CML Microcircuits

COMMUNICATION SEMICONDUCTORS

Application Note

CMX869B DAA with Line State Detection

AN/Telecom/869B/DAA/1 July 2007

1 Introduction

The CML Microcircuits' CMX869B V.32 bis wireline modem provides the designer with a wide range of functionality while offering very low power consumption. Most of the applications for the CMX869B require the modem IC to connect to the telephone network for data exchange with a remote computer. Some applications require additional features such as Caller ID (CID) detection and "911" detection. The latter feature refers to the ability to release the telephone line should a parallel extension be taken off hook, such as would happen during an emergency "911" call in the USA.

The circuitry used to connect a modem to a telephone line, also referred to as a "direct access arrangement" or DAA, can represent a significant hurdle for some customers. To assist these customers, this application note describes one method of connecting the CMX869B to the telephone network using low-cost components. In addition to the basic DAA function, other circuitry is provided for the CID and 911 detection functions.

While the CMX869B V.32 bis wireline modem is highlighted in this application note, the circuitry in this document is equally suitable for any other CML wireline modem.

The user should consult the CMX869B datasheet during the review of this application note.

1.1 General Information

All products that connect to the telephone line must be certified for this purpose in the end country of sale. This process, also known as “type approval”, is required for most countries and the specific technical requirements vary from country to country.

The circuitry depicted in this application note is based on proven designs that have passed type approval testing for both the USA and Europe. The circuitry in this document has been specifically designed for USA applications and has not been submitted for type approval testing. Consequently, this circuitry should be considered as a starting point for a CMX869B based design.

The customer is encouraged to consult with a qualified compliance engineer regarding questions on type approval testing.

2 Hardware Description

2.1 CMX869B

The CMX869B V.32 bis wireline modem offers considerable functionality while consuming minimal power from the host (8.6mA typical at Vdd=3.3V). The feature set of the CMX869B is summarized below:

Feature	CMX869B
V.32 bis/V.32/V.22 bis/V.22 automodem function	Yes
V.22 bis/V.22/ manual modem function	Yes
V.23/Bell 202 manual modem function	Yes
V.21/Bell 103 manual modem function	Yes
Support for ‘fast connect’ modem handshakes	Yes
DTMF Transmit/Receive	Yes
Call Progress Tone Transmit/Receive	Yes
Custom Tone Transmit/Receive	Yes
Ring/Line Reversal Detector	Yes
On-chip Tx & Rx Line Drivers	Yes
Hook Switch Relay Drive Output	Yes
CBUS Microcontroller Interface for Control & Data	Yes
HDLC Tx/Rx	Yes
Power Supply Voltage	3.0 - 3.6 V

Table 1: CMX869B Features

Some of the applications served by the CMX869B include:

- Electronic Point-Of-Sale (EPOS) terminals
- Utility meter reading
- Alarm and security panels

- Industrial control and telemetry
- Feature phones and payphones
- Set-top boxes

2.2 DAA Circuit

The DAA circuit, see Figure 4, in this application note is centered around the Clare ITC107P integrated telecom device. The ITC107P integrates many required telecom functions while reducing external part count and bill-of-material (BOM) cost. The features provided by the ITC107P include:

- Hookswitch
- Bridge Rectifier
- Darlington transistor
- Optocoupler that can function as a ring detector

A 1.25A “slow blow” fuse is connected to the tip lead to assist the design in passing the UL60950 power cross safety requirement. The particular fuse chosen for this application, the Wickmann 4571250 “TTP” surface mount fuse, requires no series resistors to assist in passing surge tests. Fuses are available in many form factors, and only the end customer can determine the optimal fuse for their particular application.

A Littelfuse® Sidactor® provides overvoltage protection across tip and ring leads. The P3100EC Sidactor® was chosen to protect against voltage surges while allowing ringing signals to pass without attenuation. “Class B” ringing signals in the USA can range from 40Vrms-150Vrms[1]. Since…

150Vrms + 56.5V (maximum DC bias) = 268.7Vpeak

…the Sidactor® must not conduct for this signal level. The P3100EC begins to conduct at 275Vpeak and fully conducts at 350Vpeak, so ringing signals are passed without attenuation. (Note: The P3100EC is a through-hole TO-92 component and was chosen for its cost savings. A surface mount version of this Sidactor, the P3100SC, is also available at slightly higher cost.)

