



HEART RATE SYSTEMS TECHNICAL CERTIFICATION TRAINING

Field Engineering | 2010

LifeFitness
WHAT WE LIVE FOR

Course Objectives

» Topics to be covered in this section:

- ◆ Types of Heart Rate (HR) acquisition
 - > Contact
 - > Telemetry
- ◆ HR Systems Common Issues
- ◆ Consumer HR Systems

Heart Rate monitor – Types

» Two types of Heart Rate Monitoring systems are used at LF.

♦ 1. Contact Heart Rate (LifePulse™)

Note:

Some of the consumer cardio machines use a solution that is not Life Pulse. It is very different in terms of performance.

♦ 2. Telemetry Heart Rate (Polar®)

Note:

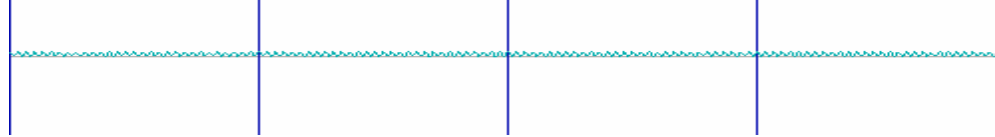
Some of the consumer cardio machines use a receiver that was not designed by Polar. The performance of those devices may be much different from the Polar® receivers.

LIFEPULSE™ HEART RATE SYSTEM

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Signal Noise

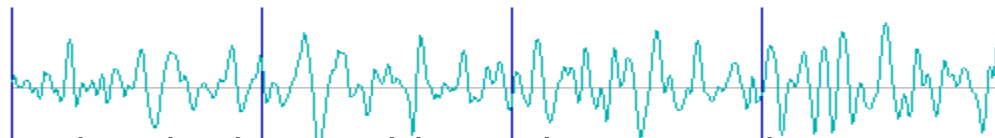
- » Clean signal (no noise and no electrical heart beat signal)



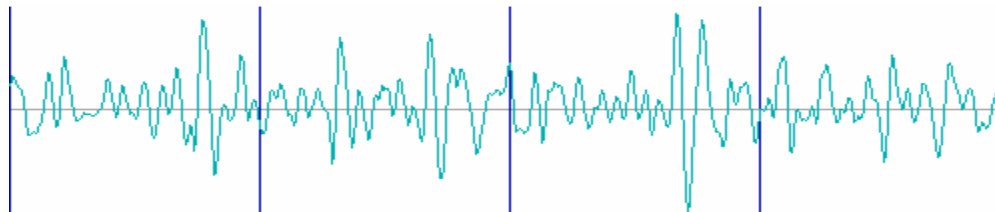
- » Clean electrical heart beat signal



- » Noisy signal (no electrical heart beat signal)



- » Noisy signal with electrical heart beat signal
(Where is the electrical heart beat signal?)



LifePulse™ Heart Rate Monitoring

» Contact Heart Rate (Life Pulse)

- ◆ Direct contact with users palms and fingers
- ◆ Dependent on strength of electrical signal at palms and strength of the grip
- ◆ Proprietary LF Software and Hardware
- ◆ 2-wire and 4-wire

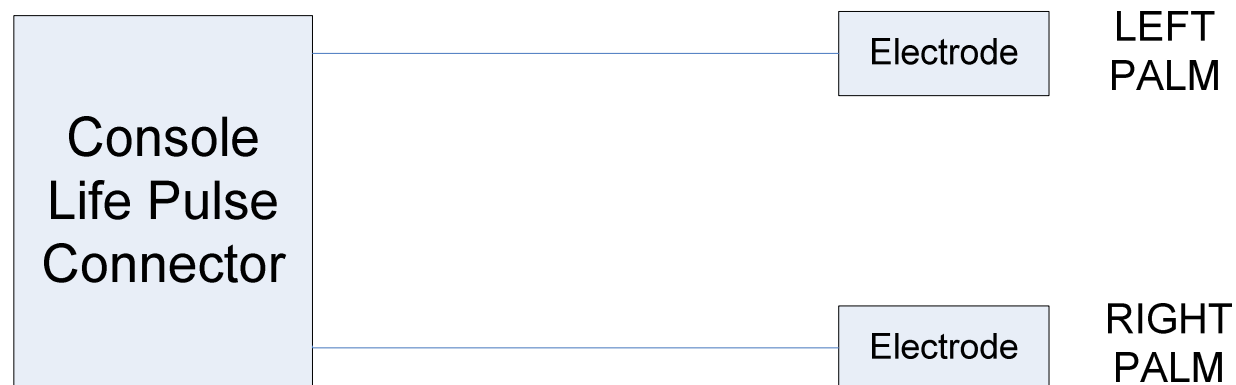
Note:

