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APPLICATION NOTE

A VERY LOW COST AND POWERFUL SOLUTION FOR V.23 APPLICATION : TS7514

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SUMMARY

1 - INTRODUCTION

The TS7514 is a single chip F.S.K. voiceband modem offering a real low cost powerful solution for all C.C.I.T.T. V.23 recommended standard applications.

Indeed, TS7514 integrates many possibilities and functionalities by requiring only very few external components.

Its Block Diagram is shown Figure 1.

The TS7514 main features are :

PROGRAMMABLE MODES :
- MODEM 75/1200 or 1200/75 bps (full duplex on 2 wire line),
- MODEM 75/75 or 1200/1200 bps (full duplex on 4 wire line),
- D.T.M.F. dialing,
- Analog test loop,

- Tone detection (ring, dialing, ...)

PROGRAMMABLE FUNCTIONS :
- Transmit/receive levels,
- Receive filter gain,
- Hysteresis and detection levels,
- Line monitoring level,
- Signalling frequency (2982Hz) level

ADDITIONAL FEATURES :
- Integrated duplexer,
- Auxiliary analog signal transmission (voiceband),
- Automatic bias distortion adjustment,
- Tax rejection filter (12 and 16kHz),
- Fixed compromise equalization,
- Standard low cost crystal (3.579MHz),
- C.M.O.S. technology,
- Less than 100mW power dissipation,
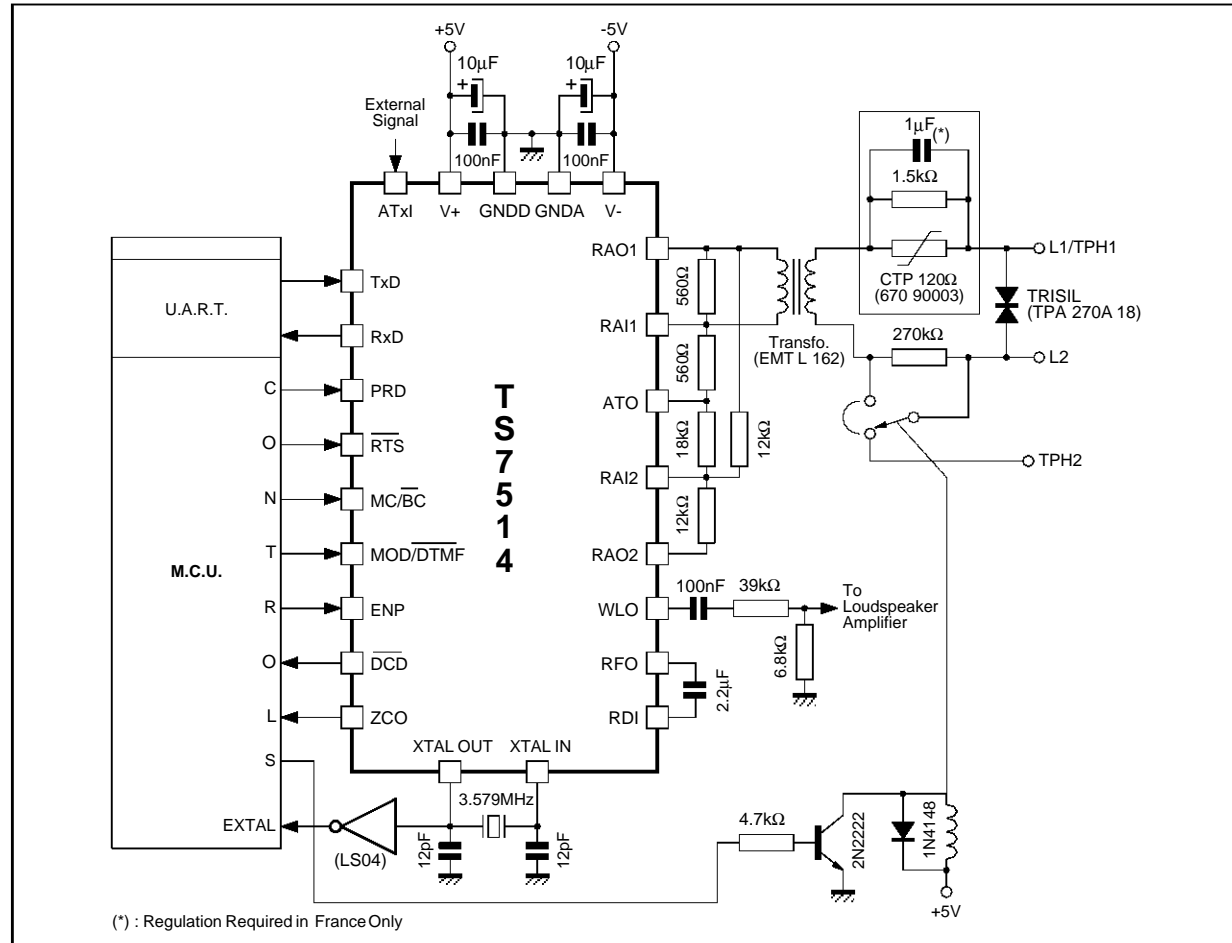- ± 5V supplies,
- 24 pin package.

