

4006 Compression Amplifier

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1. general description

1.01 The 4006 Compression Amplifier, figure 1, combines continuously adjustable linear gain with linear level limiting adjustable over a wide range of output levels. The result is a low-distortion compression amplifier designed for use in voice frequency circuits where undistorted limiting of speech or data signals is desired.

1.02 The 4006 provides voice frequency gain from 0 to 20dB, with maximum output level capability of +17dBm. By front panel adjustment, the output signal can be limited to any level between -30 and +17dBm, with capability for up to 30dB of gain/level compression. Compression is linear, resulting in less than two percent total distortion at 30dB of compression.

1.03 The amplitude limiting threshold of the 4006 is continuously adjustable within two ("high" and "low") ranges. The low range limits output from the 4006 to any desired maximum level between -30 and -5dBm. The high range overlaps the low range somewhat, limiting outputs to any desired level between -10 and +17dBm.

1.04 The 4006 is a true *Compression Amplifier*, providing linear gain for all signals that result in output levels below the limiting threshold. Above the limiting threshold, gain (or loss) is introduced only as required to limit the output level to the desired maximum. A compression attack time of less than one millisecond for high level signals ensures that speech waveform peaks are limited, but not distorted. Gain is restored to its preset linear level within approximately 300ms of reduction in input signal level to a point below the limiting threshold. (Note that the entire threshold-exceeding waveform is "compressed" — the top of the waveform is not "clipped".)

1.05 The compression control loop is unconditionally stable, resulting in precisely controlled gain adjustment in the compression mode.

1.06 Balanced, 600 ohm impedance matching transformers face the input and the output ports of the 4006. Simplex leads are derived by both input and output transformers.

1.07 Two front-panel switches are provided on the 4006 to assist in alignment. One switch disables

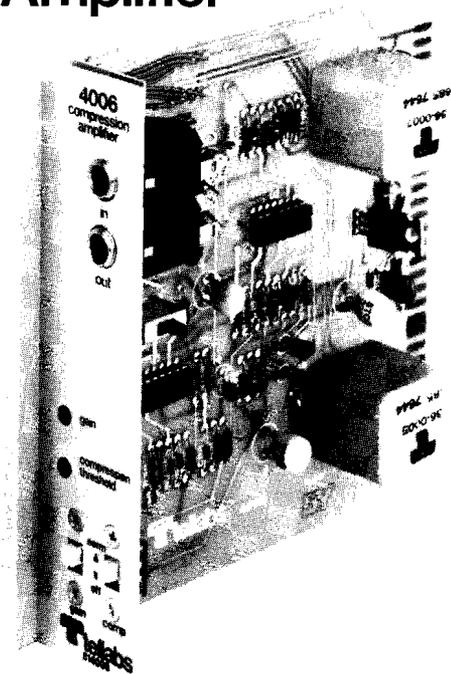


figure 1. 4006 Compression Amplifier

the module's compression circuit, while the other removes gain introduced by the module. Front-panel jacks are provided to access the 4006's input and output ports. Gain and compression threshold adjustments are also accessible at the front panel. The 4006 may, therefore, be aligned while mounted in place.

1.08 Internal voltage regulation allows the 4006 to operate on any input between -22 and -56Vdc. Reverse battery protection circuitry and transient limiting circuitry are integral to the module.

1.09 Pinouts on the 4006 module are arranged for compatibility with the universal wiring scheme employed in the Tellabs 261 Signaling and Terminating System.

1.10 Mounting for the 4006 is provided via the Tellabs Type 10 Shelf, variations of which allow relay rack or apparatus case installation. In relay rack applications, up to 12 modules may be mounted across a 19" rack, while a 23" rack accommodates up to 14 modules across. In either case, 6" of vertical rack space are utilized.

2. application

2.01 The 4006 Compression Amplifier is a unidirectional gain device that amplifies those signals requiring amplification and prevents those signals that might overload a circuit from being transmitted at an excessive level. The 4006 may be used, for example, prior to the transmit input port of a carrier channel to ensure that the channel receives a signal of sufficient magnitude, yet is not overloaded.

