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Introductory Information

GPT Designs is an Australian based electronic manufacturer specialising in Induction Loop Systems for the hearing impaired. GPT Designs has been manufacturing induction loop systems for over 10 years and have developed a product range that is world class, founded on the experience of hundreds of real world projects. We are committed to high levels of customer support with engineering advice and design services for the simplest to the most complex of projects.

GPT Designs has designed a complete range of induction loop products called the I-AMP range. The I-AMP range includes:

Induction Loop Power Amplifiers

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPT 20</td>
<td>20 VA Induction Loop Amplifier</td>
<td>Small Area and Counter Loops</td>
</tr>
<tr>
<td>GPT 60-IV</td>
<td>60 VA Induction Loop Amplifier</td>
<td>Meeting Rooms</td>
</tr>
<tr>
<td>GPT 300</td>
<td>300 VA Induction Loop Amplifier</td>
<td>Large Areas</td>
</tr>
</tbody>
</table>

Induction Loop Receivers

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Venue Listener</td>
<td>Induction Loop Receiver</td>
</tr>
<tr>
<td>Venue Assistant</td>
<td>Calibrated Induction Loop Receiver</td>
</tr>
<tr>
<td>Venue Master</td>
<td>Professional Induction Loop Field Strength Meter</td>
</tr>
</tbody>
</table>

Accessories

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>International Induction Loop System Labels</td>
<td>Indicates System Availability</td>
</tr>
<tr>
<td>PH1 90 Quadrature Phase Shifter</td>
<td>Use in low spillage, complex systems</td>
</tr>
<tr>
<td>Flat Cable</td>
<td>For under carpet induction loop installation</td>
</tr>
</tbody>
</table>
Overview of Induction Loop Amplifiers

Induction loop systems transmit a signal to the hearing impaired person via baseband electromagnetic waves. One of the greatest advantages of the induction loop system is the ability for the hearing aid to receive the transmitted signal without the use of a separately supplied receiver headset. This is possible since most hearing aids have an option to switch off the internal microphone and receive sound via an internal telecoil pick-up. The telecoil pick-up was originally designed to pick-up electromagnetic radiation from a telephone hand set speaker but this can also be used to receive signals from any magnetic source such as generated by the induction loop system. Telecoils are now fitted to hearing aids specifically for induction loop transmission systems.

“baseband”: sound is an air vibration or sound pressure wave. A baseband magnetic wave is created if the sound pressure wave is directly proportional to the magnetic field created.

The pick-up area of a loop system is defined by a continuous loop of wire that encloses the area required. A high level baseband audio signal is passed through the induction loop wire creating a magnetic field inside the loop. Since the induction loop defines the pick-up area, the loop can be made to cover different sizes and shapes, in both 2 and 3 dimensions.

Induction loop systems are susceptible to electromagnetic interference from sources such as high current mains wiring, florescent lighting and dimming controllers which produce magnetic fields within the audio spectrum.

Advantages and Disadvantages of induction loop systems:

**Advantages**
- Does not require a specialised receiver to be supplied to each hearing impaired person.
- Listening area can be controlled by the layout of the induction loop.
- System is not interrupted by physical obstacles in the pick-up area.

**Disadvantages**
- Susceptible to interference from mains wiring, florescent lighting and dimming controllers.
- Current required by the loop is dependent on the metallic structure surrounding the pick-up area.
- Some spill over outside the induction loop area.
- Magnetic field strength can vary in the loop area in complex layouts.
What are Induction Loop Amplifiers?

Induction Loop Amplifiers are designed to produce a base band magnetic field within an area covered by a loop of cable, the induction loop. Magnetic fields are generated by current within the induction loop cable. This magnetic field then allows direct transmission to a hearing aid fitted with a T-Coil.

Most hearing aids are fitted with a T-Coil which allows the user to select between the normal microphone pick-ups or the T-Coil. If the T-Coil is selected, the hearing aid user will only hear the signal transmitted over the induction loop.

Induction loop systems are the only hearing impaired augmentation system which does not require headsets to be distributed to the hearing impaired due to this T-Coil function.

Why do we need to have Induction Loop Amplifiers?

Hearing aids are the most common method currently in use for the augmentation of sound to an individual. These hearing aids detect the sound via a microphone in close proximity to the hearing aid user, amplify the signal then re-transmits to the ear using an internal speaker. This arrangement can lead to the following problems, all caused by the acoustic transmission path:

Limited volume or loudness can be obtained at the hearing aid due to acoustic feedback. This is heard as squealing of the hearing aid speaker.

