新颖的免调整AM接收芯片

文/唐黎明

编者按：PT8R2012W是由上海百利通公司生产的AM接收芯片，如果有谁对它感兴趣，并想动手试验一下其实际效果，可以写信到《无线电》杂志社，来信请注明“百利通IC索取表”，信件中请写明姓名、邮编、地址、单位、联系电话、E-mail及索取目的。我们将提供50片样片为您试验与代换提供最大的便利，同时也希望您有好的设想和设计方案与我们分享。

索取表请寄至：北京市崇文区夕照寺街14号A座《无线电》杂志社，邮编：100061。

在无线遥控和无线数据传输系统中，调幅（AM－amplitude modulation）传输方式仍然牢牢占据半壁江山，调幅方式指采用调制信号去控制高频载波的振幅，使载波的振幅按调制信号的变化而变化。调幅接收系统可分为直放式、超再生式和超外差式等，其中超外差接收相对而言是最完善、稳定，产品一致性最好的方案，超外差式调幅接收系统包括高放、本振、混频、多级中放、检波及低放电路，其功能方框图见图1。

产品设计和生产者完成一个完整的超外差AM接收系统需要计算天线回路阻抗匹配、高放/本振线圈或变压器设计和调整、多级中频耦合变压器的配合调整以及整机统调等步骤，不单对于设计工程师而言是一个不小的挑战，而且由于多级耦合变压器的存在也导致产品成本无法降低，还特别要求生产线工人具备一定的操作水平和熟练程度，否则无法统调出性能优良的整机。为此，笔者在此介绍一款不需生产线调整的完整AM接收方案。

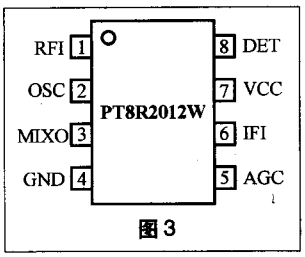


图3

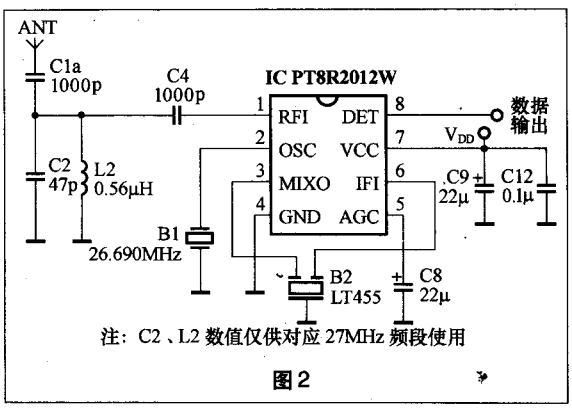


图2

PT8R2012W是一款专门设计为遥控玩具、民用安全报警系统、交互式传信系统、民用远传测量系统等用途而使用的整合式AM接收IC，包含从高频输入到解调输出所需的全部电路。该IC具有外围元器件极少、工作电压低、耗电小、高集成度、免调整、灵敏度较高等特点。其工作电压低至1.8V～3.0V，推荐标称工作频率范围10MHz～60MHz，覆盖了常用的SW频段(频点)如27MHz/35MHz/40MHz/49MHz/55MHz等。采用基本工作线路（见图2）时典型接收灵敏度为－85dBm～－90dBm。经对比测试，在接收的信号频率不高于75MHz时对IC性能无影响。如果用户用于更高工作频率，将导致IC的接收灵敏度有所降低，例如用于80MHz～90MHz时其灵敏度将可能降低5dBm～8dBm，高于100MHz后更是锐减以致无法使用。测试中，在同样采用1kHz信号，调制度90%时，该芯片动态范围优于85dB。该IC采用廉价的8引脚贴片式封装（SOP－8），其引脚分配和内部功能框图分别见图

