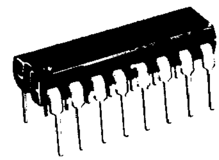
MX-COM, INC. MX611

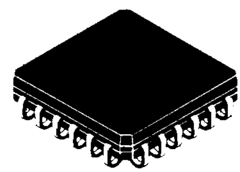
SUBSCRIBER PULSE METERING (SPM) DETECTOR

FEATURES:
- Meets 12 KHz and 16 KHz Specifications
- Programmable Threshold Detection Level
- Tone Follower and SPM Packet Detection Modes
- Low-Cost 4.433619 MHz Crystal Required
- Low Power and Current Requirements

APPLICATIONS:
- PABX SPM Systems
- Telephone Systems



MX611J (CDIP)
MX611P (PDIP)
16 pins



MX611LH
(24p PLCC)

DESCRIPTION:
The MX611 is a single chip, low-power CMOS tone detector designed for use in both PABX and telephone applications for Subscriber Private Metering (SPM). The decode and not-decode band edges are accurately defined by the use of an external 4.433619 MHz crystal.

Operation to either the 12 KHz or 16 KHz SPM systems is pin programmable. Within each system, there are two modes of operation:

1) **Tone Follower Mode:** A logic "0" is output whenever a tone of the correct frequency and period is detected.

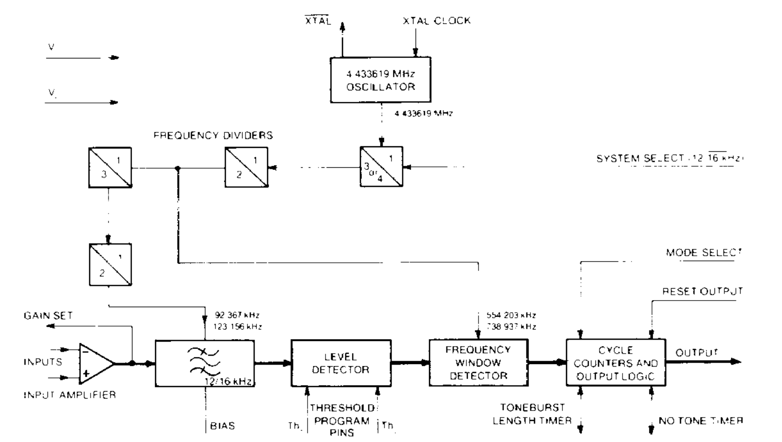
2) **SPM Packet Mode:** This mode gives an output only when both the mark and space timing criteria of an SPM pulse have been fulfilled.

The MX611 can be tailored to meet various mark/space periods and detection level thresholds through external component selection.

SPM Background

Subscriber Private Metering (SPM) is an increasingly popular method of charge metering telephone calls at the PABX and subscriber level. Charge units are signified by transmitting 12 KHz, 16 KHz, or 50 Hz tonebursts down the line.

Belgium, Finland, France, Germany, Spain, Switzerland, and Sweden are among the countries with SPM standards. Each specifies unique tone pulse repetition rates, pulse lengths, pulse pause lengths, pulse levels, and frequency "must" and "must not" decode bandwidths.