An incoming ringing signal is passed through R10, C6, back-to-back zener diodes D1 and D2, and then to the bi-directional LEDs across pins 9 and 10 of the ITC107P. The ringing signal causes the LEDs to conduct, and this causes the phototransistor across pins 7 and 8 to turn on. The CMX869B RDN pin is normally high, but the conducting phototransistor causes the RDN line to be pulled low. When this happens, the CMX869B will generate an interrupt so long as its Ring Detect IRQ is not masked.

The host microcontroller can seize the telephone line by setting CMX869B General Control ($E0) register b9 = 1. This action causes the photodarlington hook switch in the ITC107P to turn on, and this allows loop current to flow through the ITC107P’s internal bridge rectifier and Darlington transistor. For a worst case DC feeding condition of 56.5V and 400 ohms loop resistance[2], an estimated 99.6mA of loop current will flow into the ITC107P when configured in accordance with Figure 4. The ITC107P has a maximum power dissipation rating of 1W, so an external NPN transistor, Q1, is used to pass this loop current and divert the power dissipation away from the ITC107P.

R7 passes most of the loop current, and as much as 300mW can be dissipated by this resistor under the maximum DC feeding condition. Two options exist for this component:

- A single component of suitable power rating.
- Two components, in parallel, with smaller individual power ratings.

A single component represents less board space and reduced manufacturing cost, but the component itself can be significantly more expensive (>10x) than a typical resistor with a more modest power rating. The second option (two parallel resistors with reduced individual power ratings) will occupy more board space but will represent a fraction of the cost of the single resistor option. The end customer must decide the approach which best serves their needs.

The output of the ITC107P hookswitch (pin 16) is connected to an Etal P5233 ‘dry’ transformer via the DC blocking capacitor C4. The 50V rating of this capacitor was chosen for a ‘worst case’ scenario involving the tip/ring voltage being directly applied across the component. C4 will be exposed to a portion of the ringing signal, but the 50V rating is sufficient for this condition as well.

The P5233 transformer was selected for its attractive balance between performance and cost, and the termination was recommended by the transformer manufacturer. For information regarding other transformers or termination recommendations, please contact Profec at www.profec.com.

The CMX869B transmitter differentially drives the transformer to allow sufficient signal swing at low power supply voltages. The power supply voltage used in this design (Vdd=3.6V) was chosen to allow maximum transmitted power for communications across long telephone lines.

The CMX869B receiver is configured as a single-ended inverting input, referenced to the IC's V_{BIAS} pin. Two receive input gain values are possible by selecting between the RXAN input (lower gain) or the RXBN input (higher gain). This feature can be useful when very low amplitude signals are expected, such as would occur for Caller ID signals that are attenuated by an on-hook AC signal path. The RXAN/RXBN input selection is made with bit 14 of the CMX869B's General Control ($E0) register.

2.3 Caller ID Circuit

To allow on-hook Caller ID (CID) signals to be received by the CMX869B, a high impedance AC transmission path is implemented with C7 and C8. Since the CID signals will be attenuated by this high impedance path, additional signal gain can be provided by enabling the RXBN pin on the CMX869B. (Note: the values shown in the schematic will provide +25dB of gain for RXBN and -3.5dB for RXAN.) Further increases in gain can be realized by reducing R4 below the 5.6kΩ value shown in the Figure 4.

It is possible for a portion of the ringing signal to be applied to the transformer via the high impedance CID AC transmission path. To ensure that excessive signal transients are not coupled across the transformer and possibly damage the CMX869B, back-to-back zener diodes D3 & D4 are placed across the transformer secondary.

2.4 Another Phone Off-Hook (APOH) Circuit

It is desirable in many applications for the modem to check the status of the telephone line before it attempts to place a call. This feature will prevent the modem from seizing the line and potentially disrupting an important telephone call, such as an emergency "911" call (USA). Clare's TS117 multifunction telecom switch can be used as the basis for such a circuit.