2.02 Because of its low distortion, the 4006 may be applied to virtually any voice frequency circuit. Non-linear distortion introduced by the module amounts to less than 0.5% below the compression threshold and does not exceed 2% at 30dB of compression. The compression control loop is unconditionally stable, resulting in precisely controlled gain adjustment in the compression mode.

2.03 Inputs and outputs of the 4006 are arranged to allow the module to be utilized with the universal wiring scheme of Tellabs Type 261 SF Signaling and Terminating System. When used in a 261 Assembly, the 4006 mounts in the slot normally occupied by a 4001 Line Amplifier. The 4006 performs its functions in the transmit channel and provides a bypass in the receive channel.

2.04 The 4006 Compression Amplifier may be used at standard transmission level points of -16 or $+7$, or at any other convenient TLP between approximately -20 and $+10$ TLP. A compression range switch located on the printed circuit board options the unit for either **high range** or **low range** compression. Generally, the high compression range should be used at $+7$ transmission level points, and the low range at -16 transmission level points. In the high range position, maximum output level may be adjusted from $+17$ to -10 dBm. When optioned for **low range limiting**, the output level may be limited to any desired level between -30 and -5 dBm. When used in the transmit direction of a Type 261 Signaling/Terminating System (or equivalent), the **limiting range** switch should be in the LOW position.

2.05 The 4006 is equipped with input and output transformers to provide impedance matching and dc isolation. Balanced input and output impedances of 600 ohms accommodate a well-matched interface with carrier, sf signaling units, non-loaded cable and station apparatus. The input and output transformers are center-tapped to derive simplex leads, allowing the module to be applied to circuits employing dx signaling, loopback and other external dc signaling techniques.

2.06 Installation and alignment of the 4006 at either a centralized or remote location is accommodated by the module's contingent of front-panel controls and jacks that allow alignment while the module is mounted in place. Gain and compression may be switched on or off to assist in alignment (see section 3). Gain and compression threshold level adjustments are accessible. Input and output jacks permit measurement of the module's effect on the circuit.

2.07 The 4006 may be operated at any input dc potential between -22 and -56 Vdc. The unit requires approximately 15mA of current at nominal 24Vdc input and approximately 22mA at 48Vdc input. Reverse battery protection and transient limiting circuitry are provided in the internal power regulating circuit.

2.08 The 4006 is afforded relay rack or apparatus case installation by virtue of the Tellabs Type 10 Mounting Shelf.

3. installation

inspection

3.01 The 4006 Compression Amplifier module should be visually inspected upon arrival in order to find possible damage incurred during shipment. If damage is noted, a claim should immediately be filed with the carrier. If stored, the module should be visually inspected again, prior to installation.

mounting

3.02 Each 4006 module mounts in one position of the Tellabs Type 10 Mounting Shelf which is available in configurations for both relay rack and apparatus case installation. The module plugs physically and electrically into a 56-pin connector at the rear of the Type 10 Shelf.

installer connections

3.03 Before making any connections to the mounting shelf, make sure that power is **off** and modules are **removed**. Modules should be put into place only **after** properly optioned and **after** wiring has been completed.

3.04 Table 1 lists external connections to the 4006 Compression Amplifier. All connections are made via wire wrap at the 56-pin connector at the rear of each module's mounting shelf position. Pin numbers are found on the body of the connector.

connect	to pin
INPUT (amplifier input)	49 and 55
OUTPUT (amplifier output)	41 and 47
SX (simplex-lead input)	45
SX (simplex-lead output)	51
-V (-22 to -56 Vdc battery input)	35
GND (ground)	17
internal through connection*	7 and 13 to 5 and 15