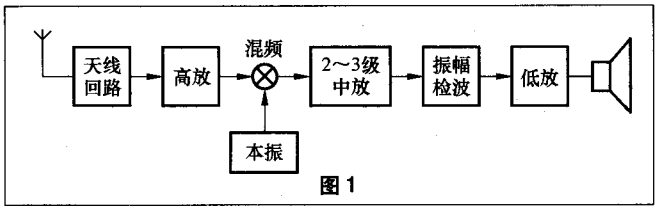


图1

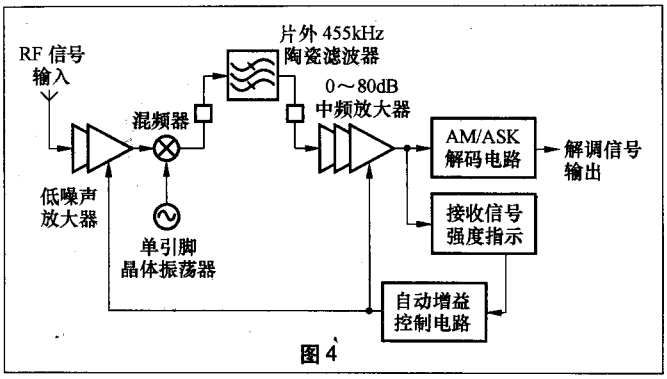


图4

3和图4。

这款IC的显著优点在于针对设计、生产、调试困难的诉求对IC内部作了一些相应的优化，在不降低产品性能的前提下大幅度简化了AM接收电路的外部元器件，并实现了免调整生产。即只要元器件完好，安装无误，无需任何调整，装配完成即可工作。如图2及图4所示，RF信号从1脚（RFI）输入，经内部低噪声放大器放大到适当幅度后与2脚（OSC）输入的本机振荡信号混频，混频后产生的中频信号经外部455kHz陶瓷滤波器选频后送入中频放大器，然后解码输出，该中频放大器与前面的低噪声高频放大器同时受AGC（自动增益控制）电路的控制，所以可以自动设定适当的放大量，尽量保证输出合适的中频电压供给混频电路。流程与标准超外差AM接收电路基本上一样，但是其内部各个单元都有独特的优点。

首先来看其内部的低噪声高频放大器。该放大器采用宽带输入，取消了选频回路。它具有输入阻抗低，输出阻抗较高的优点，实测在27MHz频率下其典型输入阻抗约60Ω。采用极低输入阻抗的好处是可以直接匹配天线回路，而不需要通常的天线阻抗变换电路，甚至可以直接接驳拉杆天线。这样就绕过了天线回路的调试过程。其次，该IC内部采用新型本机振荡电路，可以用单一引脚连接外部晶振（晶振另一引脚直接接地），这样可以大幅度节省辅助零件和PCB空间。最后，其中频放大器本身具有一定选频作用，因此只要采用一个455kHz陶瓷滤波器就可以得到足够的选择性。IC内建中频放大电路配合自动增益控制（AGC）电路，其放大量在0～80dB范围内自动调节，保证整机动态范围大于85dB。在采用一个普通455kHz陶瓷滤波器时，其－3dB带宽约7.5kHz。值得指出的是，因为带宽仅7.5kHz，加之在解码输出端需要一个RC滤波，导致调制信号频率无法提高，实用数据率一般不高于2kHz，加之IC内部解码电路针对数据传输作了一些优化，导致解码出的信号线性不会太好，因此这款IC用于语音传输效果不太理想，主要应用目标还是低速数据和编码、按键控制信号等。如果要试用于低端语音玩具或仅传递人声的产品，可以取消解码输出端的RC滤波器，以及考虑将455kHz陶瓷滤波器用其他通带稍宽的带通滤波器代替。极限应用下甚至可以取消它，仅仅用一个数十至数百皮法的电容连通电路即可。

图5是推荐的简单应用线路，该电路由于采用了一个天线匹配回路和高频放大器，因此电路整体灵敏度可达－95dBm～－100dBm。其中C1、C2、L2组成匹配回路，VT、R1、L3组成宽带放大器，这样既可额外提供约20dB的放大量，又不需在生产时增加调整步骤。放大后的高频信号送入IC与2脚输入的本地振荡信号混频后从3脚输出，通过B2的选频作用滤除杂信，然后经过多级中频放大后由内部乘积式检波器检出被调制信号，由8脚输出，经外接π形滤波器滤波后给出解调后的信号。5脚是内部AGC电路的控制端，提高此引脚电平可以适当提高AGC放大量，反之（增加一个电阻到地）可以减少AGC放大量。虽然整体电路已经非常简洁，如果不是特别注重性能，还有可以减少的余地，例如可以去掉VT、R1、L3组成的附加高频放大器，这样虽然整体灵敏度降低了15dB～20dB，但如果配用单管振荡，一级三极管高频放大的发射电路，还是可以保证20m以外的传输距离。另外R4、C6、C7组成的外接π形滤波器也可以酌情省略。这样就组成最简应用线路，见图2。