Figure 1 : Detailed Block Diagram
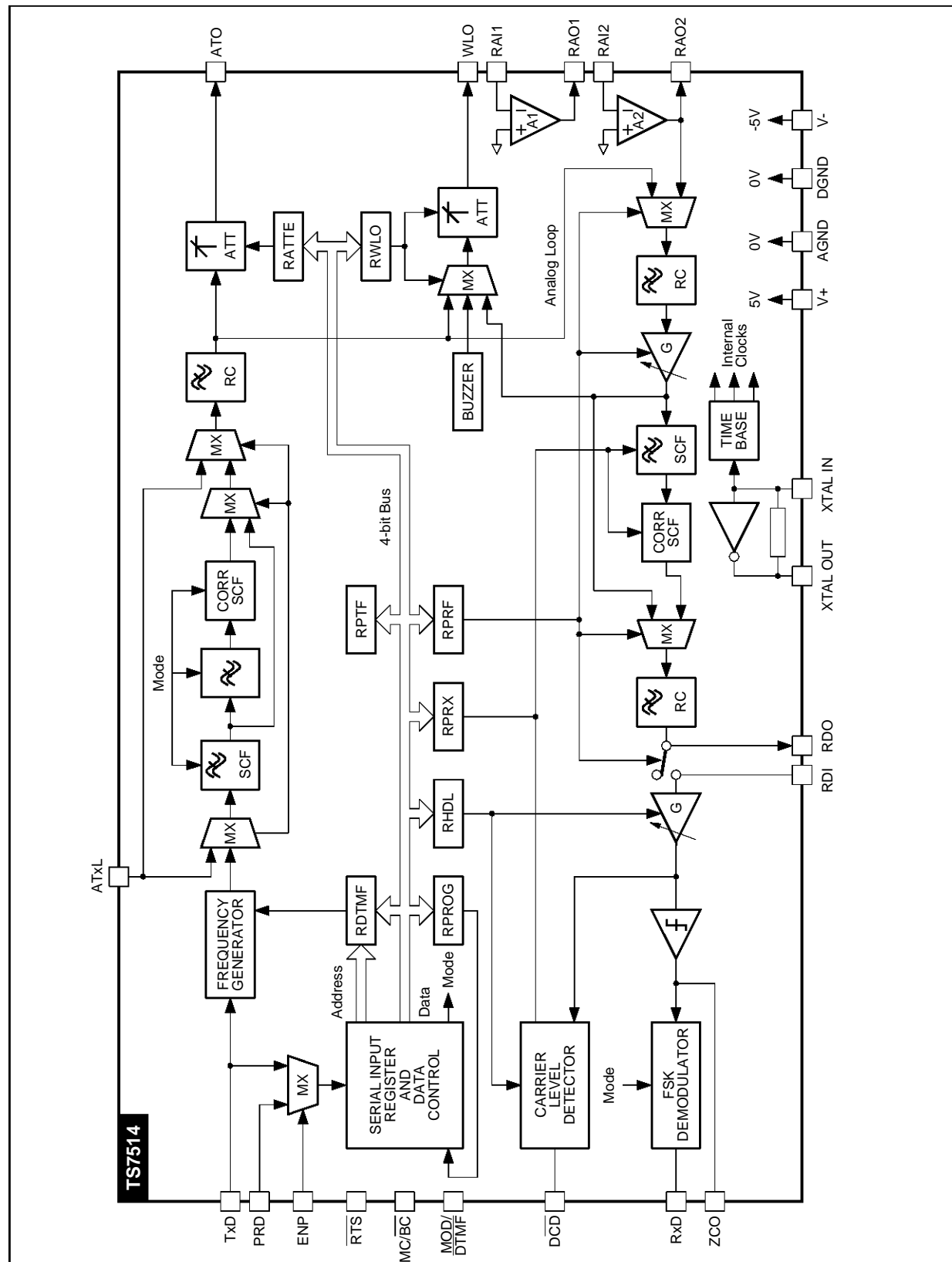
AN349-01.EPS

This Application Note describes some of the TS7514 most important features detailed before from a typical and simplified application scheme shown Figure 2 (more information are given in the following sheets).