(*receive channel bypass when used, for example, in a 261 4Wire Signaling and Terminating System)

table 1. 4006 external connections

option selection

3.05 A single slide switch on the 4006 printed circuit board selects HIGH or LOW range compression. The switch is labeled "LIMITING RANGE". In the high range, maximum output level of the 4006 may be adjusted within a $+17$ to -10 dBm range. Low range maximum output levels may be adjusted within a -30 to -5 dBm continuum. If the output signal from the 4006 is to be limited to levels below -10 dBm, place this switch in the LOW position. If limiting is to be introduced at levels above -10 dBm, place this switch in the HIGH position. With respect to standard $+7$ and -16 TLP's, the high range is generally chosen if the module is applied to the $+7$ TLP side of the circuit and the low range is generally chosen if it's applied to the -16 TLP side.

alignment

3.06 When aligning the 4006, place the front panel COMP switch to the OFF position to disable the compression circuitry. This will permit normal alignment of the circuit and ensure that alignment signals are not limited by the 4006. If desired, the amplifier gain may also be reduced to unity during alignment by positioning the front panel gain switch to the OFF position. Both switches should be returned to the NORM position after alignment.

3.07 To adjust the gain of the 4006, place the COMP switch to the OFF position and adjust the front-panel GAIN control for the desired insertion gain. (The output level may conveniently be measured by using a meter at the module's front-panel output jack.)

3.08 To adjust the output limiting threshold (the LIMITING RANGE switch has already been set per paragraph 3.05), introduce a signal at the input jack that will result in a level 10dB above the desired limiting threshold, and then adjust the **compression threshold** potentiometer clockwise to reduce the output to the desired level. Both gain and compression threshold have now been properly adjusted, and the circuit is ready for use.

input and output level restrictions

3.09 Input signal levels in excess of approximately +5dBm will produce input overload of the 4006 Amplifier and should be avoided. In addition, output limiting will occur if the LIMITING RANGE switch is in the LOW position and output levels in excess of approximately -5dBm are required. If signal levels above this level are desired, the LIMITING RANGE switch should be set to the HIGH position. When in the HIGH position, output levels up to +17dBm may be accommodated, depending, of course, upon the compression threshold selected.

4. circuit description

Note: Please refer to the Functional Block Diagram (Section 5) as an aid in understanding the following.

4.01 The 4006 makes use of a gain-controllable operational transconductance amplifier (OTA) as the gain control element. The OTA is followed by a linear operational amplifier with continuously adjustable gain, and then a power amplifier output section. Both input and output are coupled to external circuits through balancing transformers. Control input to the transconductance amplifiers is derived through use of a full-wave rectifier and peak

detector arrangement. The full-wave rectifier consists of an operational amplifier with diode feedback, resulting in a nearly ideal full-wave rectifier. The peak detector makes use of a second operational amplifier that also provides a high impedance summing point for the full-wave circuit. A direct coupled voltage gain stage follows the peak detector and provides the level control for the transconductance amplifier.

4.02 Power for the 4006 is provided through a linear voltage regulator and active voltage divider. Internal circuits operate on potentials of -10 and -20Vdc. A diode in the power input lead prevents damage to the circuit under reverse battery connection conditions.

4.03 Input transients to the 4006 are limited by a multiple junction varistor, and output transients are limited by a high voltage surge arrester connected across the output transformer primary winding.

6. specifications

input impedance

600 ohms $\pm 5\%$, 300 to 4000Hz

output impedance

600 ohms $\pm 5\%$, 300 to 4000Hz

gain range

0 to 21dB, continuously adjustable

frequency response

± 0.5 dB re 1000Hz level, 200 to 4000Hz

output overload level

+17dBm (with no compression) -5.0dBm with Range Switch in LOW position

maximum input level

+5dBm (either compression range)

