

# Performance operational amplifiers and comparators



January 2005

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## Operational amplifiers

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## Sales offices and representatives

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# A complete range of operational amplifiers and comparators

STMicroelectronics has a broad portfolio of operational amplifiers and comparators, including a complete family of rail-to-rail amplifiers.

This brochure focuses on those operational amplifiers and comparators that have specific performance advantages, ranging from high-speed/high-bandwidth, to ultra-low power consumption.

Detailed tables of electrical characteristics are provided, as well as a cross-reference table which relates ST's devices to those of competitors.

## High-speed op-amps

In developing STMicroelectronics' high-speed op-amp portfolio, we are always trying to obtain the best bandwidth/power ratio. High-speed op-amps are used in a variety of applications, ranging from video and ADSL line driving, to medical instrumentation.

### Very high bandwidth

The TSH330 is a current feedback operational amplifier which uses extremely high-speed complementary technology to achieve a bandwidth of 1GHz, while drawing only 15.4mA of quiescent current. Stable at unity gain, with a 0.1dB gain flatness up to 760MHz, the TSH330 also offers a slew rate of 1800V/ $\mu$ s and an output stage optimized for driving a standard 100 $\Omega$  load. These characteristics make this device an excellent choice in applications where speed and low distortion are the main requirements, such as professional video signal applications.

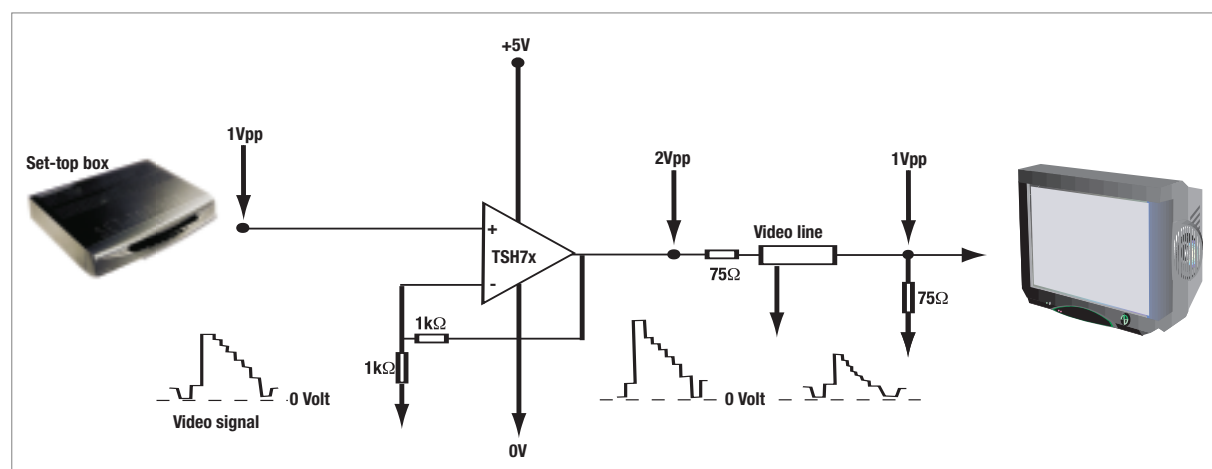
### Extremely low power consumption

The very low power, high-speed TSH310 operational amplifier has a bandwidth of 120MHz while drawing only 400 $\mu$ A of quiescent current. Its low power consumption makes it particularly well-suited for battery-powered equipment which requires high-speed, dynamic performance, such as portable metering or medical instrumentation.

### Video applications

The TSH7x, 8x, 9x and 11x op-amp families are optimized for video applications.

The TSH7x and TSH8x feature high video performance with large bandwidth (70MHz GBP), low distortion and excellent supply voltage rejection. With a large output voltage swing and high output current for driving standard 150 $\Omega$  loads, this family also features a standby mode.

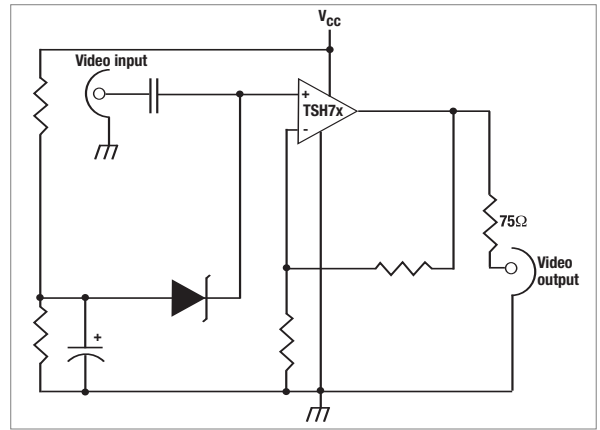


Video driving application for TSH7x-8x

The TSH9x high-frequency family is designed for high-quality video signal processing. The device offers an excellent speed vs. power consumption ratio with 4.5mA per amplifier for 150MHz GBP. Its high slew rate and low noise also make it suitable for high-quality audio applications.

### DSL applications

The TS616 family is ideally suited for xDSL (high-speed asymmetrical digital subscriber line) applications, featuring a high output current of 410mA, and drivers that can be configured differentially for driving signals in telecommunication systems using multiple carriers.



Output video amplifier

## Precision op-amps

Precision operational amplifiers, by virtue of their low offset voltage, are ideal for use in dynamic bridge-based signal conditioning applications. The TS51x family includes dual and quad op-amps aimed at precision instrumentation and industrial and telecom applications. These medium speed (3MHz GBP) devices offer a power consumption of only 350µA per amplifier and a low offset voltage of 500µV (maximum). They combine high signal accuracy (low distortion: 0.03%; low noise: 8nV/√Hz; excellent channel

separation: 120dB) and stable operation in voltage follower circuits. The TS507 is a high-performance, rail-to-rail input/output amplifier with very low offset voltage (60µV max). This amplifier uses a new trimming technique which yields ultra-low offset voltages without the need for external adjustment. The TS507 presents very stable electrical characteristics over its entire supply voltage range, and is particularly suited for medical, industrial and telecom applications.

