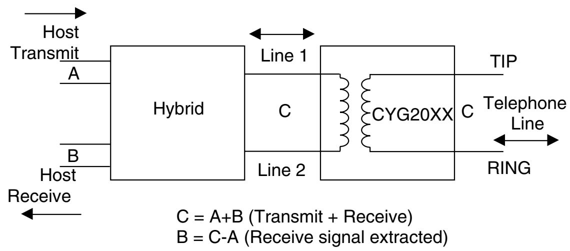



**Figure 4. Two-to-Four Wire Hybrid Diagram**

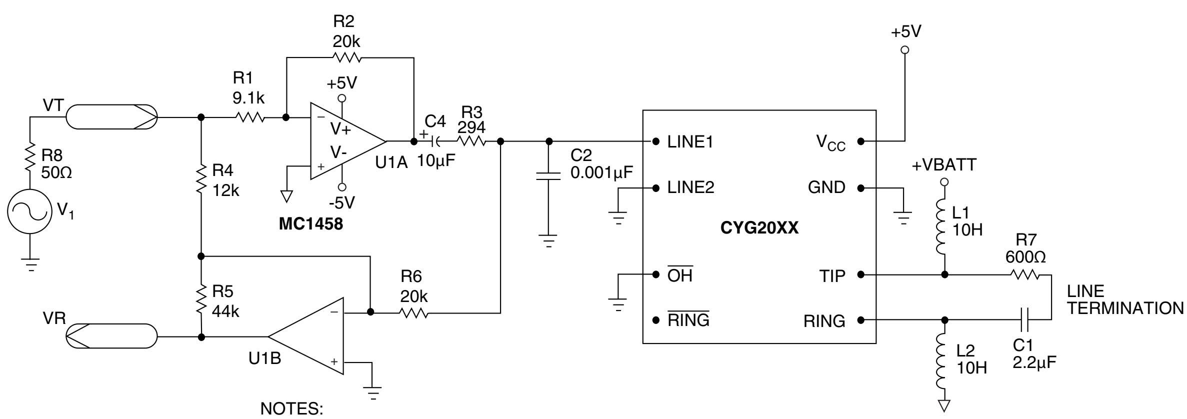
### Applications Requiring an External 2-4 Wire Hybrid Circuit

For full-duplex communications over the telephone line, it is required that both transmit signals (signals from the host to the telephone line) and receive signals (signals from the telephone line to the host) appear simultaneously on the single pair telephone line. It is the function of the 2-4 wire converter or hybrid to separate the transmit and receive signals from the single pair telephone line and put out the receive signal for the host to process. The hybrid also functions – along with the coupling transformer – to set the proper matching impedance for the telephone line and transmit the host transmit signal to the coupling transformer. It's important to note that most modems today have this hybrid function built into the chip set (refer to figure 3) so it won't be required to design a hybrid circuit in many cases. However, other applications including voice processing circuits may require an "external" hybrid circuit.

Referring to figure 4, the host transmit pair sends a signal denoted as 'A' to the telephone line via the Cybergate. Signal 'C' on LINE1/LINE2 and TIP/RING represents both the transmit signal from the host 'A' and the signal from the telephone line to the host denoted as 'B'. Signal 'C' is the sum A + B. The hybrid extracts the receive signal from the telephone line by subtracting the transmit signal from the composite signal appearing at C or B = C-A.

The practical implementation of the above scheme varies depending on the particular application; we will examine a very basic hybrid circuit as an example. The hybrid circuit usually consists of a dual operational amplifier and some discrete resistors as shown in figure 5. To simplify the analysis of the circuit, we will explain the operation of:

- Transmit to the telephone line
- Receive from the telephone line
- Transmit signal separation from receive path: transhybrid loss
- Frequency Response




NOTES:
Adjust R4 for maximum transhybrid loss from VT to VR. This circuit provides approximately -20dB loss.

R2/R1 provides +7dB amplification to compensate for -7dB transmit insertion loss in circuit.

R5/R6 provides +7dB amplification to compensate for -7dB receive insertion loss in circuit.

R3 at 294Ω provides optimum return loss for nominal 600Ω line termination.

**Figure 5. Hybrid Circuit**

### Transmit to the Telephone Line

Suppose that the VT signal from the host system is at a level of -9dBm and we wish to have this signal presented to the telephone line at this level. Since the transmit insertion loss from the data sheet is specified at 7dB, it is necessary to select resistor values R2 and R1 such that U1A will amplify VT by 7dB. Since gain (dB) = 20 Log [R2/R1] we select an arbitrary value of R2 and then calculate R1. For this example we select R2 = 20K which yields an R1 of approximately 9.1K.

### Receive from the Telephone Line

In a similar manner to the transmit calculation, we obtain the receive insertion loss from the data sheet and note that it is approximately 7dB. For an overall DAA gain of 1, it is necessary to select resistor values R5 and R6 such that 7dB amplification is achieved. Assuming R6 is 20K, R5 is calculated to be 44K.

