



# MC13029A

## Advance Information

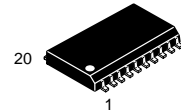
# Advanced Medium Voltage IF and C-QUAM<sup>®</sup> AM Stereo Decoder with FM Amplifier and AM/FM Internal Switch

The MC13029A is a third generation C-QUAM stereo decoder targeted for use in medium voltage, CD/Cassette, Mini-Component, and Hi-Fi AM/FM Electronically Tuned radio applications. Advanced features include a signal quality detector that analyzes signal strength, signal to noise ratio, and stereo pilot tone before switching to the stereo mode. A "blend function" has been added to improve the transition from both mono to stereo and stereo to mono. The audio output level is adjustable to allow easy interface with a variety of AM/FM tuner chips. The IC further includes an AM/FM switch, an audio mute and internal high pass filtering on AM. The external components have been minimized to keep the total system cost low.

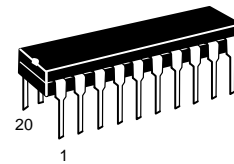
- Operation From 4.0 to 12 V Supply
- IF Amplifier with IF AGC Circuit
- Single Pin-Out, Temperature Compensated VCO
- VCO Shut Down Mode at Weak Signal Condition
- Precision Pilot Tone Detector
- Stereo Blend Function
- Forced Mono Function
- Adjustable Audio Output Level
- AM/FM Switch
- Separate AM De-Emphasis
- Mute Function
- Internal AM High Pass Filters

C-QUAM is a registered trademark of Motorola, Inc.

**C-QUAM AM STEREO  
ADVANCED MEDIUM VOLTAGE  
IF AND DECODER  
FOR E.T.R. RADIOS**

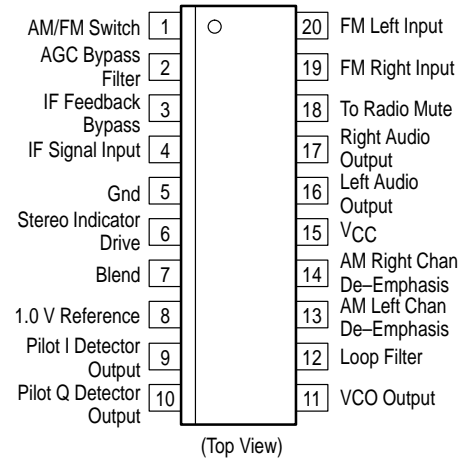


**DW SUFFIX  
PLASTIC PACKAGE  
CASE 751D  
(SO-20)**



**H SUFFIX  
PLASTIC PACKAGE  
CASE 738**

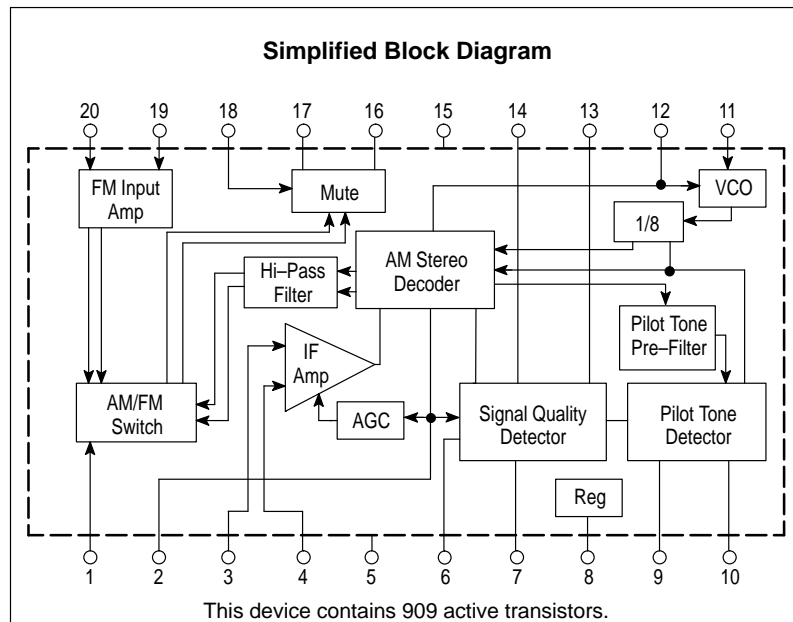
### PIN CONNECTIONS



### ORDERING INFORMATION

Device	Operating Temperature Range	Package
MC13029ADW	T <sub>A</sub> = -25° to +70°C	SO-20
MC13029AH		DIP-20

The purchase of the Motorola C-QUAM<sup>®</sup> AM Stereo Decoder does not carry with such purchase any license by implication, estoppel or otherwise, under any patent rights of Motorola or others covering any combination of this decoder with other elements including use in a radio receiver. Upon application by an interested party, licenses are available from Motorola on its patents applicable to AM Stereo radio receivers.



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## MAXIMUM RATINGS (T<sub>A</sub> = 25°C, unless otherwise noted.)

Rating	Symbol	Value	Unit
Power Supply Input Voltage	V <sub>CC</sub>	14	Vdc
Operating Junction Temperature	T <sub>J</sub>	150	°C
Operating Ambient Temperature	T <sub>A</sub>	-25 to +70	°C
Storage Temperature Range	T <sub>stg</sub>	-55 to +150	°C
LED Indicator Current	I <sub>LED</sub>	10	mA

**NOTE:** ESD data available upon request.

## ELECTRICAL CHARACTERISTICS (V<sub>CC</sub> = 5.0 Vdc, T<sub>A</sub> = 25°C, Input Signal Level = 74 dBμV, Modulating Signal = 1.0 kHz @ 50% Modulation, Test Circuit of Figure 1, unless otherwise noted.)

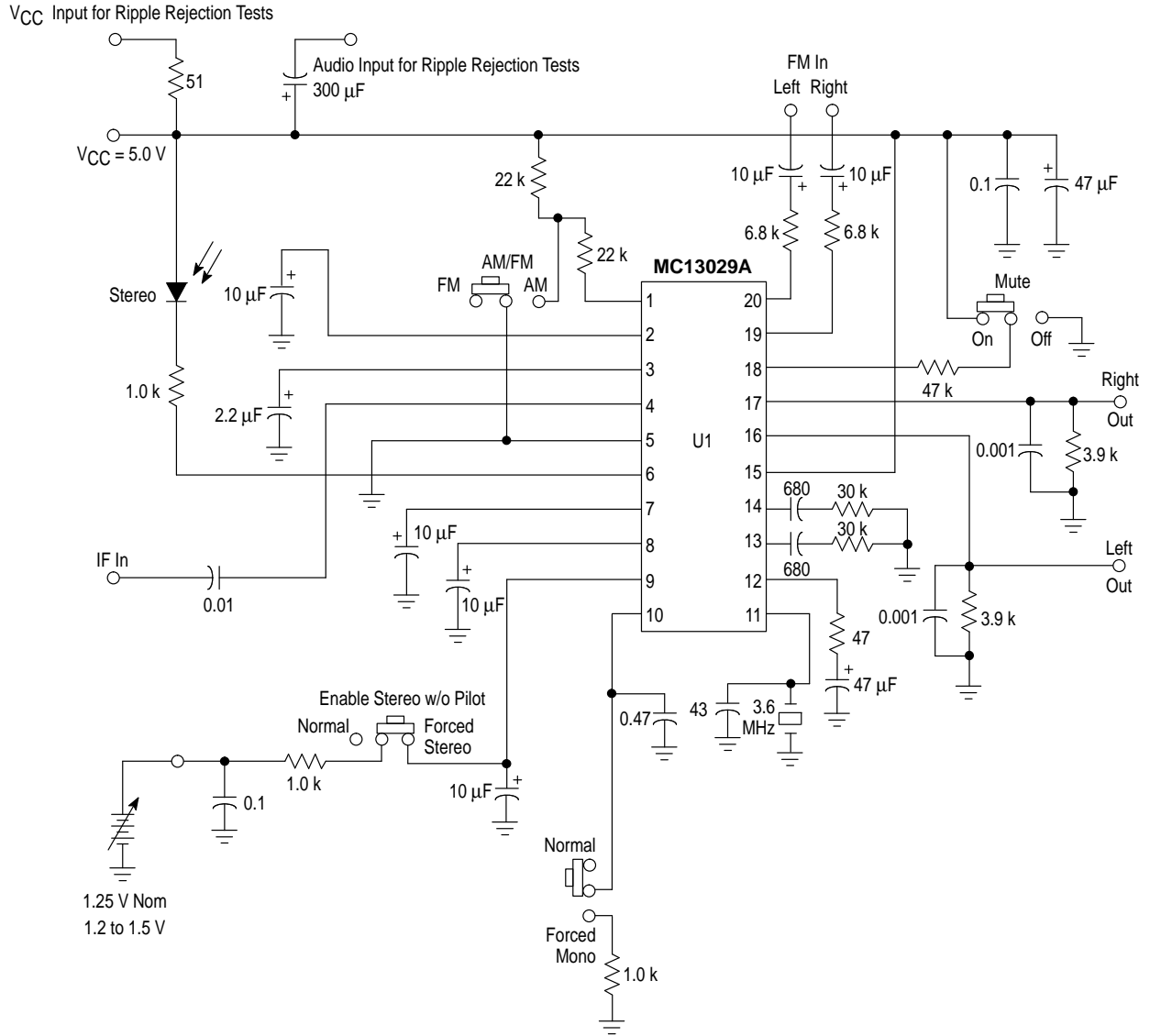
Characteristic	Symbol	Min	Typ	Max	Unit
Supply Current Drain V <sub>CC</sub> = 12 V V <sub>CC</sub> = 5.0 V	I <sub>CC</sub>	– 9.0	12 11	– 13	mA
Audio Output Level, L+R, Mono Modulation R <sub>O</sub> = 3.9 k	V <sub>out</sub>	50	80	110	mVrms
Audio Output Level, L only or R Only, Stereo Modulation R <sub>O</sub> = 3.9 k	V <sub>out</sub>	110	170	260	mVrms
Output THD Stereo, L or R Only Mono, L+R	THD1 THD2	– –	0.6 0.1	1.8 0.6	%
Channel Separation, L or R Only	R or L	23	35	–	dB
Decoder Input Sensitivity, V <sub>out</sub> = -10 dB	V <sub>in</sub>	–	33	–	dBμV
Force to Mono Mode, at Pin 10	–	0.25	0.3	–	Vdc
Signal to Noise Ratio Stereo, 50%, L or R Only, 1.0 kHz Mono, 50%, L+R, 1.0 kHz	S/N	40 40	59 62	– –	dB
Input Impedance (Reference Specification)	R <sub>in</sub> C <sub>in</sub>	– –	10 8.0	– –	kΩ pF
Blend Voltage Mono Mode Stereo Mode Out of Lock	BI	0.7 1.2 –	– 1.30 0.12	0.9 1.4 0.2	Vdc
VCO Lock Range	OSC <sub>tun</sub>	–	±2.5	–	kHz
AGC Range	AGC <sub>rng</sub>	–	44	–	dB
Channel Balance	C–B	-1.2	–	1.2	dB
Pilot Sensitivity	–	–	–	4.0	%

