# The CED 3505 V4 Programmable Attenuator Owners Handbook



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## Potential for Radio/Television Interference *(USA only)*

The CED 3505 generates and uses radio frequency energy and may cause interference to radio and television reception. Your CED 3505 complies with the Specification in Subpart J of Part 15 of the Federal Communications rules for a Class A computing device. These specifications provide reasonable protection against such interference in a residential installation. However there is no guarantee that interference will not occur in a particular installation. If the CED 3505 does cause interference to radio or television reception, which can be determined by turning the CED 3505 mains supply off and on, you can try to eliminate the interference problem by doing one or more of the following:

- Re-orient the receiving antenna
- Re-orient the position of the CED 3505 with respect to the receiver
- Move the CED 3505 away from the receiver
- Plug the CED 3505 into a different outlet so that the CED 3505 and the receiver are on different branch circuits

If necessary, consult CED or an experienced radio/television technician for additional suggestions. You may find the booklet, prepared by the Federal Communications Commission, helpful: *How to Identify and Resolve Radio/TV Interference Problems*. The booklet is available from the US Government Printing Office, Washington DC 20402, Stock no. 004-000-00345-4.

To comply with FCC rules, Part 15 B Class A Computing device, use only shielded interface cables.

## Use of symbols

Where applied, the following symbols have the meanings below:

This symbol declares that the equipment passes the relevant clauses of EU directives on safety and EMC emissions; see the certificate reproduced on page 35

The CED 3505 Programmable Attenuator is lead-free and conforms to the EU RoHS directive

The CED 3505 Programmable Attenuator is subject to the EU WEEE regulations and may be returned to CED Ltd for recycling

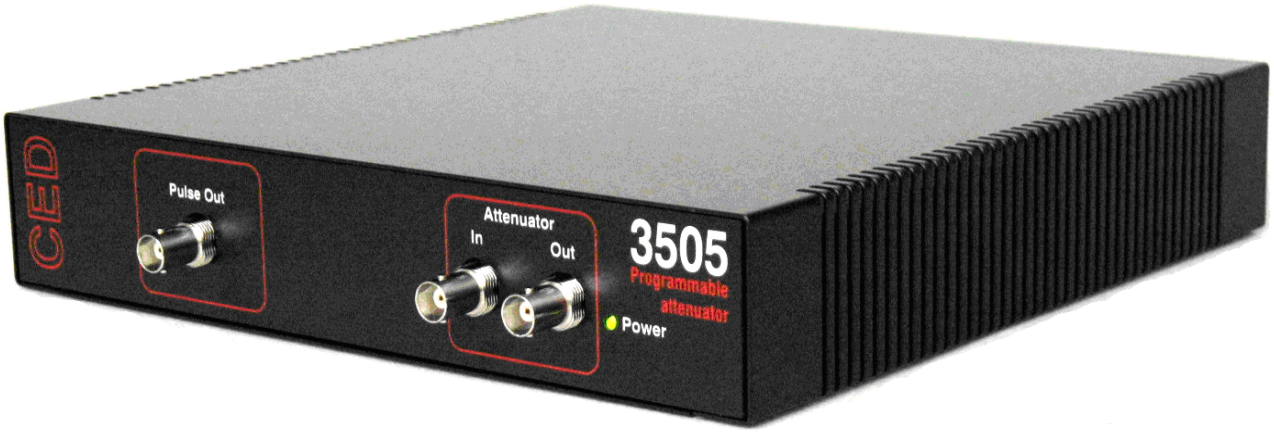
Attention, consult accompanying documents

The DC symbol indicates that the CED 3505 Programmable Attenuator chassis is powered from a DC-only supply

## Life support

**CED products are not authorized for use as critical components in life support systems without the express written approval of the chairman of the board of directors of CED.**

Life support systems in this context are systems which support or sustain life, and whose failure to perform, when properly used in accordance with instructions for use provided, can be reasonably expected to result in a significant injury to the user. A critical component in this context is any component of a life support system whose failure to perform can reasonably be expected to cause the failure of the life support system, or to affect its safety or effectiveness.




*CED 3505 Programmable Attenuator V4*

## Introduction

The CED 3505 version 4 is a single channel programmable attenuator with a separate muting control. Attenuation is set via USB or a parallel interface. In its standard form, a pulse is output on a front-panel BNC connector with each attenuation change. An enhanced version (CED 3505HP) replaces the pulse output circuitry with a driver and output connector for audiometric headphones and bone conduction transducers. The balanced analogue I/O version (CED 3505B) offers reduced noise at high attenuations.

| **Specification** | **(main attenuator)** |
|---|---|
| Number of channels: | 1 |
| Attenuations: | Standard: 0 dB to 102 dB in 3 dB steps; other step sizes available to order |
| Input connector: | BNC (or ODU, Balanced option) |
| Input signals: (Attenuator input & output) | ±8 V max with ±12 V supplies, ±10 V max with ±15 V supplies |
| Input impedance: | 1 MOhm |
| Driving source impedance: | 1 kOhm or less (recommended) |
| Output connector: | BNC (or ODU, Balanced option) |
| Output load: | > 2 kOhm for specified accuracy |

| | |
|---|---|
| Frequency response: | DC – 100 kHz (–3 dB), no filter fitted |
| Filter option: | 4th-order low-pass |
| Filter frequency: | Specify a frequency in the range 5 kHz – 50 kHz at time of order |
| Filter characteristic: | Butterworth (standard), Bessel, or sinc-compensated Butterworth (special order) |
| Attenuation accuracy: | ±0.2 dB 10 Hz – 20 kHz |
| Mute: | Greater of attenuation set and –70 dB, DC – 20 kHz |
| Output offset: | < 0.5 mV, all attenuations |
| Pulse out: (standard 3505 only) | 5 V TTL, approx. 2 μs length, selectable polarity |