MX611 Internal Block Diagram

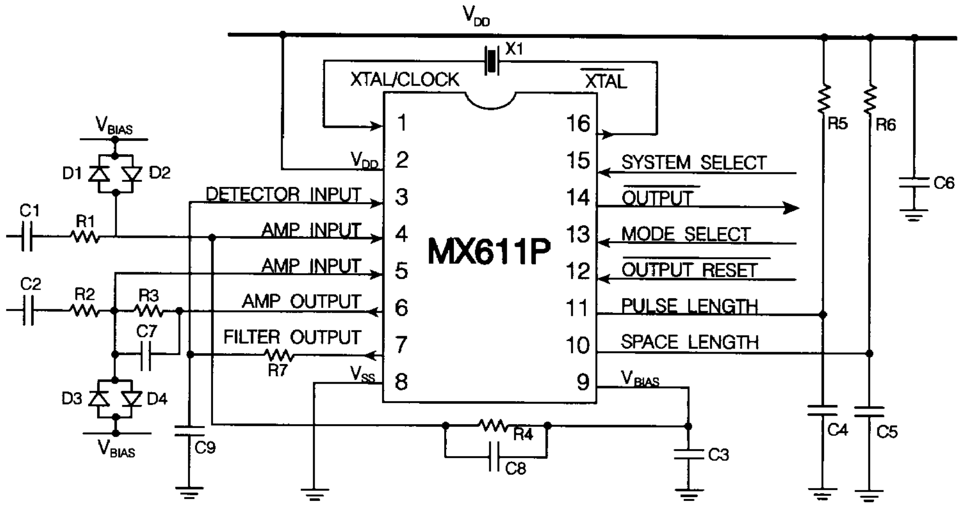
PIN FUNCTION TABLE

Pin J, P	Pin LH	Function
1	1	Xtal/Clock: Input to the clock oscillator inverter. A single 4.433619MHz Xtal or external clock pulse input is required. See Figure 2.
2	2	V_{DD}: The positive supply rail. A single +5V supply is required.
3	5	Detector Input: "Schmitt Trigger" level detector circuitry whose input thresholds are set internally. This input must be connected to the FILTER OUTPUT pin using the external integration components R_7 and C_9 as shown in Figure 2.
4	6	Amplifier Input (+): The positive and negative amplifier inputs. With single or differential inputs this amplifier and its external circuitry can be used to provide the gain required to set the device to the user's National Level Specification. If used, external diodes protect against line input levels that exceed the supply rails (above the Absolute Maximum Rating). See Figures 2 and 3.
5	7	Amplifier Input (-)
6	8	Amplifier Output: The output of the input stage amplifier. It is used with gain-setting components. See Figures 1 and 2.
7	11	Filter Output: The switched (12/16kHz) bandpass filter output. It must be connected to the Detector Input pin using the external integration components R_7 and C_9 as shown in Figure 2.
8	12	V_{SS}: The negative power supply rail (GND).
9	13	V_{BIAS}: The analog bias point. It should be externally decoupled to V_{SS} via capacitor C_3.
10	14	Space Length Time: Active only in the SPM Packet Mode, this input uses an external R/C network to set the minimum valid No-Tone (space) period for the incoming packet using the formula: $t_s = 0.7\ (R_6 x C_5)$. If the SPM Packet Mode is not required, omit these components and leave the input unconnected.
11	17	Pulse Length Time: Active only in the SPM Packet Mode, this input uses an external R/C network to set the minimum valid Tone period for the incoming packet using the formula: $t_m = 0.7\ (R_5 x C_4)$. If the SPM Packet Mode is not required, omit these components and leave the input unconnected.
12	18	$\overline{\text{Output Reset}}$: This input is used only in the SPM Packet Mode. A logic "0"on this pin resets the Output pin to a logic "1." This input has an internal 1MΩ pullup resistor.
13	19	Mode Select: A control pin to select either the Tone Follower Mode or the SPM Packet Mode. A logic "1" selects Tone Follower,and a logic "0" selects SPM Packet. This input has an internal 1MΩ pullup resistor (defaults to Tone Follower Mode).
14	20	$\overline{\text{Output}}$: The digital output of the SPM Detector. In the Tone Follower Mode, a valid tone gives a logic "0" and no-tone gives a logic "1." Tonebursts and tone dropouts of less than 16 cycles are ignored. In the SPM Packet Mode, the output is set to a logic "0" when a valid packet is measured. The output remains latched low until reset by a logic "0" at the $\overline{\text{Output Reset}}$ function. See Figure 3.
15	23	System Select: A control pin to set the device to work on either a 12kHz (logic "1") or 16kHz (logic "0") SPM system. This input has an internal 1MΩ pullup resistor (defaults to 12kHz operation).
16	24	$\overline{\text{Xtal}}$: The output of the clock oscillator inverter.