## FM AUDIO SWITCH ELECTRICAL CHARACTERISTICS (V<sub>CC</sub> = 5.0 Vdc, T<sub>A</sub> = 25°C, Signal = 1.0 kHz.)

Characteristic	Symbol	Min	Typ	Max	Unit
FM Switch Nominal Audio Input V <sub>CC</sub> = 5.0 V	V <sub>in</sub>	200	–	500	mV <sub>pp</sub>
Signal to Noise Ratio (FM Audio Input = 200 mVrms)	S/N	–	80	–	dB
Channel Separation, L or R Only	R or L	–	>60	–	dB
Output THD FM Audio Input = 200 mVrms FM Audio Input = 500 mVrms	THD1 THD2	– –	0.01 –	– 2.0	%
AM/FM Switch Input (Pin 1) AM Mode FM Mode	–	– 2.6	– –	0.5 –	Vdc
Mute Threshold (Pin 18) Mute On Mute Off	–	2.6 –	– –	– 0.5	Vdc

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Figure 1. Test Circuit



## PIN FUNCTION DESCRIPTION

Pin	Symbol	Internal Equivalent Circuit	Description/External Circuit Requirements
1	AM/FM		<b>AM/FM Mode Switch</b> The dc level applied to this pin will determine whether the AM or FM audio is switched to output Pins 16 and 17. A voltage greater than 1.2 V will cause the FM audio to be output.
2	AGC <sub>cap</sub>		<b>AGC Filter Bypass Capacitor</b> An electrolytic capacitor is used as a bypass filter and it sets the time constant for the AGC circuit action. The recommended capacitor value is 10 $\mu$ F from Pin 2 to ground. The dc level at this pin varies as shown in the curve in Figure 13. AGC Voltage versus Input Level.
3	IFB <sub>cap</sub>		<b>IF Amplifier Feedback Capacitor</b> A capacitor which is specified to have a low ESR at 450 kHz is normally used at Pin 3. The value recommended for this capacitor is 0.47 $\mu$ F from Pin 3 to ground. This component forms a low pass filter which has a corner frequency around 30 kHz.
4	IF <sub>in</sub>		<b>IF Amplifier Input</b> Pin 4 is the IF input pin. The typical input impedance at this pin is 10 k. The input should be ac coupled through a 0.01 $\mu$ F capacitor.
5	Gnd		<b>Supply Ground</b> In the PCB layout, the ground pin should be connected to the chassis ground directly. This pin is the internal circuit ground and the silicon substrate ground.
6	S <sub>IND</sub>		<b>Stereo Indicator Driver</b> This driver circuit is intended to light an LED or other indicator when the decoder receives the proper input signals and switches into the stereo mode. The maximum amount of current that the circuit can sink is 10 mA.  A current limiting resistor is applied externally to control LED brightness versus total power supply current.

PIN FUNCTION DESCRIPTION (continued)

Pin	Symbol	Internal Equivalent Circuit	Description/External Circuit Requirements
7	CAPBlend		<p><b>Blend Capacitor</b></p> <p>The value of the capacitor on this pin will effect the time constant of the decoder blend function. The recommended value is 10 <math>\mu</math>F from Pin 7 to ground. The dc level at Pin 7 is internally generated in response to input signal level and signal quality. This pin is a key indicator of the operational state of the IC (see text Functional Description). It is recommended to discharge the Blend Capacitor externally when changing stations.</p>
8	V <sub>ref</sub>		<p><b>Regulated Voltage, 1.0 V</b></p> <p>An electrolytic capacitor used as a bypass filter is recommended from Pin 8 to ground. The capacitor value should be 10 <math>\mu</math>F.</p>
9	I <sub>Pilot</sub>		<p><b>Pilot I Detector Output</b></p> <p>The Pilot I Detector Output requires a 10 <math>\mu</math>F electrolytic capacitor to ground. The value of this capacitor sets the pilot acquisition time. The dc level at Pin 9 is approximately 1.0 Vdc, unlocked, and 1.1 to 2.4 Vdc in the locked condition.</p>
10	Q <sub>Pilot</sub>		<p><b>Pilot Q Detector Output</b></p> <p>This pin is connected to the Pilot Q Detector and requires a 0.47 <math>\mu</math>F capacitor to ground to filter the error line voltage at the PLL pilot tone detector. If the value of this capacitor is made too large, the decoder may be prevented from coming back into stereo after a signal dropout has been experienced in the field. The force to mono function is also accomplished at this pin by pulling the dc voltage level at the pin below 1.0 V.</p>
11	OSC <sub>in</sub>		<p><b>Oscillator Input</b></p> <p>The Oscillator pin requires a ceramic resonator and parallel capacitor connected to ground. The recommended source for the ceramic resonator is Murata, part number CSA 3.60MGF108. A 43 pF NPO capacitor is in parallel with the resonator. The dc level at Pin 11 is approximately 1.1 Vdc.</p>
12	LOOP <sub>Filter</sub>		<p><b>Loop Filter</b></p> <p>A capacitor which forms the Loop Filter is connected from Pin 12 to ground. The recommended value is 47 <math>\mu</math>F in series with 47 <math>\Omega</math>. This capacitor should be of good construction quality so it will have a very low specification for leakage current in order to prevent stereo distortion. The 47 <math>\Omega</math> resistor in series with the capacitor controls fast lock rate. The dc level at Pin 12 is approximately 0.6 Vdc in the locked condition.</p>

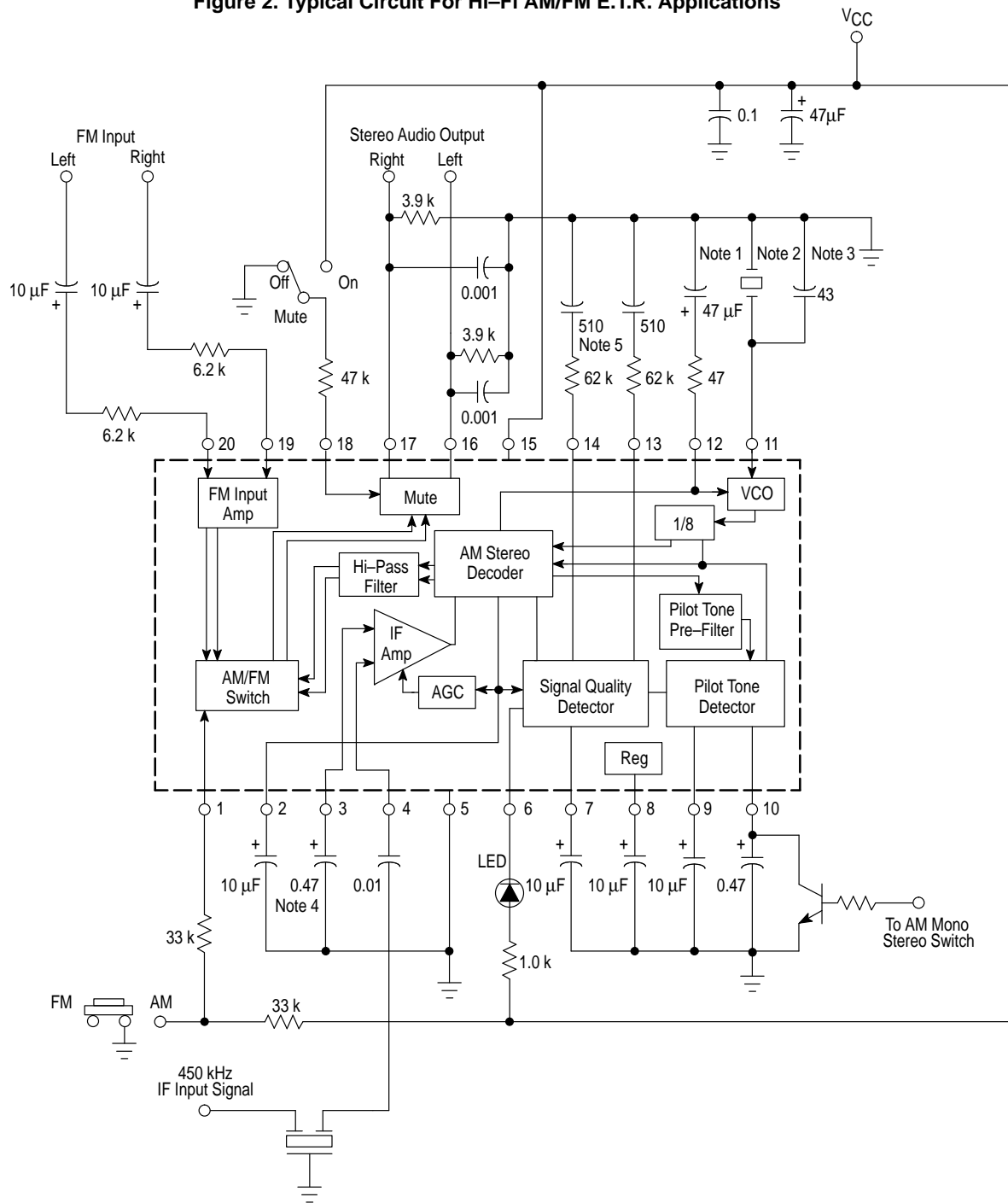
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## PIN FUNCTION DESCRIPTION (continued)

Pin	Symbol	Internal Equivalent Circuit	Description/External Circuit Requirements
13 14	DE-L DE-R		<b>AM De-Emphasis, Left Channel/Right Channel</b> An RC network attached at this pin can be used to add de-emphasis to the AM tone response. The AM tone response is primarily shaped by the IF filter. Additional roll-off may be applied here.
15	VCC		<b>Supply Voltage (VCC)</b> The operating supply voltage range is from 4.0 Vdc to 12 Vdc.
16 17	LEFT <sub>out</sub> RIGHT <sub>out</sub>		<b>Audio Output</b> Output is approximately 1.3 $\mu$ A <sub>pp</sub> drive current for each percent of mono modulation. A resistor to ground sets the voltage level of the audio output.
18	Mute		<b>Mute Input</b> A dc voltage exceeding 1.5 V applied to this pin will cause a shutting down of the left and right channel outputs at Pins 16 and 17.
19	FM-R		<b>FM Audio Right Channel Input</b> The audio output from the FM detector is input at this pin. The dc level applied at Pin 1, the AM/FM Mode Switch, then determines whether this audio, or that from the AM channel will be output at Pin 17. An external series resistor between this pin and the FM detector is used to set the FM audio levels at the output Pin 17.
20	FM-L		<b>FM Audio Left Channel Input</b> The audio output from the FM detector is input at this pin. The dc level applied at Pin 1, the AM/FM Mode Switch, then determines whether this audio or that from the AM channel will be output at Pin 16. An external series resistor, between this pin and the FM detector, is used to set the FM audio levels at the output Pin 16.