## Micropower op-amps

Micropower op-amps are for use in low-power applications - especially portable, battery-powered ones. They are also suitable for high source impedance signal amplification (piezoelectric-based measurements). Micropower, high-speed op-amps are ideal for capacitive sensors, dynamic signal amplification and active filters.

### CMOS inputs

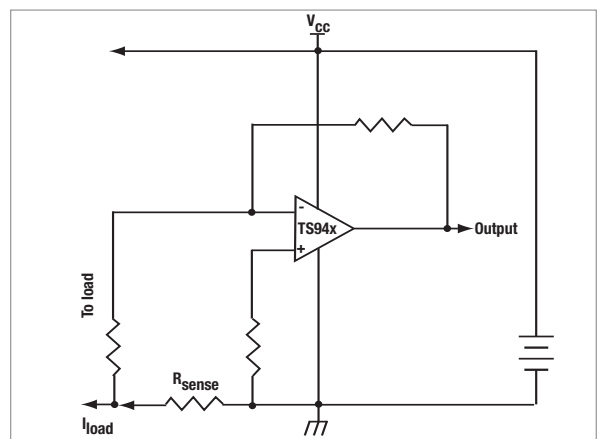
At only 1.2µA  $I_{CC}$  (typ.), the TS94x family of rail-to-rail single supply devices is perfect for the low-frequency amplification needed in buffering and conditioning applications where high impedance is required. When mid-range bandwidth is required, the TS93x rail-to-rail family offers a modest consumption of 20µA  $I_{CC}$  (typ.) with a GBP of 100kHz.

### High-speed performance

When an application requires both high speed and low consumption, such as portable multi-media applications, the TSH310 offers a bandwidth of 110MHz at a consumption of 400µA  $I_{CC}$  (typ.).

### Wide variety of performance options

The TS185x offers rail-to-rail input/output and is intended for general purpose, very low voltage applications (1.8V). It is optimized for loads higher than 2kΩ and offers high dynamic stability on capacitive loads with an undistorted output. The TS185x family has an excellent speed/consumption ratio, with 500kHz gain bandwidth for only 120µA current consumption.



Micropowered low-side current sensing

# Low voltage rail-to-rail op-amps

## High output current

Able to drive 200mA down to voltages as low as 2.7V, the TS982 is a dual operational amplifier highly suited to industrial and automotive applications, including hall sensor compensation coils, servo-amplifiers and motor drivers. It can operate at supply voltages ranging from 2.5 to 5.5V and offers rail-to-rail input and output as well as unity gain stability.

## Low noise

The TS97x and TS46x families of class A, rail-to-rail output amplifiers boast exceptionally low noise and linearity (low distortion) characteristics, and are specified to work down to 3V. The TS97x, for example, has 4nV/√Hz equivalent input noise voltage, very low THD, and 12MHz GBP, making it an excellent choice for applications with low signal levels (such as audio signal pre-amplification).

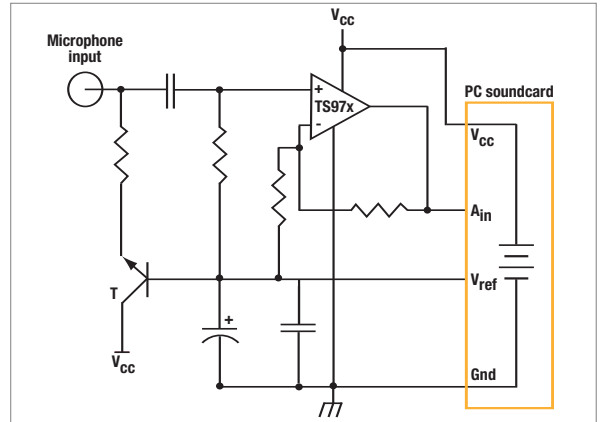
## Full CMOS

The main benefits of the CMOS process in operational amplifiers are low power consumption (200µA) coupled with ultra low input bias currents (150pF max), making such devices a perfect match for applications requiring high input impedance, such as sensors and industrial control. The TS91x and TS90x families offer a wide operational voltage range (2.7 to 16V) and a high output current, capable of driving loads up to 600Ω.

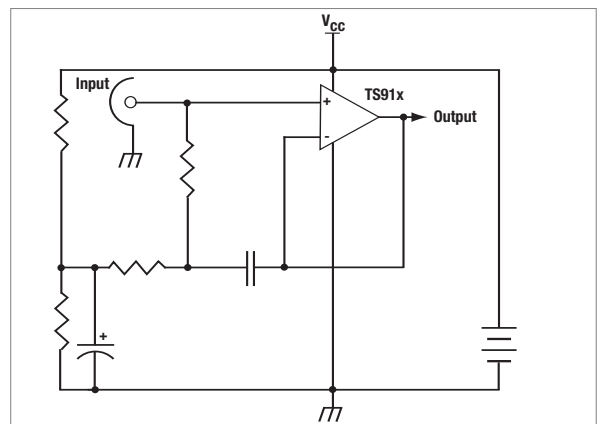
## An excellent mix of performances

The TS92x family are input/output rail-to-rail amplifiers which offer high output current (80mA) when supplied at 2.7V. This family has been specifically designed to provide outstanding linearity and low input offset voltage. With high phase and gain margins, TS92x op-amps remain stable even under large capacitive loads up to 500pF. With a GBP of 4MHz, sub-mV input offset voltage and low noise, these op-amps are tailor-made for applications where high gain and precision are necessary.

The TS187x family offers rail-to-rail input/output, with the added features of higher output current drive (20mA minimum) and speed (1.6MHz). It offers a typical current consumption of only 400µA, making it well suited to battery-driven and portable equipment applications, and its 1.6MHz GBP fulfills requirements for higher speeds. Stability and minimum overshoot with capacitive loads is maintained at 53° of phase margin with a 100pF load capacitor. Intended for more demanding low voltage applications, where higher GBP and/or output current is required, the TS187x family is designed to drive loads as low as 32Ω and is ideal for applications such as headphone amplifiers and cable driving.