The Omni-directional characteristics of the hearing aid microphone cause unwanted sounds to be mixed with the desired sounds. Internal room reverberation compounds this problem. The signal to noise ratio in the acoustic transmission path can be very low in some environments.

Induction Loop Amplifiers provide a method of overcoming many of these shortcomings of hearing aids when used with the internal microphone.

How do they Work?

The induction loop power amplifier is a specialized amplifier that is designed to supply a variable current into the induction loop for a variable input voltage signal. This means that the induction loop power amplifier is not like a conventional speaker power amplifier which outputs a given voltage for a given input voltage (a voltage amplifier). Since an induction loop power amplifier has input voltage and output current it is termed a “transconductance” amplifier. An interesting characteristic of a current output is that the output voltage will vary dependent on the load impedance, but the current output will remain constant, independent of the load.

The I-AMP range of induction loop power amplifiers feature a number of internal signal processing functions. These include fast limiters to limit the maximum output current and protect the output electronics.
from damage, and compressors which reduce the dynamic range of the input program, increasing the clarity for many hearing impaired.

A compressor is used to reduce an audio signal’s dynamic range. The dynamic range is determined by the following equation:

\[
\text{Dynamic range} = \frac{\text{Loudest Sound}}{\text{Quietest Sound}}
\]

Typically humans can detect (hear) sound over a 140dB dynamic range. Most electronic equipment cannot directly process this dynamic range without running into the electronic “noise floor” of the electronics itself. Typically electronic systems can produce around 90dB dynamic range. Even this reduced dynamic range can cause problems with the hearing impaired and should be reduced to 45dB or less. This can be achieved with a 2:1 compression ratio dynamics processor.

Planning the installation - Locating Induction Loops.

Perimeter Loops:
Generally simple perimeter induction loop systems require the routing of the induction loop cable around the outside of the required pick-up area. This area can be rectangular, square, or circular. The closer two sides are, in a rectangular layout, the lower the induction loop power amplifier drive current required.

The induction loop may be placed at floor level or above. The loop may be routed around small obstacles in the pick-up area (such as doors and window, etc.) without significant changes to the generated magnetic field.

Figure-8 Loops:
The induction loop coverage area may be extended with the use of “Figure-8” cable layout. This arrangement effectively increases the area that a single induction loop power amplifier can cover by a factor of 2. Note that the length of the induction loop cable will increase and the induction loop cable cross sectional area may need to be increased to allow for a maximum DC loop resistance of 1.8Ω.
Double Loops:
Some installations require the use of a double loop cable on the output. The double loop is easily implemented with standard figure-8 cables. The double loop increases the field strength for a given output current by 12dB, however the frequency response can suffer. This configuration also allows for increasing the overall loop resistance (for small loops) or reducing the current requirement by a factor of 4. Note also that the length of the induction loop cable will increase and the induction loop cable cross sectional area may need to be increased to allow for a maximum DC loop resistance of 1.8Ω.

Metal Loss:
The Induction loop cable does not present a constant load at all frequencies of interest. The impedance of the cable increases with frequency. This will not cause any problems for an induction loop amplifier since it will automatically increase the output voltage, at high frequencies, to compensate and produce the required current at all frequencies, independent of cable loading. However, the magnetic field generated in the loop will not only be dependant on the loop current, but the structure surrounding the loop. Metallic structures create greater loading of the magnetic field at high frequencies. This can be compensated by increasing the high frequency levels input to the induction loop power amplifier with a graphic equalizer or other filter.
The Venue Master field strength meter (part of the I-AMP range of products) has been designed to allow full frequency response measurement of an induction loop system, allowing compensation of metal loss.

