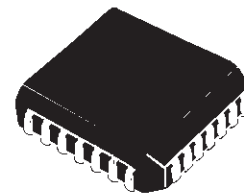


POWER LINE MODEM

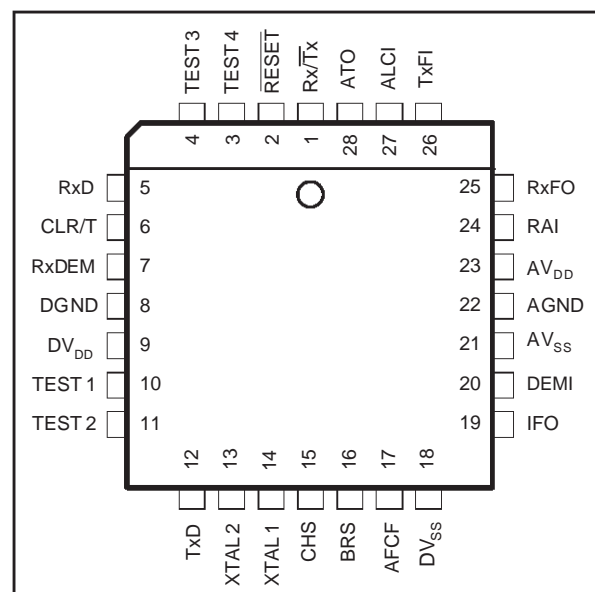
- HALF DUPLEX SYNCHRONOUS FSK MODEM
 - TWO PROGRAMMABLE CHANNELS FOR 600BPS DATA RATE
 - TWO PROGRAMMABLE CHANNELS FOR 1200BPS DATA RATE
- AUTOMATICALLY TUNED Rx AND Tx FILTERS
- TX CARRIER FREQUENCIES SYNTHESIZED FROM EXTERNAL CRYSTAL
- LOW DISTORTION Tx SIGNAL ($S/H2 \geq 50dB$)
- AUTOMATIC LEVEL CONTROL ON Tx SIGNAL
- Rx SENSITIVITY: $2mV_{RMS}$ (600bps)
 $3mV_{RMS}$ (1200bps)
- Rx CLOCK RECOVERY
- POWER-DOWN MODE
- SUITABLE TO APPLICATION IN ACCORDANCE WITH DH028/29 ENEL, EN50065-1 CENELEC AND FCC SPECIFICATIONS



PLCC28
(Plastic Leaded Chip Carrier Package)

ORDER CODE : ST7536CFN

PIN CONNECTIONS



DESCRIPTION

The ST7536 is a half duplex synchronous FSK MODEM designed for power line communication network applications.