Microphone pre-amplifier for PC soundcards

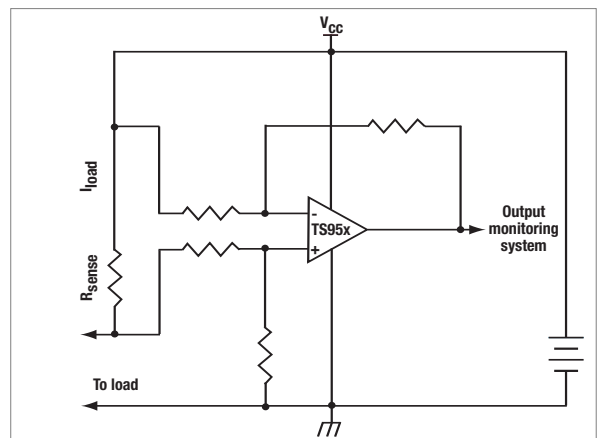


Very-high input impedance rail-to-rail buffer

## Attractive cost/performance ratio

The TS95x family has a wide supply range (2.7 to 12V) in a space-saving SOT23 package and offers a performance similar to the TS92x family: excellent linearity and stability, speed and low consumption.

Featuring 25mA output current and a 3MHz GBP, the dual TS952 and quad TS954 are recognized as offering an attractive cost/performance ratio for applications which do not need the full performance of the TS92x family.



PC power management high-side battery current monitoring

# Comparators

## Micropower

The Ts72xx family of micropower comparators feature rail-to-rail input performance in a tiny SOT23-5 package. This comparator is fully specified at 2.7V, 5V and 10V operation over the industrial temperature range (-40 to +85°C). Both push-pull and open drain output stages are available in this family, and their speed-to-power ratio makes these devices ultra-versatile for a wide range of applications.

## High-speed

TS302x comparators feature fast response time (40ns) coupled with rail-to-rail input and push-pull outputs. These products have a supply voltage range of 2 to 5V, as well as a wide temperature range (-40 to +125°C), making them suitable for a wide variety of applications. The TS302x family also has very low power consumption – as low as a few tens of  $\mu\text{A}$  – providing an excellent ratio between current consumption and response time.

# High-temperature op-amps and comparators

Automotive and industrial environments require high-temperature amplifiers and comparators. In these segments, sensors and electronics have to be placed close to their function modules, to limit the use of high-cost, high-end wiring needed to avoid interference effects.

ST has carried out in-depth reliability testing in order to qualify a selection of standard products (op-amps TS922H, and LM2904H, comparators LM2901H and LM2903H) within the extended -40° to +150°C temperature range.

Specific production processes are used to ensure the high level of quality required by such electronic components, based on 100% test coverage at production line temperatures. Testing is performed at +150°C during wafer conditioning and at +125°C for SO packages with a guarantee by correlation up to +150°C. This means customers can use these products with a high level of confidence.

## Application overview

| Supply voltage                         | Design requirements                                                    | Typical applications                                                             | Recommend ST op-amp family                        |
|----------------------------------------|------------------------------------------------------------------------|----------------------------------------------------------------------------------|---------------------------------------------------|
| $V_s \leq 3V$                          | Low input bias current, low offset current, high input impedance       | Industrial, test equipment, optical networking (ONET), high-end audio            | TS185x, TS187x, TS93x, TS94x                      |
| $V_s \leq +3V$                         | Rail-to-rail, low power, precision, small packages,                    | Battery-powered, handheld                                                        | TS91x, TS92x, TS185x, TS187x, TS94x, TS93x        |
| $V_s \leq 16V$                         | Rail-to-rail, low power, low voltage offset, precision, small packages | Industrial, automotive                                                           | TS91x, TS92x, TS185x, TS187x, TS97x, TS95x, TS46x |
| $\pm 5V$ to $\pm 15V$ dual supply      | High-speed on dual supplies                                            | xDSL, video professional imaging, data converter signal conditioning             | TS616                                             |
| $2.75V \leq V_s \leq 5V$ single supply | High-speed on single supply                                            | Consumer imaging, data converter signal conditioning, safety-critical automotive | TSH7x, TSH8x, TSH11x                              |

# Operational amplifiers cross-reference selector

| Part number                           | Direct replacement | Similar |
|---------------------------------------|--------------------|---------|
| <b>Analog Devices</b>                 |                    |         |
| AD822                                 | TS922              |         |
| AD824                                 | TS924              |         |
| OP186                                 | TS941              |         |
| OP213                                 | TS922              |         |
| OP279                                 | TS922              |         |
| OP281                                 | TS942              |         |
| OP292                                 | TS922              |         |
| OP293                                 | TS942              |         |
| OP295                                 | TS1852             |         |
| OP450                                 | TS924              |         |
| OP491                                 | TS924              |         |
| OP492                                 | TS924              |         |
| OP495                                 | TS934              |         |
| SSM2275                               | TS922              |         |
| SSM2475                               | TS924              |         |
| AD820                                 |                    | TS921   |
| AD8531                                |                    | TS922   |
| AD8532                                |                    | TS923   |
| AD8534                                |                    | TS924   |
| AD8541                                |                    | TS925   |
| AD8542                                |                    | TS926   |
| AD8544                                |                    | TS927   |
| AD8594                                |                    | TS928   |
| OP113                                 |                    | TS929   |
| OP181                                 |                    | TS930   |
| OP183                                 |                    | TS931   |
| OP193                                 |                    | TS932   |
| OP196                                 |                    | TS933   |
| OP213                                 |                    | TS934   |
| OP250                                 |                    | TS935   |
| OP283                                 |                    | TS936   |
| OP284                                 |                    | TS937   |
| OP291                                 |                    | TS938   |
| OP293                                 |                    | TS939   |
| OP296                                 |                    | TS940   |
| OP413                                 |                    | TS941   |
| OP450                                 |                    | TS942   |
| OP481                                 |                    | TS943   |
| OP484                                 |                    | TS944   |
| OP491                                 |                    | TS945   |
| OP493                                 |                    | TS946   |
| OP496                                 |                    | TS947   |
| SSM2135                               |                    | TS948   |
| <b>Burr-Brown (Texas Instruments)</b> |                    |         |
| OPA2237                               | TS922              |         |
| OPA2241                               | TS932              |         |
| OPA2342                               | TS912              |         |
| OPA241                                | TS931              |         |
| OPA4237                               | TS924              |         |
| OPA4241                               | TS934              |         |
| OPA4342                               | TS914              |         |

