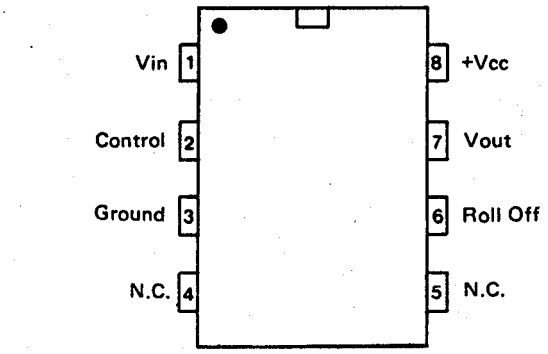
RS **Data Library**

Electronic attenuator

Stock number 306-803

A silicon monolithic gain controlled A.C. amplifier programmed by an external D.C. voltage or resistor. Applications include remote volume controls, speech compressors and expander circuits. The device is housed in an 8 pin D.I.L. plastic package suitable for use over the operating temperature range of 0°C to 75°C.

Pin connections



Absolute maximum ratings $T_A = 25°C$

Supply voltage	20V d.c.
Power dissipation	1.2 Watts
Derate above 25°C	10mW/°C
Operating ambient temperature range	0 to + 75°C.

Electrical characteristics

e_{in} = 100mV (r.m.s.), f = 1 kHz, $R_{control}$ = 0, V_{cc} = 16V

Operating supply voltage	9-18V d.c.
Control sink current (e_{in} = 0)	2mA d.c. (max)
Input voltage	0.5V (r.m.s.) max
Input resistance	17 kΩ (typ)