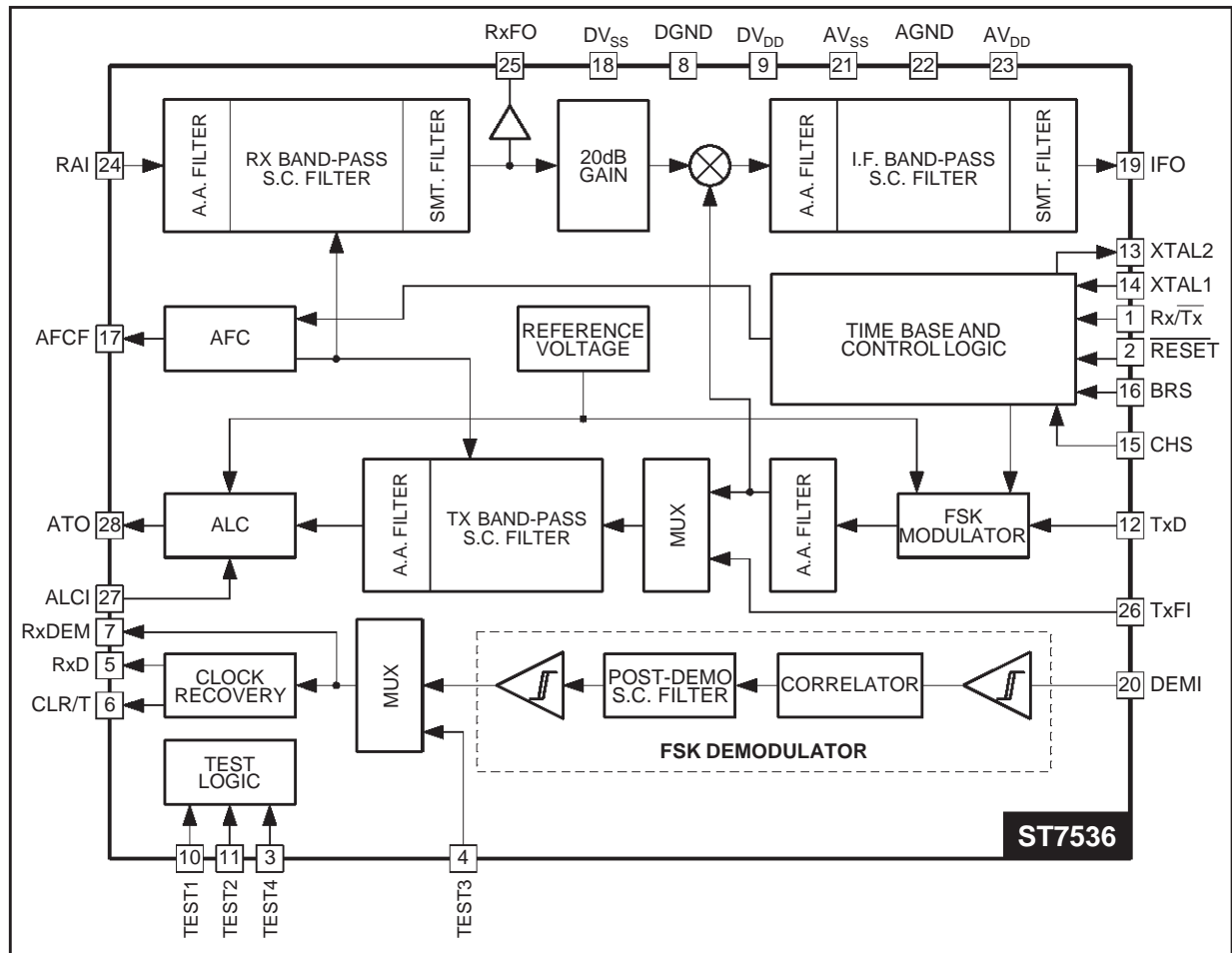
It operates from a dual power supply +5V and -5V, and requires an external interface for the coupling to the power line. It offers two programmable data rate with two programmable channels each.

PIN DESCRIPTION

| Pin Number | Name | Type | Description |
|------------|------------------|---------|--|
| 1 | Rx/Tx | Digital | Rx or Tx mode selection input |
| 2 | RESET | Digital | Logic reset and power-down mode input. Active when low. |
| 3 | TEST4 | Digital | Test input which selects the Tx band-pass filter input (TxFI) when high. |
| 4 | TEST3 | Digital | Test input which gives an access to the clock recovery input stage. This input is selected when TEST1 is high. |
| 5 | RxD | Digital | Synchronous receive data output |
| 6 | CLR/T | Digital | Rx or Tx clock according to the functional mode |
| 7 | RxDEM | Digital | Demodulated data output |
| 8 | DGND | Supply | Digital ground |
| 9 | DV _{DD} | Supply | Digital positive supply voltage : 5V ± 5% |
| 10 | TEST1 | Digital | Test input which cancels the Tx to Rx mode automatic switching and validates TEST3 input. Active when high. |
| 11 | TEST2 | Digital | Test input which reduces the Tx to Rx mode automatic switching time. Active when high. |
| 12 | TxD | Digital | Transmit data input |
| 13 | XTAL2 | Digital | Crystal oscillator output |
| 14 | XTAL1 | Digital | Crystal oscillator input |
| 15 | CHS | Digital | Channel selection input |
| 16 | BRS | Digital | Baud rate selection input |
| 17 | AFCF | Analog | Automatic frequency control output for connecting compensation network. |
| 18 | DV _{SS} | Supply | Digital negative supply voltage : -5V ± 5% |
| 19 | IFO | Analog | Intermediate frequency filter output |
| 20 | DEMI | Analog | FSK demodulator input |
| 21 | AV _{SS} | Supply | Analog negative supply voltage : -5V ± 5% |
| 22 | AGND | Supply | Analog ground : 0V |
| 23 | AV _{DD} | Supply | Analog positive supply voltage : 5V ± 5% |
| 24 | RAI | Analog | Receive analog input |
| 25 | RxFO | Analog | Receive filter output |
| 26 | TxFI | Analog | Transmit filter input (selected when TEST4 is high) |
| 27 | ALCI | Analog | Automatic level control input |
| 28 | ATO | Analog | Analog transmit output |

7536-01.TBL

BLOCK DIAGRAM



7536-02.EPS

FUNCTIONAL DESCRIPTION

1 - Transmit Section

The transmit mode is set when $Rx/\overline{Tx} = 0$, if Rx/\overline{Tx} is held at 0 longer than 3s, then the device switches automatically in the Rx mode. A new activation of the Tx mode requires Rx/\overline{Tx} to be returned to 1 for a minimum 2 μ s period before being set to 0.