## Headphone option (3505HP)

| | |
|---|---|
| Headphone output: | ±5 V max (standard); ±10 V max (option) Drive for audiometric headphones, ≥16 Ohm, each ear mutable |
| Headphone connector: | 6.35 mm stereo (TRS) jack socket |
| Headphone calibration: | Separate L + R headphone calibration attenuators 0 – 24 dB, 0.4 dB resolution |

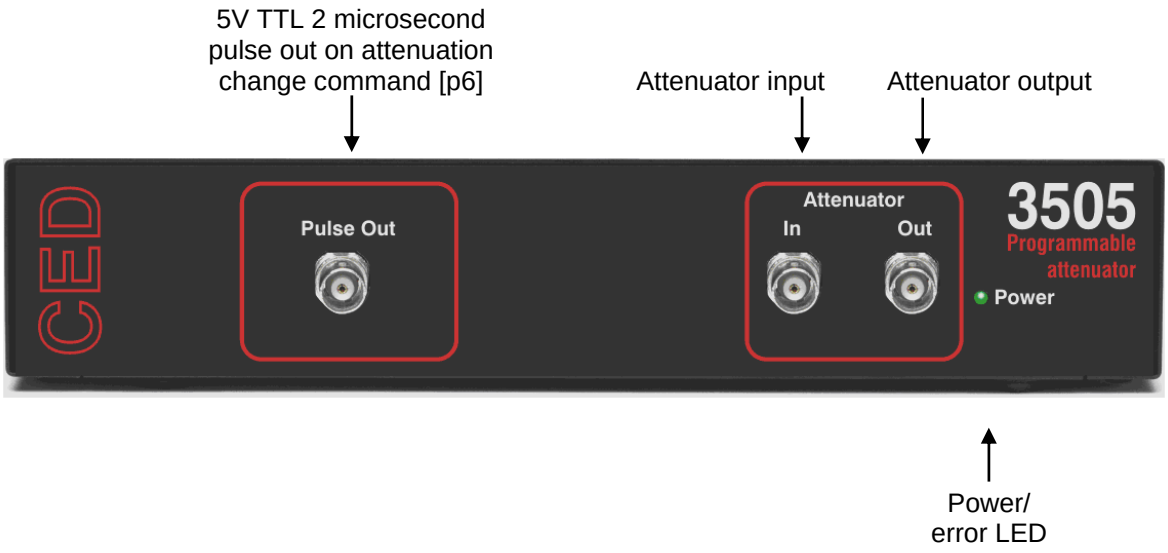
## Balanced option (3505B)

| | |
|---|---|
| Input & Output connector: | ODU (or 2× BNC, single-ended only) |
| Input voltage maximum: (differential) | ±20 V peak (+25 dBu, 14 V r.m.s.) |
| Input voltage maximum: (single-ended) | ±10 V peak (+19 dBu, 7 V r.m.s.) |
| Input impedance: (differential) | 24 kOhm |
| Input impedance: (common-mode) | 18 kOhm |

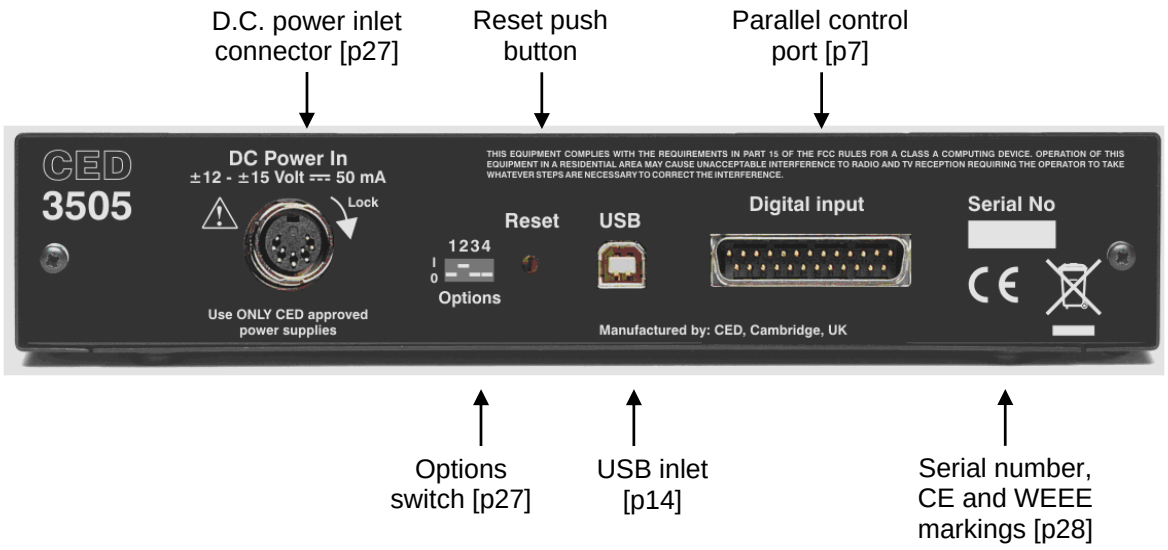
| | |
|---|---|
| Input common-mode rejection: | 90 dB |
| Input offset voltage: (differential) | ±10 μV |
| Output voltage maximum: (differential) | ±20 V peak (+25 dBu, 14 V r.m.s.) |
| Output voltage maximum: (single-ended) | ±10 V peak (+19 dBu, 7 V r.m.s.) |
| Output impedance: | 50 Ohm |
| Output signal balance: | 54 dB |
| Output offset voltage: (differential) | ±10 μV |
| Output offset voltage: (common-mode) | ±50 mV |
| Output short-circuit current: | ±85 mA |

## Interface & power

| | |
|---|---|
| Serial control: | USB virtual serial port at 9600 baud |
| Parallel control: | 7-bit parallel 5 V TTL on 25-way D-plug; 8 mA load to ground per line |
| Control cable (option): | 2 m terminating in 25-way D-socket for CED 1401 digital output |
| Power required: | ±12 to ±15 V DC 50 mA (standard 3505)<br>800 mA (3505HP, headphones driven) |
| Power supply: | CED type B15, 100 – 240 V AC mains input 50 – 60 Hz, ±15 V DC output |
| Case size: | 240 mm × 240 mm × 46 mm (W × D × H) excluding connectors and power supply |
| Weight: | 3 kg including mains power supply |




*CED 3505 front panel (standard model)*




*CED 3505 rear panel*

## Data input: rear-panel parallel

The rear-panel parallel digital input attenuation data bypasses the microprocessor in the 3505 in order to get consistent, fast attenuation change timings and direct control of the main attenuator. Of the parallel input data, only the mute bit is available to the microprocessor.