**SELECTION OF THE INDUCTION LOOP CABLE**

The selection of the Induction loop cable is based on a minimum required induction loop resistance at DC of 0 Ohms and a maximum of 1.8 Ohms. The following guide indicates typical wire gauges and their associated DC resistance:

<table>
<thead>
<tr>
<th>Typical Conductor Stranding</th>
<th>Cross-sectional Area</th>
<th>Approximate Ohms per 100m</th>
<th>Approximate Ohms per meter</th>
<th>Cable Current Rating Guide</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 Strands of 0.2mm ø</td>
<td>0.44 mm²</td>
<td>4.2</td>
<td>0.042</td>
<td>3</td>
</tr>
<tr>
<td>20 Strands of 0.18mm ø</td>
<td>0.51 mm²</td>
<td>3.3</td>
<td>0.033</td>
<td>4</td>
</tr>
<tr>
<td>24 Strands of 0.2mm ø</td>
<td>0.75 mm²</td>
<td>2.1</td>
<td>0.021</td>
<td>5</td>
</tr>
<tr>
<td>32 Strands of 0.2mm ø</td>
<td>1.00 mm²</td>
<td>1.85</td>
<td>0.0185</td>
<td>6</td>
</tr>
<tr>
<td>30 Strands of 0.25mm ø</td>
<td>1.50 mm²</td>
<td>1.14</td>
<td>0.0114</td>
<td>9</td>
</tr>
<tr>
<td>40 Strands of 0.25mm ø</td>
<td>2.00 mm²</td>
<td>0.83</td>
<td>0.0083</td>
<td>11</td>
</tr>
<tr>
<td>50 Strands of 0.25mm ø</td>
<td>2.50 mm²</td>
<td>0.65</td>
<td>0.0065</td>
<td>15</td>
</tr>
</tbody>
</table>

Cable Selection Step 1: Calculate the length of the induction loop required to cover the pick-up area selected. Allow for the connection to and from the GPT 60-IV.

**INDUCTION LOOP AMPLIFIER**

**EXAMPLE LOOP LENGTH = (2 X 12M) + (2 X 25M) + CONNECTION TO EQUIPMENT RACK (10M)
= 84 METRES**

Cable Selection Step 2: Multiply the loop length by each of the ohms/per meter values shown in the table above. Select the cable that gives a total loop resistance between 0 and 1.8 Ohms.
The above example would give:

- Cable Type 1, 1.00 mm² = 84 x 0.0185 = 1.55 Ohms
- Cable Type 2, 0.75 mm² = 84 x 0.021 = 1.76 Ohms
- Cable Type 3, 0.51 mm² = 84 x 0.033 = 2.77 Ohms
- Cable Type 1 or Type 2 could be selected since the induction loop resistance is between 0 Ohms and 1.8 Ohms.

Some installations require the use of a double loop cable on the output. The double loop is easily implemented with standard figure-8 cables. The double loop increases the field strength for a given output current by 12dB, however the frequency response can suffer. This configuration also allows for increasing the overall loop resistance (for small loops) or reducing the current requirement by a factor of 4.

**SETTING THE LOOP OUTPUT CURRENT**

The easiest way of setting the loop current is with the “Venue Master” Induction Loop field strength meter. The recommended field strength, based on Australian Standard 60188.4, “Magnetic Field Strength in Audio-Frequency Induction Loops for Hearing Aid Purposes”, is 0.1 AMP/Meter average with short term peaks up to 0.4 Amps/meter.

A field strength meter can also be used to determine the background noise levels that exist in the pick-up area. Some sources of magnetic noise can be air-conditioning equipment, lighting and lighting dimming systems.

Often the differing installation requirements make all but the simplest induction loop configurations difficult to calculate. Testing in the pick-up area may be required before a full installation of the induction loop.

A quick estimate of the current requirement can be made by considering the requirements for a square induction loop pick-up area.

\[
\text{Average current requirement (AMPS)} \approx \frac{\text{Length of one side of a square pick-up area}}{10}
\]

Audio signals have a wide dynamic range and the peak current requirement can be significantly higher than average. Typically this figure can be taken as around 4 times or 12dB, however this will vary with the input program material. The output current meter on the GPT 60-IV indicates the peak output current of the
amplifier. With the internal 2:1 compressor the typical dynamic range will be reduced, reducing the peak current requirements.

\[
\text{Peak current requirement (AMPS)} \approx \frac{\text{Length of one side of a square pick-up area}}{2.5}
\]

This can be used as a guide to the installation requirements, however the field strength meter should be used to set the final current through the induction loop.

**INSTALLATION RECOMMENDATIONS**

The induction loop produces a base-band audio magnetic field in the pick-up area. As such it can **interfere with the operation of dynamic microphones and cause feedback** in the induction loop and any speakers sourced from the same microphone. It is therefore recommended that condensor type microphones be used in the induction loop pick-up area.