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Figure 2. Typical Circuit For Hi-Fi AM/FM E.T.R. Applications



- NOTES:**
1. This part is recommended to be a low leakage type capacitor. Leakage current due to this capacitor causes increase in stereo distortion and poor separation performance.
  2. The recommended source for this part is Murata Products, CSA3.60MGF108. The location of this part should be carefully considered during the layout of the decoder circuit. This part should not be near the audio signal paths, the 25 Hz pilot filter lines, or the V<sub>CC</sub> high current lines, and the ceramic element ground line should be direct to the chassis ground lead in order to avoid any oscillator inter-modulation.
  3. This capacitor is recommended to be an NPO type ceramic part. Changing the value of this capacitor alters the lock range of the decoder PLL.
  4. This part is recommended to be a low ESR type capacitor, (less than 1.5 Ω) in order to avoid increased audio output distortions under weak input signal conditions with higher modulation levels.
  5. Component values for this stage of the NRSC filter will vary from receiver manufacturer to manufacturer due to the additive nature of the particular response slopes of the frequency selective parts, (RF and IF coils, and the ceramic IF filter) within a radio design. Since these responses may vary somewhat in each custom design, the filters at Pins 13 and 14 are included to provide any remaining response roll-off that might be necessary to comply with the overall NRSC frequency standard.

## FUNCTIONAL DESCRIPTION

## Introduction

The MC13029A is designed as a medium voltage decoder for the C–QUAM AM Stereo technology and is completely compatible with existing monaural AM transmissions. The IC requires relatively few, inexpensive external parts to produce a multi–featured C–QUAM AM Stereo implementation. The layout is straightforward and should produce excellent stereo performance results. This device performs the function of IF amplification, AGC, modulation detection, pilot tone detection, signal quality inspection, blend, left and right channel FM input amplification, muting, AM and FM switching function, and amplified left and right audio output levels which are adjustable. The IC is targeted for use in CD/Radio/Cassette, Mini–Component, and Hi–Fi AM/FM E.T.R. AM Stereo radio applications.

From the output of a ceramic IF filter and through a coupling capacitor, the IF amplifier circuit of the MC13029A receives its input at Pin 4 as a 450 kHz, typically modulated C–QUAM signal. The input signal level for stereo operation can vary from 50 dB $\mu$ V to about 90 dB $\mu$ V. This IC design incorporates feedback in the IF circuit section which provides excellent dc balance in the IF amplifier. This balanced condition also guarantees excellent monophonic performance from the decoder. An IF feedback filter at Pin 3 is formed by a 0.47  $\mu$ F, low leakage, low ESR capacitor. It is used to filter out the 450 kHz signal which is present on the IF amplifier feedback line. An AGC circuit controls the level of IF signal which is subsequently fed to the detector circuits. An AGC bypass capacitor is connected to Pin 2 and forms a single pole, low pass filter. The value of this part also sets the time constant for the AGC circuit action.

The amplified C–QUAM IF signal is fed simultaneously to the envelope detector circuit, and to a C–QUAM converter circuit. The envelope detector provides the L+R (mono) signal output which is fed to the stereo matrix. In the converter circuit, the C–QUAM signal is changed into a Quam signal when it is divided by the  $\cos \phi$  term. The Quam IF signal is then fed into the I detector, the L–R detector, and the Q detector circuits. The outputs of the Envelope detector and the I detector circuits feed back into a comparator circuit which looks at both signals and uses the differences to create the  $\cos \phi$  signal. The Quam IF signal fed to the L–R and the Q detectors is multiplied by a 450 kHz signal that is phased 90° from the one in the I detector circuit. This quadrature relationship is necessary in order to detect the L–R (or stereo) audio information from the Quam signal. The audio outputs from both the Envelope and the L–R detectors are first filtered to minimize the harmonics of the IF signal that are created in the mixing process. (The outputs from the I and Q detectors are also filtered similarly.) Then they are fed into a matrix circuit where the Left channel and the Right channel outputs are extracted and fed into a high pass filter block. Here the audio signals are conditioned so they can be fed to an output amplifier which, if left unmuted, delivers the left and the right output at Pins 16 and 17. At this time, a stereo output will occur if the input IF signal is: a.) larger than the stereo threshold level, b.) not too noisy, and c.) a proper pilot tone is present. At Pin 6, the stereo indicator driver circuit, which can sink up to 10 mA, is also enabled.

After turn on or tune in, if the input signal level threshold for stereo operation is not exceeded, or if the incoming signal is too noisy, the blend circuit, at Pin 7, (even in the presence of

a pilot signal) will hold the decoder in the monaural mode. A blend circuit is included in this design because of the effects of conditions which occur during field use that can cause input signal strength fluctuation, strong unwanted co–channel or power line interference, and/or multi–path or re–radiation. When these aberrant conditions occur, rapid switching between stereo and mono might occur, or the stereo quality might be degraded. Since these effects could be annoying to the listener, the stereo information is blended towards a monaural output. This creates a condition for listening where the aberrant effects are more tolerable.

Intentional mono operation is a feature sometimes required in receiver designs. There are several ways in which to accomplish this. First, a 10 k resistor from Pin 10 to ground can be switched into the circuit, as is shown in Figure 18. A second method is to shunt Pin 10 to ground through an NPN transistor as shown in Figure 2.

A third method to force a mono condition on the decoder is to shunt Pin 7 of the decoder to ground through an NPN transistor. This discharges the blend capacitor (10  $\mu$ F), and the blend function internally forces the decoder into mono. This third method does not necessarily require extra parts as most electronically tuned receiver designs require an audio muting function during turn on/turn off, tuning/scanning, or band switching (FM to AM). When the muting function is designed into an AM Stereo receiver, it also should include a blend capacitor reset (discharge) function. The purpose of the blend reset during muting is to re–initialize the decoder back into the “fast lock” mode from which stereo operation can be attained much quicker after any of the interruptive activities mentioned earlier, (i.e. turn on, tuning, etc.).

The VCO in this IC is a phase shift oscillator type that operates with a ceramic resonator at eight times the IF frequency, or 3.60 MHz. With IF input levels below the stereo threshold level, the oscillator is not operational. This feature helps to eliminate audio tweets under low level, noisy input conditions.

The phase locked loop (PLL) in the MC13029A is locked to the L–R signal. This insures good stereo distortion performance at the higher levels of Left only or Right only modulations. Under normal operating conditions, the PLL remains locked because of the current capability of the loop driver circuit. This high gain, high impedance circuit is filtered by a 47  $\Omega$  resistor in series with a 47  $\mu$ F capacitor from Pin 12 to ground. It is recommended that the capacitor be a very low leakage type electrolytic (less than 200  $\mu$ A), or a tantalum part. Any significant leakage through the capacitor will unbalance the loop driver circuit and result in less than optimum stereo performance, see Figures 10 and 11.

The pilot tone detector circuit is fed internally by a signal from the Q detector output and is filtered by an internal, 50 Hz low pass pilot pre–filter. This filter is designed to prevent the pilot tone detector input from being overloaded by higher levels of L–R audio modulation. A pilot I detector circuit employs a capacitor to ground at Pin 9 to operate in conjunction with an internal resistor to create an RC integration time. The value of the capacitor affects the amount of time required to produce a stereo indication. The minimal time period must be long enough to include the time it takes for the circuit to check for detector falsing due to noise



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or interference, station re-tuning by the customer, and pilot drop-out in the presence of heavy interference. The pilot Q detector incorporates a filter on its pilot tone PLL error line at Pin 10. This capacitor to ground (usually 0.47  $\mu\text{F}$ ) is utilized to filter any low frequency information that may be present on the error line. If the value of this capacitor is allowed to be too small, the level of interference near the pilot tone frequency of 25 Hz may become large enough to cause stereo drop-out. If the capacitor value is made too large, the pilot tone may be prevented from being re-acquired if it is somehow lost due to fluctuating field conditions.

A 1.0 V reference level is created within the IC. This regulated line is used extensively by circuits throughout the MC13029A design. An electrolytic capacitor from Pin 8 to ground is used as a filter for the reference voltage.

At Pin 1, the MC13029A provides a function which allows the user to switch between AM and FM audio signals. The actual switching is controlled by dc level with a low for AM and a high for FM audio output.

The level of the audio output at Pins 16 and 17 can be set by the value of a resistor to ground at these pins. The output pins are connected to the collectors of PNP audio output amplifiers. At strong signal, these amplifiers can supply about 1.3  $\mu\text{A}_{\text{pp}}$  of drive current for each percentage of mono modulation present. In other words, for a 100% LTR signal, 130  $\mu\text{A}_{\text{pp}}$  will flow through the load. Thus, the value of resistor to ground will determine the peak-to-peak output.

The MC13029A IC provides a true mute function, controlled at Pin 18. A dc level of about 2.6 Vdc is sufficient to ensure muting of the audio outputs at Pins 16 and 17. This feature is useful when tuning in a different radio station, and the designer may also choose to utilize muting when switching between AM and FM.

The FM input audio signals are fed through series external resistors to Pins 19 and 20. Since AM broadcasters normally use heavy audio processing, the value of these resistors is chosen so that the audio output levels of FM are approximately 2.0 dB higher than the audio output levels of AM for the same modulation levels. Under these conditions, there will be only minimal volume differences perceived by the consumer when the MC13029A is switched between AM and FM outputs.

In order to comply with the FCC ruling on the NRSC AM audio response, a connection for de-emphasis circuitry in the MC13029A is provided at Pins 13 and 14 for left and right AM channels respectively. Typically, a series R-C network to ground will provide sufficient additional response shaping to the overall AM response so that the NRSC standard shape can be achieved. The values of these de-emphasis components will vary from design to design. The AM RF and IF coil responses, ceramic filter response and NRSC circuit response all contribute in an additive manner to the shape of the overall AM audio responses at the IC output pins.

## DISCUSSION OF GRAPHS AND FIGURES

The curves in Figures 3 through 8 depict the separation and the distortion performance in stereo for 30%, 50% and 65% single channel modulations respectively. The data for these figures was collected under the conditions of  $V_{CC} = 8.0$  V and  $R_O = 3.9$  k in both the left and the right channels as recommended in the application circuit of Figure 2. A very precise laboratory generator was used to produce the AM Stereo test signal of 450 kHz at 75 dB $\mu$ V fed to Pin 4. An NRSC post detection filter was not used. The audio separation shows an average performance at 30% and 50% modulations of  $-38$  dB in the frequency range of 1.0 to 5.0 kHz. The corresponding audio distortions are about 0.3% at 30% modulation and about 0.4% or better at 50% modulation.