The parallel digital input gives direct control of the two multiplexers that select high and low resolution attenuation settings, three selection bits being assigned to each multiplexer. The user must present the required pair of TTL three-bit codes, as described in the 3505 command set, below.

## Data input: USB

If attenuation data is input via the USB port, the 3505 microprocessor firmware takes the dB attenuation requested by the ATnn command, together with its knowledge of the attenuation step size fitted in the particular 3505, to form the two three-bit data fields. The data fields from the microprocessor and the rear-panel parallel input are OR-ed in hardware and the result is used as the multiplexer addresses.

## Attenuation stages

The CED 3505 V4 has two cascaded stages of attenuation, plus a muting position. The standard-build first stage has six steps of 15 dB, giving 0 dB to 90 dB of attenuation. The standard second stage has four steps of 3 dB, giving 0 dB to 12 dB of attenuation. Attenuation steps are custom fitted and must be specified at time of order.

## Filter option

The CED 3505 attenuator can be supplied with a 4-pole low-pass filter fitted. The cut-off frequency is specified by the user at time of order and can be in the range 5 kHz to 50 kHz. A Butterworth characteristic is standard, but optionally it may be specified to be either Bessel or a modified Butterworth characteristic that incorporates an approximation to an inverse sinc ( sin (x)/x ) for correction of DAC output frequency responses, in applications where a fixed update sampling rate is used. If the output filter is not fitted, the attenuator frequency response extends to 100 kHz or higher. The ?FF command can be used to check the cut-off frequency of a CED 3505. The frequency is returned as a number in kHz, or as 0 if no filter is fitted.

## Pulse out BNC (standard CED 3505 only)

The BNC connector on the CED 3505 front panel outputs a pulse whenever the attenuation setting is updated from the serial line, even if the same attenuation value is written as is currently set. If a new attenuation value is sent when the 3503 output is muted, generation of the pulse is delayed until the mute is cancelled. The pulse is 5 V TTL compatible, and the polarity can be set using the `OP1x` serial line command. The output can drive 2 mA to a high or low level. In addition, the serial line `PO` command can be used to generate a single pulse at this output.

## Headphone drive output (CED 3505HP only)

An enhanced model of the version 4 attenuator is available, (CED 3505HP), fitted with an audiometric headphone drive circuit and 6.35 mm jack socket in place of the pulse output connector. The socket is wired: tip = left channel, ring = right channel, sleeve = return (ground).

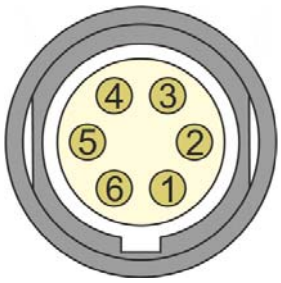
The headphone drive circuitry has a number of features designed for single-voiced audiometric applications.

- Two-channel power amplifier suitable for driving audiometric headphones and bone conduction transducers having an impedance of 16 Ohms or greater
- AC coupled low-frequency response at approximately 40 Hz; other frequencies to special order
- Servo circuit to null the DC offset on the headphone outputs on each channel
- Individual muting controls for L and R channels
- Individual calibration attenuators with approximately 0.4 dB step size on each of the L and R channels, software settable to correct for known deviations in the headphone response from the nominal values
- Overall global headphone mute without affecting other settings
- Sound pressure levels in excess of 140 dB achievable with standard THD49 headphones
- Option for additional 6 dB output level for non-continuous tones

## Balanced output (CED 3505B only)

At high attenuations, ground noise can be a problem. To overcome this, the CED 3505B provides chassis-earth isolation, and differential analogue input and output routed through a 6-way ODU socket. This is fitted on the front panel, in place of the pulse output of the standard CED 3505.

### 6-way ODU socket




| Pin | Function |
|---|---|
| 1 | Analogue ground |
| 2 | Lo = select ODU input |
| 3 | –ve Differential output |
| 4 | +ve Differential output |
| 5 | –ve Differential input |
| 6 | +ve Differential input |

It is recommended that the input and output leads from the mating ODU plug are wired as separate, screened, wire pairs, so as to minimize pickup between input and output.

### Choice of I/O mode

Single-ended I/O, referenced to analogue ground, remains available as before through front-panel BNC sockets. Analogue input is switched from BNC (single-ended) to ODU (differential) by grounding pin 2 of the ODU connector. Analogue output is always available on both BNC and ODU connectors. See block diagram, page 9.

Use of balanced differential I/O gives an improvement in signal-to-noise ratio of about 20 dB.

### I/O signal levels

The differential output is generated by inverting the single-ended output to form the antiphase. Hence the differential output has twice the amplitude (+6 dB) of single-ended output. Differential input is converted to single-ended before attenuation, which halves the amplitude (–6 dB). This means that overall attenuation is unaffected by choice of single-ended or differential I/O, as long as input and output are the same mode. Choosing mixed-mode I/O will involve 6 dB gain or attenuation through the signal path relative to the attenuator setting. See table, page 8.