| Part number              | Direct replacement | Similar |
|--------------------------|--------------------|---------|
| <b>Harris</b>            |                    |         |
| ICL7612                  | TS912              |         |
| ICL7621                  |                    | TS912   |
| ICL7641                  |                    | TS914   |
| <b>Linear Technology</b> |                    |         |
| LT1367                   |                    | TS914   |
| LT1495                   |                    | TS942   |
| LT1495                   |                    | TS942   |
| LT1496                   |                    | TS944   |
| LT1638                   |                    | TS1872  |
| LT1639                   |                    | TS1874  |
| <b>Maxim</b>             |                    |         |
| ICL7612                  | TS912              |         |
| MAX4040                  | TS931              |         |
| MAX4041                  | TS931              |         |
| MAX4042                  | TS932              |         |
| MAX4044                  | TS934              |         |
| MAX406                   | TS941              |         |
| MAX407                   | TS942              |         |
| MAX4122                  | TS951              |         |
| MAX4126                  | TS922              |         |
| MAX4129                  | TS924              |         |
| MAX4129                  | TS942              |         |
| MAX4162                  | TS931              |         |
| MAX4163                  | TS932              |         |
| MAX4164                  | TS934              |         |
| MAX4165                  | TS1871             |         |
| MAX4167                  | TS922              |         |
| MAX4169                  | TS924              |         |
| MAX418                   | TS944              |         |
| MAX4240                  | TS931              |         |
| MAX4242                  | TS932              |         |
| MAX4244                  | TS934              |         |
| MAX4250                  | TS1851             |         |
| MAX4250                  | TS1871             |         |
| MAX4250                  | TS951              |         |
| MAX4252                  | TS1872             |         |
| MAX4254                  | TS1874             |         |
| MAX4326                  | TS922              |         |
| MAX4329                  | TS924              |         |
| MAX4400                  | TS1871             |         |
| MAX473                   | TS971              |         |
| MAX474                   | TS972              |         |
| MAX475                   | TS974              |         |
| MAX492                   | TS1852             |         |
| MAX494                   | TS1854             |         |
| MAX495                   | TS1851             |         |
| ICL7621                  |                    | TS912   |
| IC7641                   |                    | TS914   |
| MAX4322                  |                    | TS1871  |
| MAX985                   |                    | TS861   |

| Part number                   | Direct replacement | Similar |
|-------------------------------|--------------------|---------|
| <b>Micrel</b>                 |                    |         |
| MIC7211                       | TS7211             |         |
| <b>Mitsubishi</b>             |                    |         |
| M5216                         | TS922              |         |
| <b>Motorola</b>               |                    |         |
| MC33502                       | TS1852             |         |
| MC33201                       |                    | TS921   |
| MC33202                       |                    | TS922   |
| MC33204                       |                    | TS924   |
| MC33207                       |                    | TS925   |
| <b>National Semiconductor</b> |                    |         |
| LMC6041                       | TS931              |         |
| LMC6042                       | TS932              |         |
| LMC6044                       | TS934              |         |
| LMC6082                       | TS912              |         |
| LMC6084                       | TS914              |         |
| LMC6434                       | TS934              |         |
| LMC6442                       | TS942              |         |
| LMC6462                       | TS932              |         |
| LMC6582                       | TS1872             |         |
| LMC6584                       | TS1874             |         |
| LMC660                        | TS914              |         |
| LMC662                        | TS912              |         |
| LMC7211                       | TS7211             |         |
| LMV321                        | TS951              |         |
| LMV324                        | TS954              |         |
| LMV358                        | TS952              |         |
| LMV822                        | TS922              |         |
| LMV824                        | TS924              |         |
| LMV924                        | TS1874             |         |
| LPV321                        | TS931              |         |
| LPV324                        | TS934              |         |
| LPV358                        | TS932              |         |
| LM7301                        |                    | TS951   |
| LMC6032                       |                    | TS912   |
| LMC6034                       |                    | TS914   |
| LMC6035                       |                    | TS912   |
| LMC6036                       |                    | TS914   |
| LMC6482                       |                    | TS912   |
| LMC6484                       |                    | TS914   |
| LMC6492                       |                    | TS912   |
| LMC6494                       |                    | TS914   |
| LMC7101                       |                    | TS951   |
| LMC7111                       |                    | TS931   |
| LMV821                        |                    | TS1871  |
| <b>NJRC</b>                   |                    |         |
| NJM2100                       |                    | TS462   |
| NJM2106                       |                    | TS951   |
| NJM2107                       |                    | TS462   |
| NJM2107F                      |                    | TS951   |
| NJU7082                       |                    | TS922   |

| Part number              | Direct replacement | Similar |
|--------------------------|--------------------|---------|
| <b>Microchip</b>         |                    |         |
| MCP602                   |                    | TS912   |
| MCP604                   |                    | TS914   |
| <b>Philips</b>           |                    |         |
| NE5234                   |                    | TS914   |
| <b>Rohm</b>              |                    |         |
| BA4510                   | TS462              |         |
| <b>Texas Instruments</b> |                    |         |
| TLC2201                  | TS921              |         |
| TLC2252                  | TS932              |         |
| TLC2254                  | TS934              |         |
| TLC2872                  | TS922              |         |
| TLV2361                  | TS971              |         |
| TLV2362                  | TS972              |         |
| TLV2451                  | TS931              |         |
| TLV2452                  | TS932              |         |
| TLV2454                  | TS934              |         |
| TLV2461                  | TS921              |         |
| TLV2462                  | TS924              |         |
| TLV2464                  | TS924              |         |
| TLV2772                  | TS972              |         |
| TLV2774                  | TS974              |         |
| TLC2202                  |                    | TS922   |
| TLC2262                  |                    | TS922   |
| TLC2264                  |                    | TS924   |
| TLC2272                  |                    | TS922   |
| TLC2274                  |                    | TS924   |
| TLV2231                  |                    | TS951   |
| TLV2252                  |                    | TS932   |
| TLV2254                  |                    | TS934   |
| TLV2262                  |                    | TS1852  |
| TLV2264                  |                    | TS1854  |
| TLV2422                  |                    | TS932   |
| TLV2432                  |                    | TS912   |
| TLV2442                  |                    | TS912   |
| TLV2711                  |                    | TS931   |
| TLV2721                  |                    | TS1851  |
| TLV2731                  |                    | TS951   |
| TLV3432                  |                    | TS1852  |
| <b>TOKO</b>              |                    |         |
| TK17021M                 | TS972              |         |
| TK17031M                 | TS952              |         |
| <b>Toshiba</b>           |                    |         |
| TA75S51                  | TS932              |         |
| TA75S58F                 | TS951              |         |
| TA75S58FU                | TS952              |         |
| TC75S01F                 | TS951              |         |
| TC75W51FU                | TS922              |         |
| TC75W54FU                | TS922              |         |
| TA75S51F                 |                    | TS931   |
| TC75S56F                 |                    | TS861   |
| TC75S57F                 |                    | TS861   |
| TC75S58F                 |                    | TS861   |
| TC75S59F                 |                    | TS861   |