Pins 3,4,9,10,15,16,21, and 22 are not internally connected on the MX611LH.

External Components

(a) Differential Input Configuration



(b) Single Input Configuration

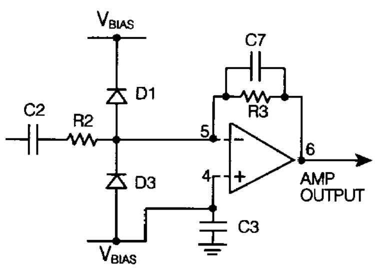


Figure 2 - Recommended External Components

Component References

Component	Reference	Component	Reference
R_1	Note 4 (next page)	C_1	Note 4
R_2	Note 4	C_2	Note 4
R_3	390kΩ ± 1.0%	C_3	1.0μF ± 20%
R_4	390kΩ ± 1.0%	C_4	Note 1
R_5	Note 1	C_5	Note 1
R_6	Note 1	C_6	1.0μF ± 20%
R_7	47kΩ ± 1.0%	C_7	12.0 pF ± 10.0%
D_1 to D_4	1N4148 or equivalent	C_8	12.0 pF ± 10.0%
X_1	4.433619MHz	C_9	100pF ± 1.0%

Component Value Notes

(1) Component values R_5 and C_4 set the minimum tone "Mark" period; R_6 and C_5 set the minimum "Space" period in the SPM Packet mode. They are calculated as follows:

$t_M = 0.7(R_5 \times C_4)$ $\quad t_S = 0.7\ (R_6 \times C_5)$

Mark and Space calculations should be made taking into consideration response times t_R and t_D (Fig. 4). Current consumption will increase if low values of timing resistor are used.

(2) Input Amplifier gain components (Figure 2 a & b). These components set the gain required to achieve the various National Level Specifications. Instructions for gain calculations are given in Figure 3 and Note 4 (below).

(3) Protection diodes: since most telephone systems operate at voltages in excess of the Absolute Maximum limits for damage, diodes D_1-D_4 are *essential* for device protection.

(4) Calculation of gain components:

For a differential input:

$R_1 = R_2$ $\quad C_1 = C_2$

$R_3 = R_4$ $\quad C_7 = C_8$

$$\text{Gain} = \frac{Z_{feedback}}{Z_{input}} = \frac{(R_4 // X(C_8))}{(R_1 + X(C_1))}$$

This calculation approximates as:

$$R_1 \approx \frac{R_4}{1.2 \times (\text{selected gain})}$$

and

$$C_1 \approx \frac{1}{2\pi \times R_1 \times 6.0\text{kHz}}$$

-using the nearest preferred value components.

The values of R_1 and C_1 have been calculated to give a high-pass cut-off between the audio and SPM tone frequencies of approximately 6kHz. C_7 and C_8 are anti-alias components and are calculated for an approximate cut-off frequency of 32kHz.

Example component values for the West German "FTZ" (16kHz) Specification

"Will Decode" Sensitivity (Min.) = -21dB
"Will-Not Decode" Sensitivity (Max.) = -27dB

From the graph of Figure 3, the calculated gain range is 0 to 3 dB. A gain value of 1.4 dB is selected from within this range. For use in the formulas above, the gain must be converted from dB.