**Grounded differential I/O**

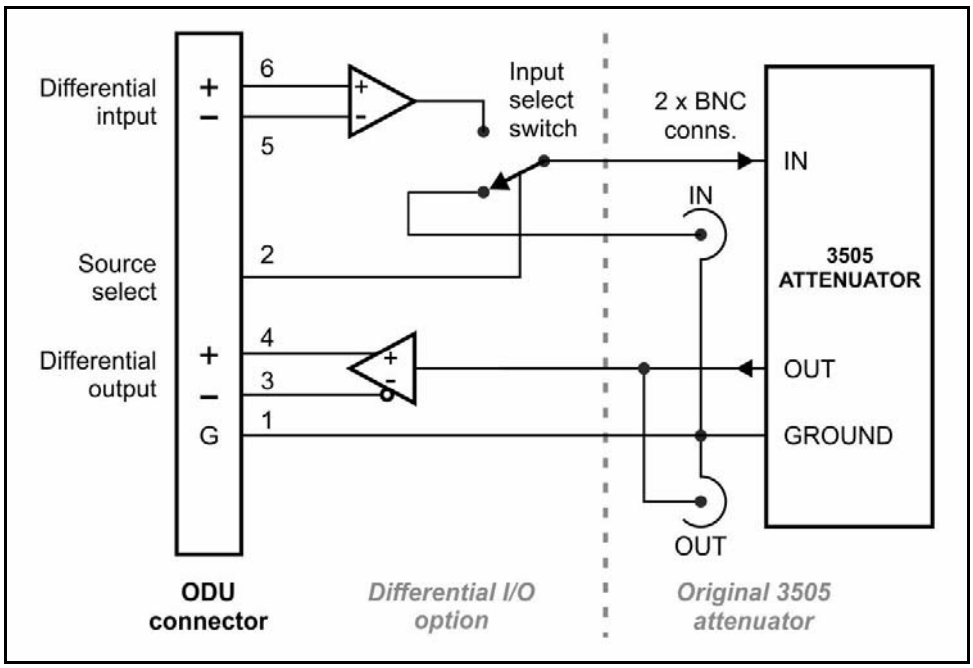
The differential input can be used with the –ve input grounded, i.e. as a single-ended input; the signal is halved in amplitude, since the –ve input stays at zero, rather than moving in antiphase. The differential output can also be used with the –ve output grounded; in this case, however, the amplitude remains the same, but it all appears as excursions on the +ve output.

**I/O mode combinations**

| Input | Output | Gain/loss (dB) [1] | Max input (±V) [2] | Max output (±V) [2] |
|---|---|---|---|---|
| BNC | BNC | 0 | 10 | 10 |
| ODU balanced | ODU balanced | 0 | 20 diff | 20 diff |
| ODU unbal. [3] | ODU unbal. [3] | 0 | 10 | 10 |
| ODU balanced | BNC | –6 | 20 diff | 10 |
| ODU unbalanced | BNC | –6 | 10 | 5 |
| BNC | ODU balanced | +6 | 10 | 20 diff |
| BNC | ODU unbalanced | +6 | 10 | 10 |

Notes:

1) gain/loss relative to programmed attenuation
2) peak values; “diff” is taken between equal and opposite signal terminals at input or output
3) “unbalanced” refers to a signal on one signal line at the ODU connector with the other grounded
4) signal levels are given as peak values; r.m.s. levels are approximately 70% of the peak level
5) signal levels in Vrms and dBu: 5Vpk = 3.54/+11dBu, 10Vpk = 7.07/+19.5dBu, 20Vpk = 14.14/+25.5dBu




*CED 3505B differential I/O, block diagram*

## Software compatibility with previous versions

Version 4 of the CED 3505 has additional main attenuation settings compared with previous versions. Software using the USB should interrogate the attenuator version number before issuing commands that are new or changed in CED 3505 V4.

The parallel input now uses bits 5 – 0 as attenuation control and bit 6 as a mute. Software that controlled previous versions via the parallel input will need minor alterations to accommodate these changes.

See page 32 for details of firmware revisions to CED 3505 issues B and C.

## Attenuation settings via parallel control

The parallel control has 6 attenuation control bits and a mute control. The attenuation value is given as follows:

L = user value of bits (2..0)

M = user value of bits (5..3)

LS = factory installed LS step size in dB

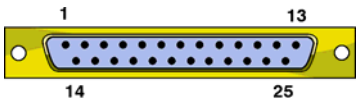
MS = factory installed MS step size in dB

Attenuation = M * MS + L * LS dB

The first stage of attenuation is controlled by data bits 5..3, and the second stage by data bits 2..0. The mute is controlled by data bit 6. When input bit 6 is a 1, the attenuator is muted; when it is a 0, the attenuator is unmuted.

## Parallel control connections

### 25-way D-plug




| Pin | Signal | Function |
|---|---|---|
| 18 | Digital input bit 6 | Mute |
| 6 | Digital input bit 5 | 1st stage, bit 2 (m.s.b.) |
| 19 | Digital input bit 4 | 1st stage, bit 1 |
| 7 | Digital input bit 3 | 1st stage, bit 0 (l.s.b.) |
| 20 | Digital input bit 2 | 2nd stage, bit 2 (m.s.b.) |
| 8 | Digital input bit 1 | 2nd stage, bit 1 |
| 21 | Digital input bit 0 | 2nd stage, bit 0 (l.s.b.) |
| 13 | Ground | |
| Shell | Cable screen | |

The diagram shows the rear-panel parallel control connector, a 25-way D-plug, as seen by the user.

## The MX command

The MX command is aimed at target applications where consistent, fast (sub-millisecond) attenuation switching between two pre-computed attenuation values is required. This version of the MX command was introduced in firmware version 11 of the CED3505 Programmable Attenuator. It supersedes the description dated 18/06/19 of the features and MX operation in the version 8 firmware.

## Action

When invoked, the MX command re-assigns the mute signal on the rear-panel D-connector to choosing between two attenuation values. These are pre-loaded using the MX command. Rear-panel switch 2 selects whether the two attenuations are to be applied to the headphone attenuators (0 – 25dB), or the main attenuator (full attenuation range). Note that, for headphone attenuation, the CED3505 must be a model fitted with the headphone output option (CED3505HP).

If the MX attenuation is configured for the main attenuator, the full range of headphone attenuator commands remains available. If MX is set for the headphone attenuators, both L and R phones receive the same MX attenuation, but the main attenuator can be used to apply additional attenuation from 0dB to the maximum fitted in that 3505 unit. As in non-MX operation, rear-panel switch 1 determines whether this is supplied via USB dB values or by 6-bit encoded values delivered directly via bits 5:0 of the rear-panel digital input.