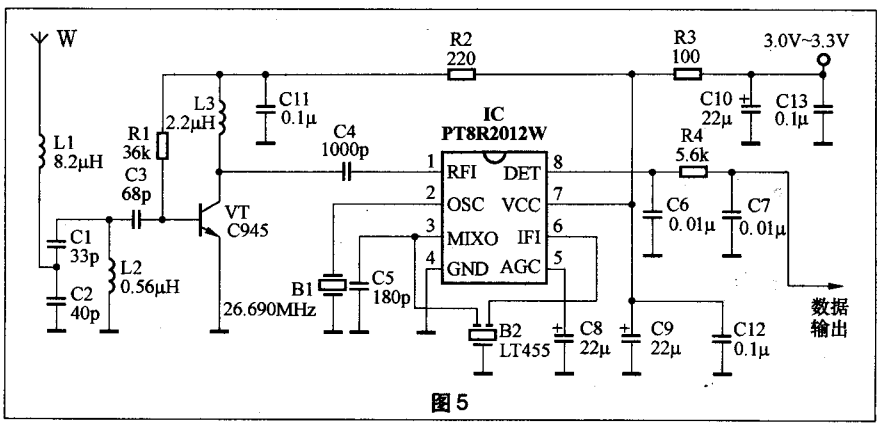


图5

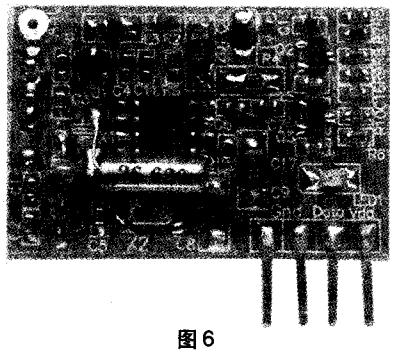


图6

由PT8R2012W组成的一款现成产品的单元电路板如图6所示。该电路在数据输出端还附有处理电路，使得输出波形更加完美。

PT8R2012W提供了一条新颖的路径来解决AM接收器长期存在的问题，但是，正如“手工打造多为精品”的道理一样，该电路为达到免调整及最简化外围电路的目的所采用的一系列措施，始终对整机性能有一定影响。例如，宽带高频输入电路可能易受其他频率强信号阻塞等。如何取舍，还有赖厂家和相关应用人员不断研究，毕竟它的“更简单，更易用”的目标代表了电子产品的发展方向。

Features

- Low power consumption and high sensitivity
- Operating at very low supply voltages: 1.8-3V
- Super-heterodyne architecture employing single-low-IF at 455kHz
- Highly integrated, lower assembly cost, smaller PCB size and better yield for a few external components
- Low cost 8-pin SOIC package suitable for mini-size toys & RC applications