## Rail-to-rail op-amps

| Part number                           | General description                                         | Operating temp °C | Number of operators | Input/ outputs | Supply voltage |                | Supply current $I_{CC}$ typ per amp $\mu$ A | Input offset voltage $V_{IO}$ max mV | Input bias current $I_B$ max nA | GBP typ MHz | Slew rate SR typ V/ $\mu$ s | Output current $I_{out}$ typ mA | $V_{OH}$ min V | Packages                    |
|---------------------------------------|-------------------------------------------------------------|-------------------|---------------------|----------------|----------------|----------------|---------------------------------------------|--------------------------------------|---------------------------------|-------------|-----------------------------|---------------------------------|----------------|-----------------------------|
|                                       |                                                             |                   |                     |                | $V_{CC}$ min V | $V_{CC}$ max V |                                             |                                      |                                 |             |                             |                                 |                |                             |
| <b>1.8V supply low power</b>          |                                                             |                   |                     |                |                |                |                                             |                                      |                                 |             |                             |                                 |                |                             |
| TS1851/2/4                            | 1.8V min voltage supply, micropower                         | -40 to 125        | 1/2/4               | RR/RR          | 1.8            | 6              | 120                                         | 3                                    | 125                             | 0.48        | 0.2                         | 40                              | 1.75 @ 1.8V    | DIP, SO, TSSOP, SOT23       |
| TS1871/2/4                            | 1.8V min. voltage supply, micropower                        |                   |                     |                |                |                | 400                                         |                                      |                                 | 1.6         | 0.54                        | 65                              |                |                             |
| <b>CMOS low power</b>                 |                                                             |                   |                     |                |                |                |                                             |                                      |                                 |             |                             |                                 |                |                             |
| TS902                                 | Low power with standby mode, CMOS inputs                    | -40 to 125        | 2                   | RR/RR          | 2.7            | 16             | 200                                         | 5                                    | 0.3                             | 0.8         | 0.5                         | 40                              | 2.97 @ 3V      | DIP, SO                     |
| TS912/4                               | Low power with CMOS inputs                                  |                   | 2/4                 |                |                |                |                                             |                                      |                                 |             | 0.4                         |                                 |                |                             |
| <b>Low noise, high output current</b> |                                                             |                   |                     |                |                |                |                                             |                                      |                                 |             |                             |                                 |                |                             |
| TS921/2/4/5                           | Excellent audio performance, low distortion (0.005%)        | -40 to 125        | 1/2/4               | RR/RR          | 2.7            | 12             | 1000                                        | 3/0.9                                | 100                             | 4           | 1.3                         | 80                              | 2.87 @ 3V      | DIP, SO, TSSOP, Flip Chip   |
| TS951/2/4                             | Input and output rail-to-rail, low distortion               |                   |                     |                |                |                | 900                                         | 6                                    | 200                             | 3           | 1                           | 22                              | 2.9 @ 3V       | DIP, SO, TSSOP, SOT23       |
| TS982                                 | 200mA high output current dual operational amplifier        |                   | 2                   |                | 2              | 5.5            | 5000                                        | 5                                    | 500                             | 2           | 0.7                         | 200                             | 4.2 @ 5V       | SO8 e-pad                   |
| <b>Micropower</b>                     |                                                             |                   |                     |                |                |                |                                             |                                      |                                 |             |                             |                                 |                |                             |
| TS931/2/4                             | Micropower amplifier with CMOS inputs                       | -40 to 85         | 1/2/4               | Single S-/ RR  | 2.7            | 5              | 20                                          | 5                                    | 0.15                            | 0.1         | 0.05                        | 1.5                             | 2.99 @ 3V      | DIP, SO, TSSOP, SOT23       |
| TS941/2/4                             | Ultra-micropower amplifier with CMOS inputs                 |                   |                     |                |                |                | 1.2                                         |                                      |                                 | 0.01        | 0.004                       | 1.5                             |                |                             |
| <b>Low noise</b>                      |                                                             |                   |                     |                |                |                |                                             |                                      |                                 |             |                             |                                 |                |                             |
| TS461/2/4                             | TS321, LM324, LM358 replacement in low-voltage applications | -20 to 70         | 1/2/4               | STD /RR        | 2.7            | 12             | 2000                                        | 5                                    | 750                             | 12          | 4                           | 1.5                             | 2.4 @ 2.5V     | DIP, SO, TSSOP, SOT23, DFN8 |
| TS971/2/4                             | High performance, for battery powered applications          |                   |                     |                |                |                |                                             |                                      |                                 |             |                             |                                 |                |                             |

RR = rail-to-rail

Single S = single supply (+ positive rail, - negative rail)