Figure 2 : Typical Application Information

2 - PROGRAMMABLE MODE
2.1 - With What to Program ?

The TS7514 contains 8 control registers.
The programming used is serial where data input is TxD or PRD and clock input $\overline{RTS}$.

From now, it is important to point out that during programming, the $\overline{RTS}$ (Request To Send) signal and the TxD (Transmit Data) signal to be transmitted from the local terminal over the telephone line are internally safeguarded in order to not modify the transmission.
- By using TxD either to program or transmit data, only one signal has to be managed. In this case, you must take in care to program the TS7514 out

of the transitions between two successive data bits and during a maximum duration equal to a "bit time" (833.3μsec. in 1200 bps) to avoid transmission errors.
- By using PRD to program the TS7514 allows to use TxD only for data to be transmitted and avoids the preceeding cautions but requires the management of these two signals.

The choice will depend on the application (microcontroller used, number of I/O ports, ..)

TxD is selected by ENP = "0" ; PRD by ENP = "1".

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2.2 - How to Program ?

The programming is indirect via an 8 bit shift register, called input register, least significant bits first.

The 4 M.S.B.'s of the input register are the address of the control register to program ; the 4 L.S.B.'s the data.

The input register is selected by MOD/$\overline{\text{DTMF}}$ = MC/$\overline{\text{BC}}$ = "0".

Then, $\overline{\text{RTS}}$ (Request To Send) and TxD (Transmit Data) signals are internally safeguarded and the corresponding pins must be used as clock ($\overline{\text{RTS}}$) and data to be programmed (TxD).

The $\overline{\text{RTS}}$ clock, active on the falling edge, shifts the programming data available on TxD or PRD.

The transfer of programming data to the control register previously addressed is made by rising MOD/$\overline{\text{DTMF}}$ or MC/$\overline{\text{BC}}$.
From now, the $\overline{\text{RTS}}$ signal comes back to its previous functioning mode : Request To Send.

There are 2 cases of end of programming :
- At the end of programming of all the control registers, excepted RDTMF, MOD/$\overline{\text{DTMF}}$ rises to "1" while MC/$\overline{\text{BC}}$ indicates the channels used for transmission before programming ("0" for low channel transmission, "1" for high channel transmission).
- At the end of programming of RDTMF register only, MC/$\overline{\text{BC}}$ rises to "1" while MOD/$\overline{\text{DTMF}}$ and $\overline{\text{RTS}}$ are "0" during all the time of D.T.M.F. signal programmed transmission.

2.3 - Timing Diagrams
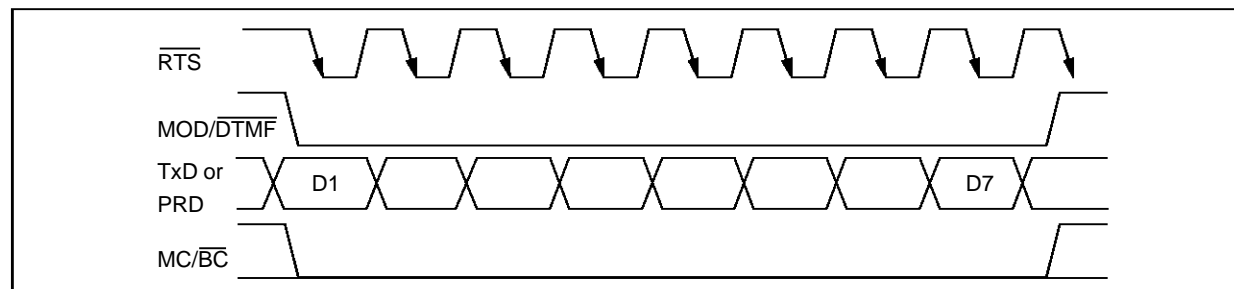
Figure 3 : Programming without Transmission

