Monolithic Linear IC

SANYO

No. 3760

LA7575

Super-split, PLL-II Video and Sound IF Signal Processor

OVERVIEW

The LA7575 is a super-split, phase-locked loop video and sound intermediate frequency signal processor incorporating super-split-carrier processing of the video and sound signals using a phase-locked loop.
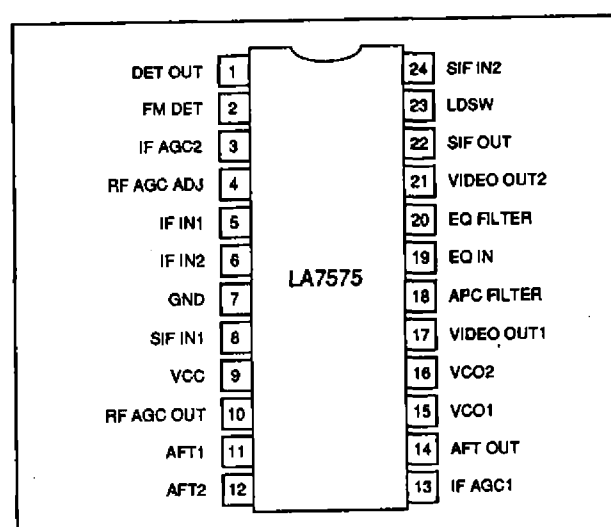
The LA7575 features audio buzz cancelation, and automatic frequency and phase control.

The LA7575 operates from either a 9 V or 12 V supply and is available in 24-pin DIPs.

FEATURES

- Super-split-carrier processing of sound and video signals
- Audio buzz cancelation
- High-fidelity sound reproduction
- Complete video and sound IF amplifier stages
- Automatic frequency tuning
- Automatic phase control
- RF and IF time-constant switching for high-speed AGC
- Mute circuit
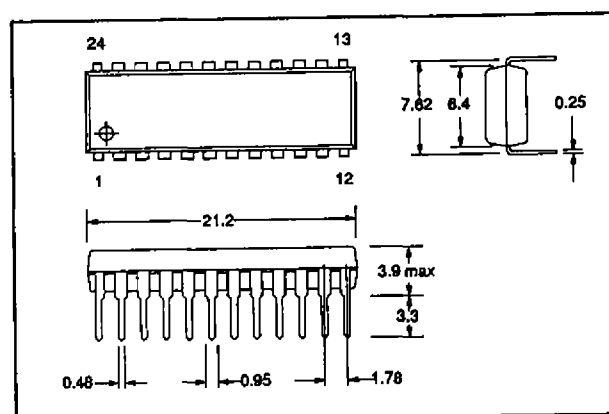- 9 or 12 V supply
- 24-pin DIP

PINOUT

Pin	Name		Pin	Name
1	DET OUT		24	SIF IN2
2	FM DET		23	LDSW
3	IF AGC2		22	SIF OUT
4	RF AGC ADJ		21	VIDEO OUT2
5	IF IN1		20	EQ FILTER
6	IF IN2		19	EQ IN
7	GND		18	APC FILTER
8	SIF IN1		17	VIDEO OUT1
9	VCC		16	VCO2
10	RF AGC OUT		15	VCO1
11	AFT1		14	AFT OUT
12	AFT2		13	IF AGC1

LA7575

PACKAGE DIMENSIONS

Unit: mm

3067-DIP24S

BLOCK DIAGRAM

PIN DESCRIPTION

Number	Name	Description
1	DET OUT	FM detector audio output
2	FM DET	FM quadrature detector
3	IF AGC2	Second IF AGC filter connection
4	RF AGC ADJ	RF AGC adjust
5	IF IN1	Balanced video IF input 1
6	IF IN2	Balanced video IF input 2
7	GND	Ground
8	SIF IN1	First sound IF input
9	VCC	Supply voltage
10	RF AGC OUT	RF AGC output
11	AFT1	AFT quadrature detection phase shift tank connection
12	AFT2	AFT quadrature detection phase shift tank connection
13	IF AGC1	First IF AGC filter connection
14	AFT OUT	AFT output
15	VCO1	VCO tank connection
16	VCO2	VCO tank connection
17	VIDEO OUT1	4.5 MHz composite video output and IF trap connection
18	APC FILTER	APC filter time constant network connection
19	EQ IN	Equalization amplifier input

Number	Name	Description
20	EQ FILTER	Video equalization filter connection
21	VIDEO OUT2	Video output
22	SIF OUT	Sound IF bandpass filter connection
23	LDSW	Lock detector switch
24	SIF IN2	Sound IF input 2

SPECIFICATIONS

Absolute Maximum Ratings

Parameter	Symbol	Rating	Unit
Supply voltage	V_{CC} max	13.8	V
Power dissipation	P_D	1.2	W
IF AGC stage input voltage	V_3, V_{13}	V_{CC}	V
AFT 90-degree phase-shifter voltage	V_{11}	V_{CC}	V
Lock detector switch voltage	V_{23}	V_{CC}	V
FM detector output current	I_1	-1	mA
Video amplifier output current	I_{17}	-5	mA
Equalization amplifier output current	I_{21}	-3	mA
Sound IF amplifier 1 output current	I_{22}	-2	mA
RF AGC amplifier output current	I_{10}	-3	mA
Operating temperature range	T_{opr}	-20 to 70	deg. C
Storage temperature range	T_{stg}	-55 to 150	deg. C

Recommended Operating Conditions

T_a = 25 deg. C

Parameter	Symbol	Rating	Unit
Supply voltage	V_{CC}	9 or 12	V
Supply voltage range	V_{CC}	8.2 to 13.2	V

Electrical Characteristics

Video IF stage

V_{CC} = 12 V, T_a = 25 deg. C, f_p = 58.75 MHz

Parameter	Symbol	Condition	Rating			Unit
			min	typ	max	
Supply current	I_0	V_{13} = 5 V	46	58	72	mA
Quiescent video output voltage	V_{21}	V_{13} = 5 V	6.4	6.8	7.2	V
Minimum RF AGC voltage	V_{10L}	V_{13} = 8 V	–	0	0.5	V
Maximum RF AGC voltage	V_{10H}	V_{13} = 8 V	10.6	11	11.4	V
Quiescent AFT output voltage	V_{14}	V_{13} = 5 V	3.0	5.9	8.0	V