The Transmit Data (TxD) is sampled on a positive edge of CLR/T which delivers the transmit bit clock when the transmit mode is selected. This data enters a FSK modulator whose two basic frequencies are selected by the Baud Rate Selection pin (BRS) and the Channel Selection pin (CHS) according to the Table 1.

Figure 1 : Tx Data Input Timing

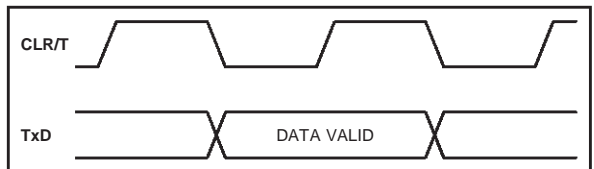


Table 1

| BRS | CHS | Baud Rate (Baud) | Tx Frequencies (kHz) TxD=1 - TxD=0 |
|-----|-----|------------------|---------------------------------------|
| 0 | 0 | 600 | 81.75 - 82.35 |
| 0 | 1 | 600 | 67.2 - 67.8 |
| 1 | 0 | 1200 | 71.4 - 72.6 |
| 1 | 1 | 1200 | 85.95 - 87.15 |

These frequencies are synthesized from a 11.0592MHz crystal oscillator ; their precision is the same as the crystal one's (100 ppm).

The modulated signal coming out of the FSK modulator is filtered by a switched-capacitor band-pass filter (Tx band-pass) in order to limit the output spectrum and to reduce the level of harmonic components.

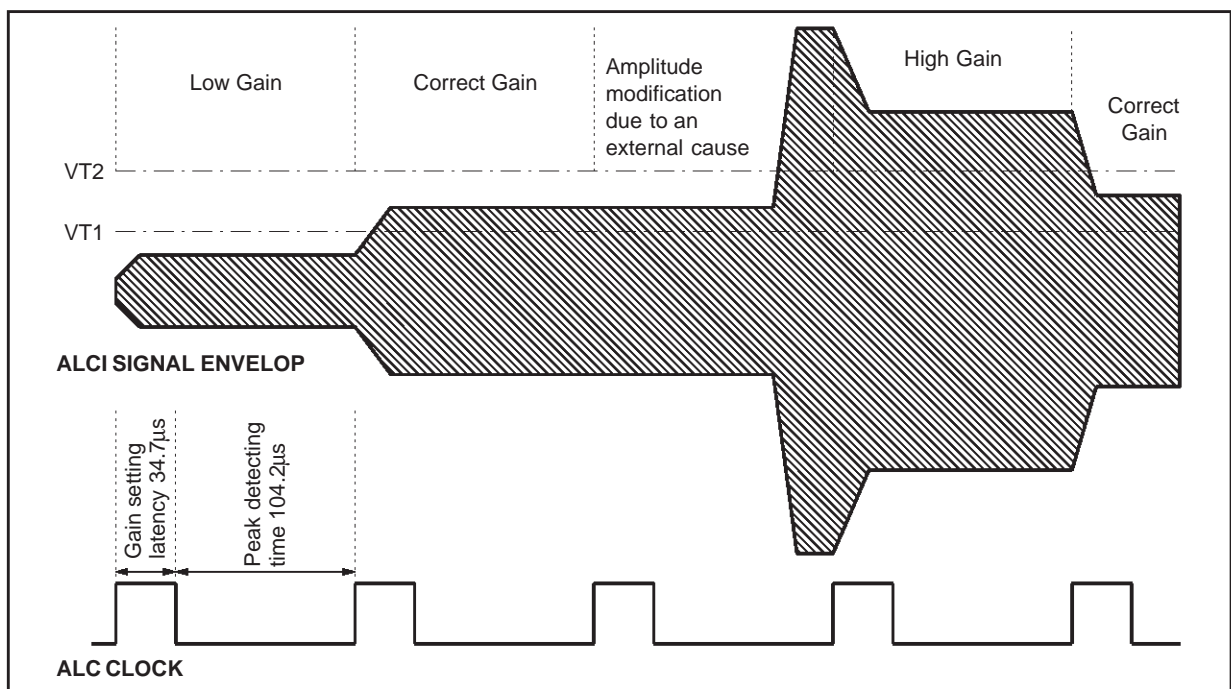
The output stage of the Tx path consists of an Automatic Level Control (ALC) system which keeps the output signal (ATO) amplitude independant of the line impedance variations. This ALC is a variable gain system (with 32 discrete values) controlled by an analog feed-back signal ALCI (see Figure 2).