Some of the consumer cardio machines use a solution that is not Life Pulse. It is vastly different in terms of performance.

Life Pulse – 2 wire systems

- » 2-wire system:
 - ♦ Only 1 electrode per hand.
 - ♦ 2 wires from main PCB.
 - ♦ Used in bikes

2-WIRE LIFE PULSE SYSTEM

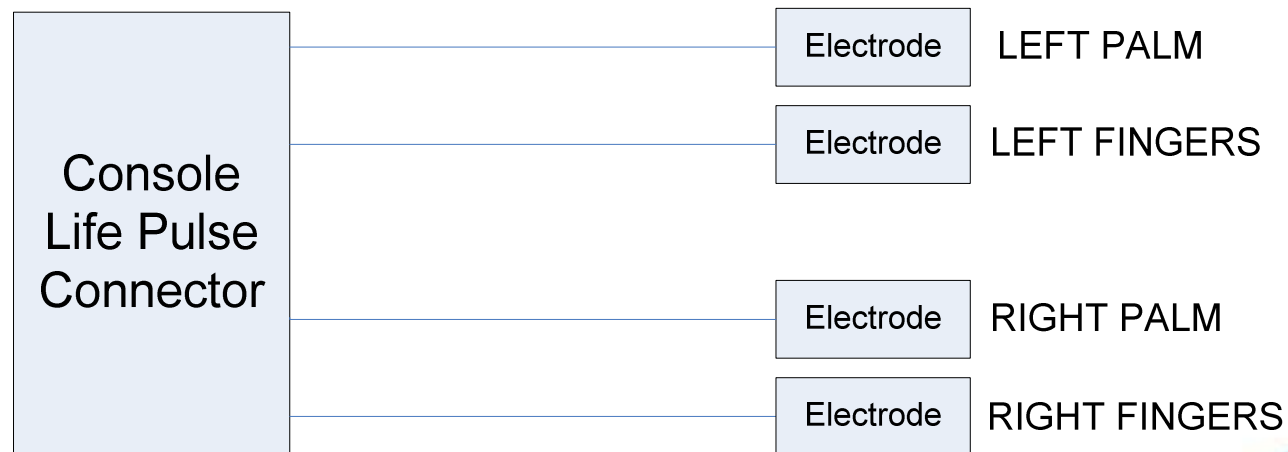


Life Pulse – 4 wire systems

» 4-wire system:

- ◆ 2 electrodes per hand.
- ◆ 4 wires from main PCB.
- ◆ Greater noise immunity than 2-wire system (upper body movement)
- ◆ Used in treadmills, cross trainers, and summit

4-WIRE LIFE PULSE SYSTEM



Life Pulse – 2- and 4-wire Systems

REFERENCE

- » 2-wire system: This type of Life Pulse is used where there is limited upper body movement. Example: Bikes.
- » 4-wire system: This type of Life Pulse is used for applications using greater upper body movement. This system offers more noise immunity for muscle noise. Example: Cross Trainer, Treadmill.

