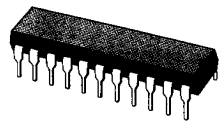
SINGLE CHIP ASYNCHRONOUS FSK MODEM

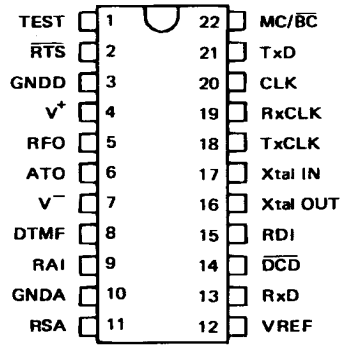
- MONOLITHIC DEVICE INCLUDING BOTH TRANSMIT AND RECEIVE FILTER
- PROGRAMMABLE MODES :
  - 75 BDS TRANSMIT / 1200 BDS RECEIVE
  - 1200 BDS TRANSMIT / 75 BDS RECEIVE
  - 1200 BDS FULL DUPLEX ON 4 WIRE LINE
  - ANALOG LOOPBACK
- FIXED COMPROMISE LINE EQUALIZER
- RECEIVE AND TRANSMIT CLOCKS FOR UART
- STANDARD LOW COST CRYSTAL (3.579 MHz)
- ± 5 % POWER SUPPLIES (+ 5 V, - 5 V)
- DTMF FILTER AND TAX REJECTION NOTCH-FILTER (kit with EFG7189 DTMF)
- 3.579 MHz CLOCK OUTPUT AVAILABLE



P
DIP22
(Plastic Package)

(Ordering Information at the end of the datasheet)

PIN CONNECTIONS



M88TS7513-01

DESCRIPTION

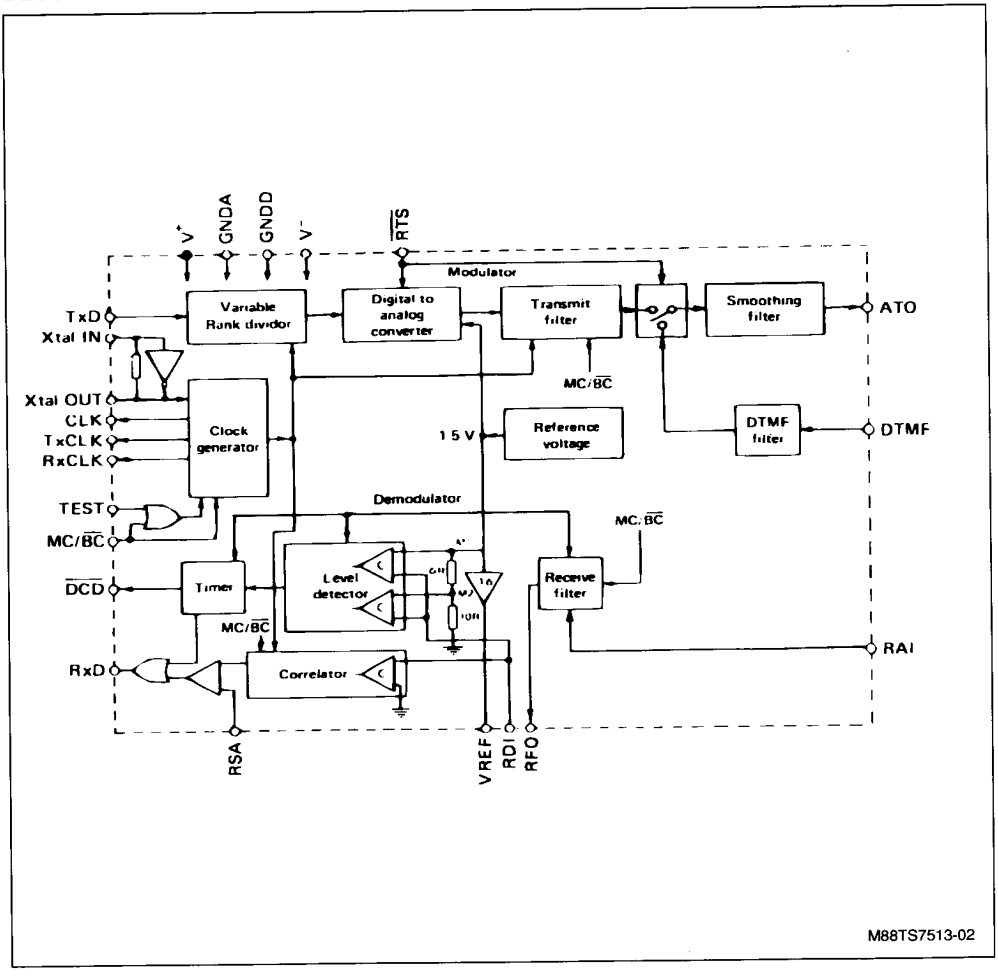
The TS7513 is a single chip asynchronous frequency shift keying voice-band modem. Operating at rates up to 75, 1200 bit per second, it is compatible with the applicable CCITT recommended standards for V.23 type modems. This device provides the essential CCITT V.24, V.25 and V.54 terminal control signals at TTL levels.

