Teleconferencing Audio System Design

Exercises and Mini-Tool Kit

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Teleconferencing Audio System Design
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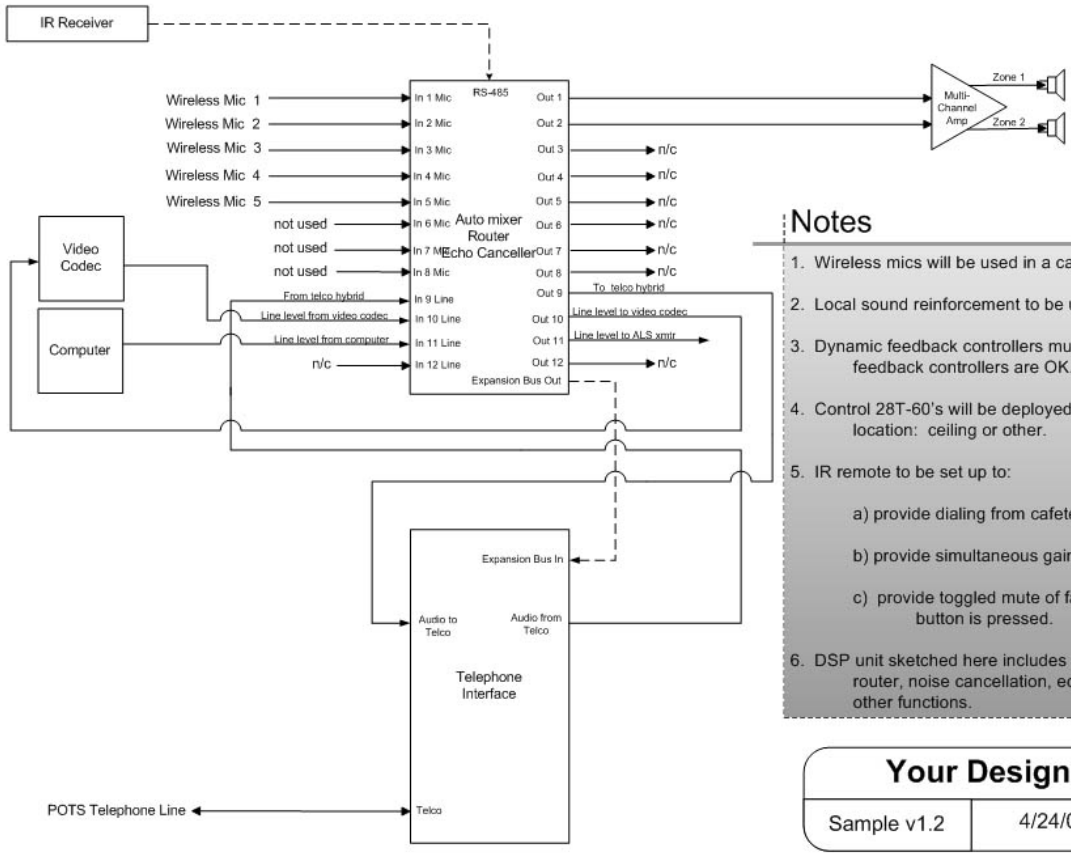
Introduction

Sample System



Notes

1. Wireless mics will be used in a cafeteria seating environment.
2. Local sound reinforcement to be used in cafeteria.
3. Dynamic feedback controllers must be disabled. Static feedback controllers are OK.
4. Control 28T-60's will be deployed. Need to verify location: ceiling or other.
5. IR remote to be set up to:
   a) provide dialing from cafeteria to a conference bridge;
   b) provide simultaneous gain adjust to both output zones;
   c) provide toggled mute of far end audio when "mute" button is pressed.
6. DSP unit sketched here includes auto-mixer, router, noise cancellation, echo cancellation, EQ and other functions.

Your Design Company		
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Basic Tool Kit

Relationships to Memorize

Power

- Twice the power is an increase of 3dB. Sometimes stated as +3dB.
- Half the power is a decrease of 3dB. Sometimes stated as –3dB.

Distance (you may hear this called the "inverse square law")

- Cutting the distance between you and an audio source in half will make the audio sound 6dB louder, i.e., the closer you get, the louder it sounds.
- Doubling the distance between you and an audio source will make the audio source sound 6dB softer, i.e., the further away you get, the lower the audio level you hear.