Figure 1 **Attenuation versus D.C. control voltage**

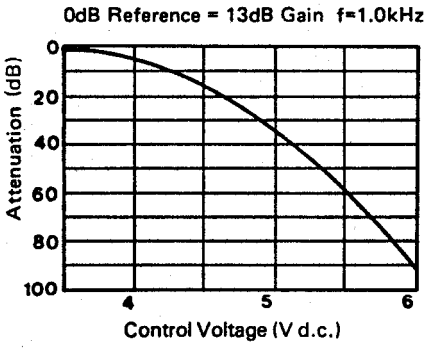


Figure 2 **T.H.D.**

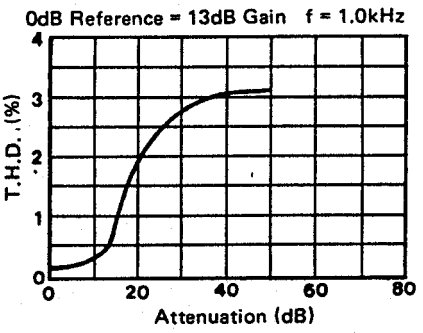


Figure 3 **Attenuation versus control resistor**

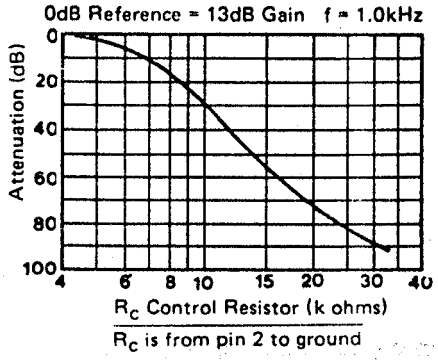


Figure 4 **Frequency response**

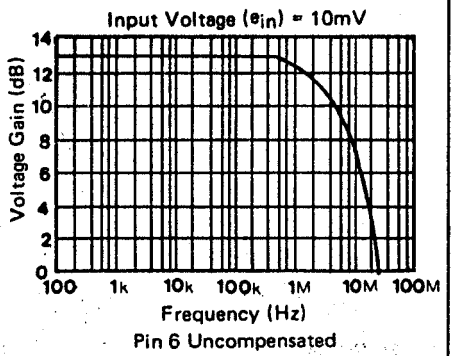
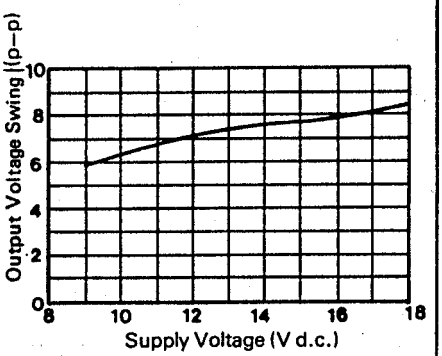
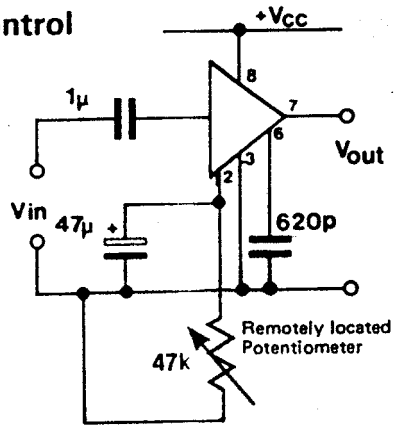


Figure 5 **Output voltage**



Applications

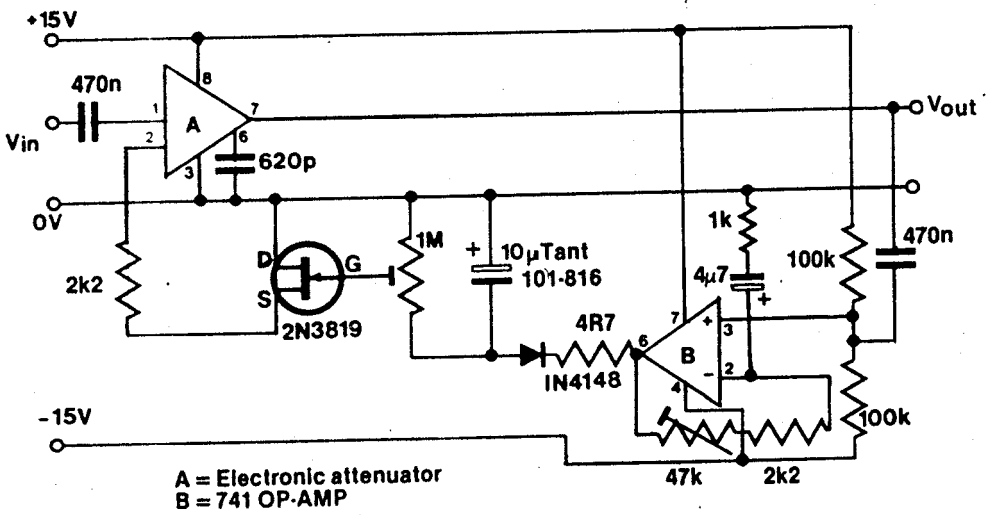
Remote volume control



A typical application where a remotely controlled amplifier is required. The potentiometer may be replaced by a D.C. voltage of 3.5 to 6V (maximum voltage or resistance gives the maximum attenuation). Useful frequency range 50 Hz to 100 kHz.

Note: The electronic attenuator can only be used to control A.C. voltages.

Audio compressor



Specification

Input signal compression range	13mV to 400mV r.m.s.
Output signal (2kΩ source)	60mV to 1.3 r.m.s.
	± 1db over input range
Bandwidth	50 Hz to 20 kHz
Distortion	< 1% over input range
Attack time	approx. 50µs
Decay time	> 0.5s

The circuit is powered by a ± 15V d.c. supply which may consist of RS Regulator 305-636, the attenuation of input voltage, V_{in} is controlled by the effective drain - source resistance of the 2N3819 field effect transistor. The output of the attenuator (A) is fed back via amplifier (B) the gain of which may be adjusted by the 47kΩ preset. The output of amplifier (B) is rectified and a negative bias is applied to the gate of the 2N3819 field effect transistor.

Circuit adjustment

1) Set the gain of amplifier, (B) to its maximum value (47kΩ preset adjusted to maximum value)

2) Apply the maximum input voltage to be tolerated (within range 13mV to 400 r.m.s.)

3) Adjust the 1MΩ preset until Vout is approximately 60mV r.m.s.

4) Increase Vout by reducing the gain of the amplifier B until Vout is approximately 4 x V_{in}

The attenuator will now compress voltages in excess of V_{in}.