noise

10dB gain: 10dBmNC

20dB gain: 20dBmNC

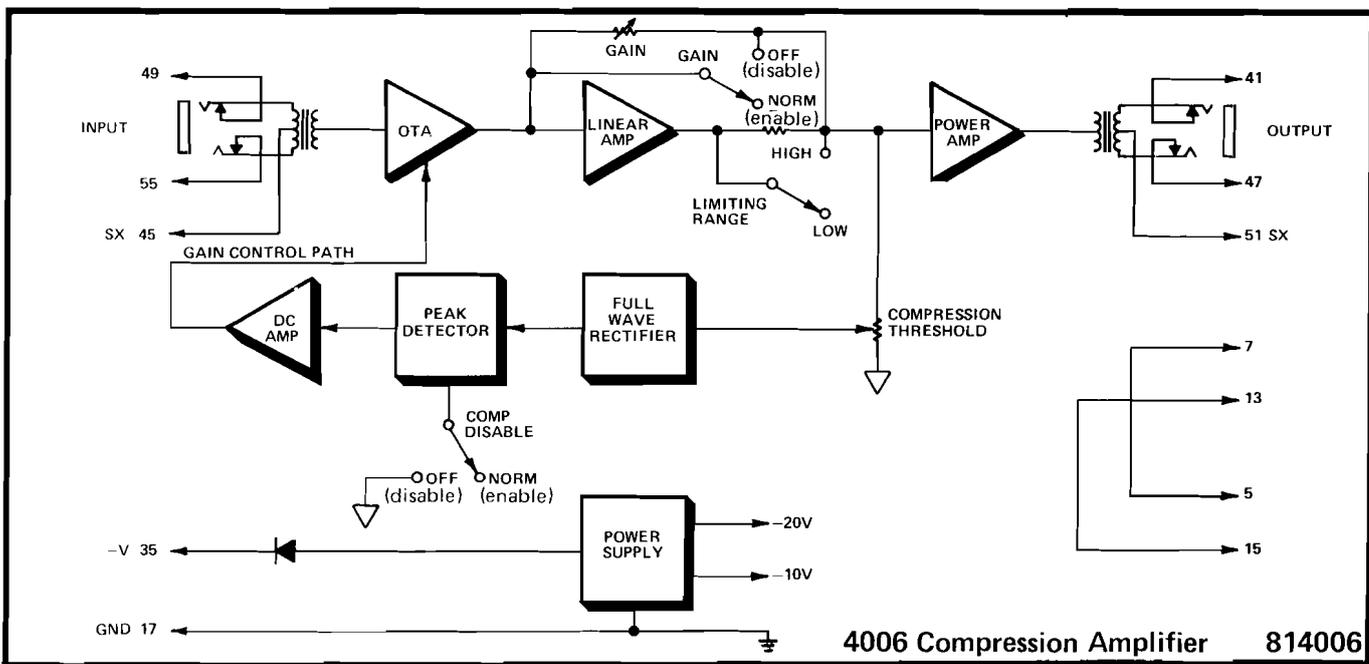
compression ranges

High: -10 to +17dBm

Low: -32 to -5dBm

compression input/output characteristics

input/output level ratio is linear (within 0.1dB) up to 1dB below the limiting threshold; the output level is constant



5. BLOCK DIAGRAM

(within +0.5dB to -1dB) for signal levels above the compression threshold, with 0 to 30dB of compression introduced.

nonlinear (Harmonic) distortion (Measured at 0dBm output level except at 30dB of compression):

- No compression 0.5% max.
- 10dB compression 1.0% max.
- 20dB compression 1.5% max.
- 30dB compression 2.0% max.

compression attack time (measured with 2kHz input signal)

- i) No signal to 10dB compression: 2ms max.
- ii) No signal to 20dB compression: 1ms max.
- iii) No signal to 30dB compression: .5ms max.
- iv) 12dB step to 10dB compression: 1ms max.
- v) 12dB step to 20dB compression: .5ms max.
- vi) 12dB step to 30dB compression: .5ms max.

gain recovery time

- i) 12dB level decrease from 10dB comp.: 400ms
- ii) 12dB level decrease from 20dB comp.: 100ms
- iii) 12dB level decrease from 30dB comp.: 100ms

power requirements

input voltage: -22 to -56VDC
input current: 25mA max.

operating environment

20° to 130° F (-7° to 54° C), humidity to 95% (no condensation)

dimensions

5.58" (14.17cm) high
1.42" (3.61cm) wide
5.96" (15.14cm) deep

weight

9.5 ounces (.269kg)

mounting

relay rack or apparatus case via one position of Tellabs Type 10 Shelf or one position Wescom Type 400 Shelf