Ordering Information

Part No.	Package
PT8R2012W	SOIC-8
PT8R2012WE	Lead free SOIC-8

Applications

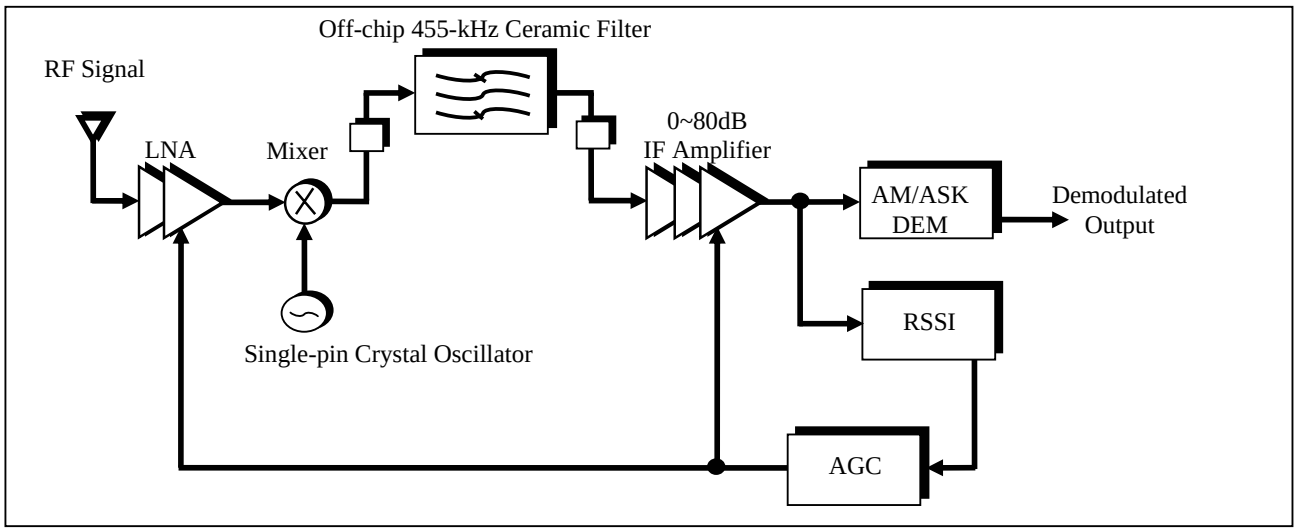
- RF front-end for RC car and toy
- Security & alarm system
- Remote measurement system
- Interactive wireless communication system

Description

The PT8R2012 is a monolithic CMOS AM/ASK receiver, which consists of Low-Noise Amplifier (LNA), Down-Conversion Mixer, Single-Pin Crystal Oscillator (LO), 0~80dB Variable-Gain IF Amplifier, Received Signal Strength Indicator (RSSI), Automatic-Gain-Control (AGC) and Amplitude Detector (DET). LNA receives and amplifies RF signal to a detectable level for mixer. The amplified RF signal is mixed with LO signal from crystal oscillator to down-conversion to the intermediate frequency (IF) of 455kHz by the mixer. An off-chip ceramic filter with center frequency of 455kHz is used for channel-selection and rejecting unwanted bands. The selected signal is further amplified and conditioned by an IF amplifier before passing to an amplitude detector. To achieve high dynamic range, an automatic gain control (AGC) circuit is employed to provide a regulated output amplitude for the amplitude detector by monitoring the output amplitude of the amplitude detector.

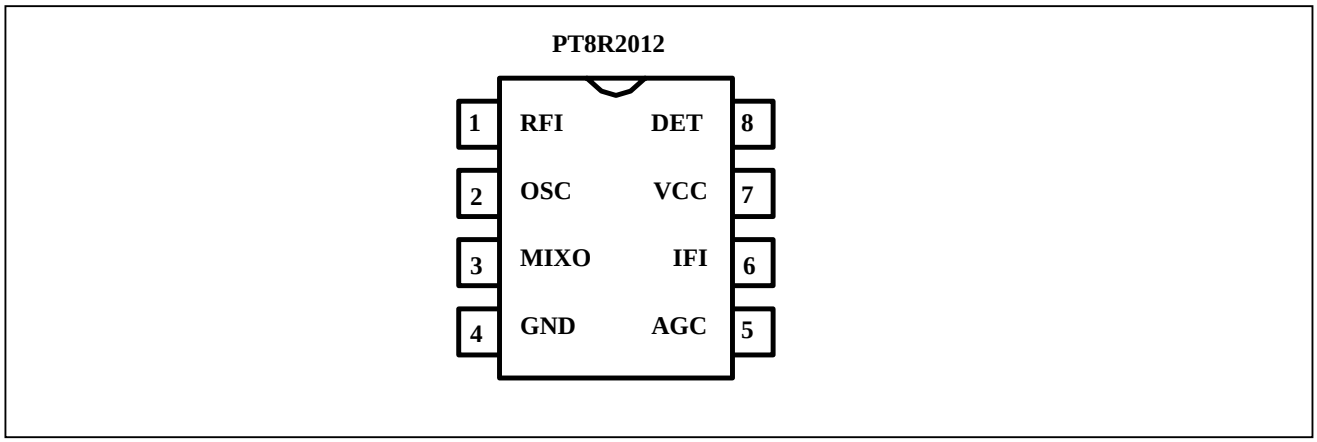
It is a highly integrated device, requiring very few external components thereby providing an extremely cost effective, compact and highly reliable wireless communications solution. The complete solution using PT8R2012 can achieve a sensitivity of about -100dBm and to design a complete AM/ASK receiver the device only requires an external good-quality crystal, a 455kHz IF filter, a few passive components. The PT8R2012 is designed to operate at a low supply voltage from 1.8V to 3.0V and cover 27MHz, 40MHz, 49MHz citizen bands.