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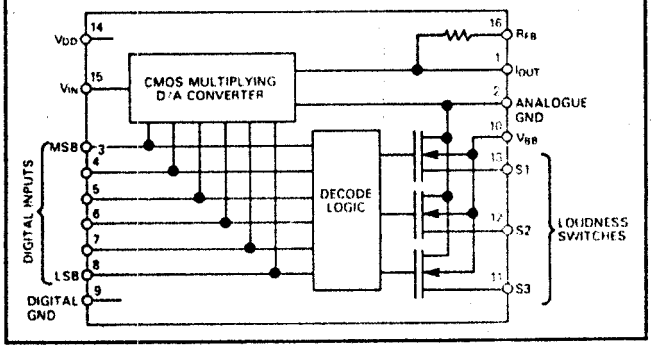
Audio characteristics $V_{DD} = +12V$, $V_{BB} = -12V$, $V_{IN} = -10V$, pins 11-13 open, $T_A = 0$ to $+50°C$ unless otherwise noted

Parameter	Test Conditions	Limit
ANALOG INPUT		
Input Resistance of V_{IN} (pin 15)	V_{OUT} = 0V (Note 4)	9kΩ min 18kΩ max
LOUDNESS SWITCHES		
Switch ON Resistance R_{ON}	Switch Current = 1mA	600Ω max
Switch OFF Leakage Current	V_{switch} = +12V	1μA max
Switch Coding		See Table 1
DIGITAL INPUTS		
V_{INH}		11.5V min
V_{INL}		0.5V max
I_{NH}		1μA max
I_{NL}		1μA max
C_{IN}		5pF typ
POWER REQUIREMENTS		
V_{DD}		+12V nom
V_{BB}		−12V nom
I_{DD}	Digital Inputs = V_{INL} or V_{INH}	1mA max
I_{BB}		100μA max
Total Power Dissipation		5mW typ

NOTES
1. Output amplifier (and, amplifier supplies) must be capable of 30V peak output.
2. Output noise voltage density includes op amp noise.
3. The RS 7110 is guaranteed monotonic for all attenuation settings between 0 and 88.5dB.
4. Input resistance for a given unit is constant for all input conditions.
5. Feedthrough is primarily dependent upon printed circuit board layout.

Block Diagram



age when using an external operational amplifier (as shown in Figure 1) and a fixed −10 volt reference applied to V_{IN} (pin 15). It may be seen that the transfer function for the circuit of Figure 1 is given by

$$V_{OUT} = -V_{IN} .10^{-\left(\frac{1.5N}{20}\right)}$$

where N is the binary input for values 0 to 59. For N = 60 through 63 the input is fully muted, that is, the attenuation is infinite.

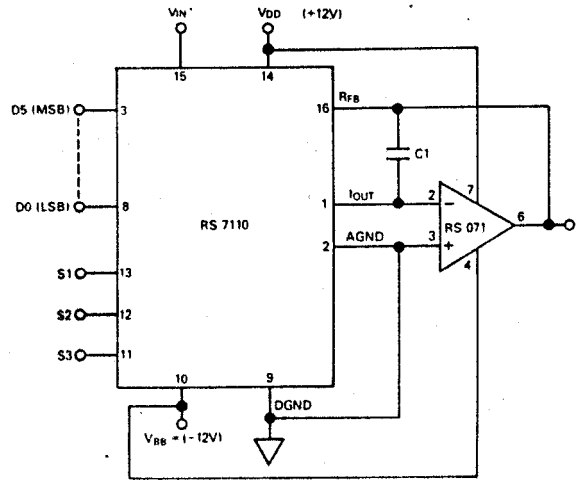
Circuit description

The block diagram above illustrates the internal structure of the RS 7110. The input signal is applied to pin 15 which is the input to a 6 bit multiplying digital to analogue converter. This D/A converter operates as an accurate digitally controlled attenuator, the attenuation being controlled by a 6 bit digital input code applied to pins 3 through to 8. The attenuated output is a current which is converted to a voltage via an external operational amplifier. An internal decoder controls 3 FET switches which can be used for loudness compensation.