Parameter	Symbol	Condition	Rating			Unit
			min	typ	max	
Minimum AFT voltage	V_{14L}		–	0.4	1.0	V
Maximum AFT voltage	V_{14H}		11	11.5	12	V
Input sensitivity	V_i		25	31	37	dB/μV
AGC dynamic range	GR		62	70	–	dB
Maximum input voltage	V_i max		100	105	–	dB/μV
Video output amplitude	V_O (video)	87.5% modulation	1.65	1.95	2.25	V_{p-p}
Output signal-to-noise ratio	S/N		49	55	–	dB
Synchronizing tip voltage	V_{21} (tip)		4.25	4.55	4.85	V
920 kHz-beat level	IF_{920}	P = 0, C = –4 dB, S = –14 dB	37	42	–	dB
Frequency response	f_c	P = 0, S = –14 dB	6	8	–	MHz
Differential gain	DG	V_i = 10 mV, 87.5% modulation, 10-step star video waveform	–	4	8	%
Differential phase	DP		–	3	8	°
White-noise threshold voltage	V_{WTH}		8.9	9.3	9.7	V
White-noise clamp voltage	V_{WCL}		5.3	5.7	6.1	V
Black-noise threshold voltage	V_{BTH}		3.1	3.4	3.7	V
Black-noise clamp voltage	V_{BCL}		5.3	5.7	6.1	V
AFT detection sensitivity	S_f		44	60	84	mV/kHz
Video IF amplifier input resistance	R_i (VIF)		0.8	1.3	1.75	kΩ
Video IF amplifier input capacitance	C_i (VIF)		–	3.0	6.0	pF
APC pull-in range (U)	f_{PU-2}		0.6	1.2	–	MHz
APC pull-in range (L)	f_{PL-2}		–	–1.7	–0.8	MHz
VCO maximum variation range	Δf_U	V_{18} = 3 V	0.6	1.8	–	MHz
	Δf_L	V_{18} = 7 V	–	–1.5	–0.8	MHz
VCO control sensitivity	β	V_{18} = 4.6 to 5 V	1.5	3.1	6.2	kHz/mV

V_{CC} = 9 V, T_a = 25 deg. C, f_p = 58.75 MHz

Parameter	Symbol	Condition	Rating			Unit
			min	typ	max	
Supply current	I_9	V_{13} = 5 V	39	49	60	mA
Quiescent video output voltage	V_{21}	V_{13} = 5 V	4.9	5.3	5.7	V
Minimum RF AGC voltage	V_{10L}	V_{13} = 8 V	–	0	0.5	V
Maximum RF AGC voltage	V_{10H}	V_{13} = 8 V	7.6	8	8.4	V
Quiescent AFT output voltage	V_{14}	V_{13} = 5 V	2.6	4.5	6.0	V
Minimum AFT voltage	V_{14L}		–	0.3	1.0	V
Maximum AFT voltage	V_{14H}		8	8.5	9.0	V
Input sensitivity	V_i		27	33	39	dB/μV
Video output amplitude	V_O (VIF)		1.15	1.45	1.75	V_{p-p}
Synchronizing tip voltage	V_{21} (tip)		3.35	3.65	3.95	V

Parameter	Symbol	Condition	Rating			Unit
			min	typ	max	
White-noise threshold voltage	V_{WTH}		6.8	7.2	7.6	V
White-noise clamp voltage	V_{WCL}		4.0	4.4	4.8	V
Black-noise threshold voltage	V_{BTH}		2.4	2.7	3.0	V
Black-noise clamp voltage	V_{BCL}		3.7	4.1	4.5	V
AFT detection sensitivity	S_f		28	39	55	mV/kHz

Sound IF stage

V_{CC} = 12 V, T_a = 25 deg. C, f_p = 58.75 MHz

Parameter	Symbol	Condition	Rating			Unit
			min	typ	max	
4.5 MHz conversion gain	VG	V_i = 10 mV, 54.25 MHz	16	22	27	dB
First sound IF amplifier input resistance	R_i (SIF)		1.2	2	2.7	kΩ
First sound IF amplifier input capacitance	C_i (SIF)		–	3	6	pF
Sound IF amplifier limiting sensitivity	V_i (lim)	f_s = 4.5 MHz	–	38	44	dB/μV
FM detector output voltage	V_O	V_i = 100 mV, f_s = 4.5 MHz, Δf = ±25 kHz at 400 Hz	330	490	640	mV
AM rejection	AMR	f_s = 4.5 MHz	40	49	–	dB
Total harmonic distortion	THD	f_s = 4.5 MHz	–	0.5	1.0	%
Audio and video IF signal-to-noise ratio	S/N (SIF)	f_s = 4.5 MHz	60	78	–	dB
AFT defeat threshold voltage	V_{D11}		0.5	2.3	–	V
Audio and video muting threshold voltage	V_{4TH}		0.5	1.9	–	V
FM muting threshold voltage	V_{2TH}		0.5	2.0	–	V
AFT defeat voltage	V_{D14}		5.4	6	6.6	V

V_{CC} = 9 V, T_a = 25 deg. C, f_p = 58.75 MHz

Parameter	Symbol	Condition	Rating			Unit
			min	typ	max	
FM detector output voltage	V_O	V_i = 100 mV, Δf = ±25 kHz at 400 Hz	330	490	640	mV
AFT defeat threshold voltage	V_{D11}		0.5	1.6	–	V
Audio and video muting threshold voltage	V_{4TH}		0.5	1.1	–	V
FM muting threshold voltage	V_{2TH}		0.5	1.9	–	V
AFT defeat voltage	V_{D14}		3.9	4.5	5.1	V

BUZZ CANCELATION

Phase-locked loop (PLL) detectors feature lower harmonic distortion in the video stage, higher IF phase differential suppression and much lower audio buzz than conventional quasi-synchronous detectors. However, voltage-controlled oscillators (VCOs) in PLL detectors, generally, are highly susceptible to interference from flyback pulses. This interference can affect the frequency of the VCO, resulting in added output noise components and audio buzz. This interference is minimized by VCO supply voltage regulation.