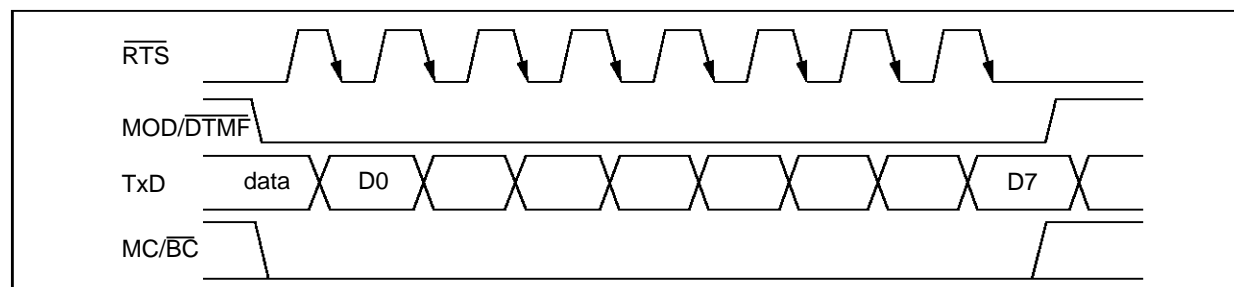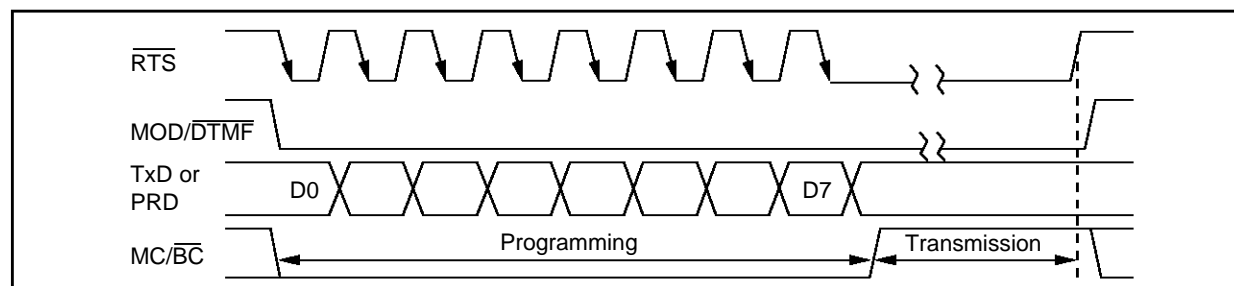**Figure 4 :** Programming during Transmission

Figure 5 : DTMF Programming and Transmission

3 - THE TS7514 REGISTERS

We are going to describe now the most important points to know about these eight control registers.

Note : In the following, all the bits described are the data bits of the control registers (X = don't care). For additional informations on these registers, refer to the TS7514 corresponding data sheet.

3.1 - Mode Register : RPROG

This control register allows to choose the functioning mode of the TS7514 : either two different or the same channels for transmit and receive.

The most used mode (power-up initialization) is the receive channel programmed in the opposite way to the transmit channel controlled by MC/BC pin. In this case, bits 2 and 3 must be programmed to "0".

If bit 3 is programmed to "0" while bit 2 is programmed to "1", then transmit and receive channels are the same (high channel if MC/BC is "1", low channel if MC/BC is "0").

This last mode can be used for the full duplex on 4 wire line modem functioning or for the test with an external analog loop between transmit and receive sections (this last mode is not a loop 3 (see RPRF register)).

3.2 - D.T.M.F. Register : RDTMF

This control register allows the D.T.M.F. dialing from the TS7514.

Bits 0 and 1 program the 4 low frequencies of the D.T.M.F. signal, bits 2 and 3 the 4 high frequencies.

This register is not initialized at the power-up.

The following table give the correspondance between the digit to be dialed and the data to be programmed.

Digit	D3	D2	D1	D0	Frequency (Hz)	
					Low	High
0	0	1	1	1	941	1336
1	0	0	0	0	697	1209
2	0	1	0	0	697	1336
3	1	0	0	0	697	1477
4	0	0	0	1	770	1209
5	0	1	0	1	770	1336
6	1	0	0	1	770	1477
7	0	0	1	0	852	1209
8	0	1	1	0	852	1336
9	1	0	1	0	852	1477
A	1	1	0	0	697	1633
B	1	1	0	1	770	1633
C	1	1	1	0	852	1633
D	1	1	1	1	941	1633
*	0	0	1	1	941	1209
"	1	0	1	1	941	1477

3.3 - Transmit Attenuation Register : RATTE

This control register allows to program a transmit attenuation from 0 (0000) to 13dB (1101), with 1dB step.

With such values, the analog transmit output level on ATO pin varies from + 4 (0000) to – 9dBm (1101).

Two programming values (1110 and 1111) allows an infinite attenuation.

Such attenuation is automatically programmed at the power-up initialization. So, a different attenuation will have to be programmed to transmit data (typically 0dBm (0100) on ATO pin).