Perceived loudness

- An increase of 10dB will sound about twice as loud to our ears.
- A decrease of 10dB will sound about half as loud to our ears.

Exercises

You feed 10 watts to a loudspeaker. Then you crank up the volume by 3dB. How much power is now being fed to the speaker?

_____

You are sitting 10 feet away from a loudspeaker putting out a level of 90dBspl. It's too loud. You move to 20 feet away. How loud is it now? _____

How far away do you need to get for the loudspeaker to sound half as loud as it did when you were at 10 feet?
Between_____and _____feet.

You have a 100 watt amplifier. You want an amp that is about twice as loud. About how big will your new amp need to be in watts?_____

A loudspeaker is rated for 90dBspl volume at 1 watt input when measured at 3 feet away. You are 12 feet away from the loudspeaker. How loud in dB will the volume be?_____

You want to hear the volume at a level of 90dBspl when you are 12 feet away. How many watts need to be fed to the speaker to achieve that level?_____

Microphones

Most Common Microphones

Basic types used in teleconferencing

In order of preference:

- Gooseneck —work 3"–12" from mouth
- Tabletop boundary mics —place 18"–22" from front of table
- Wireless lavalier mics— place as close to mouth as possible.
- Hanging ceiling mics—place no more than 7' above floor (3' above seated participants)

Things to consider

- Use unidirectional mics when possible (also called cardioid mics). 130° pattern typical.
- Always get participants as close to mics as possible.
- Know the "3x distance spacing" (10dB spacing) rule for mic placement.
- Know we usually ignore the "3x distance spacing" rule with high end automatic gated mic mixers.
- We recommend one mic for every two people in a teleconferencing application where tabletop boundary mics are used.

Exercises

12 participants around a table. Gooseneck mics are being used. State the ideal number of mics needed: _____

11 participants around a table. Tabletop boundary mics are being used. State the ideal number of mics needed: _____

Loudspeakers

Two main types of systems

Overhead speakers

The most common type of loudspeaker systems to use in a conference room are called "70-volt" or "distributed" systems. Typically these are 4", 6" or 8" in diameter. Used mainly for speech audio. Can run long distances on smaller wires than "direct" systems.

Front mounted speakers

These are speakers similar to those used at home. Called "8-ohm" or "direct" systems. Used mainly for program (music) audio. Need bigger wires to carry more current than distributed systems, therefore used over shorter distances.

Things to consider

- Use overhead speakers for speech audio.
- Use front mounted speakers for program audio.
- Don't try to send speech and program audio to the same speakers. If you make things sound good for speech, it'll sound bad for program audio. And vice-versa. Of course there are exceptions, but following this rule keeps things simple. And sounding good.

Exercises

Given a loudspeaker with a sensitivity of 89dBspl with 1 watt at 3 feet, determine how much power is needed for a volume of 86dBspl at a listener's ears. The listener is seated, with an ear height of 4 feet above the floor. The overhead loudspeaker is mounted in a 10-foot high ceiling. Power needed is _____.

Given a room that has five of these loudspeakers, how big does the power amp need to be to drive all five speakers? At least _____ watts.

Coverage patterns and general info

How many to use in a room?

For teleconferencing the answer is: as few as possible.

To be more specific (talking about overhead [distributed] speakers here)

You must determine the coverage of a loudspeaker at ear height. The pattern is a circle of some diameter.

- The circle is considered at seated ear height of four feet.
- The circle of coverage depends on the angle of the loudspeaker's projection and the height of the ceiling the loudspeaker is mounted to.

After you have determined the coverage of a single speaker, determine how many speakers will be needed to cover the entire conference room.

To consider

- Think about where participants will be seated and aim loudspeakers at those locations. Think of it like shining a flashlight down to light up the tops of participants' heads.
- Place loudspeakers over the conference room participants' seating locations to "light up" those areas.
- Avoid placing loudspeakers directly over a conference table. The hard surface of a conference table reflects loudspeaker audio—not usually a good thing.
- Too much audio energy in a room is a bad thing. So is too little. The guidelines here will get you in the ballpark.
- A rule of thumb is to put enough speakers into a room to keep the volume level within ± 3dB as you move around the seating areas. This can be measured with an SPL meter. It can be estimated using the following information. (See distributed speaker design program).