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V^+	Supply Voltage	+ 7 V	V
V^-	Supply Voltage	− 7 V	V
V_{in}	Analog Input Range	$V^- \leq V_{IN} \leq V^+$	V
V_I	Digital Input Range	$GNDD \leq V_I \leq V^+$	V
T_A	Operating Temperature Range	0 to 70	°C
T_{stg}	Storage Temperature Range	− 55 to + 125	°C
	Pin Temperature (soldering, 10 s)	260	°C

Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Standard CMOS handling procedures should be employed to avoid possible damage to device.

BLOCK DIAGRAM



ELECTRICAL CHARACTERISTICS

Symbol	Parameter	Min.	Nom.	Max.	Unit
V^+	Positive Supply Voltage	4.75	5.0	5.25	V
V^-	Negative Supply Voltage	– 5.25	– 5.0	– 4.75	V
I_{CC}	V^+ Operating Current	–	–	20	mA
I_{BB}	V^- Operating Current	– 15	–	–	mA

D.C. AND OPERATING CHARACTERISTICS

(T_A = 0 °C to + 70 °C, V^+ = + 5 V ± 5 %, V^- = – 5 V ± 5 %, GNDA = 0 V, GNDD = 0 V, unless otherwise noted).

DIGITAL INTERFACE (TEST, $\overline{RTS}$, $\overline{DCD}$, RxD, TxCLK, RxCLK, CLK, TxD, MC/$\overline{BC}$)

Symbol	Parameter	Min.	Typ. (1)	Max.	Unit
I_I	Input Current ($V_{IL\ min} \leq V_I \leq V_{IH\ max}$)	–	–	10	µA
I_{OL}	Output Low Level Current (V_{OL} = 0.4 V)	1.6	–	–	mA
I_{OH}	Output High Level Current (V_{OH} = 2.8 V)	–	–	– 250	µA
V_{IL}	Input Low Voltage	GNDD	–	0.8	V
V_{IH}	Input High Voltage	2.4	–	V^+	V

ANALOG INTERFACE, RECEIVE FILTER (DTMF, RAI, RFO)

Symbol	Parameter		Min.	Typ. (1)	Max.	Unit
I_{BRI}	Input Leakage Current, (– 3 V < V_{IN} < 3 V)	DTMF, RAI	–	± 1	± 3	µA
R_{IRI}	Input Resistance,	DTMF, RAI	1	3	–	MΩ
V_{OGSR}	Output Offset Voltage,	RFO	–	–	± 300	mV
V_{ORI}	Output Voltage Swing, (RL ≥ 10 kΩ)	RFO	–	–	± 3	V
C_{LRI}	Load Capacitance,	RFO	–	–	20	pF
R_{LRI}	Load Resistance,	RFO	10	–	–	kΩ
V_{IRI}	Input Voltage Swing,	RAI	– 2	–	+ 2	V
V_{ID}	Input Voltage Swing	DTMF	– 3	–	+ 3	V
C_{DPR}	Signal Frequency Distortion Products at Maximum Signal Level	RFO	–	– 40	–	dB

ANALOG INTERFACE RECEIVE DEMODULATOR INPUT (RDI)

Symbol	Parameter	Min.	Typ. (1)	Max.	Unit
I_{in}	Input Current	– 1	–	1	µA
N_1	Maximum Detection Level to Valid $\overline{DCD}$ Output	1.2	1.4	1.6	V_p
N_2	Minimum Detection Level to Valid $\overline{DCD}$ Output	–	1.0	–	V_p
N_1/N_2	Hysteresis Effect	2.3	3	4	dB

ANALOG INTERFACE, RECEIVE SLICER ADJUST (RSA)

Symbol	Parameter	Min.	Typ. (1)	Max.	Unit
I_{in}	Input Current	– 1	–	+ 1	µA
V_I	Input Voltage	V_{REF}	$V_{REF}/2$	GNDA	V

(1) Typical values are for T_A = 25 °C and nominal power supply values.

D.C. AND OPERATING CHARACTERISTICS (continued)

ANALOG INTERFACE, TRANSMIT OUTPUT (ATO)

Symbol	Parameter		Min.	Typ. (1)	Max.	Unit
V_{OS}	Output DC Offset, ($\overline{RTS}$ connected to V^+)		–	–	± 250	mV
C_L	Load Capacitance		–	–	20	pF
R_L	Load Resistance		10	–	–	kΩ
V_O	Output Voltage Swing (R_L = 10 kΩ, C_L = 20 pF)	390 Hz	2.8	–	3.6	V_{pp}
–		450 Hz/390 Hz Ampl. Ratio	0	–	1	dB
V_O		1300 Hz	2.8	–	3.6	V_{pp}
–		2100 Hz/1300 Hz Ampl. Ratio	0	–	1	dB
–	$\overline{RTS}$ Attenuation Ratio Efficiency		55	–	–	dB

ANALOG INTERFACE, REGULATED VOLTAGE (V_{REF})

Symbol	Parameter	Min.	Typ. (1)	Max.	Unit
V_{OR}	Output Voltage	– 2.6	– 2.2	– 1.8	V
R_{LR}	Load Resistance	10	–	–	kΩ
C_{LR}	Load Capacitance	–	–	20	pF

(1) Typical values for T_A = 25 °C and nominal power supply values.