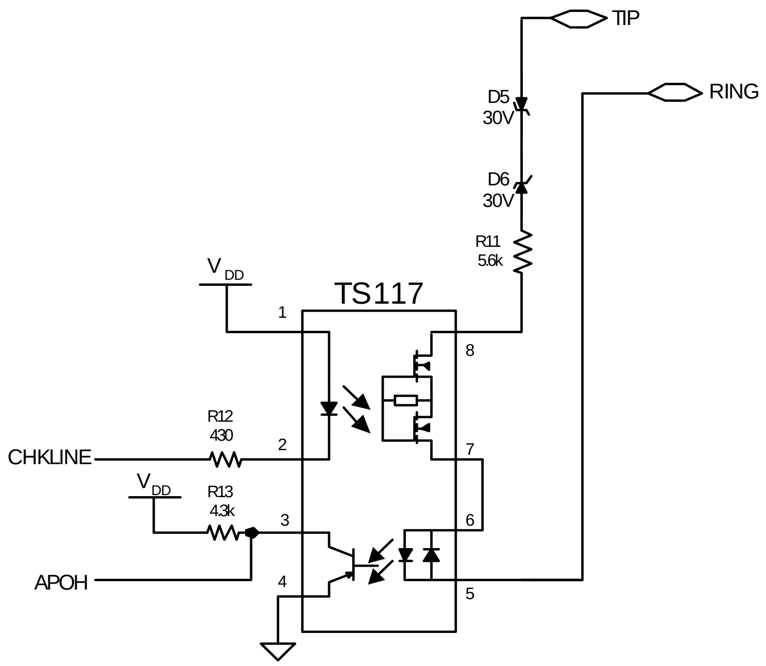

Figure 1: APOH Circuit

When the host microcontroller wishes to place a telephone call, the CHKLINE signal should be pulled low, thereby connecting the TS117 across tip/ring. Typically, the tip/ring loop voltage will be approximately 48VDC (USA) when no extensions are off-hook, and this will cause zener diodes D5 and D6 to conduct. The phototransistor will turn on and the APOH line ('another phone off-hook') will switch from a logic high to a logic low condition. The host microcontroller can interpret the APOH low signal to mean that the telephone line is available for use. R11 was selected to ensure that the current drawn from the central office (CO) will be much less than 20mA; otherwise, the CO will interpret the current flow as an off-hook event and send dial tone to the equipment.

If another telephone is off-hook when CHKLINE is asserted, the tip/ring voltage will be too low to cause the zener diodes to conduct. The TS117 solid state relay will be open, and the APOH signal will be a logic high. The host microcontroller should interpret this condition as "telephone line in use", and the call attempt should be postponed.

Note that the APOH circuit can also be used to check that the equipment is connected to a line and that the line voltage is present. Consider DECT phones; they usually flash a symbol so that the user knows the line is disconnected or faulty. Alarm Panels may also find this feature useful to warn of line cutting or lack of automatic dial out facilities.

2.5 911 Circuit

It is desirable in many applications for the modem to detect if a parallel extension is taken off-hook during a data transaction. This feature will enable the modem to release the line and allow a resident to place a potentially important telephone call, such as an emergency "911" call (USA). Clare's LDA100 solid state current sensor can be used as the basis for such a circuit.