Block Diagram



Pin Information

Pin Configuration



Pin Description

Pin No.	Pin Name	I/O Type	Description	Signal Type
1	RFI	I	RF signal input	RF Analog
2	OSC	I	RF oscillator input	RF Analog
3	MIXO	O	Mixer output	Analog
4	GND	P	Power ground	Ground
5	AGC	O	AGC output	Analog
6	IFI	I	IF signal input	Analog
7	VCC	P	Power supply	Supply
8	DET	O	Detect signal output	Analog

Functional Description

RF Amplifier and Mixer - The received signal from antenna is coupled and amplified by a low-noise amplifier through PIN "RFI". The amplified signal is coupled to mixer to down-convert to IF filter network between PIN "MIXO" and PIN "IFI".

IF Amplifier, RSSI and AGC - The IF signal after filtering is received from PIN "IFI" and coupled to an IF amplifier for signal-conditioning with a RSSI and AGC circuit, which locks the output signal amplitude to a pretty constant level for post-processing. External capacitor connected to PIN "AGC" controls the AGC response time and stability.

AM/ASK Detector – An AM/ASK detector is integrated in PT8R2012 to extract the signal information for basebands, such as decoder or MCU for further signal processing.

Oscillator Circuit - The PT8R2012 employs an external crystal oscillator, which can be easily designed with a BJT transistor. The frequency can be defined by crystal which is connected with PIN "OSC". The output of the oscillator provides local oscillating signals to a mixer to down-convert the received RF signal to the intermediate frequency (IF).

Maximum Ratings

Storage Temperature ..... -50°C to 125°C
Operation Temperature ..... 0°C to 50°C
Supply Voltage to Ground Potential (Input & VCC Only) ..... -0.5V to VCC+0.5V
Supply Voltage to Ground Potential (Output & D/O Only) ..... -0.5V to VCC+0.5V
DC Input Voltage ..... -0.5V to VCC+0.5V
DC Input/Output Current ..... +/-20mA

Note:
Stresses greater than those listed under 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 above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

Recommended operation conditions

Sym	Description	Min	Type	Max	Unit
V_{CC}	Supply voltage	1.8	2.4	3	V
T_A	Range of operating temperature	0	25	50	℃

AC Electrical Characteristics

(Over the operating ratings, T_A=25℃, V_{CC}=3V)

Description	Test Conditions	Min	Typ	Max	Unit	Remarks
Oscillator Frequency Range						
Frequency Range	-	10	27	60	MHz	
RF Input						
Input Impedance (Zin)	At 26.69MHz	45	60	75	Ω	
RF Frequency Range	-	10		60	MHz	
RF Dynamic Range						
Detector output AC amplitude	RF power = -60dBm, f_{in}=26.69MHz, Mod=90%, modulating frequency=1kHz	0.6	1.1V	0.9	V_{CC}	
Sensitivity	Mod=90%, modulating frequency=1kHz	-77	-80	-	dBm	Min. RF power in which signal can be extracted
Dynamic Range	Mod=90%, modulating frequency=1kHz	-	85	-	dB	RF power range in which signal can be decoded correctly