The PLL detector is shown in figure 1. The automatic phase control (APC) circuit multiplies the IF signal by the VCO output signal, which is phase shifted by 90 degrees, to suppress the AM component. The APC output is passed through a lowpass filter to form the VCO control signal. This results in a signal with a good carrier-to-noise ratio.
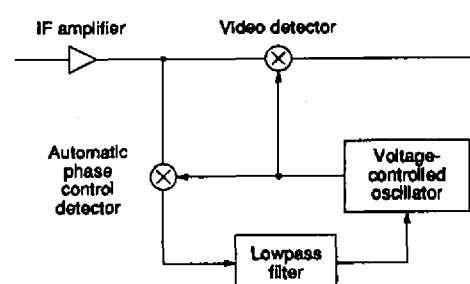
Figure 1. Structure of the PLL detector

A simple PLL detector, however, can cause other audio problems, because the broadcast signal is transmitted using vestigial sideband modulation. In this case, the RF signal is converted to an IF signal by the Nyquist slope of the SAW filter. Since the sidebands in the vicinity of the picture carrier are attenuated, the magnitudes of the upper and lower sideband vectors are different. The result is a phase distortion component, θ, in the composite vector as shown in figure 2.
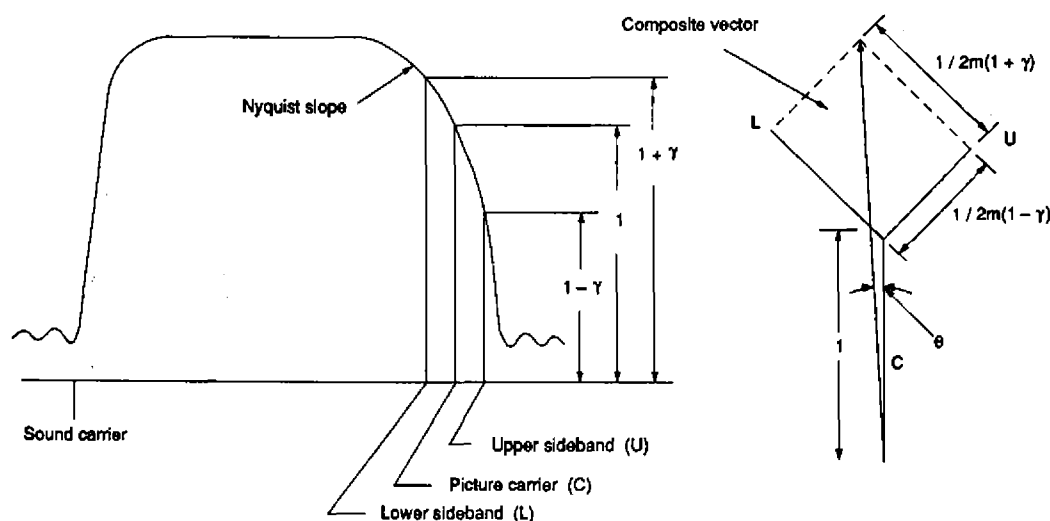
Figure 2. Phase noise components

The phase distortion is the cause of audio buzz, or Nyquist buzz, because the VCO synchronizes to the composite vector. A Nyquist buzz cancelation circuit is incorporated to reduce the level of this noise as shown in figure 3.
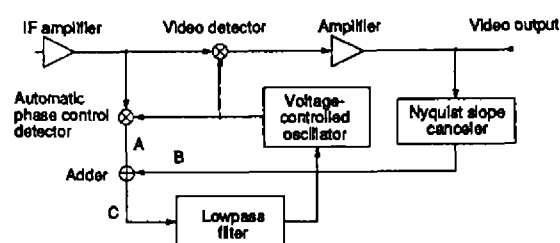
Figure 3. Detector with buzz cancelation

A typical signal with Nyquist buzz is shown in figure 4 together with the compensating signal generated by the Nyquist-slope canceler and the resultant signal.
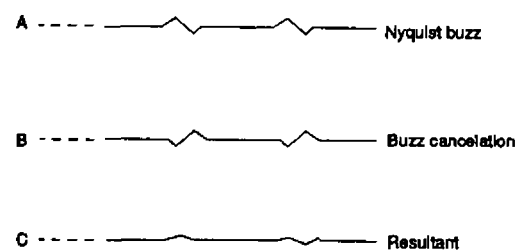
Figure 4. Nyquist buzz cancelation waveforms

DESIGN NOTES

FM Detector

The FM detector output, AF OUT, is an emitter follower with a 200 Ω series protection resistor as shown in figure 5.

In multiplex audio applications where AF OUT is connected to the input of a multiplexed audio decoder, the input resistance of the decoder can decrease causing distortion of the (L − R) signal. A 5.1 kΩ resistor, R1, should be connected to ground as shown in figure 5.
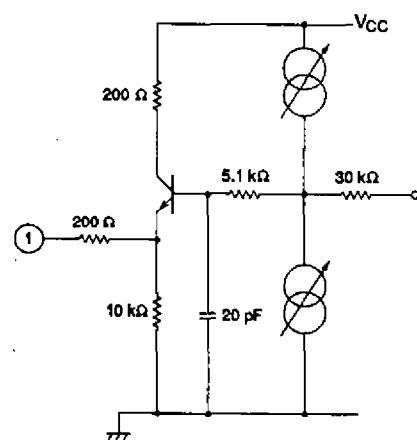
Figure 5. FM detector, audio output

In monophonic applications, an RC deemphasis circuit should be connected as shown in figure 6. The time constant is given by R2C.
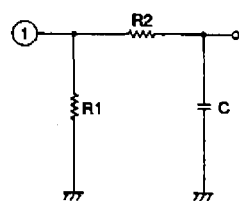
Figure 6. RC deemphasis circuit

The circuit shown in figure 3 is highly effective in suppressing audio buzz caused by the 4.5 MHz IF beat signal in Japanese multiplexed (L − R) audio or American Multichannel TV Sound (MTS).

As buzz cancelation is independent of the PLL loop time constant, other parameters such as automatic phase control can be optimized to eliminate interference from flyback pulses.

FM discriminator

The quadrature detector frequency at which the 90-degree phase shift occurs is determined by the tuned circuit connected to FM DET as shown in figure 7.
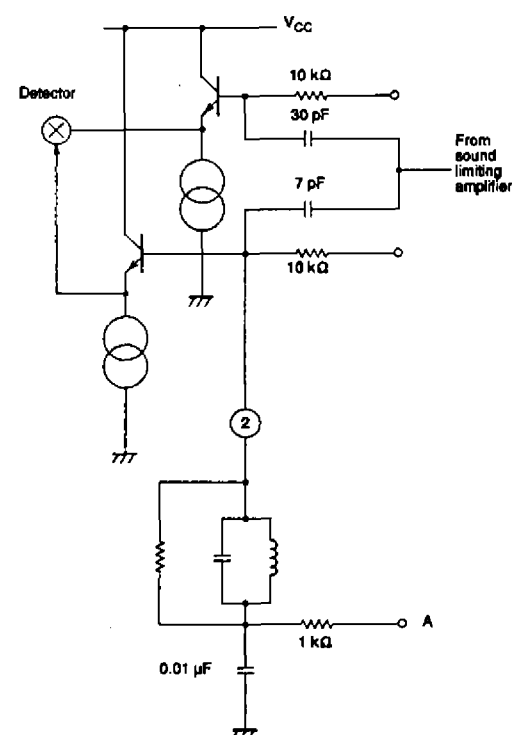
Figure 7. FM discriminator

IF AGC Filters

The IF signal is peak-detected and averaged by the filters connected to IF AGC1 and IF AGC2, which are the first and second IF AGC filters, respectively, as shown in figure 8. The IF AGC audio component of the input signal to the video IF stage is first removed by an audio trap.