$1.4\text{ dB} = 20\log_{10}(\text{Gain})$

$\text{Gain} = 1.17$

$$R_1 = \frac{390\text{k}\Omega}{1.2 \times 1.17} = 277778\ \Omega$$

Use $R_1 = 270\text{ k}\Omega$

$$C_1 = \frac{1}{2\pi \times 270\text{ k}\Omega \times 6.0\text{ kHz}} = 9.82 \times 10^{-11}\text{ F}$$

$= 98.2\text{ pF}$

Use $C_1 = 100\text{pF}$

The minimum tone length $t_M = 80\text{ms}$
The minimum space length $t_S = 135\text{ms}$

Using the formulas from Note 1:

Select $R_5 = 130\text{ k}\Omega \pm 1\%$, $C_4 = 1.0\ \mu\text{F} \pm 10\%$
$R_6 = 220\text{ k}\Omega \pm 1\%$, $C_5 = 1.0\ \mu\text{F} \pm 10\%$

$t_M = (0.7)\ (130\text{ k}\Omega)\ (1.0\ \mu\text{F}) = 91\text{ ms}$
$t_S = (0.7)\ (220\text{ k}\Omega)\ (1.0\ \mu\text{F}) = 154\text{ ms}$

Using the worst-case component values:

$t_M = 81\text{ ms}$
$t_S = 137\text{ ms}$

To summarize for this example, the components would take these values:

R_1	270 kΩ	C_1	100 pF
R_2	270 kΩ	C_2	100 pF
R_3	390 kΩ	C_3	1.0 µF
R_4	390 kΩ	C_4	1.0 µF
R_5	130 kΩ	C_5	1.0 µF
R_6	220 kΩ	C_6	1.0 µF
		C_7	12 pF
X_1	4.433619MHz	C_8	12 pF
		C_9	100 pF

Tolerances:
Resistors ±1%.
Capacitors C3, C6 ±20%, all others ±10%.