STD = standard

## High-speed op-amps

| Part number             | General description                                                | Operating temp °C | Number of operators | Supply current I <sub>cc</sub> typ mA | Supply voltage        |                       | Input offset voltage V <sub>io</sub> max mV | GBP typ MHz | Slew rate SR typ V/μs | Input equivalent noise nV/√Hz | Rail-to-rail |
|-------------------------|--------------------------------------------------------------------|-------------------|---------------------|---------------------------------------|-----------------------|-----------------------|---------------------------------------------|-------------|-----------------------|-------------------------------|--------------|
|                         |                                                                    |                   |                     |                                       | V <sub>cc</sub> min V | V <sub>cc</sub> max V |                                             |             |                       |                               |              |
| <b>Voltage feedback</b> |                                                                    |                   |                     |                                       |                       |                       |                                             |             |                       |                               |              |
| TSH70                   | Wide band video op-amp in SO23-5                                   | 0/70              | 1                   | 7.2                                   | 3                     | 12                    | 10                                          | 100         | 100                   | 8                             | Yes          |
| TSH71                   | Wide band video op-amp with standby mode                           | 0/70              | 1                   | 7.2                                   | 3                     | 12                    | 10                                          | 100         | 100                   | 8                             | Yes          |
| TSH72/4                 | Dual wide band video op-amp                                        | 0/70              | 2/4                 | 7.2                                   | 3                     | 12                    | 10                                          | 100         | 100                   | 8                             | Yes          |
| TSH73/5                 | Triple wide band video op-amp with standby mod                     | 0/70              | 3/4                 | 7.2                                   | 3                     | 12                    | 10                                          | 100         | 100                   | 8                             | Yes          |
| TSH80/1/2               | Wide band rail-to-rail operational amplifier with standby function | -40/85            | 1/2                 | 8.2                                   | 4.5                   | 12                    | 10                                          | 100         | 100                   | 8                             | Yes          |
| TSH93/4/5               | Video amplifier                                                    | -40/125           | 3/4                 | 4.5                                   | 7                     | 12                    | 4                                           | 150         | 110                   | 4.2                           |              |

| Part number              | General description                                           | Operating temp °C | Number of operators | Supply current I <sub>cc</sub> typ mA | Supply voltage        |                       | Input offset voltage V <sub>io</sub> max mV | Bandwidth   |           | Slew rate SR typ V/μs | Input equivalent noise nV/√Hz | Rail-to-rail |
|--------------------------|---------------------------------------------------------------|-------------------|---------------------|---------------------------------------|-----------------------|-----------------------|---------------------------------------------|-------------|-----------|-----------------------|-------------------------------|--------------|
|                          |                                                               |                   |                     |                                       | V <sub>cc</sub> min V | V <sub>cc</sub> max V |                                             | Gain        | MHz       |                       |                               |              |
| <b>Current feedback</b>  |                                                               |                   |                     |                                       |                       |                       |                                             |             |           |                       |                               |              |
| TSH110/1/2/3/4           | Wide band, low noise video op-amp                             | -40/85            | 1/2/3/4             | 3                                     | 5                     | 12                    | 3                                           | 1           | 100       | 450                   | 3                             |              |
| TSH330                   | 1.1GHz low noise op-amp                                       | -40/85            | 1                   | 16.6                                  | 4.5                   | 5.5                   | 7                                           | 2           | 1100      | 1800                  | 1.3                           |              |
| TSH350                   | Wide band, low noise video op-amp                             | -40/85            | 1                   | 4.1                                   | 4.5                   | 5.5                   | 4                                           | 1           | 550       | 940                   | 1.5                           |              |
| TSH310                   | 400 mA high-speed op-amp                                      | -40/85            | 1                   | 0.4                                   | 4.5                   | 5.5                   | 6.5                                         | 2           | 120       | 115                   | 7.5                           |              |
| <b>ADSL line drivers</b> |                                                               |                   |                     |                                       |                       |                       |                                             |             |           |                       |                               |              |
| TS612                    | ADSL line driver with standby mode                            | -40/85            | 2                   | 14                                    | 7                     | 12                    | 6                                           | 4           | 32        | 40                    | 3                             |              |
| TS613                    | ADSL line driver                                              | -40/85            | 2                   | 11                                    | 7                     | 12                    | 6                                           | 4           | 32        | 40                    | 3                             |              |
| TS615                    | ADSL line driver with standby mode (short circuited output)   | -40/85            | 2                   | 11.9                                  | 5                     | 12                    | 6                                           | 4           | 40        | 410                   | 2.5                           | Yes          |
| TS616                    | Dual wide band operational amplifier with high output current | -40/85            | 2                   | 11.9                                  | 5                     | 12                    | 6                                           | 4           | 40        | 410                   | 2.5                           | Yes          |
| <b>VGA</b>               |                                                               |                   |                     |                                       |                       |                       |                                             |             |           |                       |                               |              |
| TS652                    | Differential variable gain amplifier with standby mode        | -40/85            | Differential        | 28                                    | 5                     | 12                    | 6                                           | -0.35<br>30 | 110<br>18 | 100                   | 4.5                           |              |

## High-temperature op-amps and comparators

| Part number                   | General description                                 | Operating temp °C | Number of operators | Supply current I <sub>cc</sub> typ mA | Supply voltage V <sub>cc</sub> max V | Input offset voltage V <sub>io</sub> max mV | GBP typ MHz | Response time μs |
|-------------------------------|-----------------------------------------------------|-------------------|---------------------|---------------------------------------|--------------------------------------|---------------------------------------------|-------------|------------------|
| <b>Voltage comparators</b>    |                                                     |                   |                     |                                       |                                      |                                             |             |                  |
| LM2901H                       | High-temperature, low-power quad voltage comparator | -40/150°C         | 4                   | 275                                   | 36                                   | 7                                           |             | 1.3              |
| LM2903H                       | High-temperature, low-power dual voltage comparator | -40/150°C         | 2                   | 200                                   | 36                                   | 7                                           |             | 1.3              |
| <b>Operational amplifiers</b> |                                                     |                   |                     |                                       |                                      |                                             |             |                  |
| LM2904WH                      | High-temperature, dual general-purpose op-amp       | -40/150°C         | 2                   | 350                                   | 32                                   | 7                                           | 1.1         |                  |
| TS922H                        | High-temperature dual low-noise rail-to-rail op-amp | -40/150°C         | 2                   | 1000                                  | 12                                   | 3                                           | 4           |                  |