## MX command usage

MXn1;MXn2 preset the required attenuations n1 and n2 (in dB)

MXn subsequent values of n (up to next MXX) replace previous MX values (see MXA)

MXX Initialise the MX command variables and/or revert to standard mute operation

MXG Trigger a new attenuation choice without waiting for a mute signal line change

MXA Set alternation of storage destination (n1,n2) when sending further MX values rather than continually overwriting n2 value. Original condition is reset by power cycling or by operation of the rear-panel push button.

### The mute bit

Rear-panel bit 6, the re-purposed mute bit, selects the first MX value (n1) when it is low (0), and the second value (n2) when it is high (1). First or second value is selected as soon as bit 6 changes, and is independent of the attenuation data on rear-panel input bits 5:0.

### Muting through rear-panel input

During MX operation, the rear-panel mute bit is used to select attenuation. The main attenuator can still be muted, by presenting the value 0x3F (all 6 bits high) on the data pins as the "infinity" attenuation code. This operation is independent of the state of switch 1 (USB or rear-panel data input), since the data input is configured as wired-OR. The main attenuator feeds the headphone output amplifier, hence muting the main attenuator mutes both the BNC output and the headphone output.

### Headphone-specific commands

Under MX operation, the HS headphone selection and HM headphone muting set of commands will work normally on the headphone output, independently of whether MX is using the main attenuator or the headphone attenuator. If MX is set to operate on the main attenuator, the HA command will work as normal to set static individual headphone attenuations.

### Rear-panel switch settings

| Switch 1 2 3 4 | Attenuation control | MX operation | MX range | Comment |
|---|---|---|---|---|
| L L x x | dB values via USB | Headphone amps | 0–25 dB | |
| L H x x | dB values via USB | Main attenuator | 0–full range | |
| H L x x | 6-bit rear-panel input | Headphone amps | 0–25 dB | |
| H H x x | 6-bit rear-panel input | No effect | No effect | See note 5, below |

The rear-panel switch is as seen from the rear of the 3505 unit. H represents the switch lever in the up (high) position, L represents the lever in the low (down) position. Switch positions 3 & 4 are shown as x x, since this manual does not describe any separate function they may have.

## General notes

1) The 3505 reads its switch settings only on a re-start after power-up or by operation of the push-button accessible through a hole in the rear-panel. Changing the switches at other times is harmless, but new settings will not be acted upon until a re-start.
2) The rear-panel digital inputs (and mute bit) are routed through optoisolators. Achieving a logic 1 requires about 5mA of current to be sourced at the high level (3 – 5V) to drive the optoisolators LEDs. The open-circuit (unplugged) state always reads as a logic 0.
3) If USB control of the main attenuator values is required without interference from the rear-panel 6-bit input, either the rear data input should not be connected, or the rear panel input data must be all zeroes. This applies only to the data input bits 5:0 and not to bit 6, which is the mute or MX data selection bit.
4) Use of the MX command when set to target the headphone attenuators will override any inter-headphone balancing attenuation (using HA commands) that may have been set up.
5) The MX command ignores MX data if the switches are set HH, since MX would operate on the main attenuator yet receive its attenuation values via the rear panel input. If required, supply the changing attenuation values as bit patterns via the rear panel input.

## Programming example

The CED 3505 V4 parallel interface connects to the **low byte** of a CED 1401 digital output. When using CED *Spike2* or CED *Signal* software, the CED 3505 is conveniently controlled using the digital sequencer's `DIGLOW` instructions:

### Parallel control from CED *Spike2* and *Signal* software

| | | |
|---|---|---|
| `LABEL:` | `DIGLOW [.1.....]` | set mute bit without changing the attenuation |
| | `DIGLOW [..xxxxxx]` | leave mute bit set and load new attenuation data xxxxxx |
| | `DIGLOW [.0.....]` | clear mute bit and activate new attenuation setting |

### Control via a virtual serial port

As an alternative to using the parallel control input, the CED 3505 Version 4 can be controlled via ASCII command strings sent to a USB virtual COM port (9600 baud, 1 stop bit, no parity). It will function correctly on USB 2.0 as well as USB 1.0 ports, but it is not recommended that the CED 3505 be connected to a USB 2.0 hub along with other devices that require USB 2.0 high-speed operation. Depending on the operating system in use, a driver may be needed to implement the computer end of the virtual COM port. You should select the driver appropriate for your operating system from the FT232BM VP drivers available on the FTDI website: www.ftdichip.com.

### Hot plugging

Connecting a USB cable from a powered-up computer to a powered-up CED 3505 enables the USB virtual serial port. Parallel port control operation remains active, but the USB commands have no knowledge of any attenuations set by the parallel port.

The CED 3505 has an option to set XON/XOFF flow control protocol for the virtual serial port.

## Serial control instructions

A set of simple ASCII commands is used to control and interrogate the CED 3505. The general format of a command takes one of two forms: a set form and a query form. The query form begins with a question mark. The command itself consists of two alphabetic characters followed (where appropriate) by alphanumeric arguments. A command is terminated either by a semicolon or a <cr> (carriage return) character.

| | | | |
|---|---|---|---|
| Set form: | XYn; | or | XYn<cr> |
| Query form: | ?XY; | or | ?XY<cr> |
| Response: | mm<cr> | or | mm<cr><lf> |

where XY is the command, n is one or more concatenated arguments and mm is the response appropriate to the query form of the command. Some commands take an argument n in the query form.

## The EC command

The `EC` command controls whether the received characters are echoed back to the controlling computer and also whether <lf> (line feed) is appended to the <cr> that terminates returned values.

## Numeric quantities

The CED 3505 handles numeric quantities as unsigned decimal integers by default, but this may be changed to be hexadecimal by the use of the `OP01` command. The `FF`, `SN`, `HA` and `MX` commands do not accept hex values.