DYNAMIC CHARACTERISTICS

RECEIVE FILTER TRANSFER CHARACTERISTICS

Symbol	Parameter		Min.	Typ.	Max.	Unit
G_{AR}	Absolute Passband Gain at 1300 Hz	(V_{RFO}, R_L = ∞)	0.9	1.5	2.6	dB
G_{RR}	Gain Relative to Gain at 1300 Hz (maximum input signal) (2)	390 Hz	–	– 60	– 50	dB
		450 Hz	–	– 60	– 48	dB
		2100 Hz	2.8	3.1	4	dB
		2900 Hz	– 30	–	– 17	dB
		12000 Hz	–	– 45	– 40	dB
G_{AR}	Absolute Passband Gain at 390 Hz	(V_{RFO}, R_L = ∞)	0.9	1.5	2.6	dB
G_{RR}	Gain Relative to Gain at 390 Hz (maximum input signal)	450 Hz	1	1.5	2	dB
		800 Hz	– 30	–	20	dB
		1300 Hz	–	– 50	– 48	dB
		2100 Hz	–	– 55	– 50	dB
		12000 Hz	–	– 45	– 40	dB

DTMF FILTER TRANSFER CHARACTERISTICS

Symbol	Parameter		Min.	Typ.	Max.	Unit
G_{AR}	Absolute Passband Gain at 100 Hz		–	0	–	dB
G_{RR}	Gain Relative to Gain at 100 Hz	1000 Hz	– 1	0	+ 1	dB
		3400 Hz	–	– 3	– 2	dB
		10000 Hz	–	–	– 20	dB

DYNAMIC CHARACTERISTICS (continued)

DIGITAL INTERFACE

Symbol	Parameter	Min.	Typ. (1)	Max.	Unit
C_{IB}	Capacitance	–	–	10	pF
t_{THL}, t_{TLH}	Input Rise-time, Fall-time, measured between 0.8 V and 2.4 V	–	–	100	ns
t_{THL}, t_{TLH}	Output Rise-time, Fall-time between 0.4 V and 2.8 V (3)	–	50	–	ns

(1) Typical values are for $T_A = 25°C$ and nominal power supply values
(2) This value refers to the integrated receive filter only, measured at RFO. The rejection value for the complete reception part must take into account the band-pass filter of the peak limiter (refer to CALCULATION OF CIRCUIT ELEMENTS). In this case the maximum gain relative to gain at 1300 Hz is – 60 dB at 16 kHz.
(3) Driving one 74L or 74LS TTL load plus 30 pF.

PIN DESCRIPTION

COMMON SECTION

N°	Name	Function	Description
4 7	V^+ V^-	Positive Power Supply Negative Power Supply	+ 5 V – 5 V
10	GNDA	Analog Ground	Pin 10 serves as the ground return for the analog circuits of the transmit and receive section. The analog ground is not internally connected to the digital ground. The digital and analog grounds should be tied together as close as possible to the system supply ground.
3	GNDD	Digital Ground	Pin 3 serves as the digital ground return for the internal clock. The digital ground is not internally connected to the analog ground. The digital and analog grounds should be tied together as close as possible to the system supply ground.
17	Xtal IN	Oscillator Input	This pin corresponds to the input of the inverter of the oscillator. It is normally connected to an external crystal, but may also be connected to a pulse generator. The nominal frequency of the oscillator is 3.579 MHz.
16	Xtal OUT	Oscillator Output	This pin corresponds to the output of an inverter with sufficient loop gain to start and maintain the crystal oscillating.
12	VREF	Regulated Voltage	This output carries an internally regulated voltage. By means of an external potentiometer connected between VREF and GNDA, an adjustable reference voltage may be applied to RSA. The adjustment of RSA is to optimize the discrimination of high anf low frequencies of the same channel. The voltage applied to RSA is approximately VREF/2.
20	CLK	Clock	This output delivers a clock signal, the frequency of which is 3.579 MHz.
22	MC/$\overline{BC}$	Main Channel/Back Channel	This input selects transmission on the main channel or back channel and defines the modulation rate according to the European standards. (refer to functional description).

PIN DESCRIPTION (continued)

TRANSMIT SECTION

N°	Name	Function	Description
2	$\overline{RTS}$	Request to Send	When a low state is present on input $\overline{RTS}$, the TS7513 delivers on output ATO a sinusoidal signal at a frequency which depends on input TxD. When a high state is present on input $\overline{RTS}$, output ATO is connected to DTMF filter.
21	TxD	Transmit Data	This input selects the high frequency or low frequency at the Analog transmit output pin (ATO) : • a high state selects the low frequency, • a low state selects the high frequency.
18	TxCLK	Transmit Clock	This output delivers a clock signal, the frequency of which is 16 times the modulation rate (± 1 %). The logic state duration is compatible to the UART clock specification.
6	ATO	Analog Transmit Output	When a low state is present on $\overline{RTS}$, the TS7513 delivers on output ATO a sinusoidal signal centered on the analog ground.