Dynamic microphones vary in their effective shielding from base band magnetic fields. This variation also gives rise to a variation in the headroom to feedback of any system using a dynamic microphone in close proximity to the induction loop.

The induction loop may be placed at floor level or above. The loop may be routed around small obstacles in the pick-up area (such as doors and window, etc.) without significant changes to the generated magnetic field.

**Practical Constraints on Induction Loop Systems:**

Not all installations are suitable for induction loop systems.

Induction loop systems should not be used where confidentiality is required unless the listening area is very small. The low spill over systems described below are more concerned with reducing adjacent areas from interfering with each other rather than increasing confidentiality.

High levels of background noise can be costly or impossible to reduce. Shielding or relocation of the offending equipment or cables can be impractical. In these cases one of the other available assisted listening systems should be used. This could include infra red or AM/FM systems.

The noise can be considered too high if the required signal to noise ratio cannot be met. The required signal to noise ratio will depend on the application and should have a minimum value of between 25dB and 45dB. The signal to noise ratio can be further improved by increasing the field strength in the area by increasing the output level of the induction loop power amplifier. Australian Standard AS 60188.4 allows for deviations from the standard value of field intensity in the event of magnetic background noise. Note that this is done
at the risk of overdriving the telecoil pick-ups in some hearing aids, producing distortion in the received signal.

Many installations can be designed to achieve signal to noise ratios of greater than 45dB. Mains wiring is not often a problem over large areas of the induction loop pick-up area since wiring usually constricts the supply and return wires in close proximity to each other, thus limiting the radiated field. However local areas of high noise can be generated due to the splitting of active and neutral in some wiring configurations.

Low spill over systems are required in some theatres and conference rooms. Induction loop systems may be used in these applications with careful design. Complex multi loop systems can be designed which cancel the magnetic field outside the loop areas. These systems are more complicated than the single loop. The GPT PS1, signal splitter drives the loops with different levels and phase relationships providing attenuation rates far better than the single loop arrangement. The design of these systems is beyond the scope of this document.
About your induction loop amplifier

The GPT 60-IV is an Industrial Induction Loop Amplifier designed to drive current into a low impedance wire loop (the induction loop). This current produces a base band electro-magnetic field which can be received by the induction coil pickup in a hearing aid placed within the loop area.

The amplifier features convection cooling (with no associated fan noise) and an internal limiter that prevents the input signal from extending the output to beyond the current capability of the GPT 60-IV. Signal Presence and Current Output is indicated via the 6 level LED meter on the front panel. An internal 2:1 compressor is used to reduce the dynamic range of incoming audio, increasing intelligibility to many hearing impaired.

The intensity and characteristics of the field produced by the current passing through the loop is set by Australian standard AS 60188.4. These standards set the operating field strengths and frequency response and the GPT 60-IV is designed to meet these requirements.

FEATURES

Rear Panel:
- All input and output connections via Phoenix
- Stereo Unbalanced Inputs
- Microphone Input with phantom power
- Input Level Control
- Output for induction loop connection via screw terminals
- Power On/Off switch
- IEC Mains input power connection
- Mains input fuse

Front Panel:
- Indication of output current via 6 level LED meter covering a range of 0dB to -21dB

Other:
- Robust steel 1RU rack mount chassis
- Power On indication
- Output current, into low impedance induction loop, of up to 4.5 Amps Peak
- Input level adjustment range +6dB to -∞
- Nominal input level +4dBu
- Frequency response tailored to Australian Standard AS 60188.4
- Internal 2:1 compressor for dynamics reduction
- Internal fast limiter with typical clamp time of 1ms to protect the amplifier from large input signals
- Large toroidal transformer for low radiation, close to the front panel for easy mounting
- Convection cooled power amplifier with rear facing heatsink

System Block Diagram

The voltage driving output of the GPT 60-IV has been designed to accommodate the higher impedance of the induction loop as the frequency is increased.

The GPT 60-IV is housed in a heavy duty standard 1RU rack mount chassis. The unit is designed to be robust and reliable.

The GPT 60-IV is “Inherently Safe” and is designed to allow continuous operation into a short circuit (0Ω) loop connection. This provides greater reliability and simple loop design.
GPT 60-IV Panel Functions:

INDUCTION LOOP FUNCTIONS:

1. **Line.** Unbalanced L/R level control at normal line level of -10dBv
2. **MIC.** Balanced Microphone level control phantom power -15V
3. **Master level Control.** The input level control provides a method of setting the required output current level into the induction loop. This control provides gain adjust from +6dB to full attenuation. This control affects both the balanced and unbalanced signals which are mixed together so that both may be used simultaneously.