## Low noise op-amps

| Part number | General description                        | Operating temp °C | Number of operators | Supply current I <sub>cc</sub> typ mA | Supply voltage        |                       | Input offset voltage V <sub>io</sub> max mV | GBP typ MHz | Slew rate SR typ V/μs | Output current I <sub>out</sub> typ mA | Input equivalent noise nV/√Hz |
|-------------|--------------------------------------------|-------------------|---------------------|---------------------------------------|-----------------------|-----------------------|---------------------------------------------|-------------|-----------------------|----------------------------------------|-------------------------------|
|             |                                            |                   |                     |                                       | V <sub>cc</sub> min V | V <sub>cc</sub> max V |                                             |             |                       |                                        |                               |
| LM833       | Very low noise and low distortion (0.002%) | -40 to 105        | 2                   | 2000                                  | 5                     | 30                    | 5                                           | 15          | 7                     | 20                                     | 4.5                           |
| LS204/LS404 | Low noise and low distortion (0.01%)       | 0 to 70           | 2/4                 | 350                                   | 36                    | 2.5                   | 1.1                                         | 0.6         | 23                    |                                        | 10                            |
| MC33078/9   | Very low noise and low distortion (0.002%) | -40 to 105        | 2/4                 | 2000                                  | 5                     | 30                    | 2/2.5                                       | 15          | 7                     | 29                                     | 4.5                           |
| MC4558      | Very low noise and low distortion (0.008%) | 0 to 70           | 2                   | 1150                                  | 4                     | 44                    | 5                                           | 5.5         | 2.2                   | 20                                     | 12                            |
| TDA2320     | Stereo preamplifier single supply          | -40 to 105        | 2                   | 2000                                  | 36                    | 5                     | 2.1                                         | 2           |                       |                                        | 9                             |

## Precision op-amps

| Part number | General description                                        | Operating temp °C | Number of operators | Supply current I <sub>cc</sub> typ µA | Supply voltage        |                       | Input offset voltage V <sub>io</sub> max mV | GBP typ MHz | Slew rate SR typ V/µs | Output current I <sub>out</sub> typ mA |
|-------------|------------------------------------------------------------|-------------------|---------------------|---------------------------------------|-----------------------|-----------------------|---------------------------------------------|-------------|-----------------------|----------------------------------------|
|             |                                                            |                   |                     |                                       | V <sub>cc</sub> min V | V <sub>cc</sub> max V |                                             |             |                       |                                        |
| OP07        | Very low offset, bipolar op-amp                            | -40 to 105        | 1                   | 5000                                  | 6                     | 30                    | 0.15                                        | 0.5         | 0.17                  |                                        |
| TEB1033     | Low noise and distortion (8nV/√Hz and 0.008%)              | 0 to 70           | 2                   | 500                                   | 6                     | 30                    | 1                                           | 2           | 1                     | 23                                     |
| TS512/4     | Low noise and distortion (8nV/√Hz and 0.03%)               | -40 to 125        | 2/4                 | 300                                   | 6                     | 30                    | 2.5                                         | 3           | 1.5                   | 23/13                                  |
| TS522/4     | Very low noise suitable for audio applications (4.5nV/√Hz) | -40 to 125        | 2/4                 | 2000                                  | 5                     | 30                    | 0.85                                        | 15          | 7                     | 29                                     |
| TS507       | High precision, input/output rail to rail op-amp           | -40 to 85         | 1                   | 850                                   | 2.7                   | 5.5                   | 60                                          | 2.2         | 0.65                  | 50                                     |

## High-temperature op-amps and comparators

| Part number                   | General description                                  | Operating temp °C | Number of operators | Supply current I <sub>cc</sub> typ µA | Supply voltage V <sub>cc</sub> max V | Input offset voltage V <sub>io</sub> max mV | GBP typ MHz | Response time µs |
|-------------------------------|------------------------------------------------------|-------------------|---------------------|---------------------------------------|--------------------------------------|---------------------------------------------|-------------|------------------|
| <b>Voltage comparators</b>    |                                                      |                   |                     |                                       |                                      |                                             |             |                  |
| LM2901H                       | High-temperature, low-power quad voltage comparator  | -40/150           | 4                   | 275                                   | 36                                   | 7                                           |             | 1.3              |
| LM2903H                       | High-temperature, low-power dual voltage comparator  | -40/150           | 2                   | 200                                   | 36                                   | 7                                           |             | 1.3              |
| <b>Operational amplifiers</b> |                                                      |                   |                     |                                       |                                      |                                             |             |                  |
| LM2904WH                      | High-temperature, dual general-purpose op-amp        | -40/150           | 2                   | 350                                   | 32                                   | 7                                           | 1.1         |                  |
| TS922H                        | High-temperature, dual low-noise rail-to-rail op-amp | -40/150           | 2                   | 1000                                  | 12                                   | 3                                           | 4           |                  |