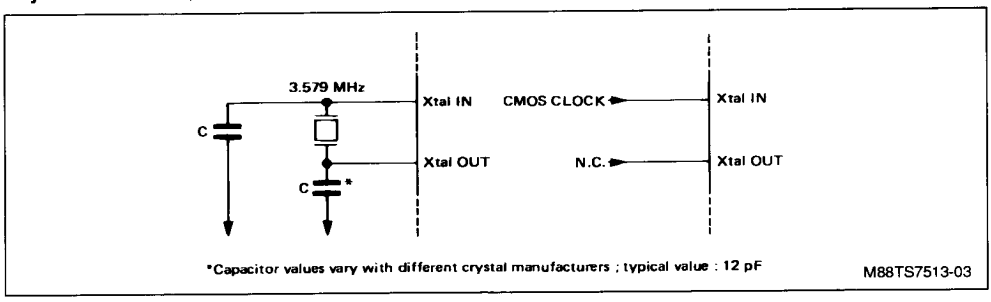
RECEIVE SECTION

N°	Name	Function	Description
1	TEST	Loop Back Mode	When high, the demodulator is tuned on the transmission modulation rate to the loop back mode or to the 4 wires full duplex operation mode. When TEST is low, the modem is in normal operating mode.
5	RFO	Receiver Filter Output	This analog output must be connected to a high-pass filter and slicer, with sufficient gain to satisfy the level detection conditions.
8	DTMF	Dual Tone Multifrequency Input	Analog input receiving a signal from a dual tone multifrequency generator. Transmitted spectrum of DTMF signal matches the gauge in Annex III.
9	RAI	Receive Analog Input	Input for modulated analog signal of amplitude lower than 4 V peak to peak and centered on analog ground.
15	RDI	Receive Demodulator Input	This is input of the demodulator. The analog signals are passed through level detection comparators and zero crossing detector.
11	RSA	Receive Slicer Adjust	Input of the decision comparator optimizing discrimination between high and low frequencies.
14	$\overline{DCD}$	Data Carrier Detect	This output is low when TS7513 receives on input RDI a signal with amplitude higher than N1 This output is high when the TS7513 receives on input RDI a sinusoidal signal with amplitude lower than N2. Within the N1 – N2 range, the detection system presents an hysteresis.
13	RxD	Receive Data	This output is low when a high frequency signal is present on input RDI, and high when a low frequency signal is present on input RDI. Without carrier on pin RAI, this output is high.
19	RxCLK	Receive Clock	This output delivers a clock signal, the frequency of which is 16 times the demodulation rate (± 1 %). The logic state duration is compatible to the UART clock specification.

FUNCTIONAL DESCRIPTION

CLOCK GENERATION

Crystal : NYMPH, NYP 035A – 18



With a minimum number of external components, the TS7513 performs all the functions of modulation, demodulation and filtering necessary to meet the requirements of CCITT Recommandation V.23.

This circuit is in five parts :

- a modulator
- a demodulator
- a clock generator
- a reference voltage generator
- a DTMF filter.

Note : The description of the demodulator also covers a subsystem, external to the circuit proper and having the following functions (refer to paragraph CALCULATION OF CIRCUIT ELEMENTS).

- Band-pass filter
- amplification
- slicer.

MODULATOR

When input $\overline{RTS}$ is low, output ATO delivers a sinusoidal signal, the frequency of which depends on MC/BC and TxD.

DEMODULATOR

When the analog signal on RDI conforms to certain criteria, output DCD detects it and output RxD delivers a digital signal, the logic state of which depends on the analog signal frequency.

CLOCK GENERATOR

This part of the circuit generates from a 3.579 MHz crystal all the internal clocks necessary to the correct performance of the TS7513 : the clocks for the switched capacitor filters as well as those for the sinewave generator. The circuit delivers on RxCLK and TxCLK, the transmit and receive clocks for the UART. It also delivers on CLK a buffered clock at 3.579 MHz.

REFERENCE VOLTAGE GENERATOR

This part of the circuit generates a regulated voltage on VREF which is used to adjust detection thresholds. It is independent of power supply values.

DTMF FILTER

This part of the circuit receives a signal from a dual tone multi-frequency generator and transmit through ATO a filtered signal when RTS is high.

FUNCTIONAL CHARACTERISTICS

MODULATOR

• Modulation Conditions :

$\overline{RTS}$	ATO
" L "	FSK Modulated Signal
" H "	DTMF Signal

• **Transmitted Frequencies :**
(for details of frequency selection see PIN DESCRIPTION – ATO)

MC/$\overline{BC}$	Modulation Rate	TxD	R.35 and V.23 Recommandations (Hz)	Frequency Generated from a 3.579 MHz Crystal	Error (Hz)
GNDD	75 Bauds	"H" "L"	390 ± 2 450 ± 2	389.52 450.20	– 0.48 + 0.20
V^+	1200 Bauds	"H" "L"	1300 ±10 2100 ± 10	1299.70 2097.40	– 0.34 – 2.61

DEMODULATOR

• **Frequencies Receive on RDI**

Analog signals centered on analog ground are received on input RDI.

RECEIVE DEMODULATION RATE
The receive Demodulation Rate Depends on MC/$\overline{BC}$ and TEST Input as Follows :

MC/BC	TEST	Demodulation Rate	Frequencies (recommendation V 23)
H	H	1200	1300 ± 16 2100 ± 16
L	H	75	390 450
H	L	75	390 450
L	L	1200	1300 ± 16 2100 ± 16

• **Level detection conditions**

Input RDI drives a signal detector the output of which (DCD) is at logic "0" if the level of signal RDI is higher than N1. The output of this detector is at logic "1" if the level of the signal RDI is lower than N2. This detector has an hysteresis effect : N1/N2.