3.4 - Line Monitoring Register : RWLO

This control register allows :
- to monitor the transmit signal from – 10 (0000) to – 40dB (0011) with 10dB step,
- to monitor the receive signal from 0 (0100) to – 30dB (0111) with 10dB step,
- to send a square wave signalling frequency (2982Hz) with a level comprised between – 4 (1000) and –34dBm (1011).

This register is initialized to 11XX (neither monitoring nor signalling transmission) at the power-up.

If a receive signal monitoring is programmed, it is possible to monitor also simultaneously the transmit signal on account of the non infinite rejection ratio of the hybrid (typically 20dB) and thanks to the TS7514 internal architecture (see Figure 1), the receive signal monitoring being implemented before the receive filter.

3.5 - Transmit Filter Register : RPTF

This control register allows to transmit on ATO pin one of the following signals :
- normal (power-up initialization) modem or D.T.M.F. signals (0000),
- external voiceband analog signal through :
  - smoothing filter and attenuator (0001),
  - low-pass filter and attenuator (0010),
  - band-pass filter and attenuator (0011),
- low frequency only (0100) in D.T.M.F. mode,
- high frequency only (1000) in D.T.M.F. mode.

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3.6 - Receive Filter Register : RPRF

This control register allows to program different configurations for the receive filter :
- receive filter gain of 0 (XX00), 6 (XX01) or 12dB (XX10),
- receive channel looped back on the transmit channel with a – 35dBm level and a 0dB gain (XX11) for analog test loop (loop 3),
- receive filter bypassed (X1XX) or not (X0XX),
- external connection (1XXX) via a 2.2μF non-polarized capacitor between RFO and RDI pins.

The external connection (bit 3 programmed to "1") with the capacitor is the most used mode to connect the receive filter output to the demodulator input.

Nevertheless, if an internal connection is used, bit 3 has to be programmed to "0" and external capacitor and connection between RFO and RDI pins have to be suppressed.

This register is initialized to X001 (receive filter enabled with 6dB gain) at the power-up.

3.7 - Detection Level and Hysteresis Register : RHCD

This register allows to control :
- the loss carrier detection level between – 41 (X000) and – 27dBm (X111) with 2dB step,
- the hysteresis between carrier detect on and off : 2.5 (0XXX) or 3.25 (1XXX) dB.

Be careful that the loss carrier detection level value (N2) is given related to the demodulator input (RDI). The on-line loss carrier detection level (NL) is obtained by substracting from N2 the receive filter and the hybrid gain values.

In consequence, the on-line detection level is obtained by adding to NL the hysteresis value.

This register is initialized to 0000 (– 41dBm for loss carrier detection level with a 2.5dB hysteresis) at the power-up.

3.8 - Receive Channel Register : RPRX

This control register allows to program different configurations for the receive channel :
- to use a wide (for data and tone detection) (XX0X) or a narrow (for data only) (XX1X) band filter for the receive low channel,
- to suppress (XXX1) or not (XXX0) the carrier detection delays for a "fast" carrier detection (DCD digital signal following the receive carrier signal level variations).

This register is initialized to XX00 (wide band filter and carrier detection delays) at the power-up.

4 - THE 4/2 WIRE CONVERSION : THE HYBRID

The TS7514 integrates two operational amplifiers. So, the hybrid implementation consists of selecting only 5 resistors in order to obtain the best adaptation and rejection possible.

With 5 % resistors and a transformer 600Ω/600Ω respecting the local agreement conditions, the hybrid so designed offers an ATO/RA02 rejection ratio upper than 20 dB.