The ALC gain range is 0dB to -26dB and gain change is clocked at 7200Hz. Gain steps are of magnitude 0.84dB typically.

A period of this clock is decomposed into a 34.7 μ s gain settling latency and a 104.2 μ s peak detecting time. The gain change is related to the result of a peak detection obtained by making a direct comparison of ALCI maximum value (during detecting time) with two threshold voltages V_{T1} and V_{T2} (see Figure 2).

- $\max(\text{ALCI}) < V_{T1}$ - The next gain is increased by 0.84dB,
- $V_{T1} \leq \max(\text{ALCI}) \leq V_{T2}$ - No gain change,
- $V_{T2} < \max(\text{ALCI})$ - The next gain is decreased by 0.84dB.

Figure 2 : Automatic Level Control Timing Chart



7536-03.EPS

7536-04.EPS

FUNCTIONAL DESCRIPTION (continued)

2 - Receive Section

The receive section is active when $\overline{\text{Rx/Tx}} = 1$.

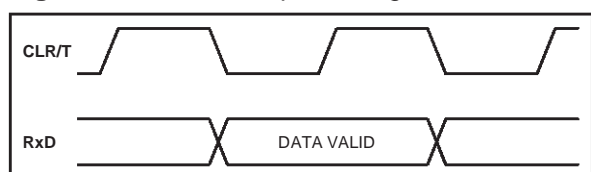
The baud rate and channel selection is also made according to Table 1.

The Rx signal is applied on RAI with a common mode voltage of 0V and filtered by a band-pass switched capacitor filter (Rx band-pass) centered on the received carrier frequency and whose bandwidth is around 6kHz. The input voltage range on RAI is $2\text{mV}_{\text{RMS}} - 2\text{V}_{\text{RMS}}$.

The Rx filter output is amplified by a 20dB gain stage which provides symmetrical limitations for large voltage. The resulting signal is down-converted by a mixer which receives a local oscillator synthesized by the FSK modulator block. Finally an intermediate frequency band-pass filter (IF band-pass) whose central frequency is 2.7kHz when $\text{BRS} = 0$ and 5.4kHz when $\text{BRS} = 1$ improves the signal to noise ratio before entering the FSK demodulator. The coupling of the intermediate frequency filter output (IFO) to the FSK demodulator input (DEMI) is made by an external capacitor C5 ($1\mu\text{F} \pm 10\%$, 10V) which cancels the Rx path offset voltage.

A clock recovery circuit extracts the receive clock (CLR/T) from the demodulated output (RxDEM) and delivers synchronous data (RxD) on the positive edge of CLR/T.

Figure 3 : Rx Data Output Timing



3 - Additional Digital and Analog Functions

A reset input ($\overline{\text{RESET}}$) initializes the device.

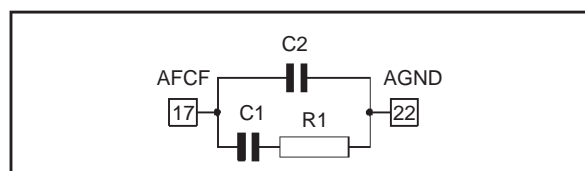
When $\overline{\text{RESET}} = 0$, the device is in power-down mode and all the internal logic is reset. When $\overline{\text{RESET}} = 1$, the device is active.

A time base section delivers all the internal clocks from a crystal oscillator (11.0592MHz). The crystal is connected between XTAL1 and XTAL2 pins and needs two external capacitors C3 and C4 depending on the crystal characteristic typically $22\text{pF} \pm 10\%$ for proper operation. It is also possible to provide directly the clock on pin XTAL1 ; in this case C3 and C4 should be removed.

An Automatic Frequency Control (AFC) Section adjusts the central frequency of Rx and Tx band-pass filter to the carrier central frequency. The stability of the AFC loop is ensured by an external compensation network C1 ($470\text{nF} \pm 10\%$, 10V), C2

($47\text{nF} \pm 10\%$, 10V) and R1 ($1.5\text{k}\Omega \pm 5\%$) connected to pin AFCF.