LifePulse™ -- Theory of Operation

- » Detect cardiac signal
- » Digitize impulses and process them (complex filtering)
- » Display heart rate value (if within range)

LifePulse™ -- Theory of Operation

REFERENCE

- » The Lifepulse™ digital heart rate monitoring system detects electrical impulses given off by the heart muscle every time the heart beats.
- » The Lifepulse™ system digitizes the electrical impulses of the heart and then processes them using a DSP (digital signal processor) microchip. Exclusive Life Fitness software filters out electrical "noise" created by other contracting muscles and focuses directly on the signal from the cardiac muscle.
- » Depending upon the noise and signal level, a Lifepulse™ value can be displayed in as little as 4 seconds. Generally speaking, the longer the Lifepulse™ sensors are held, the more accurate the results.

LifePulse™ -- Theory of Operation (cont.)

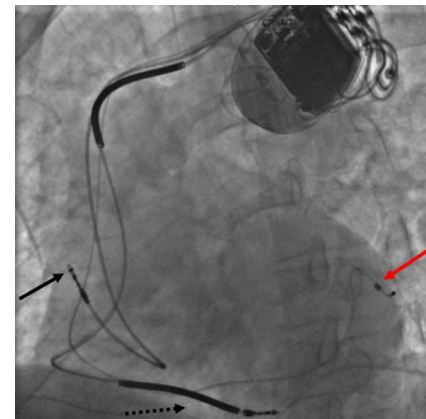
REFERENCE

- » In any given workout the system displays a heart rate that falls within a specific range. If the heart rate is too low or too high, then it will not be displayed.
- » For Polar 30 to 240 bpm
- » For LifePulse™ the range is 50 to 200 bpm – note: treadmills and cross-trainers implement a half heart rate lockout check. This software monitoring is designed to minimize erroneous heart rate readings on products known to have increased ECG signal noise due to the exercise motion. For these products a minimum heart rate reading is calculated during the workout based on the time and exercise rate. For a heart rate to be displayed a user's heart rate reading must be equal to or greater than this computed minimum value. The root cause of half heart rate values is the motion of the arm.
- » Lifepulse™ system is not and should not be used as a medical device.
- » Lifepulse™ cannot be guaranteed for all users – due to variance in impedance at users palm and fingers, circulation, pace makers, etc.

Sources of Signal Noise

- » Electrical Magnetic Interference (EMI)
- » Lifepulse cable issues
- » Muscle noise
- » Hand slipping on electrodes
- » Grip pressure differences on electrodes
- » Electrical Circuit Noise

Electromagnetic Interference



Electromagnetic Interference

REFERENCE

» Appliances

- ◆ Certain electrical appliances, capable of generating broadband RF noise, may interfere with the Lifepulse™ signal. Locate these appliances away from Lifepulse™ equipped products.

» Motor Drive Systems and other power devices

- ◆ Avoid placement near products which do not limit or filter radiated or conducted electrical energy. All Life Fitness products are designed with appropriate filtering and shielding of high frequencies. These systems need to always be maintained properly and according to the manufacturer's specifications.

Electromagnetic Interference

REFERENCE

» Portable Electronics

- ◆ Devices that have local oscillators, high frequency signals needed to drive or convert other signals, can interfere with Lifepulse™ readings. Locate these devices away from the Lifepulse™ sensors or the electronic display console.

» Pacemakers

- ◆ A pacemaker generates electrical signals which may overwhelm the Lifepulse™ input amplifier possibly resulting in measurement errors or the inability to obtain a measurement. In the worst case, the pacemaker's electrical signals may damage the Lifepulse™ input circuit. Consult a doctor about using the Lifepulse™ contact heart rate system if you have a pacemaker.

Lifepulse™ Performance

- » Hand Placement
- » Grip Pressure
- » Upper Body Activity (muscle noise)
- » Hand Conditions

Lifepulse™ Performance

REFERENCE

»Hand Placement

- ◆ Both hands must be positioned properly on the sensors to receive the best possible signal. Thumbs should wrap around to close the grip on the sensors with palms and fingers in maximum possible contact at all times.

»Grip Pressure

- ◆ The amount of pressure used to grip the Lifepulse™ sensors has an effect on the quality of the signal. Both sensors should be held firmly, but avoid excessive pressure. Hands must not be allowed to slip or move during Lifepulse™ readings.