Figure 8. IF AGC filters

Figure 9. Horizontal-synchronizing pulse distortion
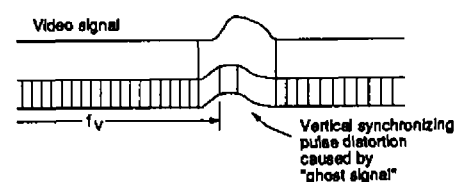
Figure 10. Video signal distortion

The typical component values of the resistors and capacitors in the first and second filter time constants are shown in table 1.

Table 1. Time constant setting components

Pin	Component	First IF filter	Second IF filter
3	C1	330 pF	330 pF
	C2	–	0.47 μF
	R1	–	2.2 kΩ
13	C3	0.47 μF	0.068 μF
	R2	820 kΩ	820 kΩ

Mute Switch

The black-noise canceler can be disabled by pulling IF AGC1 to 1 V or lower. An external AGC source can then be applied to IF AGC2 to drive the AGC circuit. This mode of operation is designed for use with an IS-15 (EIA standard) switch.

Ghosting Problems

Reflected signals, which have a phase different from that of the main signal, can cause distortion of the horizontal-synchronizing pulse as shown in figure 9. As a result, the same charge-to-discharge current ratio of the IF AGC cannot be maintained. If the phase difference is large, the video signal can also be distorted as shown in figure 10. Distortion can be minimized by connecting a resistor in the range 820 kΩ to 1 MΩ between IF AGC1 and GND.

RF AGC Adjust

The operating point of the RF automatic-gain control can be adjusted by using a variable resistor connected to RF AGC ADJ as shown in figure 11. When RF AGC ADJ is pulled to 0.5 V, both the FM output and the video output are muted.
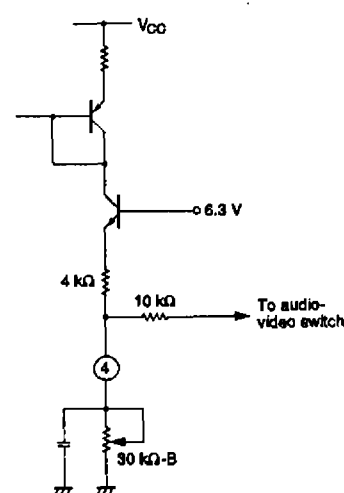
Figure 11. RF AGC adjustment resistor

Video IF Input

The video IF amplifier inputs on IF IN1 and IF IN2, shown in figure 12, should be capacitively coupled. The input signal is the average of these two inputs. The input resistance is approximately 1.5 kΩ, and the input capacitance, 3 pF.
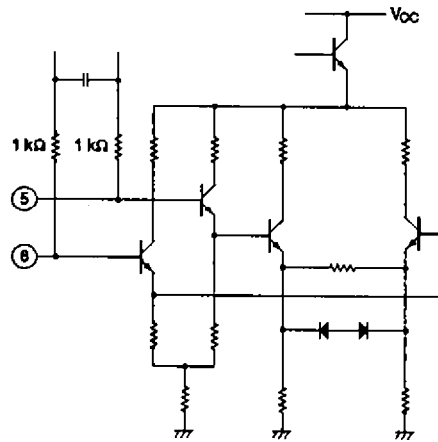
Figure 12. Video IF amplifier

First Sound IF Input

The first sound IF amplifier input, SF IN1, shown in figure 13, should be capacitively coupled. If a SAW filter is used, an inductor should also be connected as shown in figure 14. This matches the SAW filter output capacitance to the LA7575 input capacitance and increases the sensitivity.
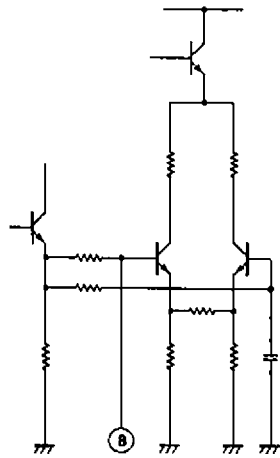
Figure 13. First sound IF input
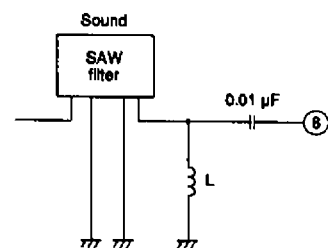
Figure 14. SAW filter matching

RF AGC Output

The RF AGC amplifier output, RF AGC OUT, is an emitter follower with a 200 Ω series protection resistor as shown in figure 15. The value of the bleeder resistor connected between RF AGC OUT and the tuner, shown in figure 16, should be chosen based on the tuner maximum gain.
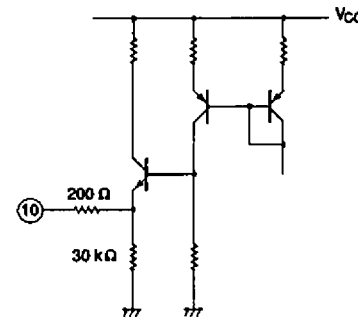
Figure 15. RF AGC output
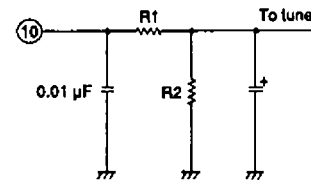
Figure 16. Bleeder resistor connection

AFT Tank

The automatic frequency tuning (AFT) tank connected to AFT1 and AFT2 generates the 90-degree phase shift required for quadrature detection. The bandpass frequency characteristic of the IF SAW filter is shown in figure 17(A), and the AFT tank, in figure 17(B). The combined response is shown in figure 17(C). The resulting extended low-frequency response, which increases susceptibility to incorrect operation, can be reduced by connecting a capacitor, C2, in series with the AFT tank as shown in figure 18. The resultant frequency response is shown in figure 17(D).