An internal 2:1 compressor is used to reduce the dynamic range of the input audio signals. This has the effect of increasing the intelligibility of normal audio programs to the hearing impaired by making small sounds louder and loud sounds quieter.

The GPT 60-IV incorporates an internal fast limiter to protect against exceeding the amplifier’s maximum output current. This limiter is not used for reducing the dynamic range of the input signal. The input level control is in circuit before the limiter.

4. **Power on Indication LED**
5. **Output Current Meter.** This meter indicates the full range current capability of the GPT 60-IV with the following sensitivities:

<table>
<thead>
<tr>
<th>LED Number</th>
<th>LED Indicator</th>
<th>LED Colour</th>
<th>Output Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0dB</td>
<td>Red</td>
<td>4.5 Amps Peak</td>
</tr>
<tr>
<td>2</td>
<td>-3dB</td>
<td>Orange</td>
<td>3.2 Amps Peak</td>
</tr>
<tr>
<td>3</td>
<td>-9dB</td>
<td>Green</td>
<td>1.6 Amps Peak</td>
</tr>
<tr>
<td>4</td>
<td>-15dB</td>
<td>Green</td>
<td>0.8 Amps Peak</td>
</tr>
<tr>
<td>5</td>
<td>-21dB</td>
<td>Green</td>
<td>0.4 Amps Peak</td>
</tr>
<tr>
<td>6</td>
<td>-40dB</td>
<td>Green</td>
<td>Signal Present</td>
</tr>
</tbody>
</table>
These output current levels are independent of the induction loop load impedance. The maximum output level is internally limited to 4.5 AMPS Peak. This internal limiting is essential on a current amplifier (or more correctly a transconductance amplifier giving a certain current output for a given voltage input), such as the GPT 60-IV, preventing the highly dynamic input signal voltage levels from exceeding the output current rating of the amplifier. This form of protection is not generally required on more conventional voltage power amplifiers since limited power supply voltages prevent overdrive (producing clipping distortion).

Note that the gain of the GPT 60-IV is set to provide full output of 4.5 AMPS Peak for a nominal input of +4dBu (Balanced) (1.23 V RMS or 1.74V 0-pk or 3.47V pk-pk) when the input gain is set to 0dB. Full output is obtained with an input signal of -2dBu when input gain control is set to +6dB.

Note also that full output current is not required for all loop configurations. See, “Setting the Loop Output Current” located on page 10. Saturation distortion in hearing aid pick-up coils and larger external loop magnetic leakage can occur if magnetic field strengths greater than the Australian Standard are generated.

6. **Power On Switch:** Turns mains power on to the GPT 60-IV

7. **Mains Input Power:** Mains input power is 240 VAC @ 50Hz via a standard IEC mains cable (supplied). This connector also houses the main input power fuse. This fuse is a standard M205 type, rated at 1 Amp.

8. **Loop Output:** The induction loop is connected to this 2-pin screw terminal connector. Note that the loop output must be left floating with no output signal connecting to ground potential. Note also that an induction loop load must be connected to the output of the GPT 60-IV for normal operation.

The output connections for the induction loop are:

<table>
<thead>
<tr>
<th>Pin Number</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(+) Current Output</td>
</tr>
<tr>
<td>2</td>
<td>(-) Current Output</td>
</tr>
</tbody>
</table>

The loop requires no minimum DC resistance and a maximum DC resistance of 1.8 Ohms to enable full current output without overheating or high frequency clipping distortion.

The output terminals may be shorted at any time for testing purposes, even when the amplifier is switched on.
The current output from the GPT 60-IV may be monitored with a good, high impedance multimeter from the (-) Current Output terminal to ground. This multimeter should have an adequate frequency response for this measurement, typically around 10kHz. The voltage reading will be proportional to the following:

\[
100\text{mV RMS @ (-) Current Output} = 0.74\text{ AMPS Peak}
\]

9. **Input Connections:** This Phoenix connector allows connection of all inputs:
   - unbalanced L/R connector at a nominal line level of –10dBV.
   - balanced line connection at a nominal line level of +4dBu.
   - microphone connection. Phantom power – 15V