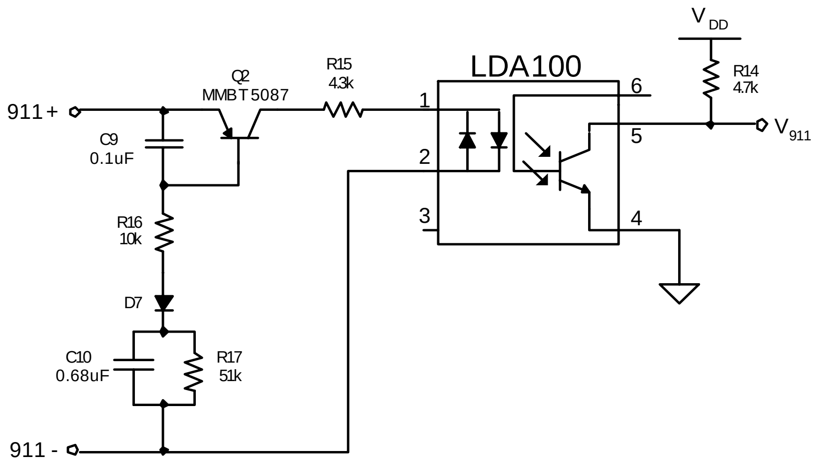

Figure 2: 911 Circuit

The “911+” and “911-“ pins are tied across the line after the hookswitch but before any ac coupling. In a typical off-hook condition, Q2 is turned on and current flows through the LDA100’s bi-directional LEDs. The LED current causes the phototransistor to turn on, and this drives the V_{911} signal to a logic low condition.

When a parallel extension goes off-hook, the tip/ring voltage will drop. The reduced tip/ring voltage will be felt on Q2’s emitter, but the Q2 base voltage will be held at its previous value due to the stored charge in C10. Q2 temporarily turns off, the phototransistor turns off, and the V_{911} signal goes to a logic high condition.

As C10 discharges through R16, the Q2 base voltage decreases until Q2 again turns on. The LDA100 phototransistor turns on and the V_{911}signal is again driven to a logic low condition. The RC time constant formed by C10 and R16 affects how long V_{911} will be at a logic high condition when an extension goes off-hook.

To summarize, a parallel extension going off-hook causes a high-going pulse on the V_{911} signal. The host microcontroller should monitor the V_{911} signal for a pulse and, if detected, immediately release the telephone line by going on-hook.

To demonstrate the operation of the 911 circuit, a simulation was performed for a tip/ring voltage change from 11V to 7V. (11V was chosen because this represents the estimated minimum tip/ring voltage for a DC feed of 42.5V across 1740ohms loop resistance. A 600ohm extension in parallel with the terminal will cause the 11V to drop to approximately 6.2V, so 7V was selected to conservatively estimate the effect on the 911 circuit.) The tip/ring voltage (V(9)) and V_{911} voltage are plotted against time in Figure 3. The tip/ring voltage is changed at approximately 100ms, and the V_{911} signal pulses to indicate the change in tip/ring voltage.

Please note that tradeoffs exist between the expected tip/ring voltage change for an off-hook extension, the RC time constant formed by C10 and R16, and the resulting pulse width on the V_{911} line. The values listed in this document are merely suggestions that can serve as a starting point in a design. Optimization will be required for any specific application.