Capacitors C1 and C2 should have a ratio of approximately 5 to 1. An inductor or resistor should also be connected in parallel with C2 to maintain the DC balance of the AFT tank.
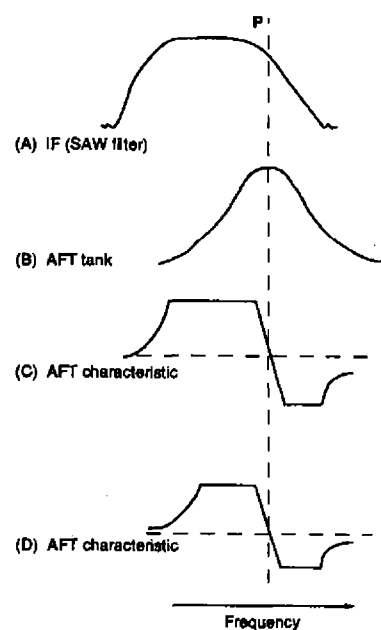
Figure 17. Tank circuit response characteristics
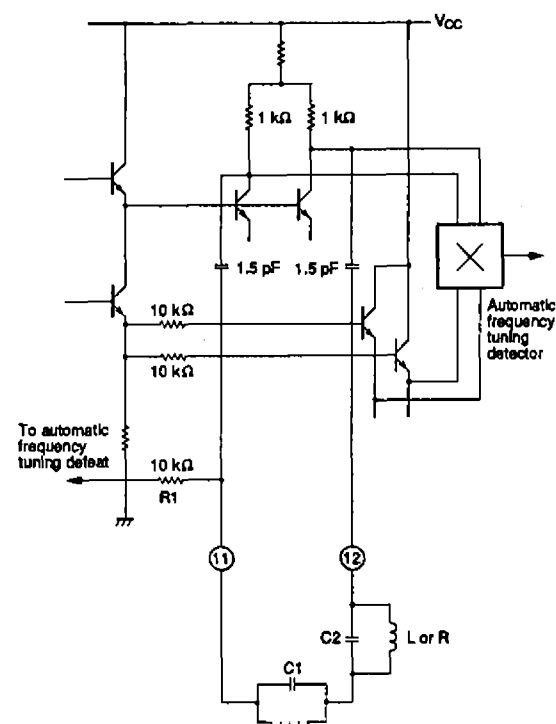
Figure 18. AFT tank

The AFT can be defeated by connecting AFT1 to ground through resistor R1, which should be 20 kΩ or lower.

AFT Output

An external bleeder resistor is required to generate the AFT voltage. The AFT loop time constant is formed by the external resistor, R3, and a capacitor, C2, as shown in figure 19. The resistor also provides series protection.

Fluctuations in the AFT quiescent output voltage, if present, can be reduced by connecting a series resistor, R4, as shown in figure 20. Note, however, that this also reduces the AFT range.
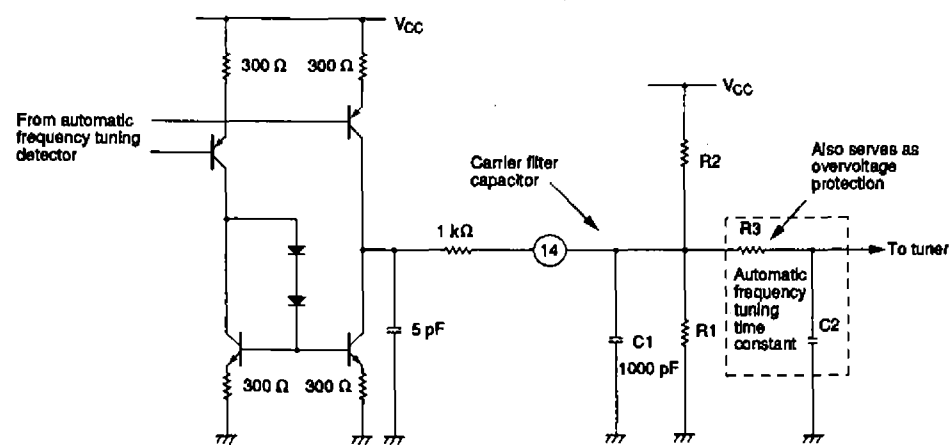
Figure 19. AFT loop time constant
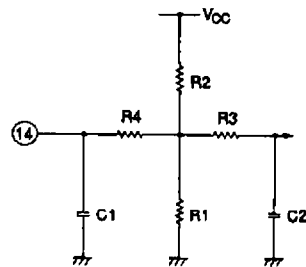
Figure 20. AFT output

VCO Tank

The VCO tank circuit is shown in figure 21. The tank capacitors connected between VCO1 and VCO2 should be in the range 20 to 27 pF (24 pF is recommended). The VCO tank susceptibility to external effects can be reduced by using either chip capacitors or capacitors integrated with the tank coil.
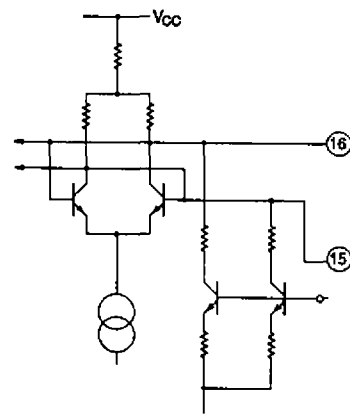
Figure 21. VCO tank

Composite Video Output

The 4.5 MHz composite video output, VIDEO OUT 1, is shown in figure 22. A resistor should be connected between this emitter follower output and ground to ensure adequate output drive capability. The resistor should be 1.2 kΩ or greater if V_{cc} is 12 V, and 1.0 kΩ or greater, if V_{cc} is 9 V.
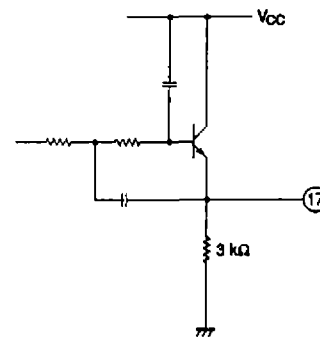
Figure 22. Composite video output

APC Filter

Time-constant switching is incorporated into the VCO for automatic phase control (APC). When the PLL is locked, the VCO is controlled by loop A as shown in figure 23. When the PLL is unlocked or the signal is weak, the VCO is controlled by loop B which has higher gain. The increased APC loop gain also increases the pull-in range.