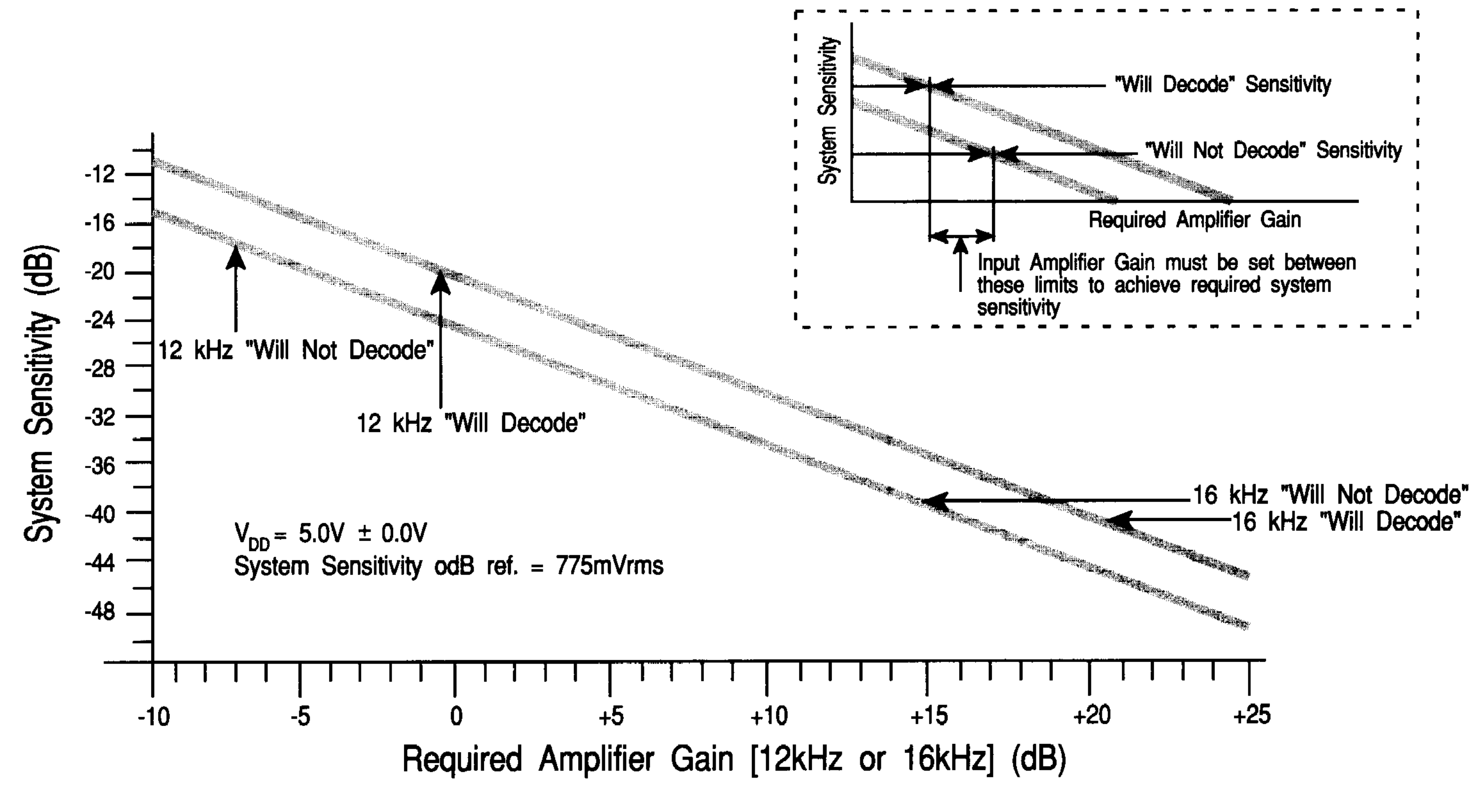
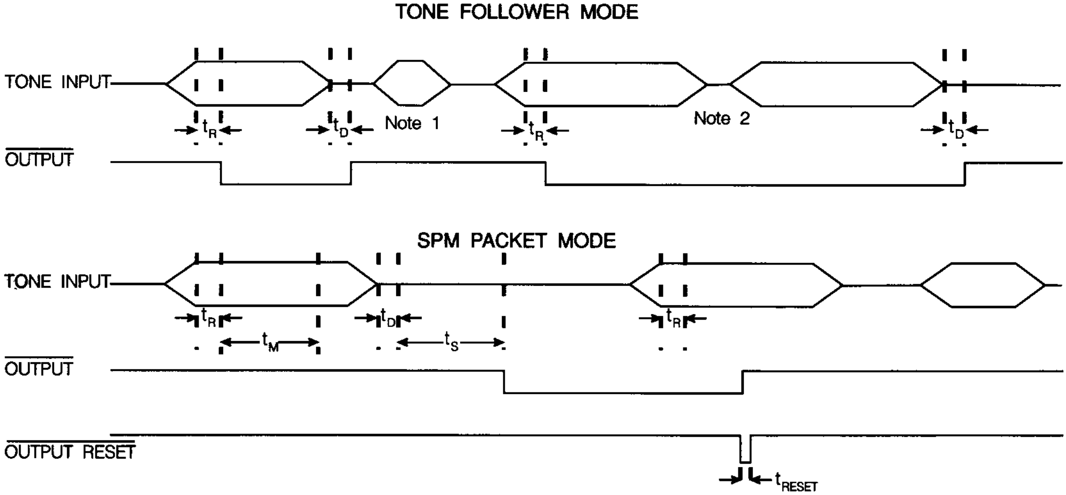


Figure 3 - Graph for the Calculation of Required Input Gain vs System Sensitivity

Input Gain Calculation

Apply the system "Will" and "Will Not" Decode sensitivity values (Y axis) to the relevant graph in Figure 3. The X axis indicates the input gain area required.



Abbreviations: (See Specifications)

t_R: Tone Response Time

t_D: Tone De-response Time

t_M: Pulse Length Time

t_S: Space Length Time

t_{RESET}: SPM Output Reset Time

Note 1: No reaction to pulses with periods less than "Tone Response Time."
Note 2: No reaction to drop-outs with periods of less than "Tone De-response Time."