Figure 4 : Automatic Frequency Loop Filter



4 - Testing Features

- An additional amplifier allows the observation of the Rx band-pass filter output on pin RxFO.
- A direct input to the Tx band-pass filter (TxFI) is available and selected when $\text{TEST4} = 1$.
- The 3 second normal duration of the Tx to Rx mode automatic switching is reduced to 1.48ms when $\text{TEST2} = 1$.
- When $\text{TEST1} = 1$ the Tx to Rx mode automatic switching is deactivated and the functional mode of the circuit is controlled by $\overline{\text{Rx/Tx}}$ as follow : when $\overline{\text{Rx/Tx}} = 0$ the circuit is transmitting continuously, when $\overline{\text{Rx/Tx}} = 1$ the clock recovery block is disconnected from the FSK demodulator for testing purpose, in this configuration TEST 3 is the data input of the clock recovery block, RxDEM follow TEST3 and RxD delivers the resynchronized data.

5 - Power Supplies Wiring and Decoupling Precautions

The ST7536 has two positive power supply pins, two negative power supply pins and two ground pins in order to separate internal analog and digital supplies. The analog and digital terminals of each supply pair must be connected together externally and require special routing precautions in order to get the best receive sensitivity performances. The three major routing requirements are :

- The ground impedance should be as low as possible, for this purpose the AGND and DGND terminals can be connected via a local plane.
- The positive and negative power supplies (AV_{DD} , DV_{DD} , AV_{SS} , DV_{SS}) should be star-connected, avoiding common current path for the digital and analog power supplies terminals.
- Five decoupling capacitors located as close as possible to the power supply terminals should be used. Two $2.2\mu\text{F}$ tantalum and two 100nF ceramic capacitors perform the main decoupling function in the vicinity of the analog power supplies and a 100nF ceramic capacitor in the vicinity of the positive digital power supply is used to reduce the high frequency perturbations generated by the logic part of the circuit.

ABSOLUTE MAXIMUM RATINGS

| Symbol | Parameter | Value | Unit |
|-------------------------|-------------------------------|-------------------------------------|------|
| $A_{V_{DD}}/D_{V_{DD}}$ | Positive Supply Voltage (1) | -0.3, +7 | V |
| $A_{V_{SS}}/D_{V_{SS}}$ | Negative Supply Voltage (1) | -7, +0.3 | V |
| $V_{AGND/DGND}$ | Voltage between AGND and DGND | -0.3, +0.3 | V |
| V_I | Digital Input Voltage | DGND-0.3, $D_{V_{DD}}+0.3$ | V |
| V_O | Digital Output Voltage | DGND-0.3, $D_{V_{DD}}+0.3$ | V |
| I_O | Digital Output Current | -5, +5 | mA |
| V_i | Analog Input Voltage | $A_{V_{SS}}-0.3$, $A_{V_{DD}}+0.3$ | V |
| V_o | Analog Output Voltage | $A_{V_{SS}}-0.3$, $A_{V_{DD}}+0.3$ | V |
| I_o | Analog Output Current | -5, +5 | mA |
| P_D | Power Dissipation | 500 | mW |
| T_{oper} | Operating Temperature | - 25, + 70 | °C |
| T_{stg} | Storage Temperature | - 65, + 150 | °C |

Notes : 1. The voltages are referenced to AGND and DGND.

2. Latch-up problems can be overcome with 2 reverse biased schottky diodes connected respectively between A/ $D_{V_{DD}}$ & A/DGND and A/ $D_{V_{SS}}$ & A/DGND.

3. Absolute maximum ratings are values beyond which damage to device may occur. Functional operation under these conditions is not implied.

GENERAL ELECTRICAL CHARACTERISTICS

The test conditions are A/ $D_{V_{DD}}$ = +5V, A/ $D_{V_{SS}}$ = -5V, A/DGND = 0V, T_{amb} = -10 to 70°C unless otherwise specified