7. testing and troubleshooting

7.01 This Testing Guide may be used to assist in the installation, testing or troubleshooting of the 4006 Compression Amplifier module. The Guide is intended as an aid

in the localization of trouble to a specific module. If a module is suspected of being defective, a new module should be substituted, and the test conducted again. If the substitute module operates correctly, the original module should be considered defective and returned to Tellabs for repair or replacement. It is strongly recommended that no "internal" testing or repairs be attempted on the 4006 module. Unauthorized testing or repairs may void the 4006's warranty.

7.02 If a situation arises that is not covered in the Testing Guide, contact Tellabs Customer Service (312)969-8800 for further assistance.

7.03 If a 4006 is diagnosed as defective, the situation may be remedied by either "replacement" or "repair and return". Because it is the more expedient method, the "replacement" procedure should be followed whenever time is a critical factor. (i.e.; service outages, etc.).

replacement

7.04 If a defective 4006 is encountered, notify Tellabs directly, via telephone, letter or twx. Notification should include all relevant information, including the 8X4006 part number (from which we can determine the Issue of the 4006 module in question). Upon notification, we shall ship a replacement module to you. If the Warranty date of the defective module has not elapsed, the replacement module will be shipped at no charge. Package the defective module in the replacement module's carton; sign the packing list included with the replacement module and enclose it with the defective module (this is your return authorization); affix the preaddressed label provided with the replacement module to the carton being returned; and ship the equipment prepaid to Tellabs.

repair and return

7.05 Return the defective 4006 module, shipment prepaid, to Tellabs. Enclose an explanation of the module's malfunction. Follow your company's standard procedure with respect to administrative paperwork. Tellabs will repair the module and ship it back to you. If the module is in Warranty, no invoice will be issued.

4006 testing guide checklist

test	test procedure	normal results	if normal results are not achieved, verify:
Linear Gain	Place front-panel <i>comp</i> switch to <i>off</i> ; use FVO with 310-type plug to insert 1000Hz signal at -20dBm0 into <i>in</i> jack. Measure level at <i>out</i> jack with TTS terminated 600 ohms.	With <i>gain</i> control fully counterclockwise (CCW), output at -20 ± 2dBm □. As control is rotated clockwise (CW), level increases to 0 ± 1dBm □.	Power connection □. <i>Gain</i> switch to <i>norm</i> □. <i>Comp</i> switch to <i>off</i> □.
Compression (low range)	Place <i>comp</i> switch to <i>norm</i> , and LIMITING RANGE switch to LOW. Adjust <i>compression threshold</i> control CW and observe output level.	As control adjusted CW, output level decreases □. At full CW, level less than -30dBm □.	<i>Gain</i> and <i>comp</i> switches both set to <i>norm</i> □. LIMITING RANGE switch to LOW □. Input level at -20dBm and <i>gain</i> control remains full CW □.
Compression (high range)	Change LIMITING RANGE switch to HIGH, and increase input to 0dBm. Adjust <i>gain</i> control to provide +15dBm output. Slowly rotate <i>compression threshold</i> control from full CCW to full CW.	Output level decreases as <i>compression threshold</i> adjusted CW □. At full CW, output level less than -10dBm □.	<i>Gain</i> and <i>comp</i> switches both at <i>norm</i> □. LIMITING RANGE switch to HIGH □. Input level at 0dBm □.
Overload Level	Place <i>comp</i> switch to <i>off</i> and input 0dBm signal. Set LIMITING RANGE switch to HIGH. Rotate <i>gain</i> CW and observe output with oscilloscope and terminated TTS.	Output level increases, with no clipping or distortion, up to +17dBm □.	<i>Gain</i> switch to <i>norm</i> □. <i>Comp</i> switch to <i>off</i> □. LIMITING RANGE switch to HIGH □. Input voltage -23Vdc minimum □.