### Receive and Transmit Signal Separation

### Transhybrid loss

We now have the transmit and receive gains of U1A and U1B set such that VR will be at the same signal level as the incoming receive signal appearing on the Tip and Ring connections. Also, the Tip and Ring connections will see the same level transmit signal as VT. We must now attenuate the signal transmitted by the host system at VT to keep it from entering the receive path at VR, thus providing receive and transmit separation and completing the 2-4 wire converter. U1B is configured as a summing amplifier that sums the transmit VT signal with the transmit signal appearing at the LINE1 input of the CYG. These signals are 180° out of phase, therefore the resultant output of U1B will be 0V, thus removing the transmit signal from VR. Completely removing VT from VR would represent an infinite transhybrid loss. In practical circuits, it is not possible to achieve infinite loss. Losses can range from -10dB to -40dB depending on how well the components are matched and the impedance of the telephone line. Since the telephone line is a complex impedance, transhybrid loss also varies over the 300Hz - 4kHz voice band as shown in figure 6. R4 should be optimized to achieve the highest return loss possible with a 600Ω termination as shown in figure 5. R7 and C1 comprise a network suggested by the FCC to emulate the typical telephone line impedance. Telephone line characteristics varies from location to location in actual applications, and the 600Ω + 2.2µF combination should serve as a reference. C2 serves to improve the transhybrid loss by counteracting the leakage inductance of the transformer at higher frequencies. Referring to figure 6, the return loss maxima occur at the center of the voice band which is desirable for optimum operation.

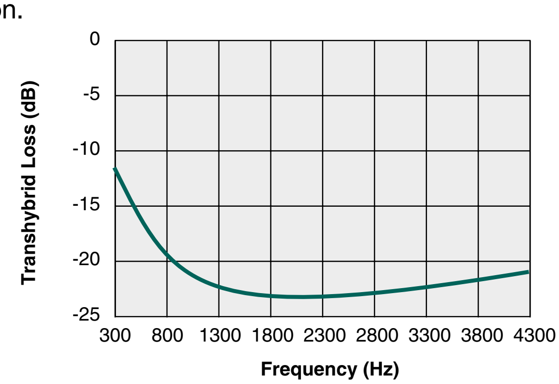



**Figure 6. CYG20XX Series Transhybrid Loss**

### Precautions When Implementing the Hybrid Circuit

Due to the small size and low distortion characteristics of the CYG20XXs transformer, it is extremely important to use op amps with a low DC output offset voltage. Generally, any DC voltage exceeding 10mV on the output of U1A can cause the transformer's distortion characteristics to degrade due to core saturation. For op amps with higher output offset, it is advisable to use a 10µF capacitor (aluminum or tantalum) in series with R3 as shown in figure 5. This capacitor will block any DC offset voltage thus maintaining the transformer secondary DC current at 0mA. Op amps such as the MC1458 were found not to require this capacitor due to their offset being sufficiently low. The voltage rating of the capacitor should be rated 50VDC.

### Return Loss Performance

The return loss is the measure of impedance mismatch of the telephone line and the DAA expressed in dB. Return loss is expressed as:

$$RL(dB) = 20 \text{ Log } \frac{[Z_L + Z_0]}{[Z_L - Z_0]}$$

$Z_L$ = Telephone line impedance in Ω

$Z_0$ = DAA impedance in Ω

If $Z_L = Z_0$ then the return loss is infinity which is the ideal case. As in the transhybrid loss case however, practical return loss figures are much lower than infinity and more like -25dB. Since impedance changes with frequency, the return loss also changes. A graph of return loss vs. frequency for the CYG20XX Series is shown in figure 7. This graph was generated with the CYG20XX terminated by a 600Ω + 2.16µF combination across Tip and Ring connections. Referring to figure 5, the key component determining the return loss match is the 294Ω resistor (R3) feeding the CYG's transformer secondary. This resistor value was selected for optimum return loss when used with the CYG and should not deviate in value by more than 5%.

### Frequency Response

The CYG's frequency response is fairly flat with a deviation of ±0.2 dB. Its frequency response is shown in figure 8.

### Regulatory Considerations

### Interface to the Public Switched Telephone Network (PSTN)

The Cybergate has been designed to comply with FCC Part 68.3 and DOC CS-03 requirements for connection to the public switched telephone network (PSTN). It is required however, that the designer submit the end product to a test lab to receive certification from the appropriate regulatory agency. The Cybergate requires two external 10Ω 1/8W metal film resistors or one 1/4A fuse to meet the metallic surge requirement referred to in FCC part 68.302(d). This resistor/fuse will open if an 800V surge appears across the telephone line, thus preventing the Cybergate from asserting a permanent off-hook condition to the telephone line in the event of a lightning strike or other induced surge. The resistor is shown in figure 9.