»Upper Body Activity (muscle noise)

- ◆ Movement in the upper body and arms during exercise can degrade the heart rate signal. For best results on these products, minimize shoulder, back, arm, and wrist movements during Lifepulse™ readings.

»Hand Conditions

- ◆ Keep hands clean as well as avoiding the use of hand lotions and gloves.
- ◆ Hands should have some moisture, not dry

Quick Notes

REFERENCE

- » Lifepulse™ system must first recognize that someone is holding the sensors before beginning to read the heart rate signal. Only if both hands are in good contact with their respective sensors will Lifepulse™ system begin to sample this signal.
- » The minimum heart rate value displayed is 50 BPM and the maximum heart rate value displayed is 200 BPM. Heart rate readings outside this range will not be displayed.
- » It may take up to 40 seconds to collect enough data to analyze and compute an accurate heart rate. The longer the sensors are held, the better the system works.
- » Limit upper body motion if possible so muscle noise is reduced.
- » The use of Lifepulse™ heart rate monitoring is not recommended after 4.5mph on Life Fitness treadmills because of difficulty in gripping the sensors and therefore in getting a good reading.

Quick Notes (cont.)

REFERENCE

- » Lifepulse™ systems (commercial) within Life Fitness comprise of two basic designs (4-wire and 2-wire). The 4-wire designs are utilized in systems with more user upper body movement which requires a more noise immunity.
- » Commercial Treadmills and Cross Trainers are designed with 4 wire Lifepulse design and Commercial Bikes use the 2-wire Lifepulse design.
- » Consumer products (not produced at Life Fitness) utilize third party Contact Heart Rate designs and follow their own requirements.

Cable routing – Cross Trainers

- » Cable routing, especially with 4 wire Life Pulse systems, is critical to Lifepulse™ performance.
- » Example below: Classic Cross Trainer cable routing to HR electrodes.

User's right side view from front of unit



User's right seen while on unit



LifePulse™ Heart Rate Systems – Common Issues

No Life Pulse reading?

- » Check proper User operation
 - ◆ Grip electrodes properly (full hand contact)
 - ◆ Limit movement of hand to electrodes
 - ◆ Hands must not be dry or use excessive lotion
 - ◆ User not guaranteed if using a Pace Maker or has an irregular heart beat
 - ◆ User with bad circulation is also difficult to pick up

- » Check Unit operation
 - ◆ Cable routing (tapping cable causes noise)
 - ◆ Broken cables/connections
 - ◆ Incorrect setup of 2-wire/4-wire HR
 - ◆ Use HR diagnostics to identify signal strength, etc.

TELEMETRY (POLAR®) HEART RATE

Telemetry (Polar) Heart Rate Monitoring

◆ Telemetry Heart Rate (Polar)

- > Uses Polar receiver
- > Requires Telemetry chest strap and a good conductivity between user's skin and the electrodes
- > Distance between receiver and transmitter critical
- > Coded vs. Non-Coded

Note:

Some of the consumer cardio machines use a receiver that was not designed by Polar. The performance of those devices may be much different from the Polar® receivers.