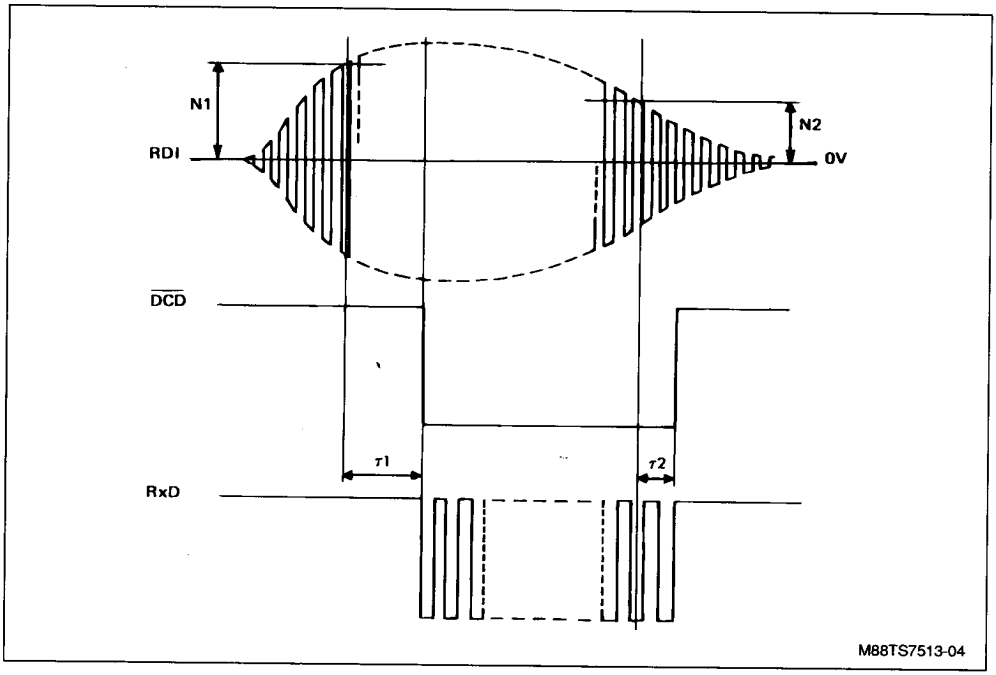
• **Timing detection conditions**

The timing performance of the level detector ($\overline{DCD}$) conforms to CCITT Recommendation V.23.

Under normal working conditions, output $\overline{DCD}$ is :

- low if signal RDI conforms to the level detection condition,
- high if signal RDI does not conform to the level detection conditions.

Output $\overline{DCD}$ goes from high to low when signal RDI conforms to the level detection conditions for 15 ms or more (respectively 15 ms for 75 bauds).
Output $\overline{DCD}$ does not go from high to low when signal RDI conforms to the level detection conditions for 10 ms or less (respectively 10 ms for 75 bauds).
Output $\overline{DCD}$ goes from low to high when signal RDI does not conform to the level detection conditions for 15 ms or more (respectively 30 ms for 75 bauds).
Output $\overline{DCD}$ does not go from low to high when signal RDI does not conform to the level detection conditions for 10 ms or less (respectively 20 ms for 75 bauds).
Note : Each transition on the MC/BC input sets the DCD output to the logical high level and initiate the detection timing.



Modulation Rate	DCD Transition	Min.	Typ. (1)	Max.	Unit
1200 bds	τ 1	10	12	15	ms
	τ 2	10	12	15	ms
75 bds	τ 1	10	15	20	ms
	τ 2	20	30	40	ms

(1) Typical values for T_A = 25 °C and nominal power supply values.

• **Demodulated Signal**

Under Normal Working Conditions, signal RxD Conforms to the Following Table :

Demodulation Rate	Level Received on RDI	DCD	Frequency Received on RAI (Hz)	RxD
1200 bds	> N1	" L "	1300	" H "
	> N1	" L "	2100	" L "
	< N2	" H "	" X "	" H "
75 bds	> N1	" L "	390	" H "
	> N1	" L "	450	" L "
	< N2	" H "	" X "	" H "

REFERENCE VOLTAGE GENERATOR
The VREF output carries a regulated reference voltage.
An external potentiometer, connected between VREF and GNDA, can supply a regulated voltage to input RSA.
Adjustement of RSA optimizes the discrimination between the high and low frequencies.

CALCULATION OF CIRCUIT ELEMENTS

The following factors must be considered in calculating the external components in the TS7513 application :

- Signal amplification introduced by the receive filter is 1.5 dB/1300 Hz.
- The maximum permissible level at RAI input is 4 Vpp (+ 5 dBm).

Note : the reference frequencies are 1300 and 390 Hz.

- A 2.5 dB hysteresis is introduced within the two signal detection level N1 and N2, in accordance with CCITT Recommendation V.23.