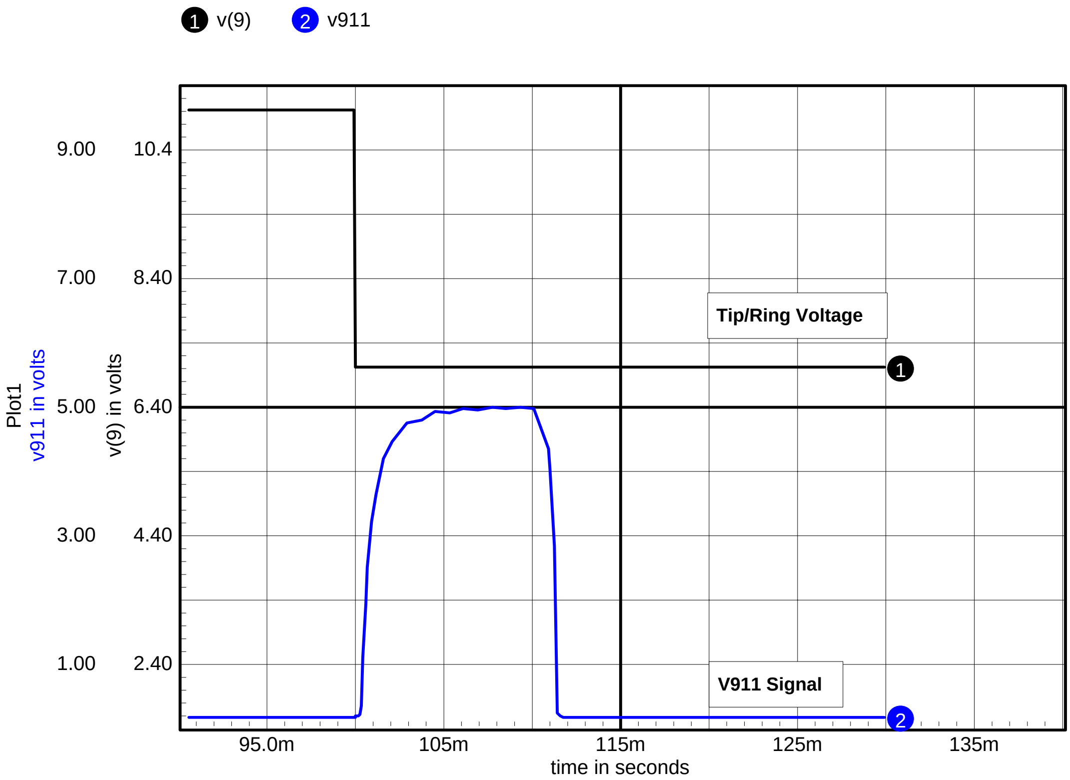

Figure 3: Simulation Results for 911 Circuit

3 Schematic

The schematic for DAA, CID, APOH and 911 circuits is provided in the following figure:

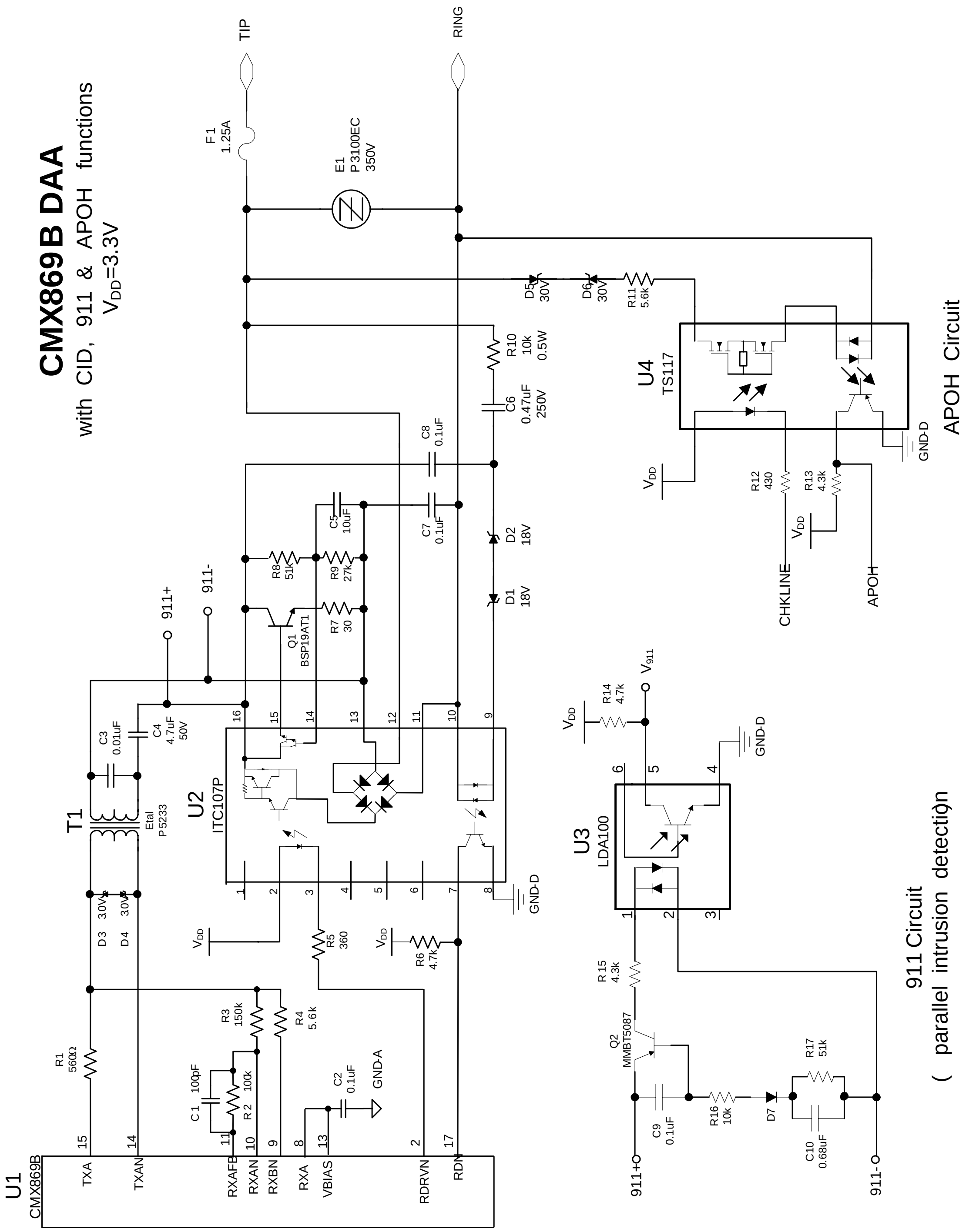

Figure 4: DAA Circuit with CID, 911, and APOH Functions

4 Bill Of Materials (BOM)

The following components are used in this design:

Circuit	Part #	Component	Description	Vendor	Vendor PN
911	C10	capacitor	0.68uF, 25V, 20%, tantalum, SMT	Nichicon	F931E684MAA
911	C9	capacitor	0.1uF, 16V, X7R, 10%, 0603	Kemet	C0603C104K4RACTU
911	D7	diode	1A, 50V, DO-41	Micro Commercial Co.	1N4001-TP
911	Q2	transistor	PNP, 50mA, 50V, SOT-23	On Semiconductor	MMBT5087LT1
911	R14	resistor	4.7k, 1/10W, 5%, 0603	Rohm	MCR03EZPJ472
911	R15	resistor	4.3k, 1/10W, 5%, 0603	Rohm	MCR03EZPJ432
911	R16	resistor	10k, 1/10W, 5%, 0603	Rohm	MCR03EZPJ103
911	R17	resistor	51k, 1/10W, 5%, 0603	Rohm	MCR03EZPJ513
911	U3	IC	solid state current sensor	Clare	LDA100
APOH	D5	zener diode	30V, 225mW, SOT23	On Semiconductor	MMBZ5256BLT1
APOH	D6	zener diode	30V, 225mW, SOT23	On Semiconductor	MMBZ5256BLT1
APOH	R11	resistor	5.6k, 1/10W, 5%, 0603	Rohm	MCR03EZPJ562
APOH	R12	resistor	430, 1/10W, 5%, 0603	Rohm	MCR03EZPJ431
APOH	R13	resistor	4.3k, 1/10W, 5%, 0603	Rohm	MCR03EZPJ432
APOH	U4	IC	multifunction telecom switch	Clare	TS117
CID	C7	capacitor	0.1uF, 16V, X7R, 10%, 0603	Kemet	C0603C104K4RACTU
CID	C8	capacitor	0.1uF, 16V, X7R, 10%, 0603	Kemet	C0603C104K4RACTU
CID	D3	zener diode	3.0V, 225mW, SOT23	On Semiconductor	MMBZ5225BLT1
CID	D4	zener diode	3.0V, 225mW, SOT23	On Semiconductor	MMBZ5225BLT1
DAA	C1	capacitor	100pF, 50V, NP0, 5%, 0603	BC Components	VJ0603A101JXACW1BC
DAA	C2	capacitor	0.1uF, 16V, X7R, 10%, 0603	Kemet	C0603C104K4RACTU
DAA	C3	capacitor	0.01uF, 50V, X7R, 10%, 0603	BC Components	VJ0603Y103KXACW1BC
DAA	C4	capacitor	4.7uF, 50V, 20%, electrolytic, SMT	United Chemi-Con	EMVA500ADA4R7MD55G
DAA	C5	capacitor	10uF, 50V, 20%, electrolytic, radial	Panasonic-ECG	ECA-1HM100I
DAA	C6	capacitor	0.47uF, 250V, 20%, electrolytic, radial	Nichicon	UVR2ER47MED
DAA	D1	zener diode	18V, 500mW, DO-35	Microsemi	1N5248BDO35
DAA	D2	zener diode	18V, 500mW, DO-35	Microsemi	1N5248BDO35
DAA	E1	voltage suppressor	Sidactor, TO-92 package, 350V clamping voltage	Littelfuse	P3100EC
DAA	F1	fuse	1.25A, 250V, slow blow, SMT	Wickmann	4571250001
DAA	Q1	transistor	NPN, 1A, 350V, SOT223	On Semiconductor	BSP19AT1
DAA	R1	resistor	560, 1/10W, 5%, 0603	Rohm	MCR03EZPJ561
DAA	R10	resistor	10k, 0.5W, 5%, 1210	Panasonic-ECG	ERJ-P14J103U
DAA	R2	resistor	100k, 1/10W, 5%, 0603	Rohm	MCR03EZPJ104
DAA	R3	resistor	150k, 1/10W, 5%, 0603	Rohm	MCR03EZPJ154
DAA	R4	resistor	5.6k, 1/10W, 5%, 0603	Rohm	MCR03EZPJ562
DAA	R5	resistor	360, 1/10W, 5%, 0603	Rohm	MCR03EZPJ361
DAA	R6	resistor	4.7k, 1/10W, 5%, 0603	Rohm	MCR03EZPJ472
DAA	R7	resistor	30, 0.5W, 5%, 1210	Panasonic-ECG	ERJ-P14J300U
DAA	R7a	resistor	62, 1/4W, 5%, 1206	Yageo	RC1206JR-0762RL
DAA	R7b	resistor	62, 1/4W, 5%, 1206	Yageo	RC1206JR-0762RL
DAA	R8	resistor	51k, 1/10W, 5%, 0603	Rohm	MCR03EZPJ513
DAA	R9	resistor	27k, 1/10W, 5%, 0603	Rohm	MCR03EZPJ273
DAA	T1	transformer	low distortion, through-hole	Etal	P5233
DAA	U1	IC	V.32 bis wireline modem IC	CML Microcircuits	CMX869B
DAA	U2	IC	integrated telecom circuit	Clare	ITC107P