Telemetry – Theory of Operation

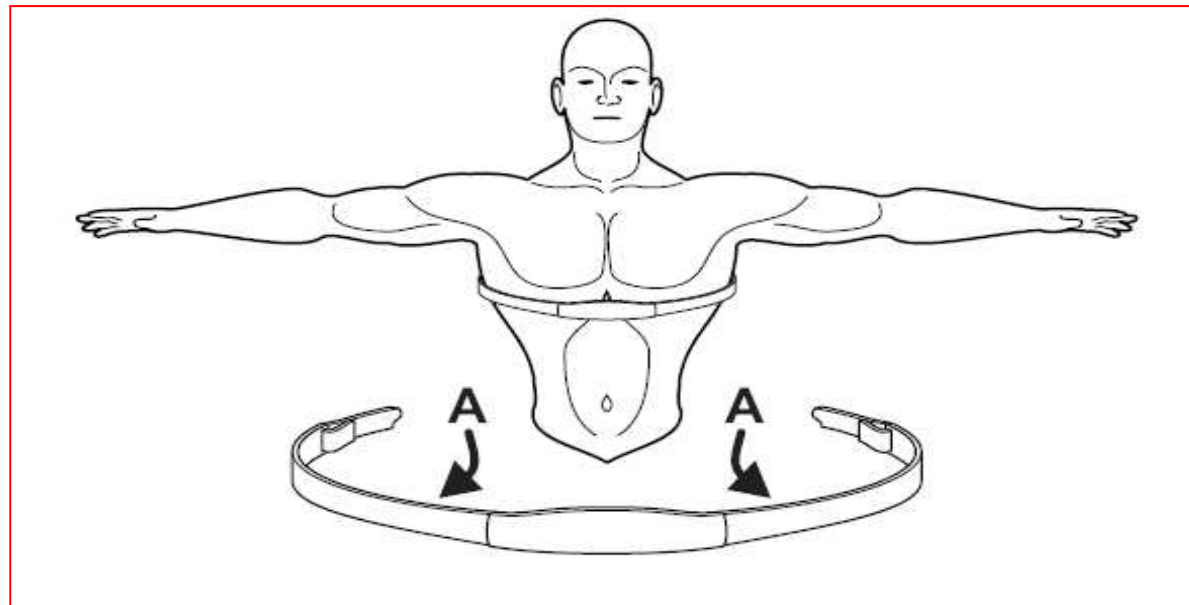
- » Telemetry: wireless transmission. Heart rate signal -> a receiver.
- » Telemetry TX and RX: Coded/Non-coded.
- » Life Fitness uses both
- » Mixing coded and non-coded RX and TX:
 - ♦ Non-coded TX -> coded RX (OK!)
 - ♦ Coded TX -> non-coded RX (usually OK, 120 bpm may be displayed as 240 due to presence of code pulses!)

Telemetry – Theory of Operation

REFERENCE

- » Telemetry is a wireless transmission of a Heart rate signal between a transmitter (chest strap) and a receiver (PCB or module in LF product).
- » Telemetry transmitters and receivers are either Coded or Non-coded.
- » Life Fitness uses both the Coded and Non-coded versions, based on application.
- » Within Life Fitness designs, mixing coded and non-coded receivers and transmitters will function seamlessly.
 - ♦ Non-coded transmitters work with both receivers as well.
 - ♦ Coded transmitters work usually fine with non-coded receivers. However, 120 bpm may be displayed as 240 due to presence of code pulses!

Heart Rate Chest Strap Placement



Telemetry Heart Rate Proper HR Signal Transmission

- » Ensure proper contact between the skin and the electrodes of the transmitter
 - ◆ Moisten
 - ◆ Tighten
 - ◆ Adjust
 - ◆ Heart Bra
 - ◆ Conductive lotion/gel



Telemetry Heart Rate Proper HR Signal Transmission

REFERENCE

- » Ensure proper contact between the skin and the electrodes of the transmitter
 - ◆ For accurate heart rate measurement, the contact between the skin and the electrodes should be as good as possible. Polar transmitters measure the electro-cardio gram (ECG) signal from the chest, where it is the strongest. The weak heart-generated signals need to be accurately measured before the calculation of the heart rate.

Improve Heart Rate Strap Contact

REFERENCE

- » Moisten the grooved electrode areas on the back of the transmitter
- » Tighten the elastic strap of the transmitter
- » Adjust the heart rate strap for best contact
- » Use the Heart Bra
- » Use a conductive lotion or gel

Transmitter Wear & Storage

- » Clean and dry the TX
- » Contact w/ damp object -> shortens life of TX
- » Damp TX in plastic bag -> mold
- » Bending of TX -> electrodes damage

Transmitter Wear & Storage

REFERENCE

- » Clean the transmitter after each use. Do not store the strap until it has dried completely.
- » Do not store transmitter in a confined space where it may come in contact with a damp object. Sensors contacting a damp object will turn the transmitter “on” and shorten battery life.
- » Do not store a damp transmitter in a plastic bag or other “non-breathable” type bag.
- » Bending the transmitter unnecessarily may damage electrodes.