Figure 7 shows that the typical separation performance at 65% modulation in the 1.0 to 5.0 kHz region is about  $-35$  dB, and the corresponding audio distortion shown in Figure 8 is about 0.9% or better. The performance level of these sinusoidal signals is somewhat less than those discussed in the previous paragraph due to the internal operation of the clamping circuits. In the field, the transmitters at AM Stereo radio stations are not usually permitted to modulate single channel levels past 70%.

Note the  $-3.0$  dB of roll-off at 80 Hz in the output responses of this decoder. These are the top traces (Desired Channel) in Figures 3, 5 and 7. That roll-off appears by design as a feature to help minimize switching transients present when between AM and FM. This roll-off also provides additional attenuation of pilot tone residuals in the detected audio.

The graphs in Figure 9 show the traces of noise response for four different bandwidths of post detection filtering, measured with respect to 30% mono modulation. It can be seen that the noise floors improve steadily with increasing levels of incoming 450 kHz as the value of the lower corner frequency of the filter is increased. Data for the stereo noise floors was collected with the decoder in the forced stereo mode. The upper trace in Figure 9, labeled Audio Level, shows the response, of the 30% mono signal transmitted, as

it appears at the decoder output. The change in response level around 55 dBmV shows the characteristic of the total decoder gain at lower signal inputs.

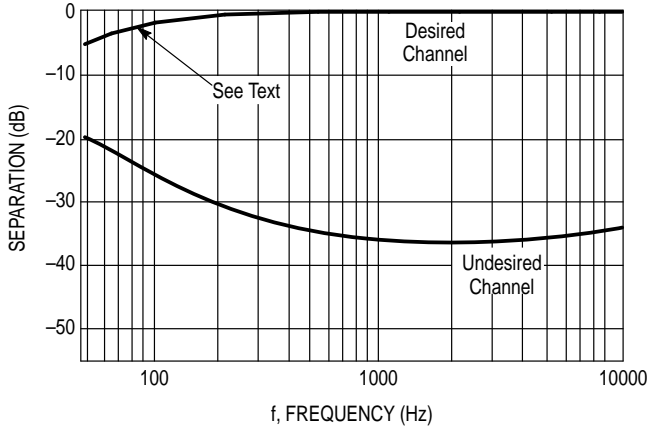
Figures 10 and 11, discussed briefly in the Function Description Section, show the importance of using a quality component at Pin 12 to ground. It can be seen that an electrolytic capacitor leakage current of 600 nA can unbalance the PLL to the point where stereo performance may degrade to only 25 dB of separation with a corresponding 2.0% distortion at 50% modulation levels.

The value of the capacitor connected to Pin 12 (47  $\mu$ F) is also a factor in the determination of the low frequency corner of the PLL circuit response. PLL responses appear in Figure 12, plotted for three different values of loop filter capacitor. The recommended value of 47  $\mu$ F provides the best response shape in this circuit where a Murata Products CSA3.60MGF108 part is used.

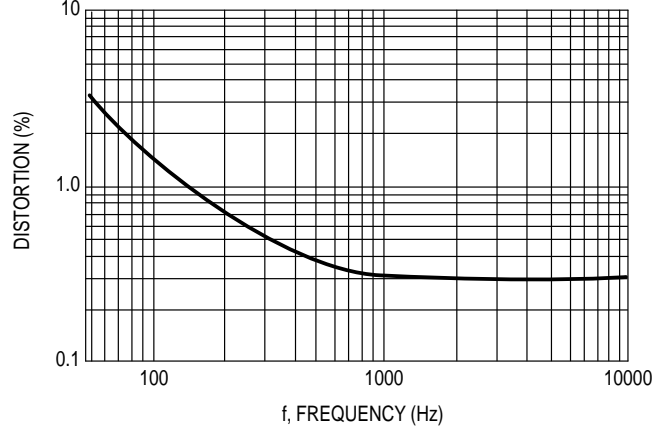
Figure 13 presents the response of the AGC voltage versus decoder input signal level in the application schematic of Figure 2. The trace begins approximately at the point of decoder sensitivity, and rises until reaching the area of stereo sensitivity. Thereafter, the circuit responds in a near linear fashion for the next 35 dB of input signal increase.

Figures 14 through 17 depict the  $V_{CC}$  ripple rejection performance for the MC13029A under mono and stereo conditions for maximum and for no NRSC filtering. It should be noted that this data was collected without any  $V_{CC}$  filtering. As one might expect, the ripple rejection is excellent during mono conditions with approximately 45 dB of 50 Hz to 100 Hz ripple rejection at the high level of NRSC filtering. Under stereo operation, the rejection is the same or better in the 6.0 to 12 V range of operation, as can be seen in Figure 16. When the decoder operates in stereo, the VCO is functional, thus the decoder becomes more susceptible to audio ripple on the  $V_{CC}$  line. Under normal operating conditions, with the recommended value of 47  $\mu$ F at Pin 15 and 10  $\mu$ F at Pin 8, a  $V_{CC}$  ripple reading will be virtually the same as measuring the noise floor of the IC.

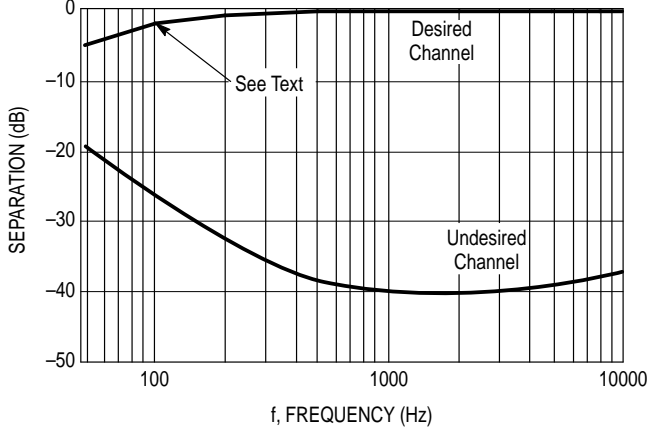
**Figure 3. Single Channel Separation at 30% Modulation**



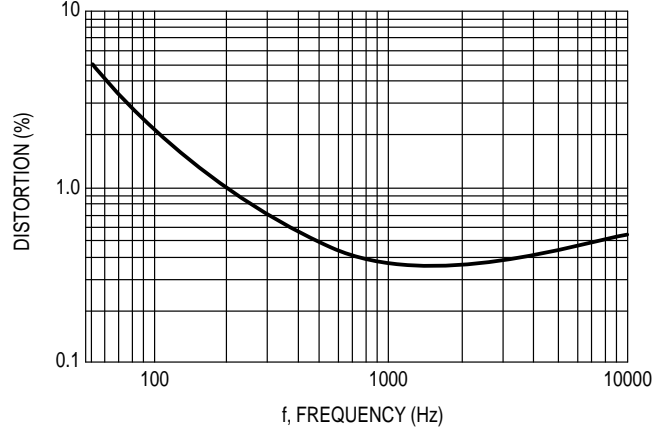
**Figure 4. Single Channel Distortion at 30% Modulation**



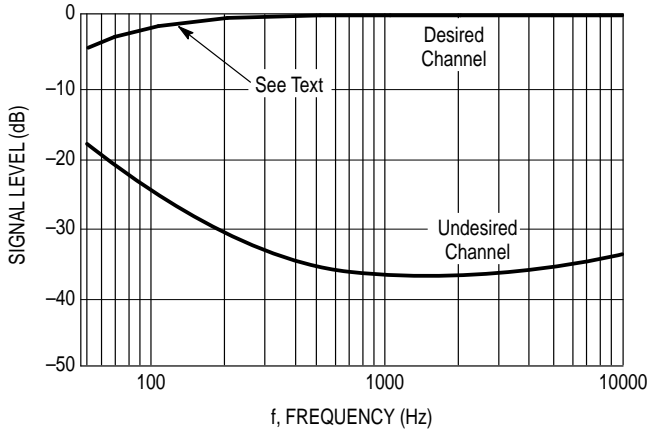
**Figure 5. Signal Channel Separation at 50% Modulation**



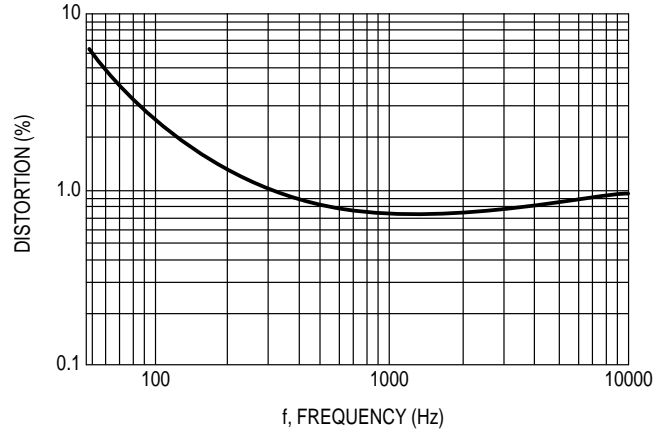
**Figure 6. Single Channel Distortion at 50% Modulation**



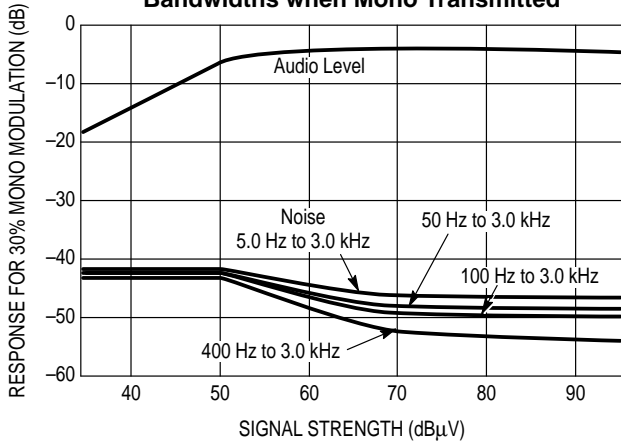
**Figure 7. Single Channel Separation at 65% Modulation**