	Square Array Patterns:	**Hexagonal Array Patterns:**
Edge to edge	+/- 4.4dB	+/- 5.4dB
Partial overlap	+/- 2.0dB	+/- 2.6dB
Center to center	+/- 1.4dB	+/- 1.2dB

How much area can a loudspeaker cover?

Some math

For any loudspeaker the diameter of the coverage pattern is determined as follows:

1. Determine ceiling height.
2. Assume listeners are seated at 4 feet height.
3. Determine distance from loudspeaker to listener: distance = ceiling height –4 feet
4. Determine the loudspeaker's coverage angle—this is printed on the manufacturer's data sheet.
5. Diameter of coverage pattern = 2(distance to ears x tan (coverage angle/2))

An example

A ceiling is 10 feet high, so distance to listener is 10 – 4 = 6 ft. Manufacturer says coverage angle is 90°. Half of that is 45°. The tangent of 45° = 1.

So, the diameter of the loudspeaker's coverage pattern at listener ear height is 2(6x1) = 12 feet diameter.

Exercises

Assume square array. If a loudspeaker's coverage diameter at ear height is 12 feet:

- Determine speaker spacing for edge to edge coverage:_____
- Approximately what dB volume variance will this give?_____
- Determine speaker spacing for center to center coverage:_____
- Approximately what dB volume variance will this give?_____

Resources

A chart showing some typical coverage diameters at 4 feet seated ear height is attached.

How many?

Put the pieces together

You must know

1. The coverage diameter (at ear height) of the loudspeakers being used.
2. The spacing of your choice (edge to edge, center to center, etc.).
3. The room dimensions.

To consider

- Don't "light up" areas of the room where there will be no listeners.
- Avoid placing loudspeakers directly over a conference table.
- Avoid placing loudspeakers too close to a wall. A rule of thumb is to keep speakers at least one-fourth the coverage diameter from the wall. For example, if the coverage pattern is 12 feet diameter, try to keep the loudspeaker at least three feet from the wall.

Exercise

Assume 12 feet is speaker coverage pattern diameter at ear height. Use a square array with edge to edge coverage.

- Determine the maximum number of speakers to use in a conference room that is 18 feet wide by 30 feet long:_____.
- Why might this be the maximum number? Or, why might we choose to not use this many?

  _____

Helpful software

See demo.

Speech Amplifiers

How much power is needed?

Just add up each loudspeaker's needed power:

If you have 10 loudspeakers that need 3 watts each to get the audio loud enough, then you need at least a 30 watt amplifier.

Needed information

- How loud does speech audio need to be at the listeners' ears?
- What is the loudspeaker's sensitivity rating?
- How far away from the listeners' ears are the loudspeakers?
- How many loudspeakers are being driven?

How loud?

Typically a volume about 24dB above ambient room noise is the target. This is loud enough to be heard clearly above room noise.

Exercises:

You measure the room's ambient noise level (check it with HVAC running). It is 60dBAspl. How loud must the audio at the listeners' ears need to be?_____

Assume the loudspeakers in the room are rated at 90dBspl at one meter at one watt. Assume the ceiling is 10 feet high. Assume listeners are all seated. Assume 6 loudspeakers will be used. What is the minimum power rating for the speech amplifier?_____

Final Exercise

Using all the bits and pieces

Given:

- Conference room with 10 foot high ceiling.
- 18 feet wide by 30 feet long.
- Conference table that will seat 4 people on each side and 1 person on each end.
- Ambient noise level in room of 60dBAspl.
- Loudspeaker coverage angle of 110°.
- Loudspeaker sensitivity rating of 89dBspl at 1 meter at 1 watt.
- Edge to edge loudspeaker coverage.
- Square array.