To be centered, the two limit values of the CARRIER DETECT signal are therefore :

- Upper : - 43 dBm, or 15.5 mV_{PP}
- Lower : - 48 dBm, or 8.7 mV_{PP}

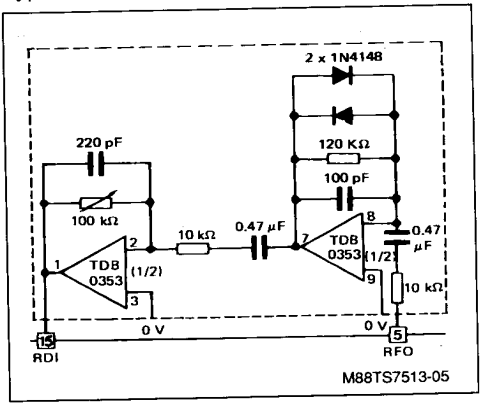
- For a correct operation of the TS7513 signal detector, the peak-limiting filter must remain linear up to - 43 dBm on line.
- At input RDI, the upper threshold level N1 of the signal detector is 2.8 VPP (2.1 dBm), and must correspond to the minimum signal level received from the line transformer. With a duplexer reception gain of + 6 dB, the peak-limiting filter gain is defined by :

A = 43 - 6 - 1.5 + 2.1 = 37.6 dB (a ratio of 76).

Note : The peak-limiting filter gain must be adjusted according to the minimum level on line. With a minimum level of :

- 38 dBm, A = 32.6 dB
- 33 dBm, A = 27.6 dB

Typical Peak-limiting Filter Configuration



ENVIRONMENTAL FUNCTIONAL DESCRIPTION (refer to typical application)

Transmit section

The transmit section comprises a single operational amplifier capable of driving a load of 600Ω , which can also be used to adjust the transmit level.

Duplexer

This amplifier provides the 2 wire/4 wire separation function and enables a low cost standard non differential transformer (ratio 1:1) to be used. The duplexer principlze provides a gain of 6 dB for the received signal.

Peak-limiting filter

This section is made of two operational amplifiers and performs three functions :

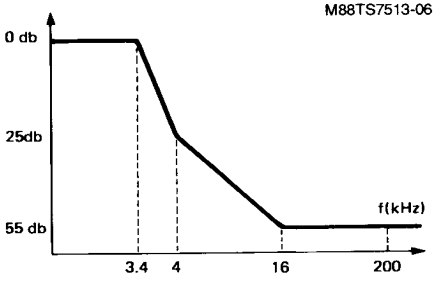
- peak-limiting amplifier, designed to meet the signal detector levels according to the signal received from the phone line.
- High-pass filter (12 dB per octave) to overcome the DC component of the signal to be demodulated.
- Low-pass filter to protect against the inherent noise of the receive filter.

TYPICAL PERFORMANCES

These typical performances are achieved with the measuring equipment described in Annex I.

• Transmitted spectrum

On output ATO, the transmitted out of band signal energy must conform to the following specification :



• Receiver

Measurement conditions

Local transmit level : - 10 dBm.
Receive level : - 25 dBm, with 511 bit pseudo-random test pattern.

Isochronous distortion

Table below shows the typical isochronous distortion values obtained with the TS7513, which conform to the french CCETT specifications for videotext applications. The characteristics of CCETT lines used for measurements are given in Annex II.

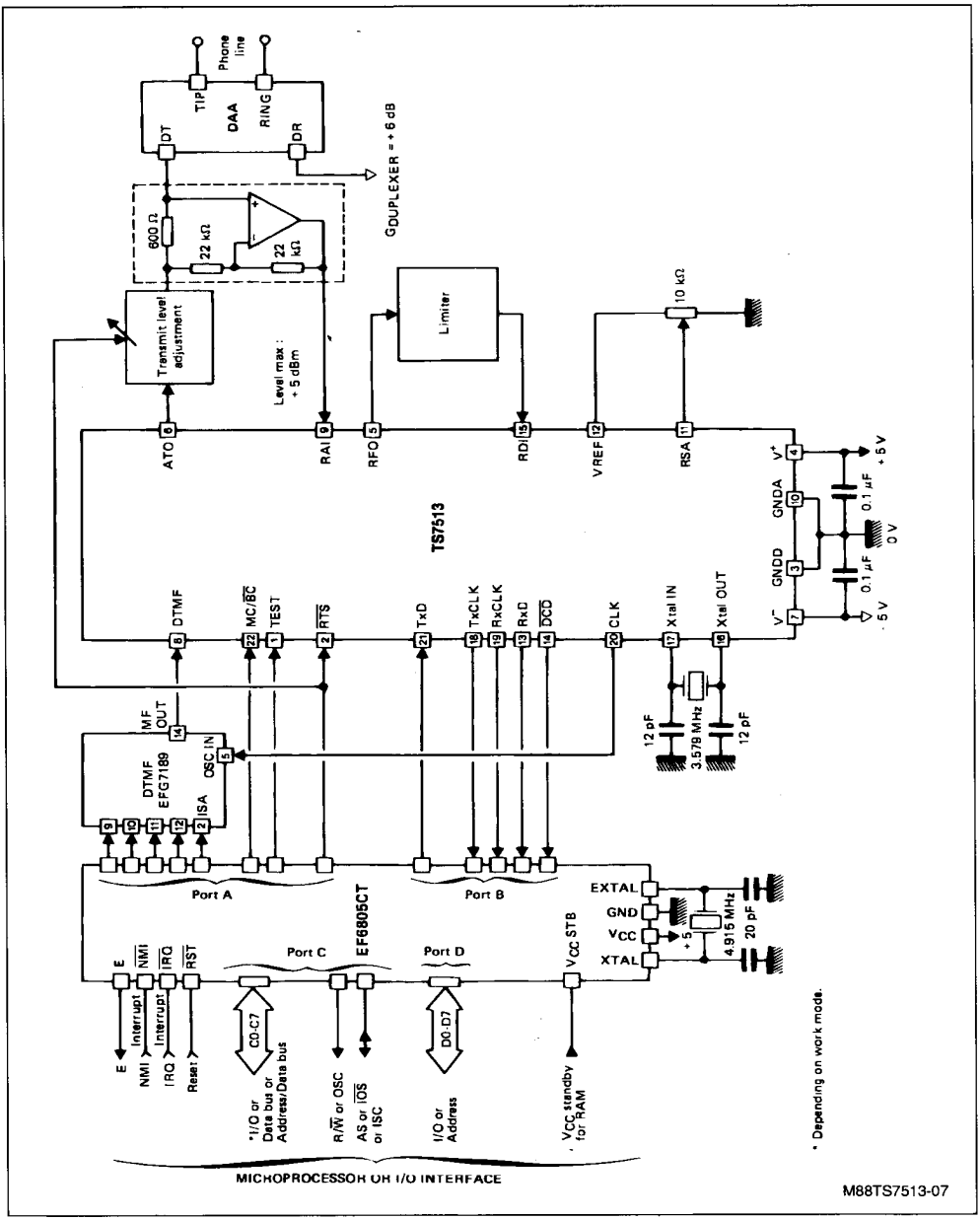
Line	1200 bds Reception	75 bds Reception
Line 1 (flat)	10 %	4 %
Line 2	12 %	4 %
Line 3	18 %	6 %
Line 4	12 %	6 %