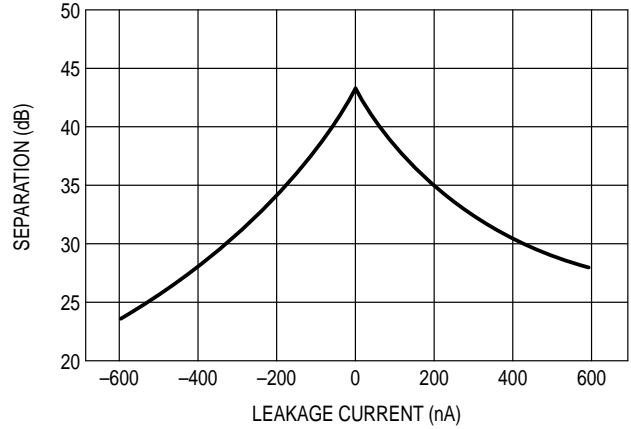
**Figure 8. Single Channel Distortion at 65% Modulation**



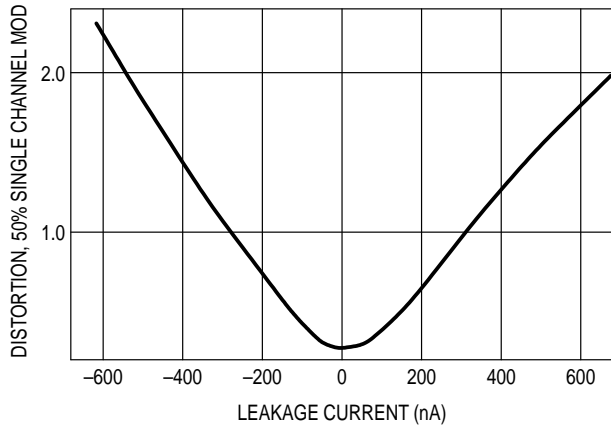
**Figure 9. Stereo Noise in Various Bandwidths when Mono Transmitted**



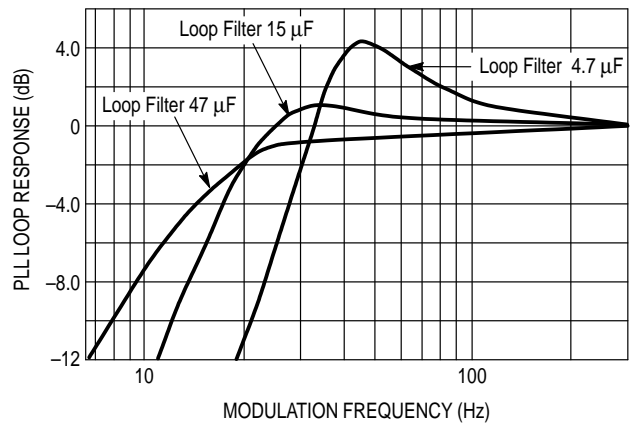
**Figure 10. Decoder Separation versus Filter Capacitor (Pin 12) Leakage Current**



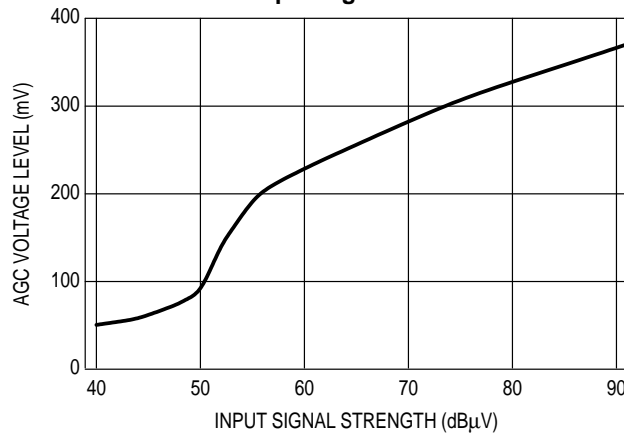
**Figure 11. Decoder Distortion versus Filter Capacitor (Pin 12) Leakage Current**



**Figure 12. Low Frequency Corner of PLL Response**



**Figure 13. AGC Voltage versus Input Signal Level**



# MC13029A

## AM STEREO TUNER/FM STEREO IF

### Description of Application

The MC13029A AM Stereo Decoder is combined with a Sanyo LA1832 Tuner. The combination results in an AM stereo tuner, along with an FM IF and FM stereo detector. The MC13029A provides the means to switch the left and right channel audio between the AM and FM. A MC145151 synthesizer controls the L.O. contained within the LA1832. The circuit schematic is shown in Figure 18.

### Circuit Board Description

The copper side layout and component locations are shown in Figure 19. The dimensions in the figure give the true size of the circuit board. With the exception of U2 and U3, all components and jumpers are mounted on the side of the board, away from the viewer.

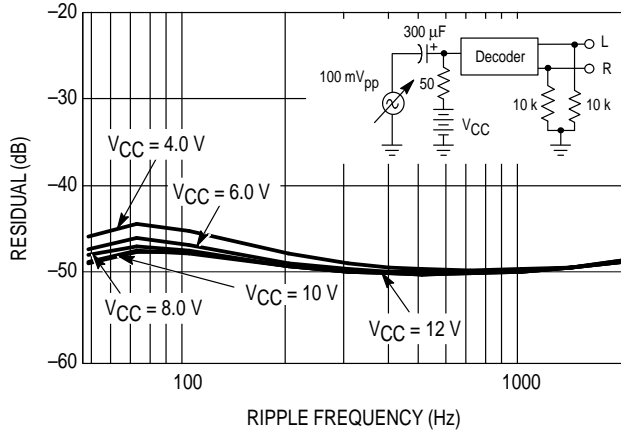
### Special Parts

Table 1 provides the circuit function, part number, and the manufacturer's name for special parts. The parts are identified by their schematic symbol. Where the part is not limited to a single source, a description sufficient to select a part is given.

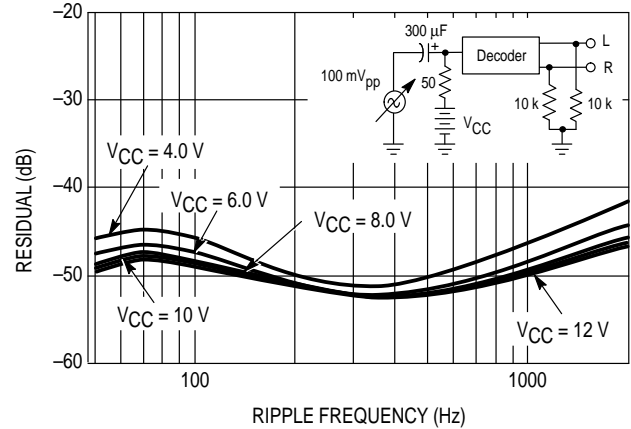
**Table 1**

U1	IC—AM Stereo Decoder, MC13029A, Motorola
U2	IC—AM/FM IF and Multiplex Decoder, LA1832M, Sanyo
U3	IC—Frequency Synthesizer, MC145151DW2, Motorola
T1	AM IF Coil, A7NRES-11148N, TOKO
F1	AM IF Ceramic Filter, SFG450F, Murata
F2	FM Detector Resonator, CDA10.7MG43, Murata
F3	FM Multiplex Decoder Resonator, CSB456F15, Murata
F4	AM Tuner Block, BL-70, Korin Giken
X1	10.24 MHz Crystal, Fundamental Mode, AT Cut, 18 pF Load Cap, 35 $\Omega$ Max Series R, HC18/U Holder
X2	3.6 MHz AM Stereo Decoder Resonator, CSA3.60F103, Murata
S5	8 Section SPST DIP Switch

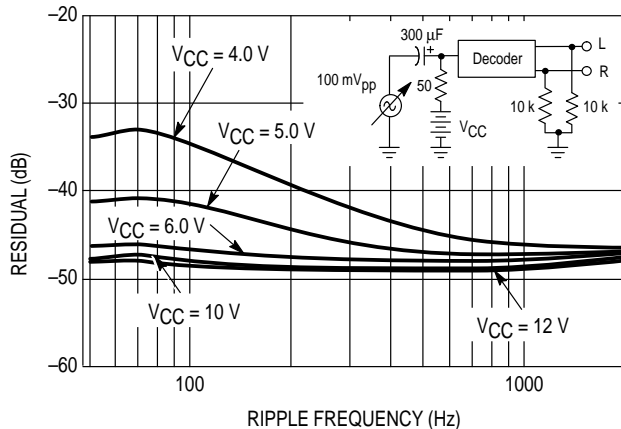
**Figure 14. Mono V<sub>CC</sub> Ripple Rejection with No NRSC Filter**