Analogue circuit performance:

Table 1 gives the nominal attenuation in dB for the RS 7110 for all digital input codes. It also shows the loudness switch states and the nominal output volt-

Figure 1 **Basic circuit**



RS Data Library

Digitally controlled audio attenuator ic

Stock number 303-747

The RS 7110 is a C-MOS digitally controlled audio attenuator i.c.

The addition of one external operational amplifier enables an audio signal to be attenuated in 1.5 dB steps over the range 0 to 88.5 dB via a 6 bit binary input code.

Full muting is provided (for input codes 11 11 XX where X is a 1 or 0).

On chip switches enable loudness compensation to provide bass boost at high attenuation settings.

Features

- Attenuation range: 0 to 88.5dB plus full muting
- Resolution: 1.5dB
- Low distortion: THD better than −98dB
  IMD better than −92dB
- Includes switches for loudness compensation
- Low power consumption
- Excellent S/N ratio: 100dB (20Hz – 20kHz)
- Complies with DIN 45403 and DIN 45405
- Latch proof operation

Absolute maximum ratings $T_A = +25°C$

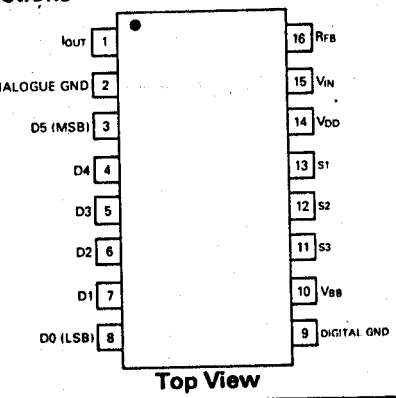
*V_{DD} (to GND)	+14V
*V_{BB} (to GND)	−14V
Voltage (pins 11, 12, 13) to GND	V_{BB}, +14V
V_{IN} (to GND)	±35V
Digital input voltage to GND	−0.3 to V_{DD}
Output voltage (pin 1) to GND	−100mV to V_{DD}
Power dissipation (package)	670mW
Operating temperature	0 to +70°C
Storage temperature	−65°C to +150°C
Lead temperature (soldering, 10 seconds)	+300°C

ATTENTION

OBSERVE PRECAUTIONS FOR HANDLING

ELECTROSTATIC SENSITIVE DEVICES

Pin Connections



Top View

NOTES
1. Output amplifier (and, amplifier supplies) must be capable of 30V peak output.
2. Output noise voltage density includes op amp noise.
3. The RS 7110 is guaranteed monotonic for all attenuation settings between 0 and 88.5dB.
4. Input resistance for a given unit is constant for all input conditions.
5. Feedthrough is primarily dependent upon printed circuit board layout.

* If loudness compensation switches (S1, S2, S3) are not used, the negative power supply may be omitted and V_{BB} (pin 10) connected instead to DGND (pin 9). In this case the absolute maximum rating of V_{DD} is +17V.

Electrical characteristics $V_{DD} = +5$ to $+12V$, $V_{BB} = 0$ to $-12V$, pins 11-13 open, $T_A = 0$ to $+50°C$ unless otherwise noted

Parameter	Test Conditions	RS 7110 with 'Ideal OP-AMP'	RS 7110 with RS 071 OP-AMP (Fig 1)	Units
Attenuation range	V_{IN} = 10V rms @ 1kHz	0 to −88.5	0 to −88.5	dB
Resolution	Frequency range 20Hz to 20kHz	1.5 max	1.5 max	dB
Attenuation accuracy (absolute) 0dB to −48dB −48dB to −88.5dB	(Note 3)	±0.7 max Monotonic	±0.7 max Monotonic	dB
Total harmonic distortion (THD)	per DIN 45403, BLATT 2 (with input level of 1V rms)	−98 max	−85 typ	dB
Intermodulation distortion (IMD)	per DIN 45403, BLATT 4	−92 max	−79 typ	dB
V_{IN}	for <1% (max) THD (Note 1)	30 max	10 max	V peak
Feedthrough error	1kHz (Note 5	−85	−85	dB
Output noise voltage density	20Hz to 20kHz (Note 2)	30 max	70 typ	nV/√Hz
Bandwidth	0dB Attenuation	dc to 150min	dc to 250 typ	kHz