Figure 6
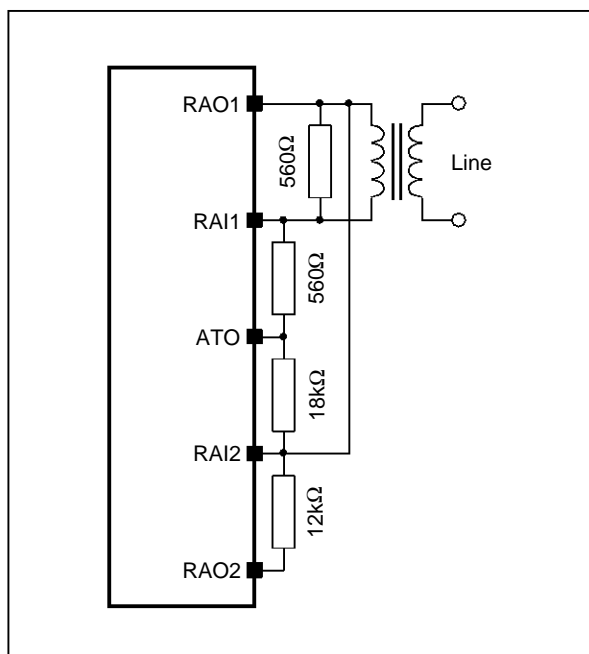
5 - THE D.T.M.F. DIALING

To dial a digit (0,..., 9, A, B, C, D,*,#) in D.T.M.F. consists of programming the RDTMF control register like an other register but leaving, at the end of programming, the MOD/DTMF and RTS signals to "0" during all the time desired (in practise, the time of pressing key on a dialer).

No external component is required for this dialing.

6 - RING DETECTION

Thanks to ZCO output, it is possible to obtain in a digital way the analog zero crossing signal available on the RA02 pin of the TS7514. Then, by not totally insulating the modem from the telephone line (L1, L2) and bypassing the receive filter, ZCO can deliver the digital form of the ringing signal that may be then processed by the microcontroller.

With the scheme given Figure 7, we avoid to use opto-coupler and other external associated components to detect ring, the only external components required being a resistor and a capacitor.

When the modem is connected to the telephone line (L1, L2), the components are bypassed (see relay) and the telephone set (TPH1, TPH2) disconnected.

The ringing signal (50Hz alternative voltage super-

imposed to the 50V telephone line voltage), is so attenuated by the resistor but the level is sufficient to be detected by the TS7514.

Do not forget during the detection to bypass the receive filter in the RPRF register (bit 2 programmed to "1").

So programmed, the TS7514 output on ZCO pin a 50Hz digital signal and on DCD pin the ring "enveloppe" (Figure 8).

Figure 7

Figure 8

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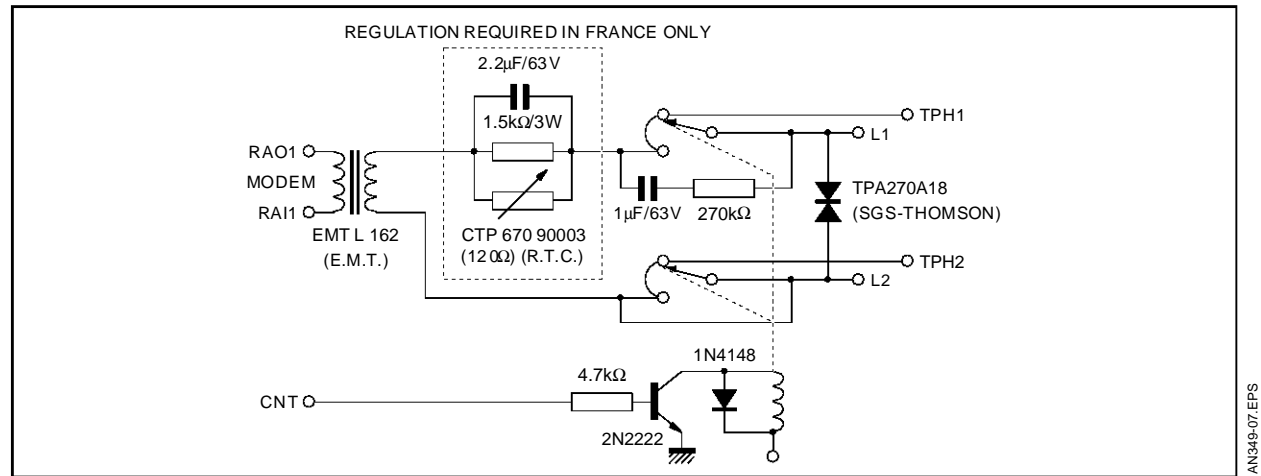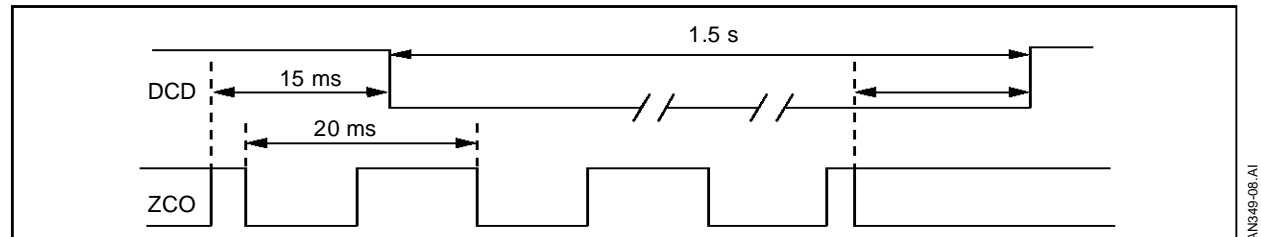
7 - ONE TRANSMISSION AND DETECTION
7.1 - 2100Hz Transmission (Figure 9)