The recommended range for the external APC filter resistor is 47 to 150 Ω, and for the capacitor, 0.47 µF. If the resistor is greater than 47 Ω, the modified circuit shown in figure 24 should be used.
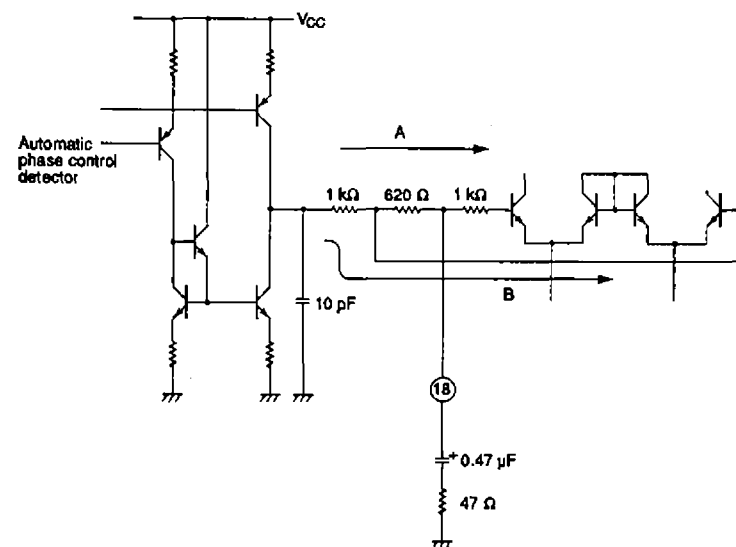
Figure 23. APC filter
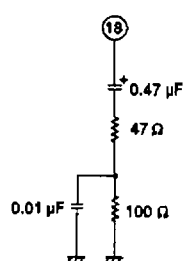
Figure 24. Modified APC filter circuit

Equalization Amplifier

The video signal, after passing through the 4.5 MHz trap, is input on EQ IN to the equalization amplifier, and output, on VIDEO OUT. A resistor should be connected between the emitter follower output and ground to ensure adequate output drive capability. The resistor

should be 2.7 kΩ or greater if V_{CC} is 12 V, and 2.2 kΩ or greater, if V_{CC} is 9 V. A buffer transistor should be used if the signal is taken off-board.

Equalization amplifier design

The equalization amplifier has an external series resonant circuit, shown in figure 25, which controls the frequency characteristic. The output voltage, V_O, is given by the following equation.

$$V_O = (R1 / Z + 1) (V_I + V_{in})$$

Since the input voltage, V_{in}, is small, the gain is given approximately by the following equation.

$$A_V = V_O / V_I = R1 / Z + 1$$

The amplifier can be used as a voltage amplifier by connecting a network to EQ FILTER as shown in figure 26. The bleeder resistance should be chosen to avoid excessive gain and extreme video synchronizing tip voltages.
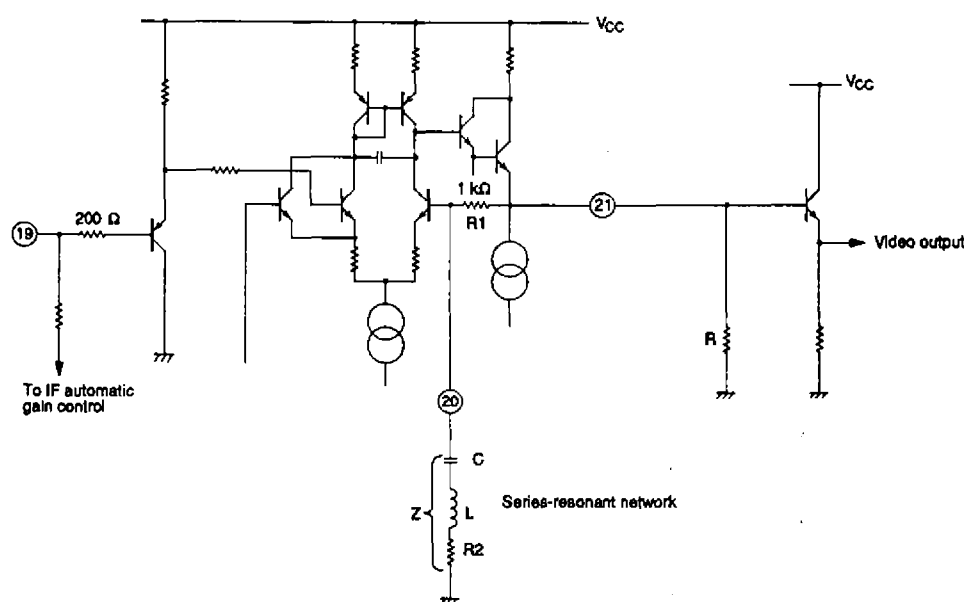
Figure 25. Equalization amplifier
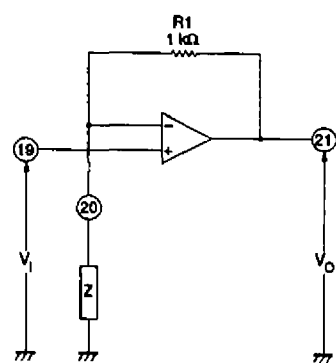
Figure 26. Voltage amplifier configuration

External bleeder resistor selection

If the equalization amplifier is configured for non-unity gain, the bleeder resistors, R2 and R3 shown in figure 27, are required to ensure that the output DC voltage does not change.

The synchronizing tip voltage does not change if V_X is approximately equal to V_{21}. V_X is given by the following equation.

$$V_X = V_{CC} \times R2 / (R2 + R3)$$

The voltage gain is given by

$$A_V = 1 + 1000 / Z1$$

where

$$Z1 = R2 \times R3 / (R2 + R3)$$

Resistors R2 and R3 are given by

$$R2 = 1000 \times V_{CC} / ((V_{CC} - V_X) \times (A_v - 1))$$

$$R3 = 1000 \times V_{CC} / (V_X \times (A_v - 1))$$
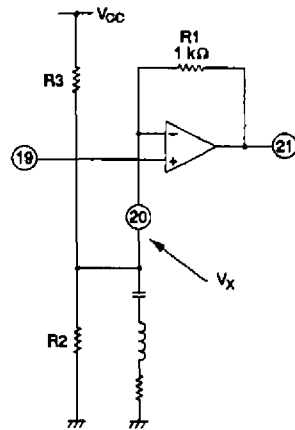
Figure 27. External bleeder resistor selection