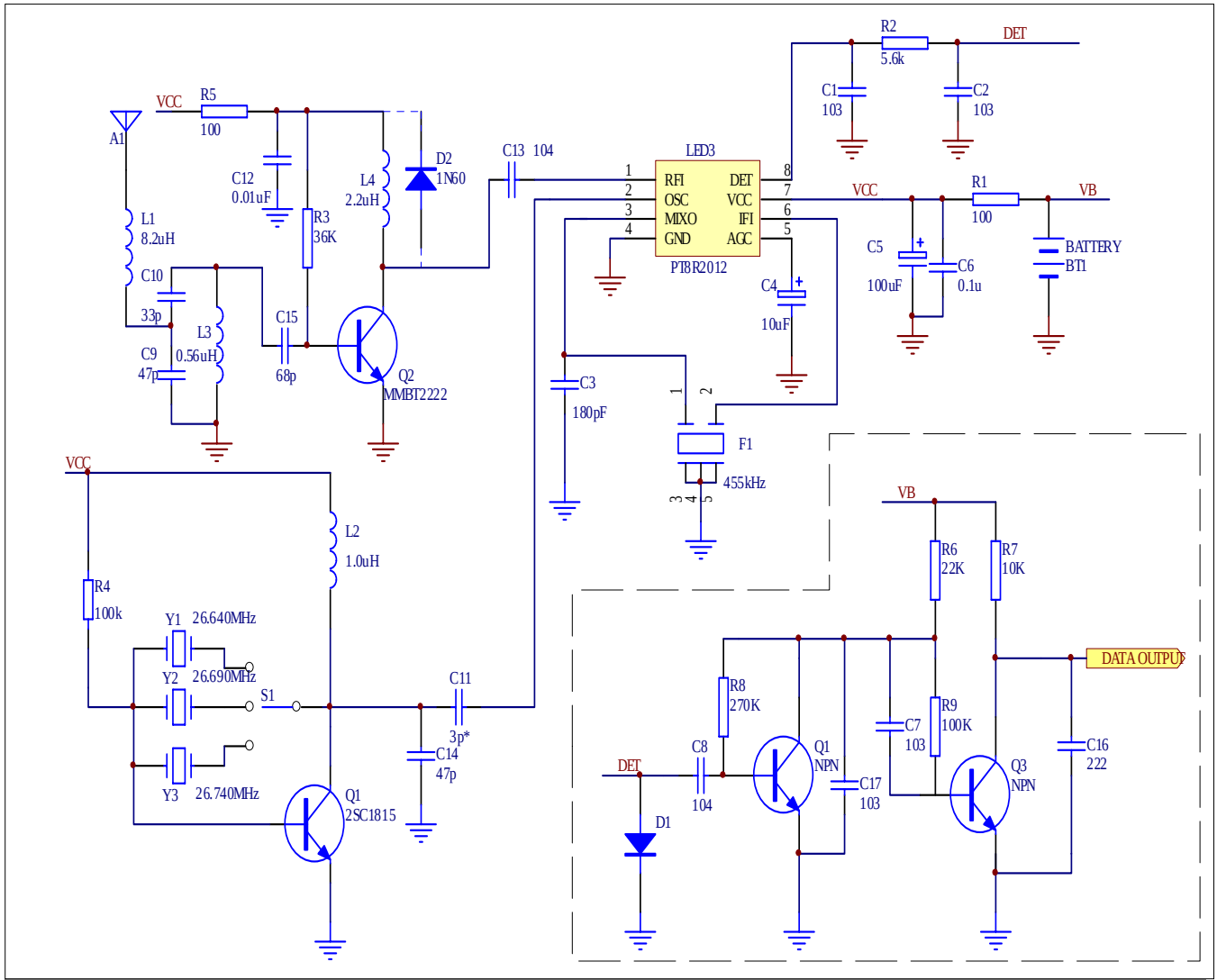
DC Electrical Characteristics

Sym	Description	Test Conditions	Min	Typ	Max	Unit
ICCQ	Quiescent power supply current	Temp=25°C, V_{CC}=3V, OSC operating	-	4	7	mA

(Over the operating ratings, T_A=25℃, V_{CC}=3V)

Parameters	Symbol	Pin Name	Test Condition	Min	Typ	Max	Units
Supply	V_{CC}	VCC		1.8	2.4	3	V
DC	V_{DC-RF}	RFI	No RF signal but with Crystal Oscillation	0.16	0.3	0.38	V
	$V_{DC-MIXER}$	MIXO		2.57	2.64	2.70	
	V_{DC-AGC}	AGC		2.50	2.60	2.94	
	V_{DC-DET}	DET		0.17	1	1.45	
	V_{DC-IF}	IFI		-	0	-	