**Figure 15. Mono V<sub>CC</sub> Ripple Rejection with Maximum NRSC Filter**



**Figure 16. Stereo V<sub>CC</sub> Ripple Rejection with No NRSC Filter**



**Figure 17. Stereo V<sub>CC</sub> Ripple Rejection with Maximum NRSC Filter**

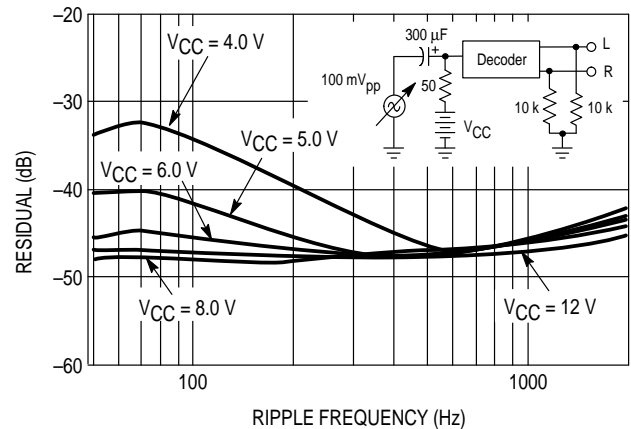
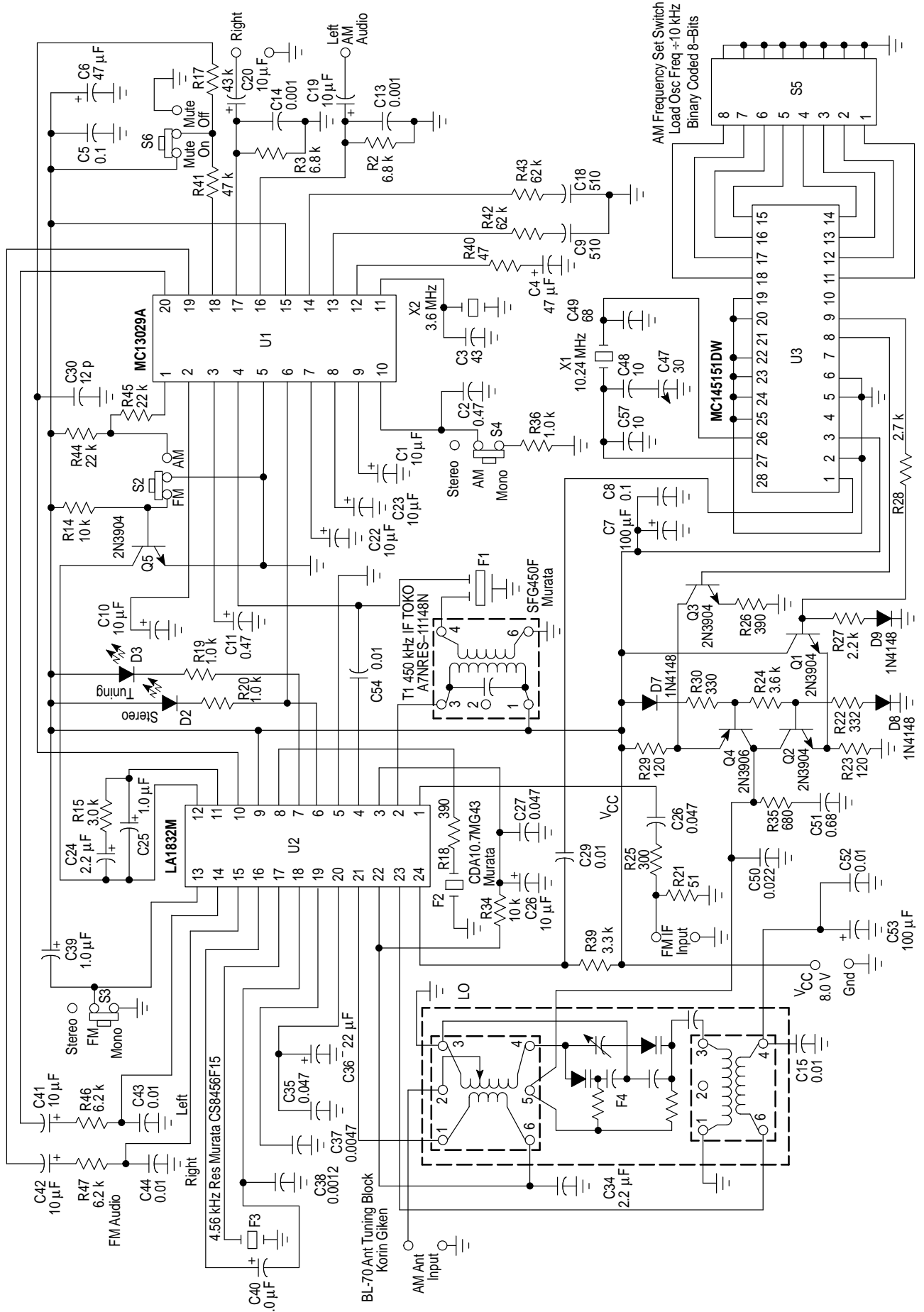
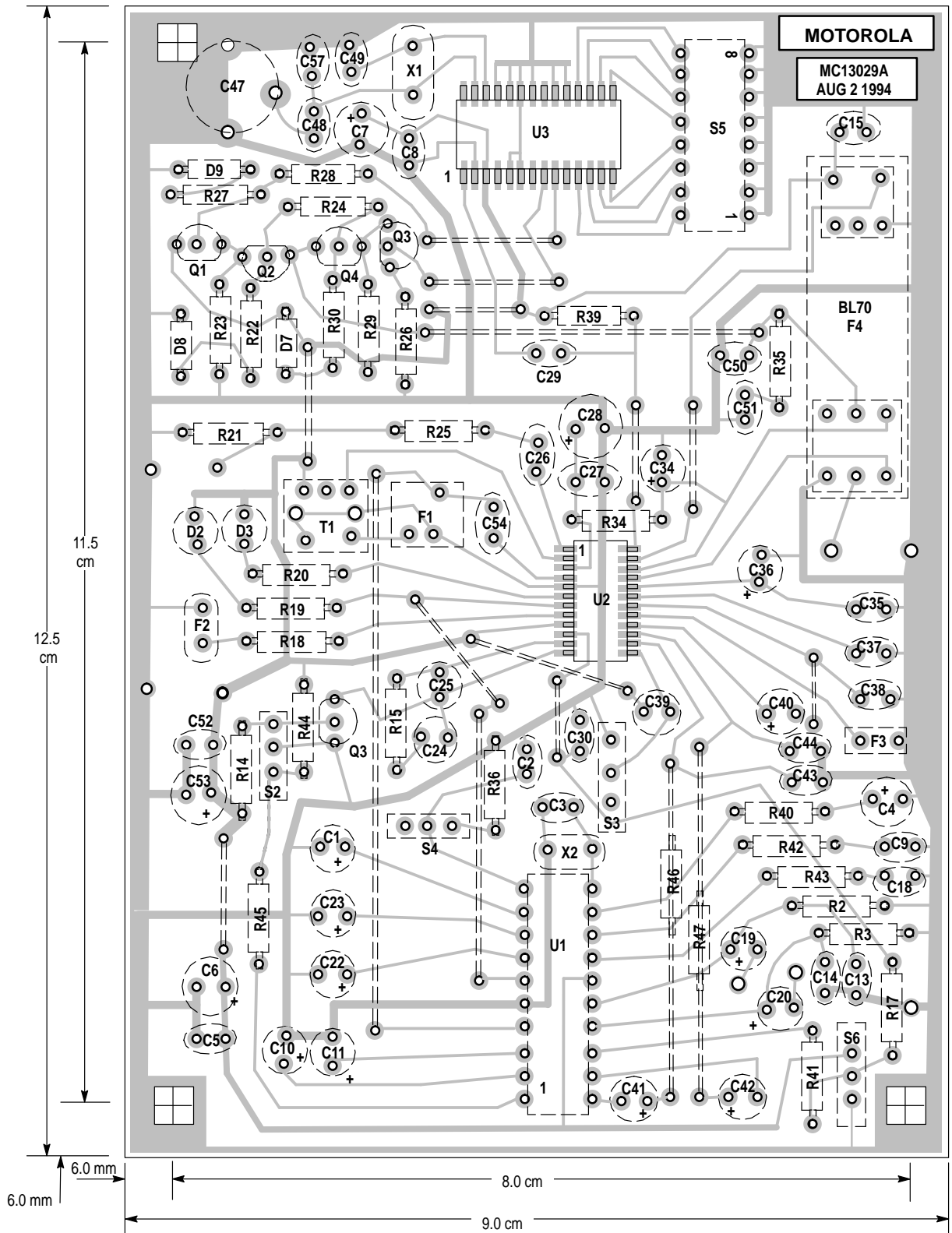


Figure 18. MC13029A Decoder IC Application



# MC13029A

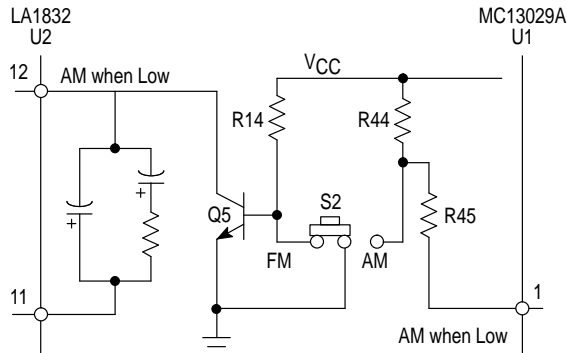
Figure 19. MC13029A Application Circuit Board  
Shown 1 1/2 Times Actual Size



CIRCUIT DESCRIPTION

To set the circuit to AM mode, Pin 12 of U2 must be pulled to ground, as is Pin 1 of U1. This operation is shown in Figure 20. Pin 12 of U2 must be isolated by a high impedance when in FM mode. To allow switch S2 to accomplish the switching of both ICs, the transistor Q5 performs the switching of Pin 12 of U2.

Figure 20. AM/FM Switch

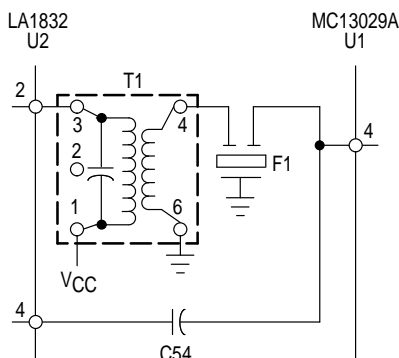


The AM local oscillator is contained in U2 with the L.O. coil located within the tuning block F4, and the coil connected to Pin 23 of U2. See Figure 18. The secondary of the coil is tuned by a varactor contained in F4, and controlled by the synthesizer IC U3. A buffer amplifier outputs the L.O. frequency from U2 Pin 24. This sample of the L.O. frequency is input to Pin 1 of the synthesizer IC U3.

The station signal is applied from a loop antenna (not shown in Figure 18) to the primary of the RF coil contained within the tuning block F4. The primary is tuned by a varactor located within F4, and controlled by the synthesizer U3. The coil secondary applies the signal to Pin 21 of U2 along with a bias voltage from Pin 22 of U2.

The 450 kHz IF signal from the mixer is output from Pin 2 of U2. Refer to Figure 21. The IF signal is applied through the IF coil T1 to the ceramic band pass filter F1. The signal is then applied to Pin 4 of the tuner IC, U2 and to Pin 4 of the decoder, U1. C54 is necessary to provide dc isolation between Pin 4 of U2 and Pin 4 of U1.

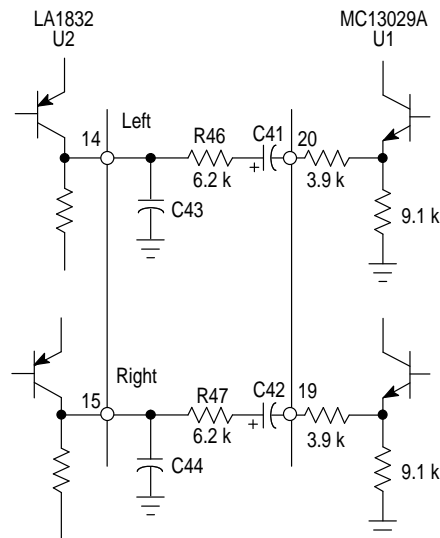
Figure 21. IF Connection



Switching of the audio between AM and FM modes takes place in the decoder IC, U1. The FM audio is conducted from the tuner IC, U2 to the decoder as shown in Figure 22. R46

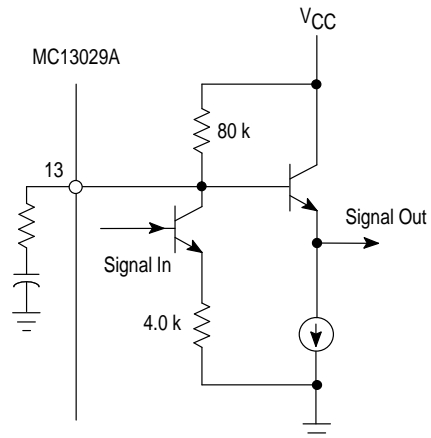
and R47 provide for the desired balance in audio levels between AM and FM modes. FM de-emphasis is provided by the capacitors C43 and C44. The output impedance of the tuner at Pins 14 and 15 is 5.0 k. The series resistance R46 and R47 in combination with the input resistance at Pins 19 and 20 of U1 bring the effective resistance down to approximately 4.0 k. For a 50  $\mu$ s de-emphasis, a capacitance value of 0.012  $\mu$ F would be used for C43 and C44.