## Errors

An invalid or malformed command will generate an error and set the front panel LED red. The error is stored by the CED 3505 until an `?ER`; command is received, when the error code will be reported and the LED returned to green. Only one level of error is stored, so new errors will be lost if a previous error has not been interrogated.

## Serial command list for CED 3505 version 4

| Format | Description |
|---|---|
| ATn;<br>ATn.m; | Set attenuation |
| ?AT; n.m | Read attenuation<br><br>Sets or reads the attenuation value in positive values of dB. The parameter *n* is an integer number in the range 0 to the installed maximum, and is optionally followed by a decimal point and a single decimal digit *m*. The attenuation value will be rounded down (less attenuation) to the nearest multiple of the least significant CED 3505 attenuation step<br><br>The query form returns in dB the last attenuation actually used (which may be a rounded or limited value), independent of whether the output is currently muted<br><br>The set form of the AT command (also the PO command) generates a pulse at the pulse output BNC connector. If the attenuator output is muted when the AT command is issued, the new attenuation is set but the output remains muted; the pulse is generated on un-muting to show that a new attenuation value is in operation. The pulse is not available on CED3505HP models |
| ?AS; ms<br>ls<br>mn<br>ln | Read attenuation step sizes and number of steps<br><br>Reads the attenuation step sizes in dB and numbers of steps for this unit<br><br>The order in which the values are returned is: MS step size, LS step size, MS number of steps, LS number of steps. The LS step size may be returned as n.m if it is non-integral |

| | |
|---|---|
| ASv; | The set form of the command allows the attenuation step sizes and numbers of steps to be set and stored in CED 3505 EEPROM during manufacture. Once these are set, the AS command cannot change them, and attempts to use the set form will give an error. The order of setting is the same as for ?AS, but note that only in this setting form of the AS command the ls step must be sent as an integer 10 times the actual size |
| MUn;<br><br>?MU; n | Mute the output<br><br>Read the mute state<br><br>MU1 mutes the output; MU0 unmutes. Query form returns n as 1 (muted) or 0 (unmuted) |
| HSn;<br><br><br><br><br><br><br>?HS; n | Select headphone for calibrating or muting (CED 3505HP only)<br><br>HS0 deselect both headphones<br><br>HS1 select left headphone and deselect right headphone<br><br>HS2 select right headphone and deselect left headphone<br><br>HS3 select both headphones<br><br>Read back the last legal setting |

| | |
|---|---|
| HAn.m; | Set the calibration attenuators on one or both headphone (as selected by HS) in range 0.0 to 24.9 dB. The hardware resolution is approximately 0.4 dB, and the requested value will be rounded to the next greater available attenuation |
| ?HA; nl nr | Read back the actual attenuations in dB currently set. Two values (L and R channels) are returned in the form xx.x, independent of HS selection |
| HMn; | Set or clear the mutes on selected headphones (CED 3505HP only)<br>HM0 clear all headphone mutes<br>HM1 set individual headphone mute<br>HM2 clear individual headphone mute<br>HM3 set global headphone mute<br>HM4 clear global headphone mute |
| ?HM; n | Read back the mute state. Set if muted<br>Bit 0 L<br>Bit 1 R<br>Bit 2 global mute<br>The global mute is designed to be used for dynamic control of headphone output. The individual L and R mutes are meant to be used when setting up test paradigms and may cause audible clicks in the output during switching |

| | |
|---|---|
| MXn1;<br>MXn2;<br><br>?MX; n | Preset the required attenuations n1 and n2 (in dB). By default, subsequent MXn commands overwrite n2 (see MXA)<br><br>Read back whether MX command inactive (0) or active (1) |
| MXn;<br><br><br>?MXV; n,n | Subsequent values of n (up to next MXX) replace previous MX values (see MXA)<br><br>Read back last attenuations sent to n1 & n2 |
| MXX; | Initialise the MX command variables and/or revert to standard mute operation |
| MXG; | Trigger a new attenuation choice without waiting for a mute signal line change |
| MXA; | Set alternation of storage destination (n1,n2) when sending further MX values rather than continually overwriting n2 value. Original condition is reset by power cycling or by operation of the rear-panel push button |

| | |
|---|---|
| PO; | Pulse the output BNC connector. This command has no effect in the CED 3505HP or 3505B version. The 2 microsecond pulse will have the polarity set by the option command. Examples of use of this command could be to trigger an averager, use as a test pulse generator, or for checking the time it takes to send serial commands from a script to the CED 3505 |
| ?ER; n | Interrogate error status<br><br>Returns a string in the format *xyz*, where *xy* is the command that generated the error and *z* is the error logged. Interrogating the error status clears any error logged. If no error has been logged since this command was last called, the command will return 000. Once an error has been logged, any further errors that occur will not be logged, so the error status should be checked on a regular basis to ensure errors are not missed<br><br>If the first two characters in the command string did not match a valid command, an 'Unknown Command' error will be logged and *z* will be set to 'U'<br><br>If there were no alphabetic characters at the start of the string, *xy* will be returned as '--', or 'X-' if there was a single alphabetic character.<br><br>If the format of a parameter in a command sent to the CED 3505 was not valid, or there was a parameter supplied unexpectedly with a query form, an 'Illegal Parameter' error will be logged and *z* will be set to 'I' |

| | |
|---|---|
| ?FF; n<br><br>FFv; | Interrogate the analogue filter frequency. n is returned in kHz, or as 0 if no filter fitted<br><br>The set form of the command allows the filter frequency to be set and stored in CED 3505 EEPROM during manufacture. Once a frequency v is set, the FF command cannot change it, and attempts to set it will give an error |
| ECn;<br><br>?EC; n | Echo Character and Line Feed control<br><br>Allows the user to select whether characters received by the unit are echoed to the PC<br><br>n = 0 (default) no echo, no LF appended;<br>n = 1 echo all characters received;<br>n = 2 append LF to CR;<br>n = 3 echo characters and append LF |
| SCn;<br><br>?SC; c | Synchronizing Character<br><br>The synchronizing character defaults to <cr> on reset and can be altered by writing the numerical ASCII value n of any character c. If the synchronizing character is not <cr>, the query form of this command returns the single synchronizing character followed by <cr> |