Figure 4 - Timing Information

SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS

Exceeding the maximum rating can result in device damage. Operation of the device outside the operating limits is not suggested.

Supply Voltage	-0.3 to 7.0 V
Input Voltage at any pin (ref V_{SS} = 0V)	-0.3 V to V_{DD} + 0.3 V
Sink/Source Current	
(supply pins)	±30mA
(other pins)	±20mA
Total Device Dissipation @ T_{AMB} = 25°C	800mW max.
Derating	10 mW/°C
Operating Temperature	-40°C to +85°C
Storage Temperature	-55°C to +125°C

OPERATING LIMITS

All devices were measured under the following conditions unless otherwise noted.

V_{DD}=5.0V

T_{AMB}=25°C

Xtal/Clock fo = 4.433619 MHz

Audio Level 0dB ref. = 775 mVrms

SNR ^18dB

Characteristics		See Note	Min.	Typ.	Max.	Unit
Static Values						
Supply Voltage (V_{DD})			4.5	5.0	5.5	V
Supply Current (I_{DD})				3.0		mA
Analog Input Impedance			1.0			MΩ
Digital Input Impedance				1.0		MΩ
Digital Output Impedance					10	kΩ
Dynamic Values						
Sensitivity	12 kHz	7	-20.5	-24	-	dB
	16 kHz	7	-	-25.5	-	dB
Required Signal to Noise Ratio		4	18	-	-	dB
Upper Detector Threshold		8	2.95	3.0	3.05	V
Lower Detector Threshold		8	1.95	2.0	2.05	V
Bandpass Filter						
Passband Gain	12 kHz		-	16.5	-	dB
	16 kHz		-	16.5	-	dB
Passband Ripple	12 kHz	6	-	-	1.0	dB
	16 kHz	6	-	-	1.0	dB
Audio Band Attenuation (<3.4kHz)						
	12 kHz		-	40.0	-	dB
	16 kHz		-	50.0	-	dB
Frequency Discrimination						
"Will-Decode" Frequency	12 kHz		11.82		12.18	kHz
	16 kHz		15.76		16.24	kHz
"Will-Not Decode" Frequency						
Upper Limits	12 kHz		12.48	-	50.0	kHz
Lower Limits	12 kHz		0	-	11.52	kHz
Upper Limits	16 kHz		16.64	-	50.0	kHz
Lower Limits	16 kHz		0	-	15.36	kHz

Characteristics		See Note	Min.	Typ.	Max.	Unit
Timing Information - Fig.3						
Valid Tone Burst Length (t_M)	12/16kHz	1,2	16.0	-	-	cycles
Valid Space Length (t_s)	12/16kHz	2	5.0	-	-	ms
Tone Response Time (t_R)	12kHz	1,3,4	1.7	-	3.0	ms
	16kHz	1,3,4	1.2	-	2.0	ms
De-response Time (t_D)	12kHz	4,5,9	1.7	-	30.0	ms
	16kHz	4,5,9	1.2	-	20.0	ms
SPM Output Reset Time (t_{reset})	12/16kHz	2	150.0	-	-	ns

Notes

1. Tone Follower mode.
2. SPM Packet mode—in this mode the minimum valid Pulse (Space) length is programmable by means of an RC network on the Pulse (Space) Length Time pin. If no RC network is used, the minimum valid tone length reverts to 16 cycles.
3. The time for the circuit to recognize a valid "Tone" in the Tone Follower Mode.
4. With the noise level at the input < 11.0dB (100 kHz noise bandwidth).
5. The time for the circuit to recognize a valid "No Tone" in the Tone Follower Mode.
6. Measured over the "Will Decode" bandwidth of the frequency discriminator.
7. Measured with the input gains set to unity. Input gain requirements are calculated according to Figure 3.
8. These thresholds are measured at 5 volts V_{DD}. Any supply variation will alter thresholds accordingly.
9. As Noise or Gain is increased the de-response time increases.