# MSK

**M.S.KENNEDY CORP.**

# HIGH SPEED/HIGH VOLTAGE NEGATIVE OUTPUT VIDEO AMPLIFIER

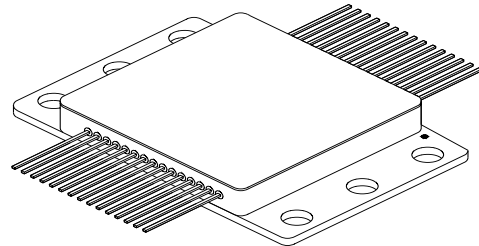# 1903 SERIES

4707 Dey Road  Liverpool, N.Y. 13088

(315) 701-6751

*MIL-PRF-38534 CERTIFIED*

## FEATURES:

- 100V$_{PP}$ Output Signal Into 10$_{PF}$
- Ultra Fast Transition Times-2.9nS
- User Adjustable Contrast and Brightness
- TTL Compatible Blanking
- On Board DC Reference Output
- Customized Versions Available Upon Request
- Available to DSCC SMD 5962-9324301HX

## DESCRIPTION:

The MSK 1903 Series of high speed, high voltage video amplifiers was designed to drive the grid of today's high performance CRT's. The MSK 1903 has user adjustable contrast and brightness levels and also comes with a blanking function. The MSK 1903 can be directly connected to many video sources including RS170, RS343 and high speed video D/A converters. The MSK 1903 is available in four versions for different applications. The MSK 1903-0 has no internal high voltage resistor or inductor allowing the user to dissipate much of the power externally. The MSK 1903-2, MSK 1903-4 and the MSK 1903-6 each have an internal resistor-inductor designed for optimum bandwidth. The MSK 1903-6 has slightly lower bandwidth but can be operated from down to -120V. Each version of the MSK 1903 is packaged in a 30 pin power flatpack that can be directly connected to a heat sink using standard 4-40 screws.

## EQUIVALENT SCHEMATIC
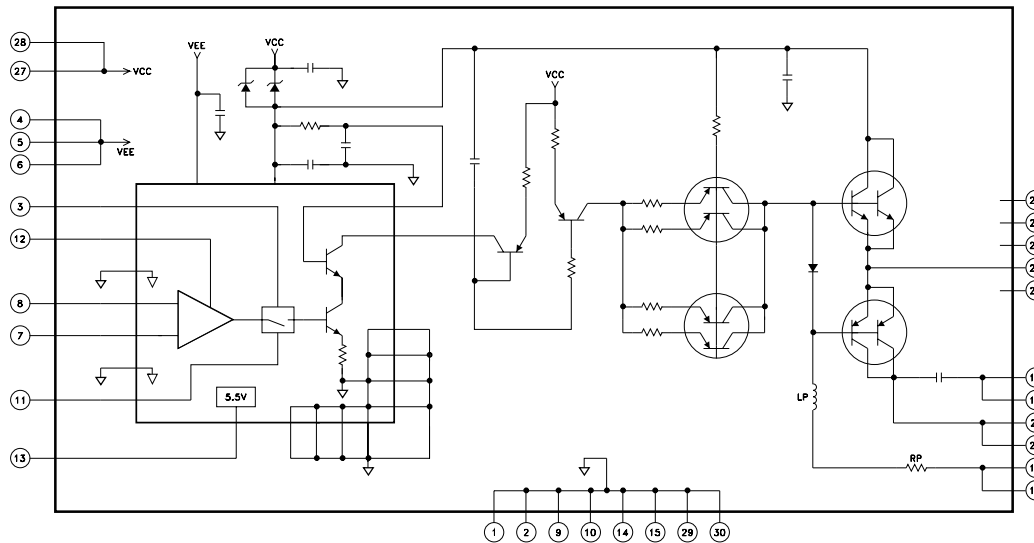


## TYPICAL APPLICATIONS

- Helmet Mounted Displays
- High Resolution RGB Displays
- High Resolution Monochrome Displays
- Automatic Test Equipment
- Beam Index Applications
- Projection Displays