First Sound IF Output

The first sound IF stage output is an emitter follower with internal 100 Ω series resistor. An extra series resistor should be added for impedance matching to the ceramic bandpass filter as shown in figure 28.
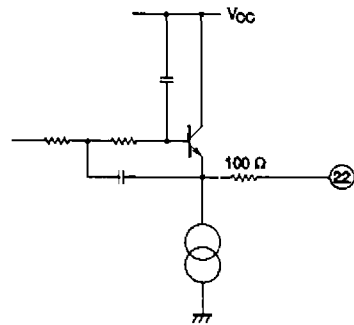

Figure 28. First sound IF output

Lock Detector Switch

The APC time-constant switching is done internally. However, the LDSW pin, shown in figure 29, can be used to monitor the PLL lock condition.
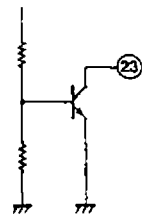
Figure 29. Lock detector monitoring

Sound IF Input

The input impedance of the amplifier, shown in figure 30, is approximately 1 kΩ. Any interference on BPF2, a video signal for example, can cause audio buzz or heterodyning. Good circuit board layout is essential. Examples of both good and poor layout are shown in figures 31 and 32, respectively.
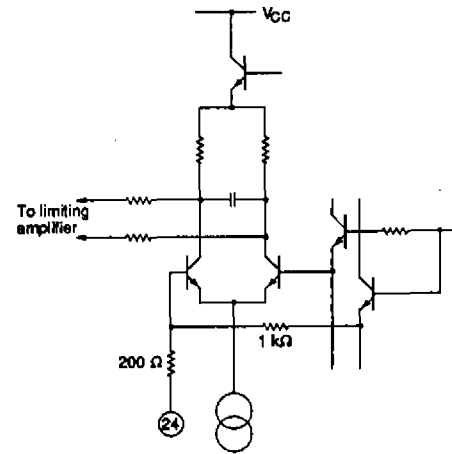
Figure 30. First audio IF amplifier
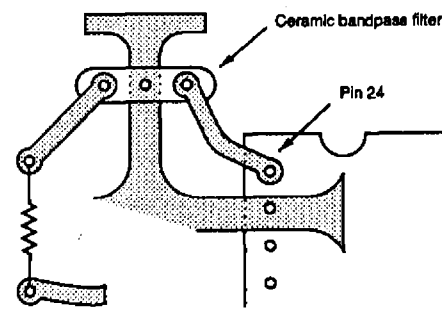
Figure 31. Good PCB layout
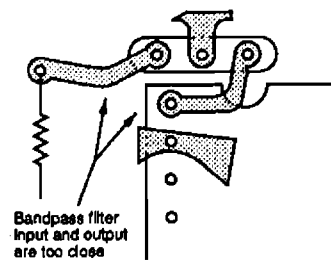
Figure 32. Poor PCB layout

APPLICATION NOTES

Sanyo SAW Filters

Two types of surface-acoustic-wave (SAW) filter built on different piezoelectric substrates can be used with the LA7575—Lithium Tantalate and Lithium Niobate.

Lithium Tantalate (LiTaO₃) SAW filters

The LiTaO₃ SAW filters have a low temperature coefficient of −18 ppm/deg. C and good stability, but have high insertion loss. An external coil is required at the output for level matching as shown in figure 33.

The LiTaO₃ SAW filters cover the Japanese and American bands, which both have relatively high IF frequencies. These filters have part numbers TSF1XXX or TSF2XXX.
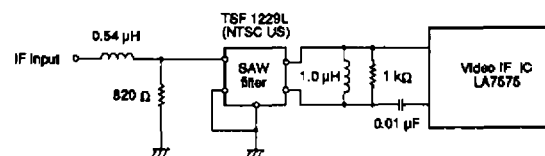
Figure 33. LiTaO₃ SAW filter

Lithium Niobate (LiNbO₃) SAW filters

The LiNbO₃ SAW filters have a relatively high temperature coefficient of −72 ppm/deg. C, but have an insertion loss of approximately 10 dB lower than LiTaO₃ filters. A matching circuit is, therefore, not required at the output as shown in figure 34. As a result of the lower insertion loss, the passband ripple is higher. However, the low impedance and low feedthrough of these filters make them less susceptible to stray capacitance effects caused by external components and printed circuit board layout, resulting in greater stability.

The LiNbO₃ SAW filters cover the PAL and American bands, which both have relatively low IF frequencies. These filters have part numbers TSF5XXX.
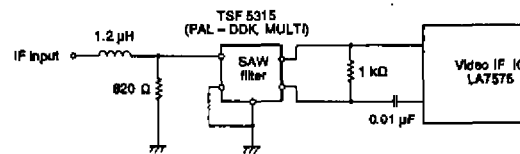
Figure 34. LiNbO₃ SAW filter

Coil Specifications

Parameter	NTSC		PAL
	Japan	U.S.A.	
IF frequency	58.75 MHz	45.75 MHz	38.9 MHz
VCO coil	6 turns 0.12 mm DIA C = 24 pF HW6226-4	9 turns 0.12 mm DIA C = 24 pF HW6227-4	11 turns 0.12 mm DIA C = 24 pF MA6389
AFT coil	3.5 turns 0.5 mm DIA MA8181	5.5 turns 0.5 mm DIA MA6343	7.5 turns 0.5 mm DIA MA7115