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---------------------------|------------------------------------|--|-------|------|-------|------|
| $A_{V_{DD}}/D_{V_{DD}}$ | Positive Supply Voltage | | 4.75 | 5 | 5.25 | V |
| $A_{V_{SS}}/D_{V_{SS}}$ | Negative Supply Voltage | | -5.25 | -5 | -4.75 | V |
| $A_{I_{DD}} + D_{I_{DD}}$ | Positive Supply Current in Tx Mode | $\overline{RESET} = 1$, $RX/\overline{Tx} = 0$ | | 30 | 35 | mA |
| $A_{I_{DD}} + D_{I_{DD}}$ | Positive Supply Current in Rx Mode | $\overline{RESET} = 1$, $RX/\overline{Tx} = 1$ | | 29 | 34 | mA |
| $A_{I_{SS}} + D_{I_{SS}}$ | Negative Supply Current in Tx Mode | $\overline{RESET} = 1$, $RX/\overline{Tx} = 0$ | - 34 | - 29 | | mA |
| $A_{I_{SS}} + D_{I_{SS}}$ | Negative Supply Current in Rx Mode | $\overline{RESET} = 1$, $RX/\overline{Tx} = 1$ | - 33 | - 28 | | mA |
| $A_{I_{DD}} + D_{I_{DD}}$ | Positive Power-down Current | $\overline{RESET} = 0$, $RX/\overline{Tx} = 1$ XTAL1 = 1 | | | 1.2 | mA |
| $A_{I_{SS}} + D_{I_{SS}}$ | Negative Power-down Current | | - 1.2 | | | mA |
| V_{IH} | High Level Input Voltage | Digital inputs except XTAL1 | 2.2 | | | V |
| V_{IL} | Low Level Input Voltage | Digital inputs | | | 0.8 | V |
| V_{OH} | High Level Output Voltage | Digital outputs, $I_{OH} = - 400\mu A$ | 2.4 | | | V |
| V_{OL} | Low Level Output Voltage | Digital outputs, $I_{OL} = 1.6mA$ | | | 0.4 | V |
| V_{IH} | High Level Input Voltage | XTAL1 input | 3.6 | | | V |
| DC | XTAL1 Clock Duty Cycle | External clock | 40 | | 60 | % |

TRANSMITTER ELECTRICAL CHARACTERISTICS

The test conditions are $A/DV_{DD} = +5V$, $A/DGND = 0V$, $A/DV_{SS} = -5V$,
 $T_{amb} = -10$ to $+70^{\circ}C$ unless otherwise specified

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|----------------|---|---|----------|-------------|------|----------|
| V_{TAC} | Max Carrier Output AC Voltage | $R_L = 2k\Omega$, $V_{ALCI} < V_{T1}$ | 2.8 | 3.2 | 3.7 | V_{PP} |
| HD2 | Second Harmonic Distortion | $R_L = 2k\Omega$, $V_{ALCI} < V_{T1}$ | | | 0.32 | % |
| FD | FSK Peak-to-peak Deviation | BRS = 0 BRS = 1 | | 600 1200 | | Hz Hz |
| TRxTx | Carrier Activation Time | After Rx/Tx 1 \rightarrow 0 transition | | | 1 | ms |
| TALC | Carrier Stabilisation Time | ALC maximum settling time, 32 gain steps | | | 5 | ms |
| DRNG | ALC Dynamic Range | | 25 | 26 | 27 | dB |
| VT1 | ALC Low Threshold Voltage | | 1.81 | 1.87 | | V |
| VT2 | ALC High Threshold Voltage | | | 2.12 | 2.18 | V |
| GST | ALC Gain Step | | | 0.84 | | dB |
| PSRR1 PSRR2 | Power supply rejection ratio on ATO (see Note 1) | $V_{IN} = 200mV_{PP}$, $f_{IN} = 50Hz$ on V_{DD} or V_{SS} | 35 10 | | | dB dB |

Note 1 : This characteristic is guaranteed by correlation.

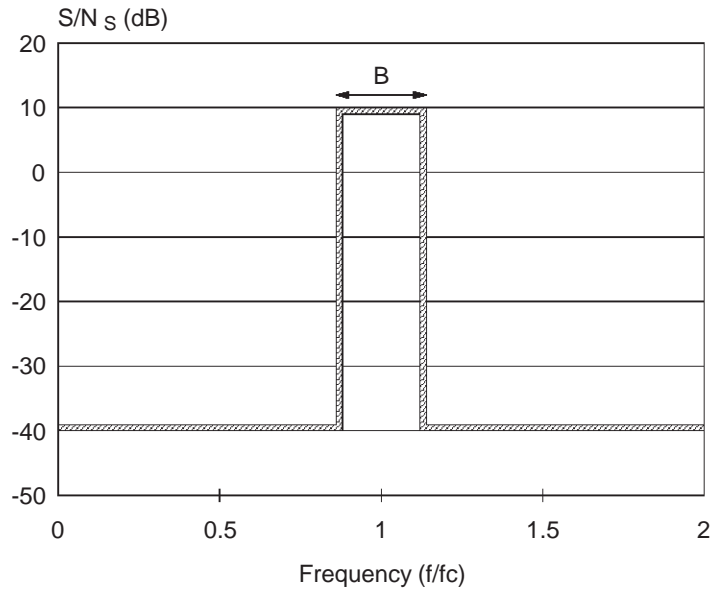
RECEIVER ELECTRICAL CHARACTERISTICS

The test conditions are $A/DV_{DD} = +5V$, $A/DGND = 0V$, $A/DV_{SS} = -5V$,
 $T_{amb} = -10$ to $+70^{\circ}C$ unless otherwise specified