## PIN-OUT INFORMATION

| | | | | | |
|---|---|---|---|---|---|
| 1 | GND | 11 | V$_{GAIN}$ | 21 | -V$_{HV}$ |
| 2 | GND | 12 | V$_{OFF}$ | 22 | NC |
| 3 | Blank | 13 | V$_{REF}$ | 23 | NC |
| 4 | V$_{EE}$ | 14 | GND | 24 | Output |
| 5 | V$_{EE}$ | 15 | GND | 25 | NC |
| 6 | V$_{EE}$ | 16 | -V$_{HV}$ RES | 26 | NC |
| 7 | -Input | 17 | -V$_{HV}$ RES | 27 | V$_{CC}$ |
| 8 | +Input | 18 | GND | 28 | V$_{CC}$ |
| 9 | GND | 19 | GND | 29 | GND |
| 10 | GND | 20 | -V$_{HV}$ | 30 | GND |

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## ABSOLUTE MAXIMUM RATINGS

| | | |
|---|---|---|
| -V$_{HV}$ | High Voltage Supply (1903-0) | -95V |
| | (1903-2) | -95V |
| | (1903-4) | -75V |
| | (1903-6) | -120V |
| +V$_{CC}$ | Positive Supply Voltage | +22V |
| -V$_{EE}$ | Negative Supply Voltage | -12V |
| V$_{IN}$ | Differential Input Voltage | 2V |
| V$_{IC}$ | Common Mode Input Voltage | ±2V |
| V$_{GAIN}$ | Gain Adjust Input Voltage | -0.6 to +6V |
| V$_{OFF}$ | Offset Adjust Input Voltage | -0.6 to +6V |
| V$_{BLANK}$ | Blank Input Voltage | -0.6 to +6V |
| I$_{REF}$ | Reference Output Current | 5mA |
| T$_{ST}$ | Storage Temperature Range | -65°C to +150°C |
| T$_{LD}$ | Lead Temperature Range (10 Seconds) | 300°C |
| T$_J$ | Junction Temperature | 175°C |
| I$_{RP}$ | Current Through Rp | 290mA |
| T$_C$ | Case Operating Temperature Range (All Devices B/E Suffix) | -55°C to +125°C |
| | (All Devices No Suffix) | -40°C to +85°C |