To send the 2100Hz answer tone over the telephone line, the TS7514 must be programmed as follows :
- MOD/$\overline{\text{DTMF}}$ = "1" (modem),
- MC/$\overline{\text{BC}}$ = "1" (main channel),
- $\overline{\text{TxD}}$ = "0" (2100 Hz),
- $\overline{\text{RTS}}$ = "0" (transmission).

7.2 - 2100Hz Detection (Figure 10)

To detect the 2100Hz answer tone sended by the far-end modem, the TS7514 must be programmed as follows :
- $\overline{\text{RTS}}$ = "1" (no transmission),

- MOD/$\overline{\text{DTMF}}$ = "0" (tone detection),
- MC/$\overline{\text{BC}}$ = "0" (back channel).

So programmed, the TS7514 detects the 2100Hz answer tone on line if $\overline{\text{DCD}}$ = "0" (carrier detection) and RxD = "0" (2100Hz).

7.3 - Low Frequency Tone Detection (Figure 11)

To detect low frequency tones (typically the 440Hz dialing tone in France) ; the TS7514 must be programmed as follows :
- $\overline{\text{RTS}}$ = "1" (no transmission),
- MOD/$\overline{\text{DTMF}}$ = "0" (tone detection),
- MC/$\overline{\text{BC}}$ = "1" (main channel),

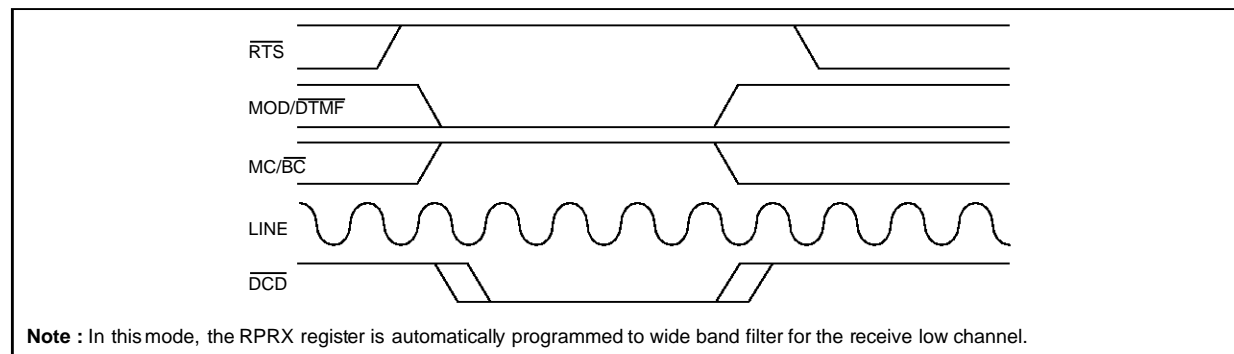Then, such tones are present on line if $\overline{\text{DCD}}$ = "0" (carrier detection).