BIT ERROR RATE

The typical bit error rates versus white noise are as follows.

	1200 bds Reception		75 bds Reception	
	S/N	BER	S/N	BER
on Line 1	6 dB	2.10^{-3}	– 1 dB	7.10^{-4}
on Line 2	7 dB	5.10^{-4}	– 1 dB	7.10^{-4}
on Line 3	9 dB	5.10^{-4}	0 dB	5.10^{-4}
on Line 4	8 dB	2.10^{-4}	0 dB	5.10^{-4}

TS7513 : Typical Application.

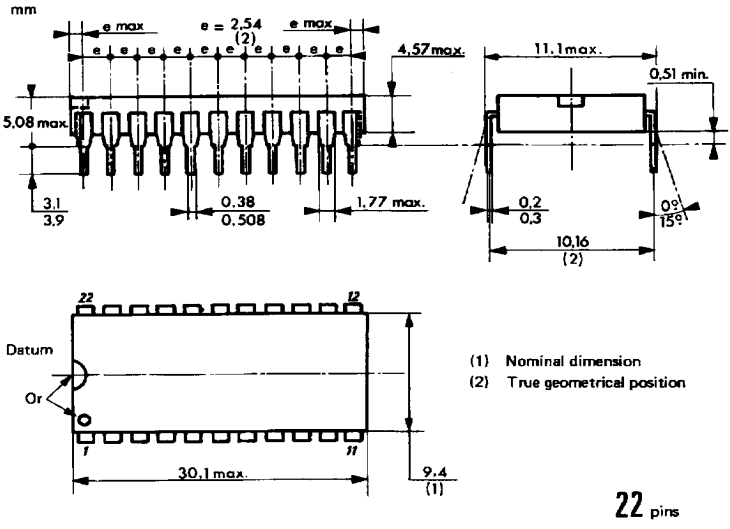


ORDERING INFORMATION

Part Number	Temperature Range	Package
TS7513CP	0 to + 70 °C	DIP 22
TS7513IP	– 40 to + 85 °C	DIP 22