| | |
|---|---|
| ?SN; n | Read Serial Number<br><br>Returns a string in the format 'PA*xyyy*'. It represents the serial number of the unit, where *x* is the major hardware revision, a decimal integer in the range 1–9, and *yyy* is the serial number of the unit, a decimal integer in the range 001–999 |
| SNssss | The set form of the command allows the serial number string to be set and stored in CED 3505 EEPROM during manufacture. Once a serial number is set, the SN command cannot change it, and attempts to set it will give an error |
| ?VS;<br><br>?VSb; | Read software version<br><br>Dump memory bank b (debug only)<br><br>?VS; returns a string in the form 00 representing the current revision of the microprocessor firmware in the CED 3505<br><br>?VSb; (b in range 0 to 3) dumps memory bank b and I/O ports as hexadecimal bytes |
| ?SW; | Read Switch Value<br><br>Returns the setting of the rear-panel DIP switch in the range 0–15 or 00–0F |

| | |
|---|---|
| OPnv;<br><br>?OPn; v | Option set / read<br><br>n in range 0–7, v is 0 or 1. The options are stored in EEPROM inside the CED 3505, so need to be set only once according to the user's requirements<br><br>n = 0 v = 0 (default) set decimal i/o<br>v = 1 set hexadecimal i/o<br><br>n = 1 v = 0 (default) BNC output pulse low-going<br>v = 1 pulse high-going<br><br>n = 2 v = 0 (default) no serial line flow control<br>v = 1 use XON/XOFF<br><br>Other values of n are reserved and may have unpredictable results if used |

| | |
|---|---|
| SUxx;<br><br>SU00;<br><br>?SU; | Set / clear / read start-up string<br><br>The CED 3505 can store a string of commands to be interpreted on start-up, as though they had been sent from the serial line. This allows the unit to be programmed via a serial line and then used stand-alone, i.e. without the serial line connected. The start-up string can contain up to 32 characters. Care must be taken only to use commands in the start-up string that are appropriate for stand-alone use, as the string is not checked for sense<br><br>**The non-volatile memory in the CED 3505 can be written only a finite number of times before its long-term storage ability is impaired. Although this number is large (>1000 string stores), the SU command should be used sparingly**<br><br>In order to avoid the CED 3505 interpreting the characters during the setting up of the start-up string, the SUxx command requires the character values to be sent one at a time as the hexadecimal value of the character. Only two-digit character values for xx in the hexadecimal range 20 (Space) to 7E ("~") are accepted. A delay of about 100 ms is needed after each character loaded to allow time for the EEPROM write and recovery<br><br>The query form of the command echoes the stored start-up string to the computer in its ASCII stored form<br><br>The command `SU00;` is a special case that has the effect of zeroing the stored string. Used on its own, it restores the CED 3505 to the state before a startup string was loaded |

Note the use of rear-panel switch 1 to disable microprocessor control of the attenuator and mute. The purpose of this is to allow parallel port control of the CED 3505 even though a start-up string may have been previously entered to set initial attenuations and mute condition

Example of the SU command usage: a *Spike2* script to load a start-up string that sets the CED 3505 to mute on start-up

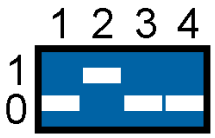
```
var sus$;

..

'set up serial port etc

..

sus$:=”MU1;”;
'required start-up string

SetStartupString(sus$);

..

..

Func SetStartupString%(sus$)

var t$,i%,ch$,v%;

if len(sus$)>32 then

     message("Requested start-up
     string too long");

     return;


endif;
```

```
serialwrite(port%,”SU00;”);
'zero the stored string
yield(.1);
'allow time for EEPROM write

for i%:=1 to len(sus$) do

     ch$:=mid$(sus$,i%,1);
'get next char from string

     v%:=asc(ch$);
'form numerical value of char

     t$:=print$("su%02x;",v%);
'form command with hex value

     serialwrite(port%,t$);
'send to CED 3505

     yield(.1);
'allow time for EEPROM write

next;

return;

end;
```

## Rear panel switch pack

The pattern set on this switch pack is sampled only on powering up the CED 3505 attenuator.

**4-way piano-key switch**




| Switch | Function |
|---|---|
| 1 | 0 = normal;<br>1 = disable microprocessor control of attenuation and mute settings |
| 2 | During MX operation:<br>0 = select attenuations to headphone attenuators;<br>1 = select attenuations to main attenuator |
| 3 | Reserved |
| 4 | Reserved |

## Power connector

The rear-panel power inlet connector is a 5-pin DIN socket.

**5-way 180° DIN socket**


| Pin | Usage |
|---|---|
| 1 | No connection |
| 2 | 0 V |
| 3 | No connection |
| 4 | – 15 V |
| 5 | + 15 V |
| Shell | Chassis earth |

## CED 3505 safety information and cleaning instructions

- Use only the power supply furnished by CED with the CED 3505 Version 4.
- There is no power switch on the CED 3505. To remove power from the unit, disconnect the mains to the power supply.
- Operate the CED 3505 in conditions of non-condensing humidity at an ambient temperature below 50 ºC.
- The CED 3505 case is not resistant to the ingress of water or other fluids.
- There are no user serviceable parts inside the CED 3505 case.
- The CED 3505 is suitable for continuous use.
- Clean only with a dry cloth when required.
- DO NOT immerse in water or any other chemical solution.

## CED 3505 environmental considerations


The case and components within the CED 3505 are recyclable. Please consult the manufacturer for details when required.

The CED 3505 is lead-free and conforms to the EU RoHS directive.

## Exchanging the PIC microprocessor

The PIC microprocessor is a socket-mounted device, so it can be exchanged in the field if necessary. This might be done to implement a firmware upgrade, or to replace a damaged part. In either case it is preferable to return the unit to CED, but if that is impractical, the PIC can be exchanged as detailed below.