### EMI Considerations (FCC Part 15A/B)

The Cybergate is a fully recognized component for both UL1459 and UL1950. When designing to UL1459, it is necessary to use a 1/4A 250V fuse in either the Tip or Ring line before the connection to the Cybergate™ in order for the recognition to remain valid.

- If possible, use a four-layer PCB design instead of a double-sided PCB. Having a separate $V_{CC}$ and ground plane will minimize radiated emissions and decrease the noise susceptibility of the device. An alternative is to do a double-sided board and four-layer board in parallel and evaluate the results.
- Include a provision on your PCB design for a 1/2 turn ferrite bead and capacitor in your layout from the Tip and Ring terminals of the DAA to the telephone jack as shown in figure 10. This LC network will form a low pass filter that will roll off high frequencies. The decision to populate the board with these components will be based on the results of the radiated emissions coming out of the telephone line during FCC testing.
- If a multi-layer board is not used, keep ground traces at least 25 mils to 50 mils wide.
- Maintain LINE1 and LINE2 connections as short as possible and use guarding techniques when running these traces.
- Maintain Tip and Ring connections at least 100 mils away from all other connections on the boards. If a ground plane is used, keep the plane away from Tip and Ring connections.

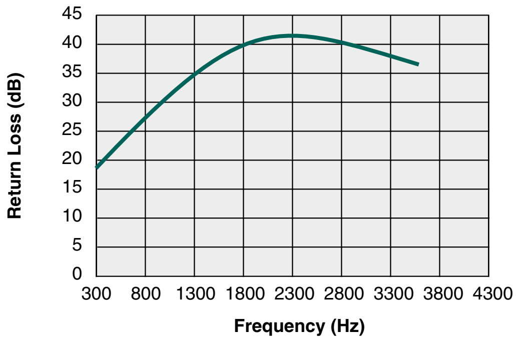



Figure 7. CYG20XX Series Return Loss

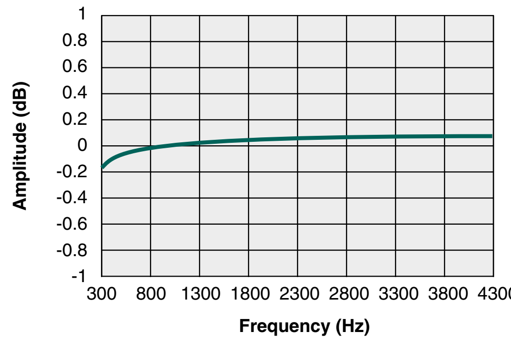



Figure 8. CYG20XX Series Frequency Response

## Conclusions

The Cybergate™ 20XX is a complete, functional Data Access Arrangement (DAA), and complements our complete line of integrated telecommunication solutions. By incorporating all of our core technologies, such as solid state switching, optical coupling and transformer/coil technology, we are able to provide an unmatched level of functionality and integration for the telecom interface design. Technically, the Cybergate includes the surge protection, transient protection, ring detection, hookswitch circuitry, and impedance balancing circuits required for the interface design in a compact 1.07" x 1.07" x 0.4" module. In addition to our current offering, ask for versions which include loop current detection and/or Caller ID features. In all, advantages are numerous when utilizing this complete drop-in DAA solution.

Some of the more obvious benefits are as follows:

- Plug and Play DAA
- Compact design for space/PCB cost savings
- Reduced design costs
- Reduced “design to market” time
- Complete integrated solution, including surge protection and transformer
- Very low risk design solution

Coupled with our company’s commitment to stand behind the user with “complete applications support”, all these benefits make the Cybergate™ 2000/2001 a must when interfacing your product to the Public Switched Telephone Network (PSTN).

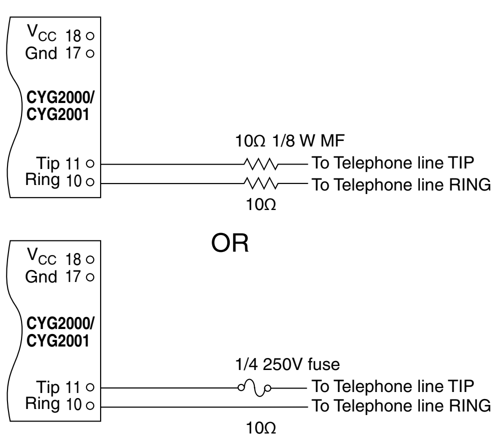



Figure 9. CYG20XX Fuse Requirements

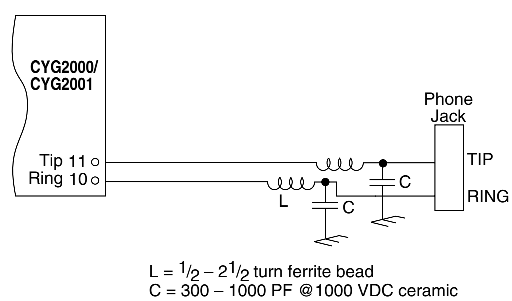



Figure 10. EMI Considerations

For additional information please visit our website at: www.ixysic.com



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