Determine:

- Number of tabletop boundary mics needed:_____
- Number of mic inputs needed on the auto-mic mixer/router/echo canceller box:_____
- Maximum number of speakers needed: _____
- Volume level needed (in dB) at listeners' ears to overcome ambient room noise: _____
- Power level needed for each loudspeaker._____
- Minimum power amplifier rating: _____

The Whole System

A basic equipment list

A complete audio system for simple, effective audio conferencing

- Microphones (you know how to determine the number of mics needed)
- Automatic gated mixer/router/echo canceller unit(s) (various manufacturers)
- Speech power amplifier (you know how to size the amplifier)
- Loudspeakers (you know how to determine the maximum number of speakers)
- Telephone interface (various manufacturers)
- Video codec

Graduation

It's just the beginning

Congratulations

You now have the basic tools to effectively design basic audio systems for successful teleconferencing in small to medium sized conference rooms.

This short course considered the elements needed for true audio conferencing at a basic implementation level. That is, how to get speech audio from one location to another and how to hear speech audio coming from another location. Mastery of the topics developed in this session is the foundation for all teleconferencing systems.

Go forth and design.

Further studies

Other topics to explore on the audio side include:

- Using program audio (CDs, VCRs, cassette players)
- Using local speech reinforcement
- Program loudspeaker considerations
- Program amplifier considerations
- Mix-minus zoning
- PAG (potential acoustic gain) and NAG (needed acoustic gain) calculations
- Acoustic treatment of rooms
- Equalization of speech audio systems
- Equalization of program audio systems
- NC (noise criteria) ratings
- SPL (sound pressure level) measurements
- What dB ratios are about
- The dB references: dBAspl, dBCspl, dBu, dBV
- Divisible room applications
- And more...☺

Microflex® MX300 Series User Guide
Boundary Microphones

GENERAL

Shure Microflex® MX300 Series microphones are surface-mounted electret condenser microphones designed primarily for mounting on conference tables, stage floors, and lecterns. Their high sensitivity and wide frequency range make them especially suitable for picking up speech and vocals in sound reinforcement and recording applications. Interchangeable cartridges provide the installer with greater flexibility and make it possible to easily reconfigure microphone coverage as the need arises. The MX392 and MX393 models include an internal preamplifier.

MX300 Series microphones take advantage of the principle that, at a barrier or boundary, the sound pressure level doubles. When placed near a sufficiently large boundary surface, the microphone has 6 dB higher sensitivity and approximately 3 dB greater direct-to-reverberant sound ratio.

FEATURES

- *Flat frequency response across the vocal range for uncolored sound*
- *Interchangeable cardioid, supercardioid, and omnidirectional cartridges that provide choices for applications*
- *Sleek, low-profile design for unobtrusive appearance*
- *Balanced transformerless output for increased immunity to noise over long cable runs*
- *Low susceptibility to electromagnetic hum and RFI*
- *Programmable on/off switch and LED on/off indicator*
- *Logic input/output terminals for remote control or use with automatic mixers (MX392 models only)*

MODEL VARIATIONS

- **MX392 Models**: Surface-mount microphone; includes a programmable membrane on/off switch, logic input/output terminals, an on/off indicator LED, screw terminal connections, and attached unterminated cable.
- **MX393 Models**: Surface-mount microphone; includes a programmable membrane on/off switch, an on/off indicator LED, and a miniature, four pin connector.

Selecting a Cartridge

All Microflex® microphones are available with any one of three interchangeable cartridges. The polar pattern of the original cartridge used in a particular microphone is indicated by the model number suffix:

C = Cardioid, S = Supercardioid, O= Omnidirectional

Cardioid (C). Recommended for general sound reinforcement applications. Pickup angle (–3 dB) = 130°.

Supercardioid (S). Recommended for sound reinforcement applications requiring narrow or more distant coverage. Pickup angle (–3 dB) = 115°.

Omnidirectional (O). Recommended for recording or remote monitoring applications. Pickup angle (–3 dB) = 360°.

MICROPHONE PLACEMENT

To maintain the flattest possible low-frequency response and optimum rejection of background noise, place the microphone on a flat surface that is as large as possible. The surface can be a floor, table, or lectern.

NOTE: Avoid locating microphones near reflective surfaces other than the boundary surface (i.e., beveled sides of pulpits or overhanging shelves). Failure to do so will result in increased levels of reverberant sound.