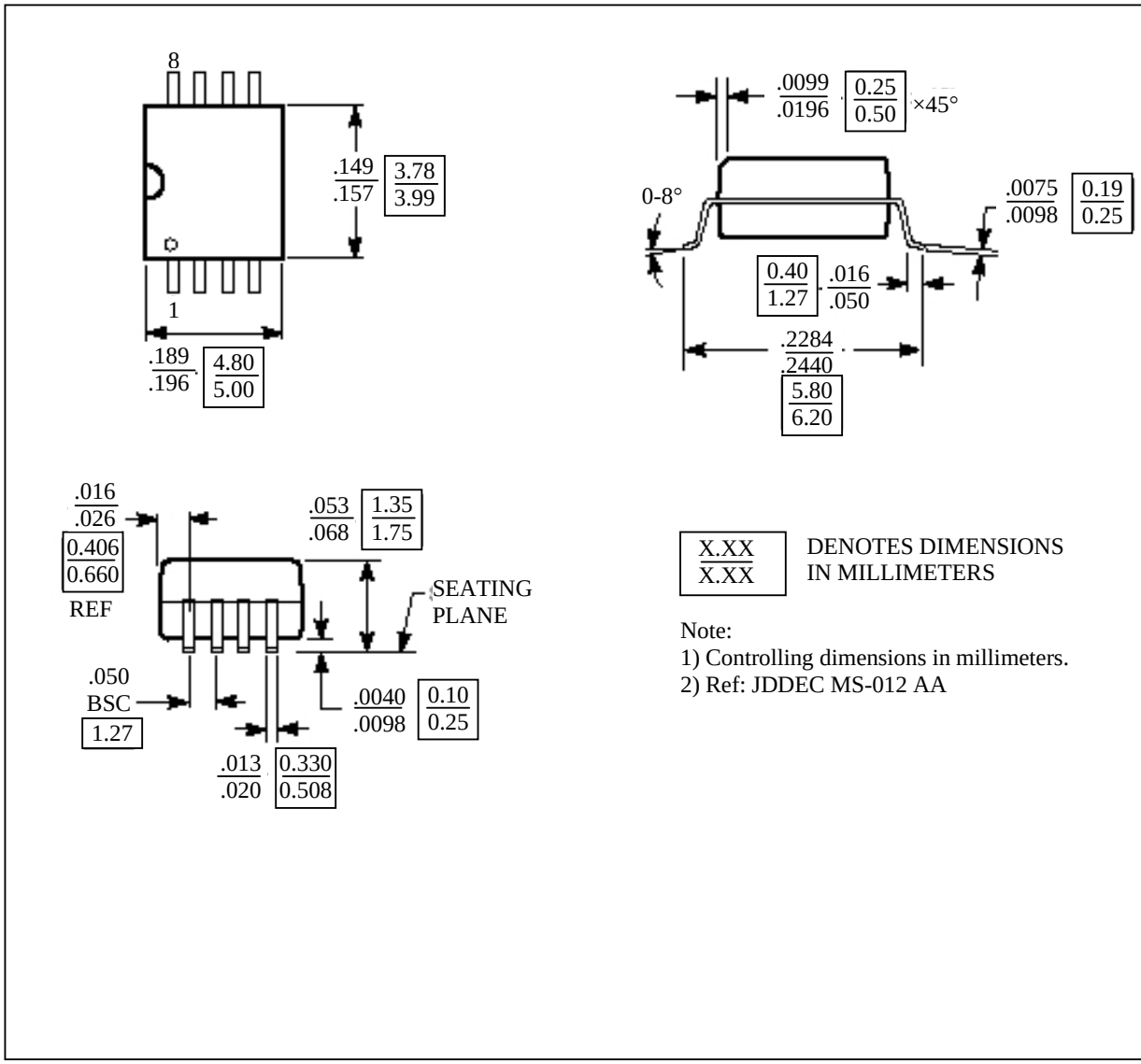
Application Circuit



Note:
Amplifying stages are needed to condition the detector output of PT8R2012W to work with general-purpose MCU.
Amplifying stages are not required when PT8R2012W are used with PTI decoders such as PT8A978P, PT8A973, PT8A991AP, PT8A993A, PT8A996 and so on, as they have built-in amplifying stages for more cost-effective solution.

Mechanical Information

W/WE (8-pin SOIC)



Note:
1) Controlling dimensions in millimeters.
2) Ref: JDDEC MS-012 AA

Notes

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