Figure 22. FM Audio Connection Tuner to Decoder



Provision for the application of AM de-emphasis is at Pins 13 (left) and 14 (right) of the decoder U1. This is shown in Figure 23. The tone response in AM mode is primarily set by the IF bandpass filter F1. This response is shown in Figure 28.

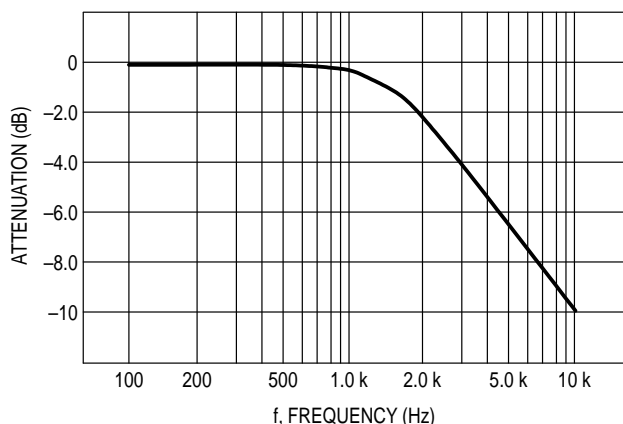
Figure 23. AM De-Emphasis Left Channel Shown



The NRSC recommended tone response is as shown in Figure 24. The tones falling within the IF filter bandpass can be contoured to this response by RC networks at Pins 13 and 14 of the decoder, U1.

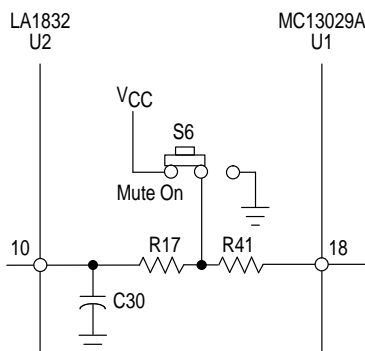


Figure 24. NRSC De-Emphasis Curve for the United States



For muting, Pin 10 of U2 and Pin 18 of U1 must be pulled high. This is done by switch S6 as is shown in Figure 25.

Figure 25. Mute Switching



The AM can be forced to mono by pulling Pin 10 of U1 to ground. This is done by switch S4. Refer to Figure 18. The FM can be forced to mono by pulling Pin 13 of U2 to ground. This is accomplished by switch S3.

**Component Choice**

The pin function section of this data sheet gives the information to select the proper components to be used with the MC13029A decoder. A similar section in the LA1832 data sheet provides the information to choose the components for the tuner.

**Tuning**

The frequency to which the AM tuner will tune is set by the eight switches contained in the S5 assembly. S5 consists of eight SPST switches. The switches are numbered from 1 to 8. Switch 8 connects to Pin 18 of the synthesizer, U3.

To tune each frequency, the switches are set to a pattern corresponding to that frequency. The pattern is derived from a binary number, equal to the local oscillator frequency divided by 10 kHz.

As an example, consider tuning to 1070 kHz. The local oscillator is 1070 kHz + 450 kHz or 1520 kHz. 1520 kHz/10 kHz is 152. The binary equivalent of 152 is 10011000. The 1 represents an open switch. The 0 represents a closed switch. The left most bit of the binary number is switch 8. Switch 8 is set open. Switch 7 is set

closed. This process is continued for all eight bits of the binary number. Table 2 summarizes the switch settings for 1070 kHz.

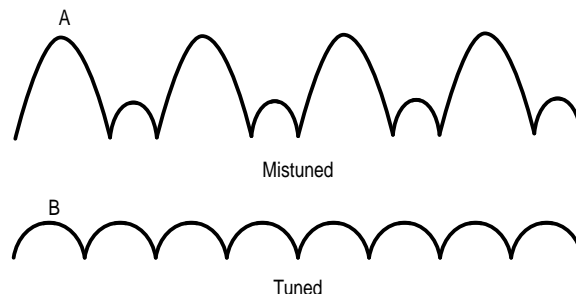
Table 2

Switch	Number	Position
8	1	Open
7	0	Closed
6	0	Closed
5	1	Open
4	1	Open
3	0	Closed
2	0	Closed
1	0	Closed

**Circuit Adjustments**

The FM circuit requires no adjustments. The AM L.O. must be able to tune from 990 to 2050 kHz to cover the broadcast range. Adjust the core of the L.O. coil, if needed, to be able to cover this range. The AM RF coil and trimmer can be adjusted for best signal after connection to the loop antenna. The coil is adjusted near the low end of the band, and the trimmer is adjusted at the top of the band. The IF coil T1 is first adjusted for maximum signal out of the filter F1. Final adjustment is shown in Figure 26.

Figure 26. Decoder Signal Output for Mistuned and Tuned Condition with Input Signal of 80% L-R and 3.0 kHz



Apply an AM Stereo signal modulated with a 3.0 kHz tone at 80% L-R. Set the pilot tone off. Observe either the left or right channel audio. When T1 is properly adjusted, the waveform should appear as waveform B shown in Figure 26. Adjust T1 as required. If the waveform can only be adjusted to appear as waveform A, then adjust for least amplitude and equal amplitudes on both the left and right channels.

**AM Circuit Test**

The connections for test are as shown in Figure 27. A 50 Ω resistor is placed on the AM antenna input. The AM Stereo generator is connected to the AM antenna input. Measurements of audio level are made with an audio voltmeter with a high input impedance (1.0 MΩ). Measurements of distortion in stereo mode are made using a 400 Hz high pass filter ahead of the distortion analyzer. Typical data is shown in Figures 28 through 34.