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|------------------------|---|---|----------|--|------------------------|------------|
| V_{IN} | Maximum Input Signal | | | | 2 | V_{RMS} |
| R_{IN} | Input Impedance | | 100 | | | $k\Omega$ |
| RCJ | Recovered Clock Jitter | Percentage of the nominal clock | - 5 | | + 5 | % |
| PSRR1 PSRR2 | Power supply rejection ratio on RxFO (see Note 1) | $V_{IN} = 200mV_{PP}$, $f_{IN} = 50Hz$ on V_{DD} or V_{SS} | 35 10 | | | dB dB |
| V_{IN0} V_{IN1} | Rx sensitivity (see Note 1) | Typical measured BER $< 10^{-5}$ BRS = 0 BRS = 1 | | | 2 3 | mV_{RMS} |
| BER1 BER2 | Bit error rate at minimum Rx signal (see Note 1) | White Noise, S/N = 15dB RAI = $2mV_{RMS}$, BRS = 0 RAI = $3mV_{RMS}$, BRS = 1 | | $2 \cdot 10^{-5}$ $3 \cdot 10^{-4}$ | 10^{-3} 10^{-3} | |
| BER3 | Bit error rate at maximum Rx signal (see Note 1) | RAI = $2V_{RMS}$, White Noise, S/N = 25dB | | 10^{-7} | 10^{-3} | |
| BER4 | Bit error rate at medium Rx signal (see Note 1) | RAI = $0.6V_{RMS}$, S/N = 15dB | | 10^{-6} | 10^{-3} | |
| BER5 | Bit error rate with impulsive noise (see Note 1) | RAI = $90mV_{RMS}$, N = $5V_{PP}$ pulse wave, $f = 100Hz$, duty cycle = 10% | | | 10^{-3} | |
| BER6 BER7 | Bit error rate with modulated sinusoidal noise N_s (see Note 1) | $S + N_s < 0.2V_{RMS}$, $N_s =$ sine carrier with 80% AM modul., $f_m = 1kHz$, See Figure 5 $S_{min} = 2mV_{RMS}$, BRS = 0 $S_{min} = 3mV_{RMS}$, BRS = 1 | | | 10^{-3} 10^{-3} | |

Note 1 : This characteristic is guaranteed by correlation

Figure 5 : S/N Mask for 80% AM Sine Noise



B = 20kHz at 600 Bit/s (BRS = 0)
 B = 40kHz at 1200 Bit/s -BRS = 1)

fc : Central Carrier Frequency

7536-07.EPS

FILTER TEMPLATES

| Frequency (kHz) | Test Conditions | Amplitude (dB) | | |
|-----------------|-----------------|----------------|------|------|
| | | Min. | Typ. | Max. |

RECEIVE AND TRANSMIT FILTER

| | | | | |
|-----------|---------------------|-----|-----|------|
| 54 | BRS = 0, CHS = 0 | | | - 35 |
| 79.05 | | - 4 | - 3 | - 2 |
| Ref 82.05 | | | 0 | |
| 85.05 | | - 4 | - 3 | - 2 |
| 123 | | | | - 35 |
| 44.4 | BRS = 0, CHS = 1 | | | - 35 |
| 65 | | - 4 | - 3 | - 2 |
| Ref 67.46 | | | 0 | |
| 69.93 | | - 4 | - 3 | - 2 |
| 101.13 | | | | - 35 |
| 47.57 | BRS = 1, CHS = 0 | | | - 35 |
| 69.64 | | - 4 | - 3 | - 2 |
| Ref 72.28 | | | 0 | |
| 74.92 | | - 4 | - 3 | - 2 |
| 108.36 | | | | - 35 |
| 57.08 | BRS = 1, CHS = 1 | | | - 35 |
| 83.57 | | - 4 | - 3 | - 2 |
| Ref 86.74 | | | 0 | |
| 89.91 | | - 4 | - 3 | - 2 |
| 130.03 | | | | - 35 |

| Frequency (kHz) | Test Conditions | Amplitude (dB) | | |
|-----------------|-----------------|----------------|------|------|
| | | Min. | Typ. | Max. |