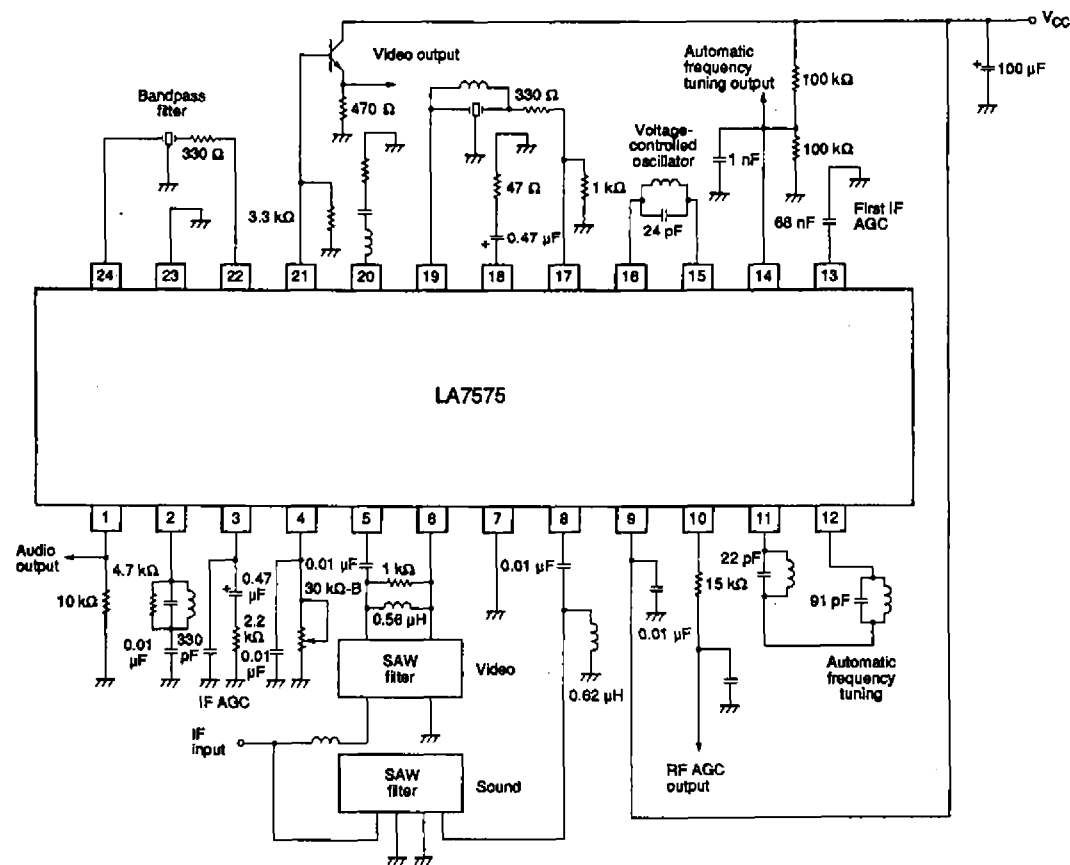| Parameter	NTSC		PAL
	Japan	U.S.A.	
Sound IF coil	S [coil symbol] 19 turns 0.08 mm DIA C = 100 pF	S [coil symbol] 19 turns 0.08 mm DIA C = 100 pF	S [coil symbol] 25 turns 0.08 mm DIA C = 100 pF
	KS6102-1	KS6102-1	MA8182
Video SAW filter	TSF1132L	TSF1229L	TSF5315
Sound SAW filter	TSB1101P	TSB1205P	–

TYPICAL APPLICATIONS
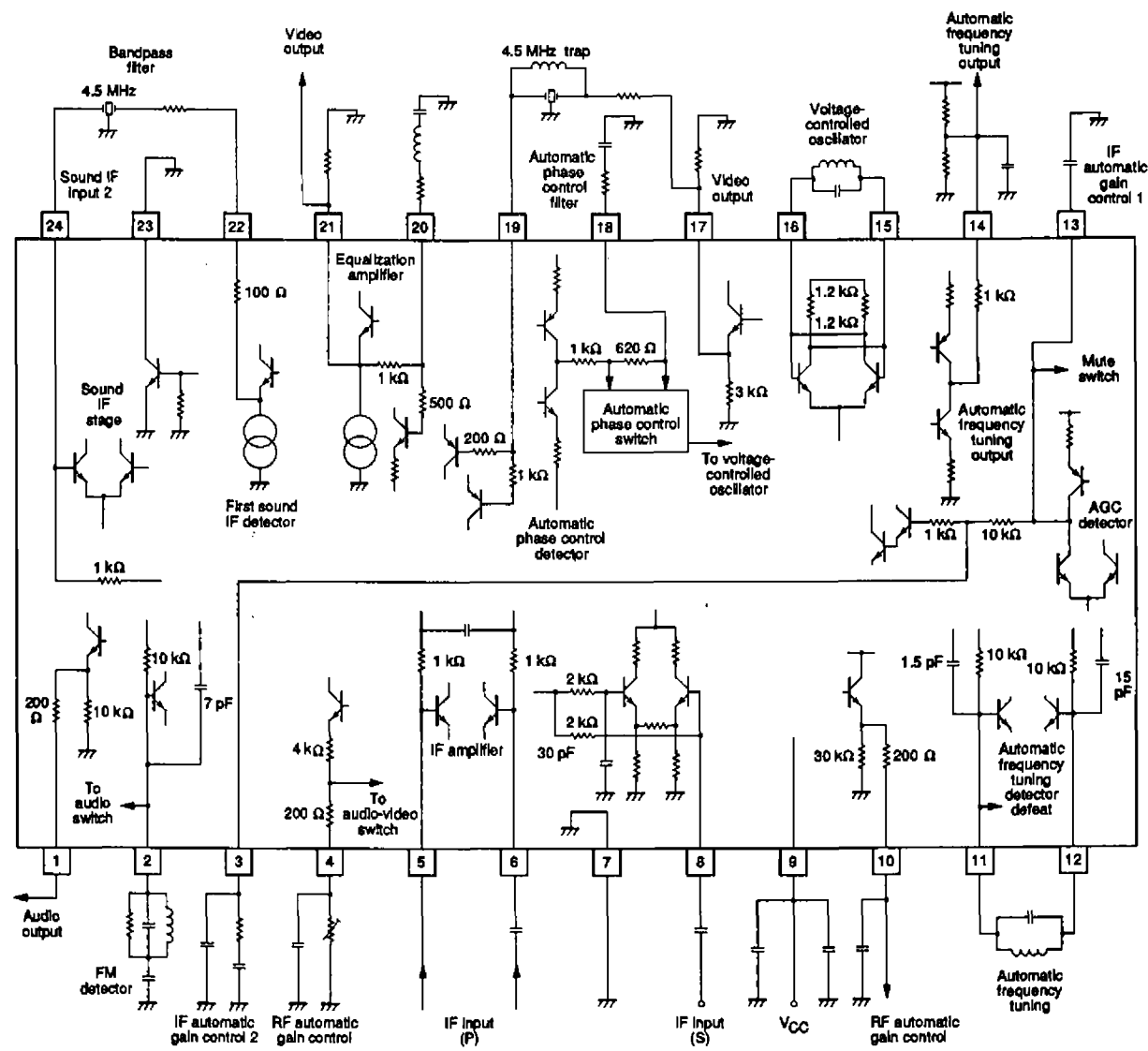
Figure 35. Interface circuit

Figure 36. Japan NTSC IF signal processor