## General purpose op-amps

| Part number   | General description                                                  | Number of operators | Supply current I <sub>cc</sub> typ/ operator µA | Supply voltage V <sub>cc</sub> max V | Input offset voltage V <sub>io</sub> max mV | GBP typ MHz | Slew rate SR typ V/µs | Output current I <sub>out</sub> typ mA |
|---------------|----------------------------------------------------------------------|---------------------|-------------------------------------------------|--------------------------------------|---------------------------------------------|-------------|-----------------------|----------------------------------------|
| LF247/347     | JFET inputs, low input bias and offset current, (15nV/√Hz and 0.01%) | 4                   | 1400                                            | 36                                   | 10                                          | 4           | 16                    | 40                                     |
| LF253/353     |                                                                      | 2                   | 1400                                            | 36                                   | 10                                          | 4           | 16                    | 40                                     |
| LF351         |                                                                      | 1                   | 1400                                            | 36                                   | 10                                          | 4           | 16                    | 40                                     |
| LM124/224/324 | Low power, low input bias current                                    | 4                   | 170/400                                         | 30                                   | 5/7                                         | 1.3         | 0.4                   | 40                                     |
| LM148/248/348 | Four UA741                                                           | 4                   | 500                                             | 44                                   | 5                                           | 1.3         | 0.5                   | 25                                     |
| LM158/258/358 | Low input bias current                                               | 2                   | 350                                             | 32                                   | 3/7                                         | 1           | 0.6                   | 40                                     |
| LM201A/301A   | Input and output overload protection, low input offset current       | 1                   | 1800                                            | 44                                   | 2/7.5                                       | 1           | 0.5                   | 30                                     |
| LM246/346     | Programmable amplifier                                               | 4                   | 250                                             | 44                                   | 3/5                                         | 1           | 0.5                   | 20                                     |
| LM2902/4      | Low power, bipolar op-amp                                            | 4/2                 | 170/400                                         | 32                                   | 7                                           | 1.3         | 0.4                   | 40                                     |
| MC1458/1558   | Wide input common mode voltage range                                 | 2                   | 1150                                            | 44                                   | 5                                           | 1           | 0.8                   | 20                                     |
| MC3303/3403   | Quad enhanced UA741 version with lower consumption                   | 4                   | 700                                             | 36                                   | 5                                           | 1           | 0.5                   | 30                                     |
| MC33171/2/4   | Low consumption versus speed                                         | 1/2/4               | 200                                             | 44                                   | 4.5/5                                       | 2.1         | 2                     | 6                                      |
| TL061/2/4     | JFET inputs, low input bias current                                  | 1/2/4               | 200                                             | 36                                   | 6/15                                        | 1           | 3.5                   | 20                                     |
| TL071/2/4     |                                                                      | 1/2/4               | 1400                                            | 36                                   | 10                                          | 4           | 16                    | 20                                     |
| TL081/2/4     |                                                                      | 1/2/4               | 1400                                            | 36                                   | 10                                          | 4           | 16                    | 20                                     |
| TS271         | Micropower, programmable op-amp                                      | 1                   | 10/150/800                                      | 16                                   | 10/5/2                                      | 0.1/0.7/2.3 | 0.04/0.6/4.5          | 60                                     |
| TS272/4       | Micropower, wide range of input offset voltage                       | 2/4                 | 1000                                            | 16                                   | 10/5/2                                      | 3.5         | 5.5                   | 60                                     |
| TS27L2/4      |                                                                      | 2/4                 | 10                                              | 16                                   | 10/5/2                                      | 0.1         | 0.04                  | 60                                     |
| TS27M2/4      |                                                                      | 2/4                 | 150                                             | 16                                   | 10/5/2                                      | 1           | 0.6                   | 60                                     |
| TS321         | Single LM324, LM358 enhanced version with lower supply voltage       | 1                   | 500/600                                         | 30                                   | 4/2                                         | 0.8         | 0.4                   | 40                                     |
| TSH22/4       | Very low distortion (0.003% at f=1kHz)                               | 2/4                 | 2150                                            | 30                                   | 2.5                                         | 25          | 15                    | 37                                     |
| UA741         | Wide applications range                                              | 1                   | 1700                                            | 44                                   | 5                                           | 1           | 0.5                   | 25                                     |
| UA748         |                                                                      | 1                   | 1800                                            | 44                                   | 2                                           | 1           | 0.5                   | 30                                     |

Under development. Electrical characteristics to be confirmed

## Comparators

| Part number            | General description                                  | Number of operators | Technology | Supply current $I_{CC}$ typ $\mu$ A | Supply voltage $V_{CC}$ max V | Input offset voltage $V_{IO}$ max mV | Response time $\mu$ s |
|------------------------|------------------------------------------------------|---------------------|------------|-------------------------------------|-------------------------------|--------------------------------------|-----------------------|
| <b>Micropower</b>      |                                                      |                     |            |                                     |                               |                                      |                       |
| <b>TS339</b>           | Open drain - micropower                              | 4                   | CMOS       | 9                                   | 16                            | 5                                    | 1.5                   |
| <b>TS3702</b>          | Push-pull - micropower                               | 2                   | CMOS       | 9                                   | 16                            | 5                                    | 1.5                   |
| <b>TS3704</b>          | Push-pull - micropower                               | 4                   | CMOS       | 9                                   | 16                            | 5                                    | 1.2                   |
| <b>TS393</b>           | Open drain - micropower                              | 2                   | CMOS       | 10                                  | 16                            | 5                                    | 1.5                   |
| <b>TS7211</b>          | Rail-to-rail inputs, push-pull outputs - micropower  | 1                   | BiCMOS     | 6                                   | 10                            | 7                                    | 0.5                   |
| <b>TS7221</b>          | Rail-to-rail inputs, open drain outputs - micropower | 1                   | BiCMOS     | 6                                   | 10                            | 7                                    | 0.5                   |
| <b>TS861</b>           | Rail-to-rail inputs, push-pull outputs - micropower  | 1                   | BiCMOS     | 6                                   | 10                            | 7                                    | 0.5                   |
| <b>TS862</b>           | Rail-to-rail inputs, push-pull outputs - micropower  | 2                   | BiCMOS     | 6                                   | 10                            | 7                                    | 0.5                   |
| <b>TS864</b>           | Rail-to-rail inputs, push-pull outputs - micropower  | 4                   | BiCMOS     | 6                                   | 10                            | 7                                    | 0.5                   |
| <b>General purpose</b> |                                                      |                     |            |                                     |                               |                                      |                       |
| <b>LM2901</b>          | Open collector - low power                           | 4                   | BIPOLAR    | 275                                 | 36                            | 7                                    | 1.3                   |
| <b>LM2903</b>          | Open collector - low power                           | 2                   | BIPOLAR    | 200                                 | 36                            | 7                                    | 1.3                   |
| <b>LM311</b>           | Open emitter and collector                           | 1                   | BIPOLAR    | 5000                                | 36                            | 7.5                                  | 0.2                   |
| <b>LM319</b>           | High-speed                                           | 2                   | BIPOLAR    | 8000                                | 36                            | 8                                    | 0.08                  |
| <b>LM339</b>           | Open collector - low power                           | 4                   | BIPOLAR    | 275                                 | 36                            | 2                                    | 1.3                   |
| <b>LM393</b>           | Open collector - low power                           | 2                   | BIPOLAR    | 200                                 | 36                            | 5                                    | 1.3                   |
| <b>TS372</b>           | Open drain - low power                               | 2                   | CMOS       | 150                                 | 16                            | 10                                   | 0.6                   |
| <b>TS374</b>           | Open drain - low power                               | 4                   | CMOS       | 150                                 | 16                            | 10                                   | 0.6                   |
| <b>TS391</b>           | Open collector - low power                           | 1                   | BIPOLAR    | 200                                 | 36                            | 5                                    | 1.3                   |

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