See page 2 for notes

Figure 4 **Digital threshold voltage vs. power supply voltage**

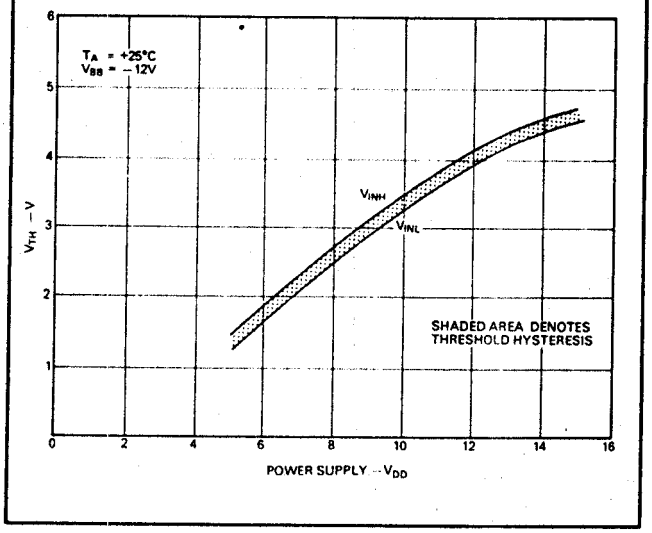
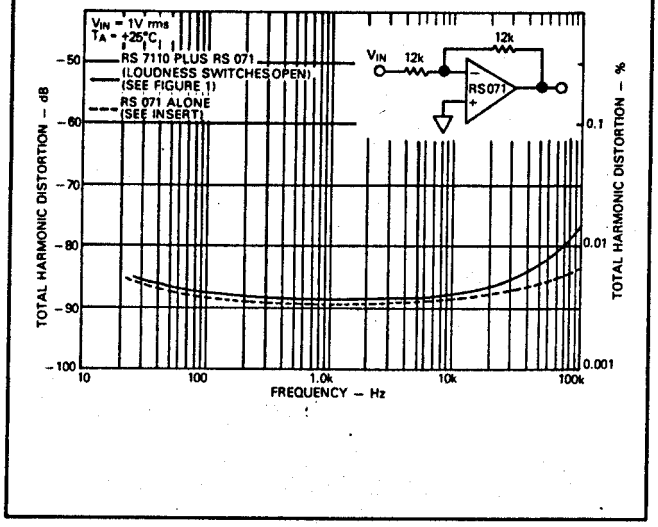


Figure 5 **Total harmonic distortion vs. frequency**



Circuit precautions

To realise the full attenuation range of the RS 7110 particular attention should be given to circuit layout and supply decoupling.

Input and output connections should be kept separate on the p.c.b. Short connections are advised, where possible, to avoid pick-up. Adequate supply decoupling is essential, 100nF disc ceramics or greater may be employed between the supply rails and their associated grounds, mounted close to the device pins.

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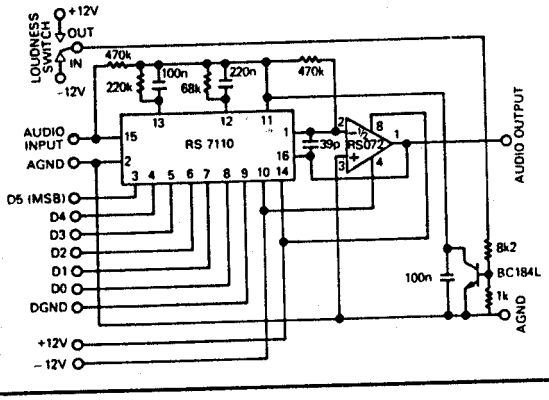
Table 1 Performance