Telemetry Heart Rate Systems – Common Issues

Telemetry not working correctly

» Electromagnetic Interference

» Cross-Talk

Telemetry not working correctly

REFERENCE

» Electromagnetic Interference

- ♦ Common items such as televisions, computers, cell phones, motors, and garage door openers can cause interference

» Cross-Talk

- ♦ Position machines so that the telemetry receivers are at least one meter (about 3 feet) from each other
- ♦ The maximum range between the transmitter and the receiver is one meter (or 3 about feet)

No Telemetry reading

- » Telemetry OFF in diagnostics
- » Coded Polar RX in product
- » If no reading after above, then:
 - ♦ bad chest strap (battery),
 - ♦ Bad skin contact, or
 - ♦ Bad Polar receiver.

No Telemetry reading **REFERENCE**

» Telemetry OFF in diagnostics

- ◆ There is a selection in the console to turn the Telemetry ON or OFF. This default is ON, but user can turn it OFF.
- ◆ If OFF set to ON

» Is there a Coded Polar receiver in product

- ◆ Coded Receivers have a function of reducing range to 2/3 of the max until a chest strap is identified. Then range is expanded. Max range is defined as about 3 feet or 1 meter.
- ◆ Move transmitter (chest strap) as close as possible to the console, for up to 30 seconds or when a reading appears.
- ◆ If a reading appears, then strap is coded and this is normal. Then use product normally and reading should stay.

» If no reading after above, then:

- ◆ bad chest strap (battery),
- ◆ Bad skin contact, or
- ◆ Bad Polar receiver.

CONSUMER HEART RATE SYSTEMS

Consumer Bike Heart Rate Systems

- » Telemetry on Advanced consoles. RX in the console.
- » All models have contact HR
- » Upright bikes: sensors in the handlebars
- » Recumbent bikes: sensors in grab bars of the seat
 - ♦ More prone to issues
 - ♦ Check the phone jack connection in the seat track first.
- » Check continuity between the grip plates and the connector at the console.



Consumer Bike Heart Rate Systems **REFERENCE**

- » Telemetry is only available on Advanced consoles. Receiver is contained in the console.
- » All models have contact HR
- » Upright bikes have the sensors in the handlebars
- » Recumbent bikes have the sensors in the grab bars on the seat
 - ♦ Recumbent bikes are more prone to issues since they have more cables and connections between the grips and the console
 - ♦ Check the phone jack connection in the seat track first. Make sure the cable is attached to the clip that prevents constant pulling on the phone jack connector.
- » Check continuity between the grip plates and the connector at the console. Trace back from there if you find no connection. Also check grip plates to ground. Should be open circuit.



Consumer Cross Trainer Heart Rate Systems

- » Telemetry on Advanced consoles. Receiver in the console.
- » Contact HR sensors: all models except the X1
- » Sensors in the stationary handlebar
- » Check continuity between the grip plates and the connector at the console.



Consumer Cross Trainer Heart Rate Systems **REFERENCE**

- » Telemetry is only available on Advanced consoles. Receiver is contained in the console.
- » All models except the X1 have contact HR sensors. Note that on the X1 the console will still have a contact board but the machine does not have contact grips or cables
- » Sensors are always in the stationary handlebar
- » Check continuity between the grip plates and the connector at the console. Trace back from there if you find no connection. Also check grip plates to ground. Should be open circuit.



10-1, 1-10 Rule

- » 10 people having problems getting a heart rate reading on 1 machine -> a problem with the MACHINE.
- » 1 person having trouble getting a heart rate reading on 10 machines -> problem with the PERSON.

Summary – Heart Rate Systems

» Topics covered in this section:

- ◆ 2 types of Heart Rate (HR) acquisition
 - > Contact (Life Pulse)
 - 2 wire vs. 4 wire
 - > Telemetry
 - Coded vs. Non-Coded
- ◆ HR Systems Common Issues
- ◆ Consumer HR systems

Questions





THANK YOU!

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