# MC13029A

Figure 27. Test Circuit

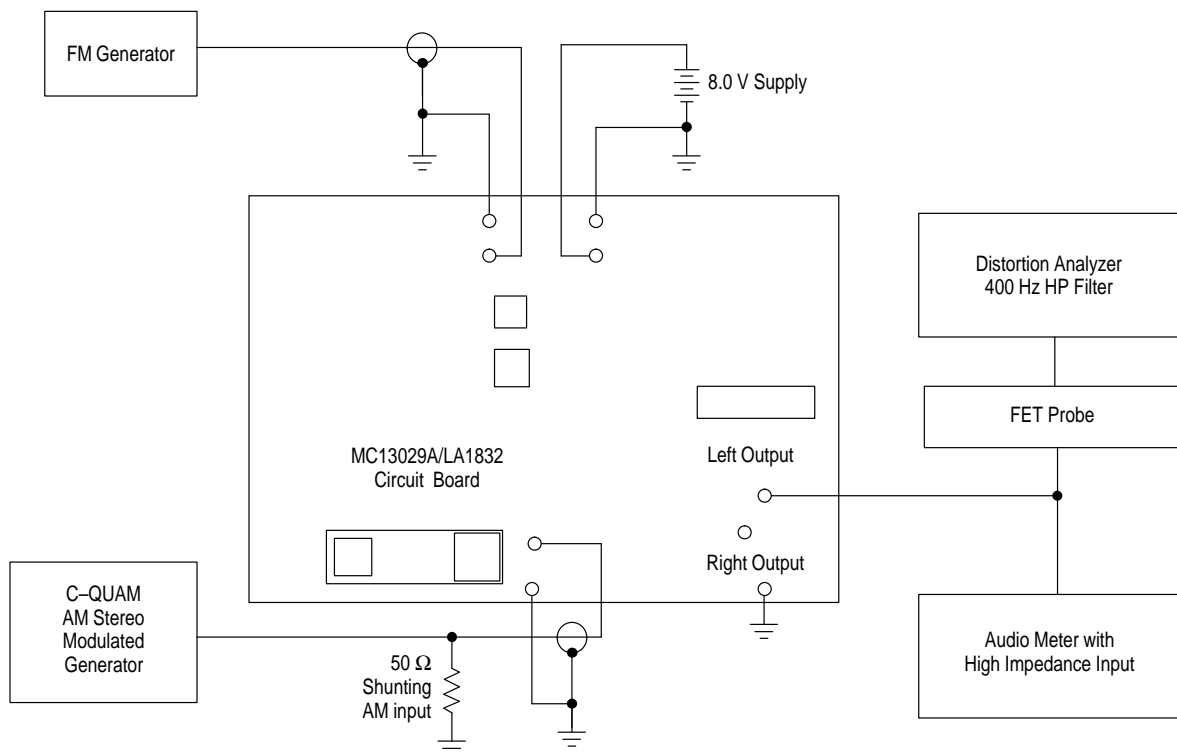


Figure 28. Tone Response without De-Emphasis Set by IF Bypass

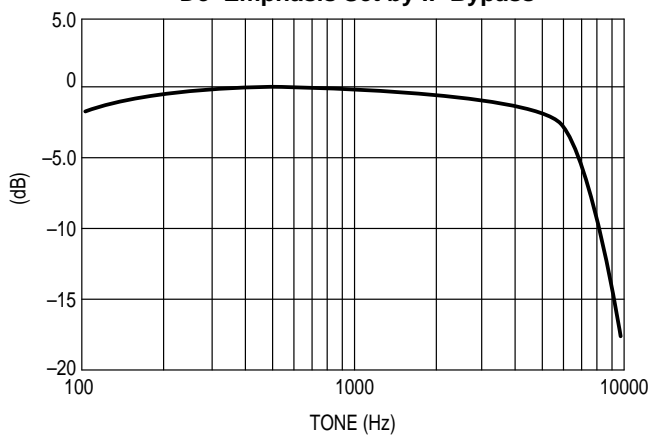


Figure 29. Tone Response with De-Emphasis

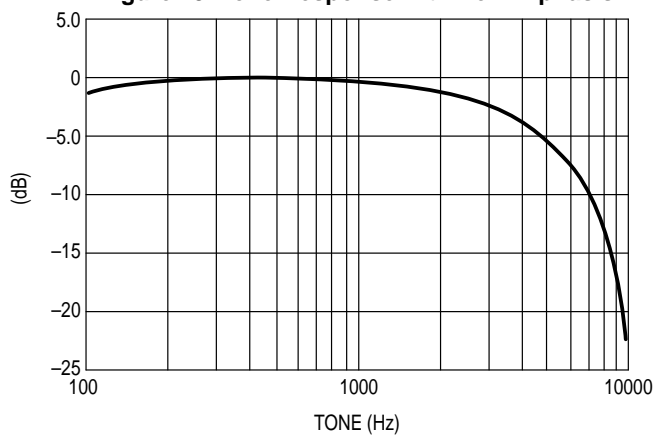


Figure 30. Single Channel Separation at 50% Modulation

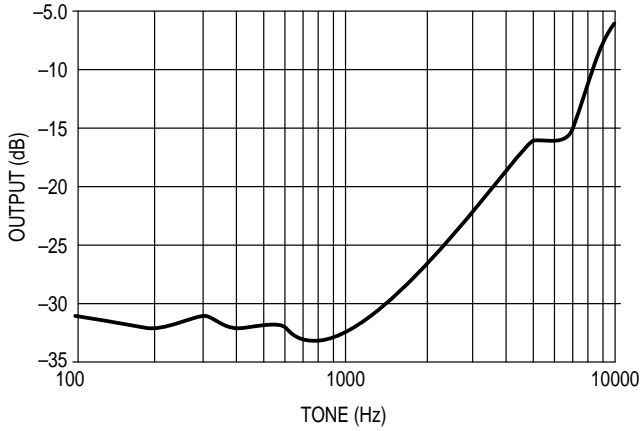


Figure 31. Single Channel Distortion at 50% Modulation

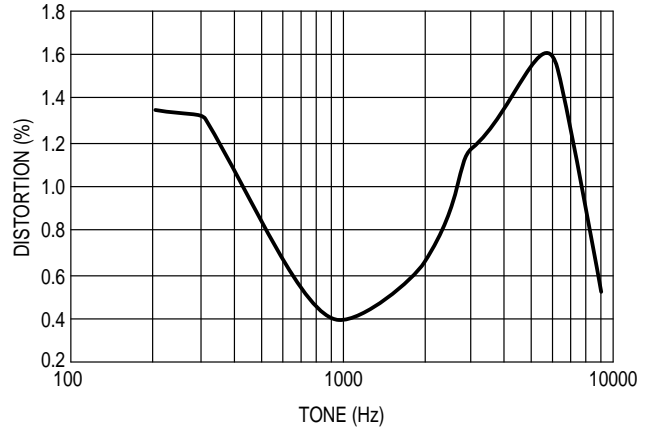


Figure 32. Mono Characteristics at 30% Modulation

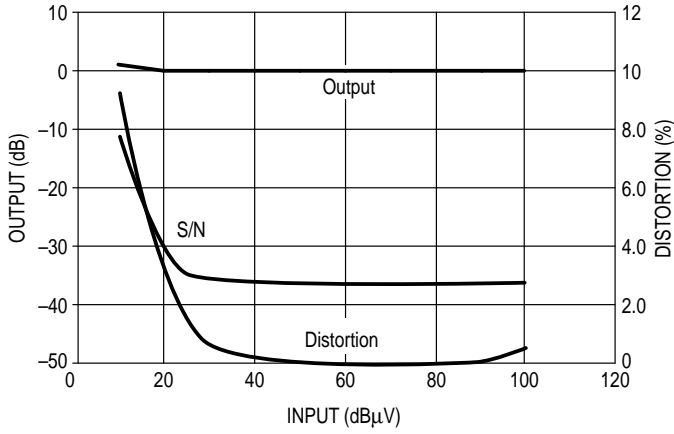


Figure 33. Mono Characteristics at 80% Modulation

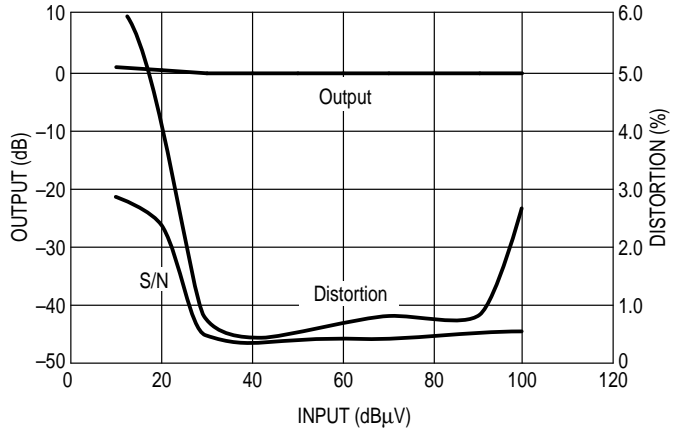
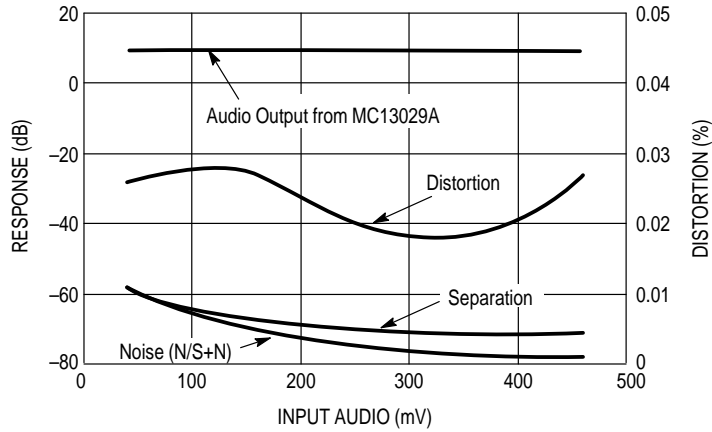
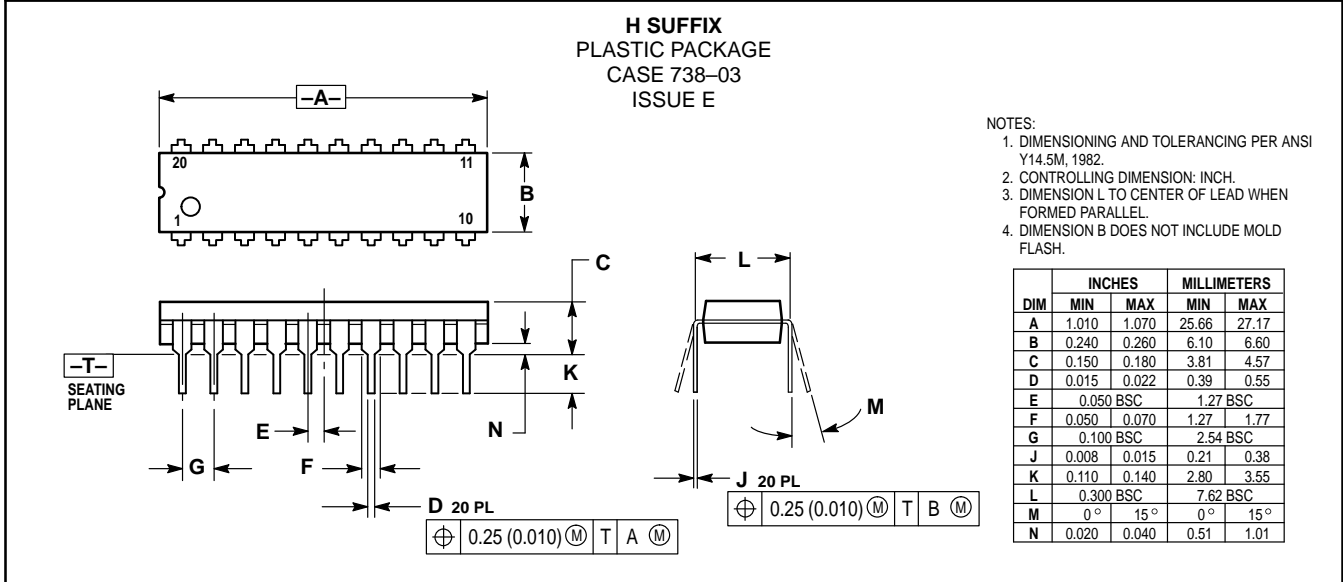
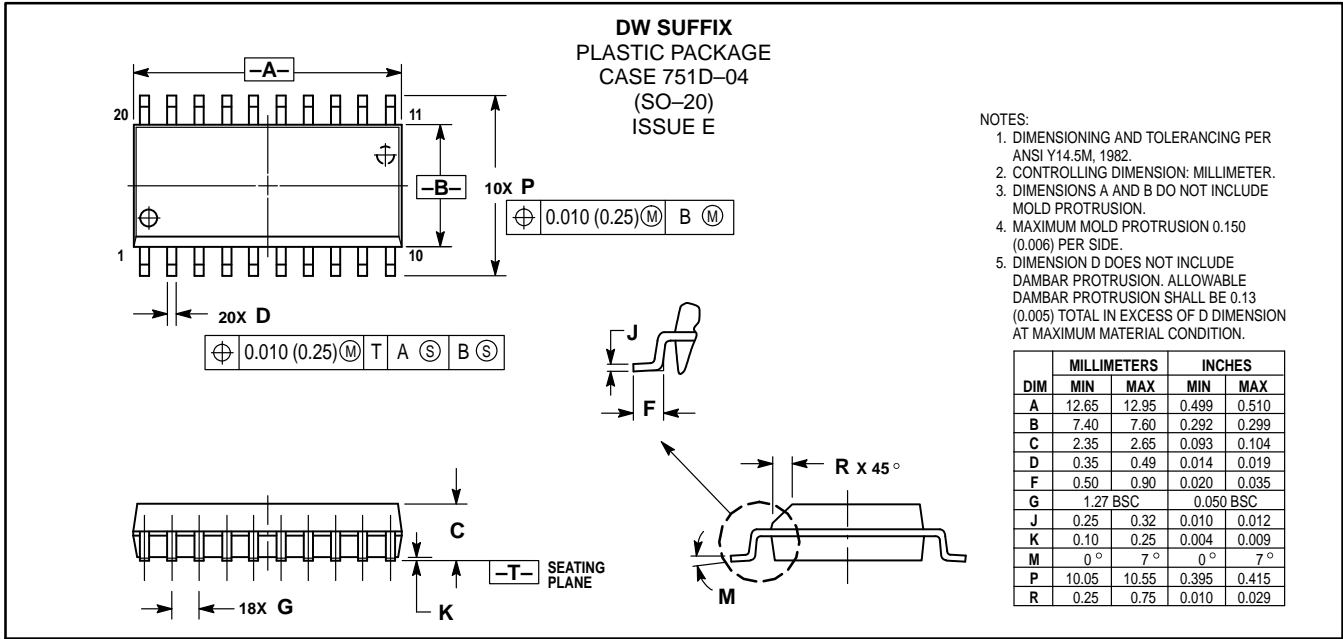


Figure 34. AM/FM Audio Switch Performance of Left FM Channel with 1.0 kHz Audio Tone



# MC13029A

## OUTLINE DIMENSIONS



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