MICROPHONE APPLICATION AND SELECTION GUIDE

Application	Mounting Surface	Microphone to Cable Connector	Cable Output Connector	Polar Pattern	Microflex® Model
Sound reinforcement for speech and vocals	Lectern, pulpit, stage floor, or conference table	Hard Wired Hard Wired TA4F TA4F	Hard Wired Hard Wired XLR XLR	Cardioid Supercardioid Cardioid Supercardioid	MX392/C MX392/S MX393/C MX393/S
Recording or remote monitoring of speech and vocals	Lectern, pulpit, stage floor, or conference table	Hard Wired TA4F	Hard Wired XLR	Omnidirectional Omnidirectional	MX392/O MX393/O
Video conferencing or computer telephony	Lecturn, pulpit, stage floor, or conference table	Hardwired	TA4F	Cardioid	MX392/CZ

27E2834 (AH)

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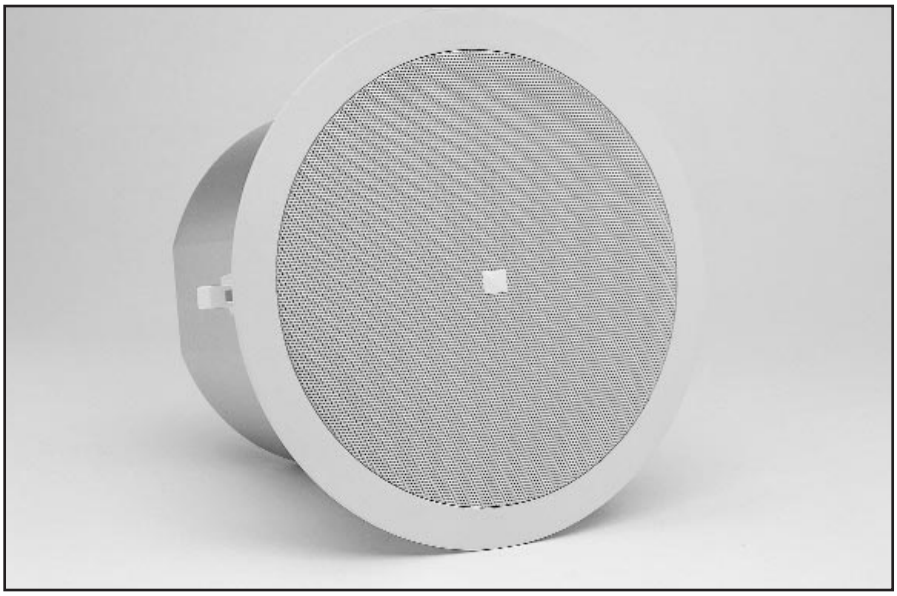
Control® 26C/CT

Background/ Foreground Ceiling Speakers

Professional Series



Key Features:

- Coaxially mounted 165 mm (6.5 in) woofer with butyl rubber surround and 19 mm (¾ in) titanium coated diffraction-loaded tweeter
- High power, wide frequency response and low distortion for high sound level capability
- Wide coverage allows fewer speakers, reducing the cost of the installed sound system without sacrificing performance
- JBL's exclusive SonicGuard™ overload protection allows higher operational levels and improved system reliability (26C only)
- Packaged with grille, backcan and tile rails for fast installation and easy dealer stocking

The Control 26C is a compact ceiling speaker providing premium performance in background, foreground music sound systems. The Control 26C is perfectly suited for a wide variety of applications from casinos and hotels to upscale restaurants and themed locations. High power handling, wide frequency response and low distortion make the Control 26C ideal for sound systems requiring a higher fidelity sound from ceiling loudspeakers. The premium performance capability ensures excellent sound character, providing pleasant, enveloping sound throughout the listening area.

The Control 26C's 16 ohm impedance allows use of multiple speakers in parallel without having to use a more expensive constant voltage distributed system. The optional Control 26CT version includes a multitap transformer for 70V/100V systems.

JBL's exclusive SonicGuard overload protection is a non-invasive loudspeaker protection system that is inaudible to the listener, ensuring reliability while providing full fidelity sound. The computer-optimized ported enclosure delivers warm, smooth bass response. Low frequency output can be further augmented with the addition of one of the Control Contractor subwoofer models.

The 165 mm (6.5 in) woofer features a polyurethane-coated cone and pure butyl-rubber surround for long life, even in high humidity environments. An aluminum voice coil former provides extra cooling for greater long-term power handling. The pole piece is vented for low distortion

The coaxially mounted 19 mm (¾ in) titanium coated tweeter provides crisp, clear highs. Diffraction-loading of the tweeter provides wide, even coverage of the listening area. The extremely broad 110° coverage pattern allows for fewer speakers to be used, making for a simpler and less expensive installation.