The 3505 Attenuator circuit board is mounted in an inner can enclosed in an outer case. In order to access the circuit board to replace the processor, you have to slide the inner can out of the outer case, and then take the lid off the can.

You will need the conductive tube containing the replacement microprocessor, and two screwdrivers: a Posidriv #1 cross-headed and a small flat-blade.

**Take precautions against electrostatic discharge. Earth yourself to the 3505 with a conductive wrist strap, and earth the 3505 to mains earth.**

1. Remove power and all cables from the 3505.
2. There are small black screws on either side of the rear panel of the outer case. Undo these two screws using the cross-headed screwdriver.
3. Push firmly on the BNC connectors at the front of the 3505, so that the inner can slides out backwards by a couple of centimetres & dislodges the back panel. You will now see that the inner can is restrained by an earthing strap of green & yellow wire, attached by a small screw.
4. Undo the screw and lock-washer from the inner can. Make a note of the order of these fixings, since it is important to replace them the same way (see also Step 11 below). Slide the bright-metal inner can fully out of the black outer case.
5. Remove the lid of the inner can. There are four screws near the corners of the can that hold the lid to the base, clamping the circuit board. These screws have built-in shakeproof washers (‘combo’ screws). Undo the screws and lift off the lid. You may need to start by prying the lid up, twisting a small flat-bladed screwdriver under the can lid where the mounting lugs protrude from the sides.

6. With the lid removed, place the 3505 with its front panel nearest you. Find the PIC microprocessor: it is in a 28-pin socket about half way back and to the left of centre.
7. Be sure to have an earth strap on your wrist during steps 8 – 10.
8. Carefully insert the tip of the small flat-bladed screwdriver under each end of the microprocessor chip in turn, making certain the blade is between the body of the chip and the top face of the socket. Twist the screwdriver gently to pry the chip out of its socket, doing this at each end of the socket in turn until the chip is free. Lift the chip out and place it on an earthed surface, but touch your hand to the earthed surface before the legs of the chip touch it.
9. Swap the microprocessor chip with the new part supplied in this upgrade. Place the chip so that the pin 1 end (arrowed) is towards the front of the 3505. Check that the chip is correctly aligned with the socket and that no pins are hanging over the socket ends. Apply pressure to the new chip to locate it securely in the socket.
10. Place the old microprocessor chip in the conductive tube that held the new chip, again ensuring that your hand touches the tube before the chip does.
11. Reassembly is the reverse of disassembly. Take care to replace the star washers correctly: the screws holding the inner case lid have star washers between the screw heads and the lid (these are specials that cannot be separated); the earth bonding strap has a star washer between the ring tag and the case (not under the screw head); the rear panel has star washers under the screw heads.
12. Apply power and the USB cable to the 3505. Use a serial line terminal program to check that the replacement microprocessor is working. Sending the command ?VS should return a number such as 08, indicating the version of the new microprocessor firmware

# Index

## Firmware revisions

Summary of 3505 firmware revisions (PCB issue B onwards)

V04 03/02/10 Major upgrade for B issue fibreglass:

The attenuator muxes now have 3 address bits each. MS and LS steps and sizes in EEPROM

LS step size can be of the form a.b, where b is a single decimal digit

Digital input bit compatibility now 5-0 = attenuations, 6 = mute

Headphone amp can be present instead of pulse output; further controls:

HS/HA commands - control individual X9C303 log-law attenuators on each headphone channel

HM command - individual and global headphone mutes with state readback

Updating the attenuator while muted on iss B delays BNC pulse until un-muting

V07 02/11/16 Un-mute headphones if digital I/O usage switch bit (no USB) set on power up

V08 13/06/19 New command MX to change the function of the mute bit (bit 6) of the parallel input. When the command is sent, it switches the function of bit 6 from being the mute bit to select 1 of 2 values for the HP attenuation

V11 15/01/24 DIPswitch 2 (sw bit 1): 0 = set MX operation to act on headphone amps, 1 = on main attenuator; DIPswitch bits 1,0 treated as a pair, but with no MX values processed if switches 1 and 2 are both 1 (see page 19 for V11 MX operation)

To minimise change time after a mute bit change, MX_val0/1 now store the decoded attenuations: the new 6-bit value for the main attenuator or the X9C303 positions for HP attenuators.

New MX command option MXG sets a flag that the idle loop tests; if set, the loop clears it and loads the relevant MX value into whichever attenuator the mute bit specifies. This forces the atten value to be used immediately rather than waiting until the mute bit changes.

New MX command option MXA to set a flag that makes MXvalue calls after the first two update both MX args sequentially. Flag cleared by reset. This method retains compatibility with V8.

V12 14/06/24 MX command expanded to have additional returned values: ?MXV returns the two stored dB attenuation values used in the MX command operation.

CE

# EC Declaration of Conformity

This is to certify that the:

## CED 3505

Manufactured by:

Cambridge Electronic Design Limited
Science Park, Milton Road, Cambridge CB4 0FE, UK
Tel (+44) 01223 420186

Conforms with the protection requirements of Council Directive 2004/108/EC,
relating to Electromagnetic Compatibility,
by the application of the following EMC standards:

**Conducted and radiated emissions:**

| | | |
|---|---|---|
| EN55022 (1987) Class B | - | COMPLIES |
| Vfg1046/1984 | - | COMPLIES |
| FCC CFR47 Part 15 Subpart J Class A | - | COMPLIES |

**EN50082-1:1991 Immunity standards:**

| | | |
|---|---|---|
| EN50082-1 (Generic immunity) | - | PASS |
| EIC801-2 (Electrostatic discharge) | - | PASS (8kV) Criterion A |
| EIC801-3 (RF field immunity) | - | PASS (3V/m) Criterion B |
| EIC801-4 (Electrical fast transients) | - | PASS (2kV - Heavy industrial) Criterion A |

Signature 

Peter Rice
Technical Director

Date 20 July 2009