Table 2: CMX869B DAA Circuit Bill of Materials

5 Conclusion

The CML Microcircuits' CMX869B low-power V.32 bis wireline modem can serve in many applications, and most of these applications require specialized DAA circuitry to connect to the telephone network. Additional features such as Caller ID (CID) detection, 'another phone off-hook' (APOH) detection, and "911" detection are desirable for certain applications and can add to the complexity of the DAA circuit.

This application note describes a cost-optimized DAA circuit for the CMX869B, and other circuitry is also provided for the CID, APOH, and 911 detection functions. It is hoped that the information presented in this document will assist the designer by serving as a starting point for their own CMX869B implementation.

6 References

1. "Technical Requirements for Connection of Terminal Equipment To the Telephone Network", TIA/EIA/IS-968, July 2001, Table 4.12.
2. "Technical Requirements for Connection of Terminal Equipment To the Telephone Network", TIA/EIA/IS-968, July 2001, Figure 1

CML Microcircuits (UK) Ltd COMMUNICATION SEMICONDUCTORS	CML Microcircuits (USA) Inc. COMMUNICATION SEMICONDUCTORS	CML Microcircuits (Singapore) Pte Ltd COMMUNICATION SEMICONDUCTORS Singapore	China
Tel: +44 (0)1621 875500 **Fax:** +44 (0)1621 875600 **Sales:** sales@cmlmicro.com **Tech Support:** techsupport@cmlmicro.com	**Tel:** +1 336 744 5050 800 638 5577 **Fax:** +1 336 744 5054 **Sales:** us.sales@cmlmicro.com **Tech Support:** us.techsupport@cmlmicro.com	**Tel:** +65 67450426 **Fax:** +65 67452917 **Sales:** sg.sales@cmlmicro.com **Tech Support:** sg.techsupport@cmlmicro.com	**Tel:** +86 21 6317 4107 +86 21 6317 8916 **Fax:** +86 21 6317 0243 **Sales:** cn.sales@cmlmicro.com.cn **Tech Support:** sg.techsupport@cmlmicro.com

- www.cmlmicro.com -