Preliminary Specifications:

System:	
Freq. Range (-10 dB)[1]:	75 Hz - 20 kHz
Power Capacity[2]:	140 Watts Continuous Program Power 70 Watts Continuous Pink Noise
Nominal Sensitivity[3]:	89 dB SPL, 1W @ 1 m (3.3 ft)
Nominal Coverage Angle[4]:	110° conical coverage
Directivity Factor (Q):	5.9 averaged 500 Hz to 4 kHz
Directivity Index (DI):	4.6 averaged 500 Hz to 4 kHz
Rated Maximum SPL:	107 dB, 1W @ 1 m (3.3 ft)
Nominal Impedance (24C):	16 ohms
Transformer Taps (24CT):	70V: 60W, 30W, 15W & 7.5W taps 100V: 60W, 30W, & 15W taps
Transducers:	
Low-Frequency:	165 mm (6.5 in) Polypropelene-coated, 1" coil on aluminum former
High-Frequency:	19 mm (¾ in) Titanium coated polyester
Physical:	
Enclosure:	Backcan: Formed steel Baffle/Rim: High impact polystyrene, fire rated UL94V-0
Overload Protection:	Full-range power limiting to protect network and transducers. (On Control 26C, not on Control 26CT)
Termination:	Removable locking connector with screw-down terminals. 2 input terminals and 2 loop-thru output terminals.
Safety Agency Rating:	Suitable for use in air handling spaces, per U.L.-2043
Outside Dimensions (H x Dia):	210 x 252 mm (8.3 x 9.9 in) 190 mm (7.5 in) front of ceiling tile to back of backcan
Cutout Size:	220 mm (8.75 in)
Net Weight (ea):	3.4 kg (7.5 lb) CT: 4.2 kg (10 lb)
Shipping Weight (pair):	8.1 kg (18.0 lb) CT: 9.7 kg (21 lb)
Included Accessories:	C-shaped support backing plate 2 tile support rails (fits both 2 x 4 ft or 600 x 1200 mm tiles) Cutout template Paint shield Removable locking wiring connector

[1]Half-space (flush mounted in ceiling)
[2]Continuous Pink Noise rating is IEC-shaped pink noise with a 6 dB crest factor for 100 hours continuously. Continuous Program power is a conservative expression of the system's ability to handle normal speech and music program material and is defined as 3 dB above the Continuous Pink Noise Rating.
[3]Half-space (in ceiling), average 100 Hz to 10 kHz
[4]500 Hz to 4 kHz

JBL continually engages in research related to product improvement. Changes introduced into existing products without notice are an expression of that philosophy.

Loudspeaker Footprint Diameters

Distributed overhead systems
Assume seated ear height of 4 feet
Charted values are in feet
v1.1

K. Hannig
4/30/2002

Ceiling Height (in feet)

Coverage Angle in Degrees	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
85	9.2	11.0	12.8	14.7	16.5	18.3	20.2	22.0	23.8	25.7	27.5	29.3
90	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0	26.0	28.0	30.0	32.0
95	10.9	13.1	15.3	17.5	19.6	21.8	24.0	26.2	28.4	30.6	32.7	34.9
100	11.9	14.3	16.7	19.1	21.5	23.8	26.2	28.6	31.0	33.4	35.8	38.1
105	13.0	15.6	18.2	20.9	23.5	26.1	28.7	31.3	33.9	36.5	39.1	41.7
110	14.3	17.1	20.0	22.9	25.7	28.6	31.4	34.3	37.1	40.0	42.8	45.7
115	15.7	18.8	22.0	25.1	28.3	31.4	34.5	37.7	40.8	44.0	47.1	50.2
120	17.3	20.8	24.2	27.7	31.2	34.6	38.1	41.6	45.0	48.5	52.0	55.4
125	19.2	23.1	26.9	30.7	34.6	38.4	42.3	46.1	49.9	53.8	57.6	61.5
130	21.4	25.7	30.0	34.3	38.6	42.9	47.2	51.5	55.8	60.0	64.3	68.6