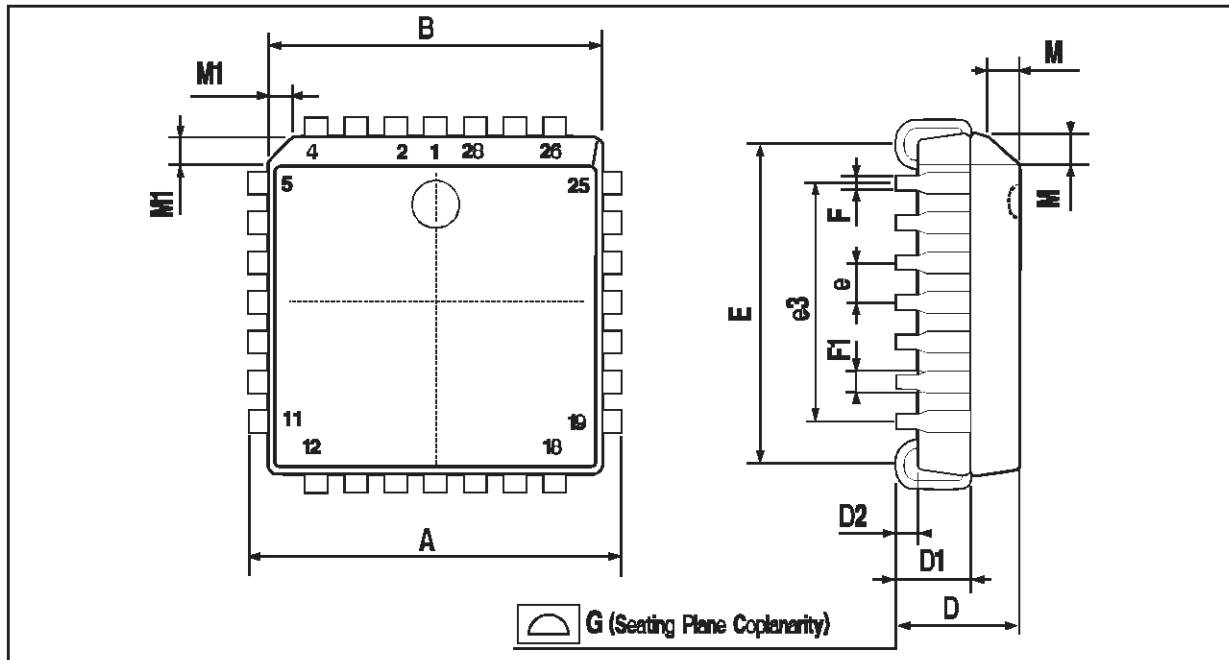
INTERMEDIATE FREQUENCY FILTER

| | | | | |
|---------|---------|-----|-----|------|
| 1.2 | BRS = 0 | | | - 35 |
| 2.15 | | - 5 | - 3 | - 2 |
| Ref 2.7 | | | 0 | |
| 3.25 | | - 5 | - 3 | - 2 |
| 5.8 | | | | - 35 |
| 2.4 | BRS = 1 | | | - 35 |
| 4.3 | | - 5 | - 3 | - 2 |
| Ref 5.4 | | | 0 | |
| 6.5 | | - 5 | - 3 | - 2 |
| 11.6 | | | | - 35 |

7536-06.TBL

PACKAGE MECHANICAL DATA

28 PINS - PLASTIC LEADED CHIP CARRIER (PLCC)



PMLCC28-EP5

| Dimensions | Millimeters | | | Inches | | |
|------------|-------------|-------|-------|--------|-------|-------|
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | 12.32 | | 12.57 | 0.485 | | 0.495 |
| B | 11.43 | | 11.58 | 0.450 | | 0.456 |
| D | 4.2 | | 4.57 | 0.165 | | 0.180 |
| D1 | 2.29 | | 3.04 | 0.090 | | 0.120 |
| D2 | 0.51 | | | 0.020 | | |
| E | 9.91 | | 10.92 | 0.390 | | 0.430 |
| e | | 1.27 | | | 0.050 | |
| e3 | | 7.62 | | | 0.300 | |
| F | | 0.46 | | | 0.018 | |
| F1 | | 0.71 | | | 0.028 | |
| G | | | 0.101 | | | 0.004 |
| M | | 1.24 | | | 0.049 | |
| M1 | | 1.143 | | | 0.045 | |

PLCC28-TBL

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