Figure 9
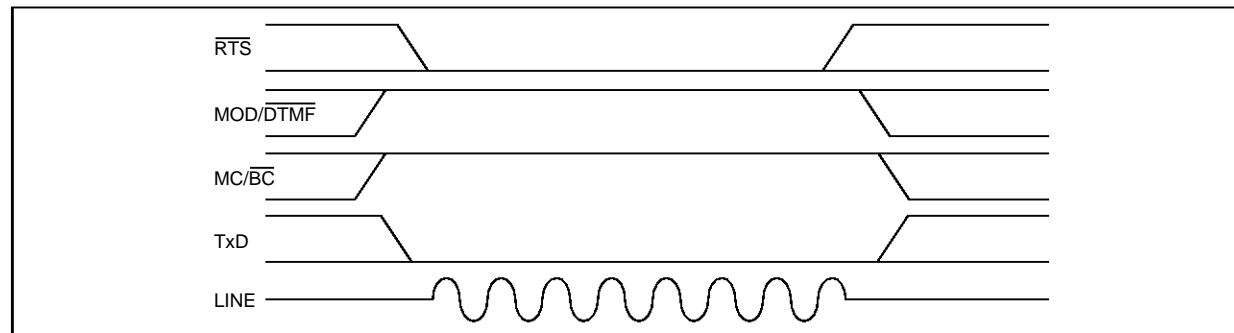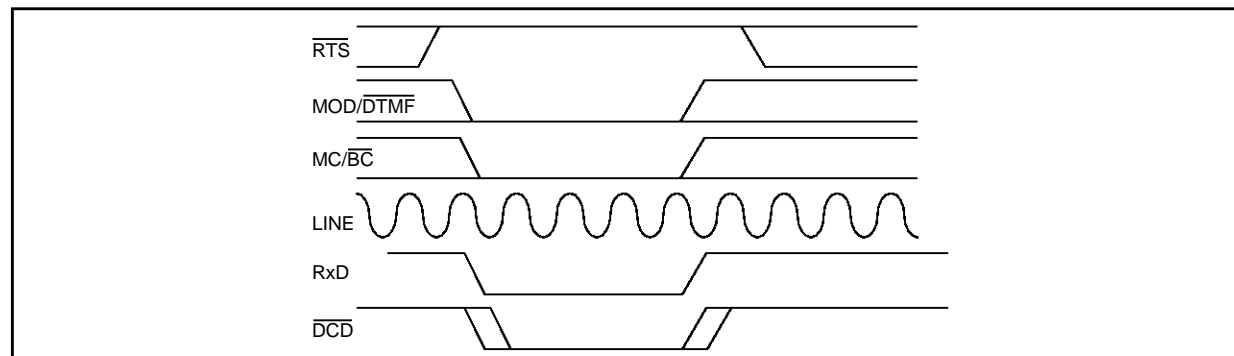
Figure 10

Figure 11

Note : In this mode, the RPRX register is automatically programmed to wide band filter for the receive low channel.

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8 - LINE MONITORING

To monitor the different signals present on the telephone line, Figures 12 and 13 give two typical loud-speaker amplifier application schemes.

Thanks to RWLO monitoring level programming register, no external potentiometer is required to adjust the volume.
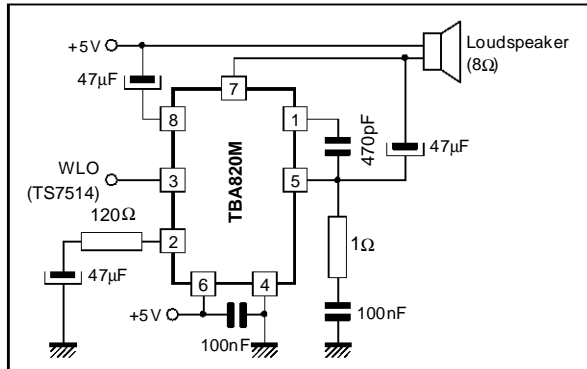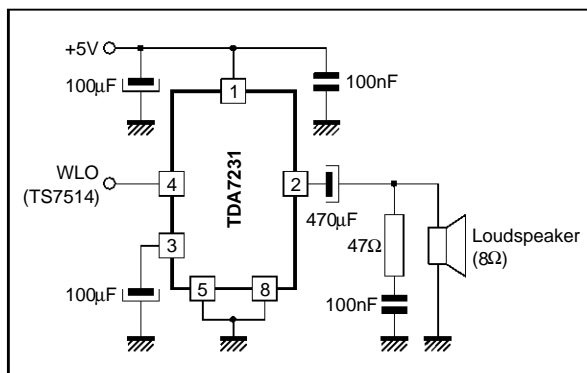
Figure 12

Figure 13

9 - OTHER FEATURES

- by ATxI, it is possible to send a voiceband signal over the telephone line,

- the XtalOUT may be used to implement via a buffer, the external clock of the microcontroller,

- the lay-out implementation must be as clean as possible in order to obtain the best electrical performances :
  - separation between analog and digital parts and tracks of the board,
  - analog and digital grounds separated and connected in a single point,
  - a ground plane for the component side,
  - a star distributed power supplies (idem for ground) to avoid any possible loop,
  - a maximum capacitive uncoupling as close as possible to the device,
  - a connection as short as possible between RFO and RDI via the external capacitor.

10 - CONCLUSION

We just saw, with this application note, the different functions and internal possibilities included in the TS7514 among which D.T.M.F. dialing, integrated duplexer, tone and ring detection and transmit and receive channel programmings are the most interesting.

For these features and all the others, only about 20 external passive components (resistors, capacitors, ...) are required (out of microcontroller interface) to implement a complete V.23 modem.

The TS7514 is a real low cost and powerful solution for all C.C.I.T.T. V.23 recommended standard applications.

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