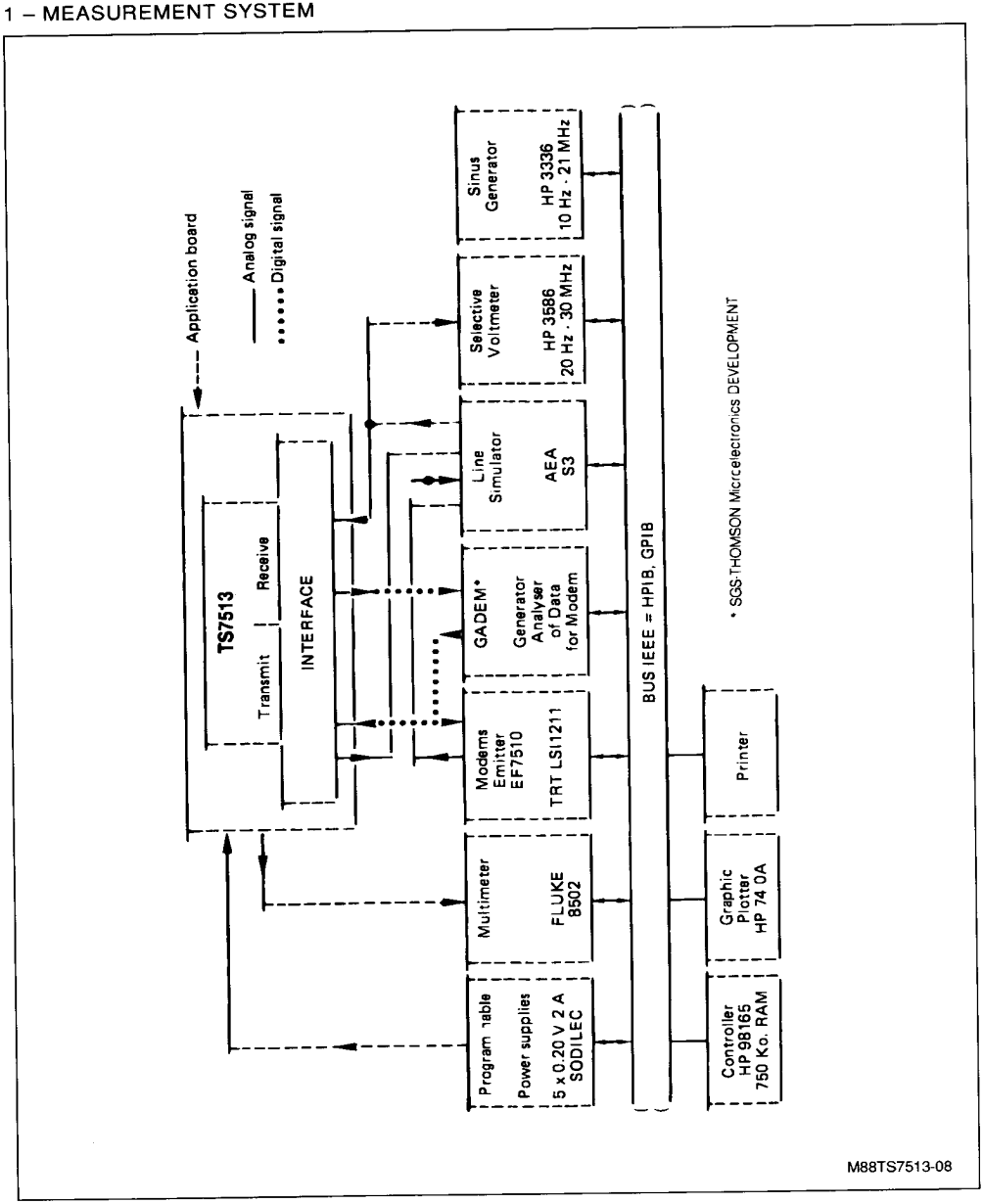
PACKAGE MECHANICAL DATA

22 PINS - PLASTIC DIP



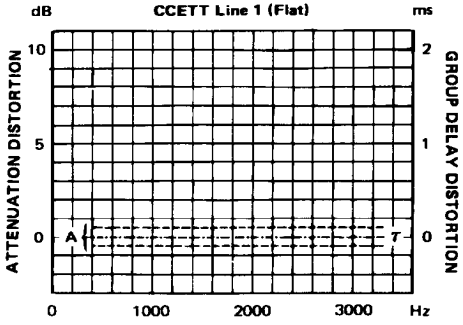
APPENDIX 1

1 – MEASUREMENT SYSTEM

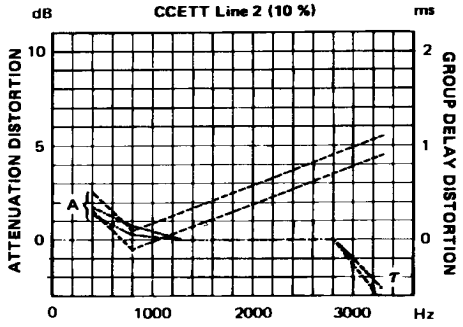


APPENDIX 2

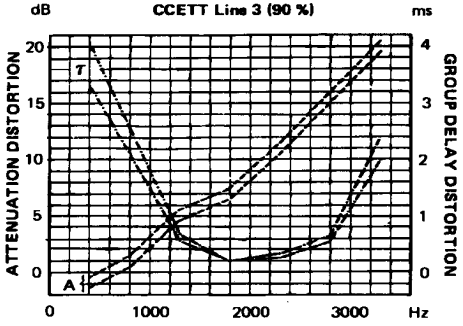
CHARACTERISTICS OF TEST LINES



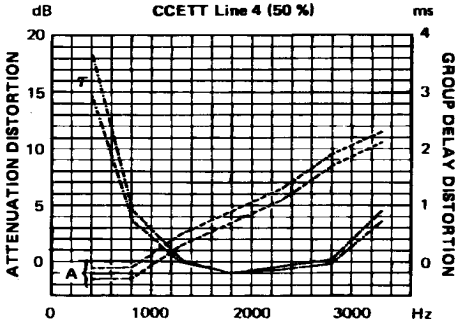
M88TS7513-11



M88TS7513-12

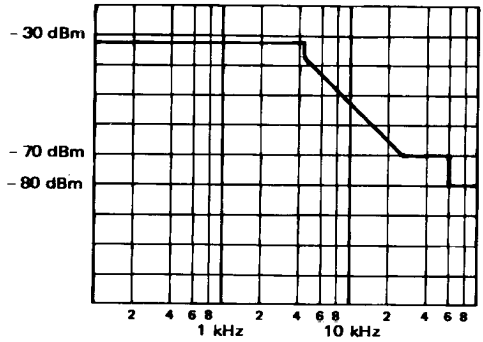


M88TS7513-11



M88TS7513-12

SPECTRUM OF DTMF SIGNAL



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K17 CCITT specification for telephone set gauge