N	Digital Input D5 D0	Attenuation dB	[1] Switches S1	S2	S3	[2] VOUT
0	00 00 00	0.0				10.000
1	00 00 01	1.5				8.414
2	00 00 10	3.0				7.079
3	00 00 11	4.5				5.597
4	00 01 00	6.0				5.012
5	00 01 01	7.5				4.217
6	00 01 10	9.0				3.548
7	00 01 11	10.5				2.985
8	00 10 00	12.0				2.512
9	00 10 01	13.5				2.113
10	00 10 10	15.0				1.778
11	00 10 11	16.5				1.496
12	00 11 00	18.0				1.259
13	00 11 01	19.5				1.059
14	00 11 10	21.0				0.891
15	00 11 11	22.5				0.750
16	01 00 00	24.0				0.631
17	01 00 01	25.5				0.531
18	01 00 10	27.0				0.447
19	01 00 11	28.5				0.376
20	01 01 00	30.0				0.316
21	01 01 01	31.5				0.266
22	01 01 10	33.0				0.224
23	01 01 11	34.5				0.188
24	01 10 00	36.0				0.158
25	01 10 01	37.5				0.133
26	01 10 10	39.0				0.112
27	01 10 11	40.5				0.0944
28	01 11 00	42.0				0.0794
29	01 11 01	43.5				0.0668
30	01 11 10	45.0				0.0562
31	01 11 11	46.5				0.0473
32	10 00 00	48.0				0.0398
33	10 00 01	49.5				0.0335
34	10 00 10	51.0				0.0282
35	10 00 11	52.5				0.0237
36	10 01 00	54.0				0.0200
37	10 01 01	55.5				0.0168
38	10 01 10	57.0				0.0141
39	10 01 11	58.5				0.0119
40	10 10 00	60.0				0.0100
41	10 10 01	61.5				0.00841
42	10 10 10	63.0				0.00708
43	10 10 11	64.5				0.00596
44	10 11 00	66.0				0.00501
45	10 11 01	67.5				0.00422
46	10 11 10	69.0				0.00355
47	10 11 11	70.5				0.00299
48	11 00 00	72.0				0.00251
49	11 00 01	73.5				0.00211
50	11 00 10	75.0				0.00178
51	11 00 11	76.5				0.00150
52	11 01 00	78.0				0.00126
53	11 01 01	79.5				0.00106
54	11 01 10	81.0				0.000891
55	11 01 11	82.5				0.000750
56	11 10 00	84.0				0.000631
57	11 10 01	85.5				0.000531
58	11 10 10	87.0				0.000447
59	11 10 11	88.5				0.000376
60	11 11 XX [3]	∞				

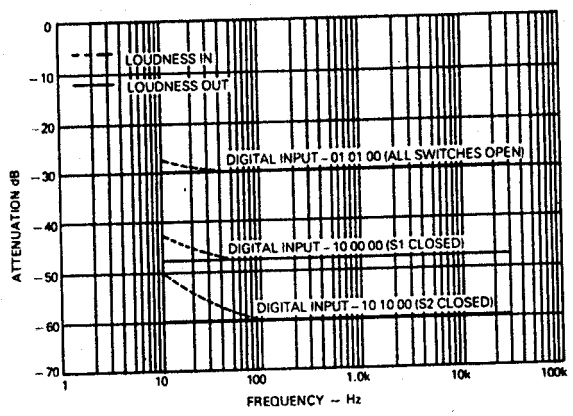
NOTES
[1] Switch closed in shaded area.
[2] VIN = −10V dc.
[3] X = 1 or 0. Output is fully muted for N>60.

Figure 2 **Single channel audio attenuator with loudness compensation**



The circuit shown in Figure 2 is a single channel attenuator with loudness compensation. Figure 3 shows the attenuation vs. frequency for two digital input codes at which the loudness compensation switches S1 & S2 are activated. If the loudness compensation switches S1, S2 & S3 are not required the negative supply for the RS 7110 may be omitted and V_{BB} (pin 10) connected instead to DIGITAL GND (pin 9).

Figure 3 **Attenuation vs. frequency**



High frequency amplifiers

R_{FB} and the output capacitance of the AD7110 create a phase lag in the output amplifier's feedback circuit. This phase lag, in conjunction with the amplifier's phase lag, may cause ringing or oscillation. When using a high speed amplifier, shunting the amplifier input to output with 30-50pF of feedback capacitance (C1) ensures stability.