## ELECTRICAL SPECIFICATIONS

| Parameter | Test Conditions ① | Group A Subgroup | MSK1903-0 Min. Typ. Max. | | | MSK1903-2 Min. Typ. Max. | | | MSK1903-4 Min. Typ. Max. | | | MSK1903-6 Min. Typ. Max. | | | Units |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **STATIC** | | | | | | | | | | | | | | | |
| Quiescent Current | V$_{CM}$=0V @ +20V ⑧ | 1,2,3 | - | 75 | 100 | - | 75 | 100 | - | 75 | 100 | - | 75 | 100 | mA |
| | V$_{CM}$=0V @ -10.5V | 1,2,3 | - | -75 | -100 | - | -75 | -100 | - | -75 | -100 | - | -75 | -100 | mA |
| High Voltage Supply ② ③ | T$_C$ ≤ 125°C | - | -30 | -90 | -95 | -30 | -90 | -95 | -30 | -70 | -75 | -50 | -100 | -120 | V |
| Thermal Resistance to Case ② | Junction to Case | - | - | 32 | 35 | - | 32 | 35 | - | 32 | 35 | - | 32 | 35 | °C/W |
| **INPUT** | | | | | | | | | | | | | | | |
| Input Bias Current | V$_{CM}$=0V | 1 | - | ±1 | ±50 | - | ±1 | ±50 | - | ±1 | ±50 | - | ±1 | ±50 | µA |
| | | 2,3 | - | ±5 | ±250 | - | ±5 | ±250 | - | ±5 | ±250 | - | ±5 | ±250 | µA |
| Blank Input Current | V$_{BLANK}$=0.4V | 1 | - | 500 | 600 | - | 500 | 600 | - | 500 | 600 | - | 500 | 600 | µA |
| | V$_{BLANK}$=2.4V | 1 | - | 300 | 400 | - | 300 | 400 | - | 300 | 400 | - | 300 | 400 | µA |
| Offset Adjust Input Current | V$_{OFF}$=1V | 1 | - | 2 | 10 | - | 2 | 10 | - | 2 | 10 | - | 2 | 10 | µA |
| Gain Adjust Input Current | V$_{GAIN}$=5V | 1 | - | 2 | 10 | - | 2 | 10 | - | 2 | 10 | - | 2 | 10 | µA |
| Blank Input Pulse Width ② | Normal Operation | - | 30 | - | - | 30 | - | - | 30 | - | - | 30 | - | - | nS |
| Common Mode Rejection Ratio | V$_{CM}$ = ±0.5V F=10Hz | - | - | 40 | - | - | 40 | - | - | 40 | - | - | 40 | - | dB |
| Input Impedance ② | Either Input F=DC | - | 10 | 20 | - | 10 | 20 | - | 10 | 20 | - | 10 | 20 | - | KΩ |
| Input Capacitance | Either Input | - | - | 2 | - | - | 2 | - | - | 2 | - | - | 2 | - | pF |
| Blank Mode Input Rejection ΔV ② ③ | V$_{BLANK}$=2.4V V$_{IN}$=0.3V ΔV=V$_{HV}$-V$_{OUT}$ | - | - | - | ±2xRp | - | - | ±2xRp | - | - | ±2xRp | - | - | ±2xRp | mV |
| Gain Adjust Rejection ΔV ② ③ | ΔV$_{GAIN}$=5V | - | - | - | ±10xRp | - | - | ±10xRp | - | - | ±10xRp | - | - | ±10xRp | mV |
| Power Supply Rejection Ratio② | +V$_{CC}$ and -V$_{EE}$=Nom ±5% | - | 25 | 30 | - | 25 | 30 | - | 25 | 30 | - | 25 | 30 | - | dB |
| Internal Rp ② ③ | | - | - | 0 | - | 380 | 400 | 420 | 190 | 200 | 210 | 380 | 400 | 420 | Ω |
| **OUTPUT** | | | | | | | | | | | | | | | |
| Reference Output Voltage | I$_{OUT}$<2mA | 1,2,3 | 5.2 | 5.5 | 5.8 | 5.2 | 5.5 | 5.8 | 5.2 | 5.5 | 5.8 | 5.2 | 5.5 | 5.8 | V |
| ΔV Blank Mode | ΔV=V$_{HV}$-V$_{OUT}$ V$_{OFF}$=1V V$_{BLANK}$=2.4V V$_{GAIN}$=5V | 1,2,3 | -3xRp | Rp | 3xRp | -3xRp | Rp | 3xRp | -3xRp | Rp | 3xRp | -3xRp | Rp | 3xRp | mV |
| ΔV Min Offset | ΔV=V$_{HV}$-V$_{OUT}$ V$_{OFF}$=0V V$_{GAIN}$=3V | 1,2,3 | 0 | 3 | 10 | 0 | 3 | 10 | 0 | 3 | 6 | 0 | 3 | 10 | V |
| ΔV Max Offset | ΔV=V$_{HV}$-V$_{OUT}$ V$_{OFF}$=5V | 1 | 32 | 42 | 52 | 32 | 42 | 52 | 16 | 21 | 26 | 32 | 42 | 52 | V |
| | | 2,3 | 28 | 42 | 56 | 32 | 42 | 52 | 16 | 21 | 26 | 32 | 42 | 52 | V |
| Voltage Gain | V$_{IN}$=0.6V F=10KHz V$_{GAIN}$=3V Both Inputs | 4 | 72 | 110 | 138 | 72 | 110 | 138 | 36 | 55 | 68 | 72 | 120 | 145 | V/V |
| Output Voltage High | V$_{GAIN}$=3V F=10KHz | 4 | -85 | -88 | - | -85 | -88 | - | -65 | -68 | - | -95 | -98 | - | V |
| Output Voltage Low | V$_{GAIN}$=3V F=10KHz | 4 | - | -1 | -5 | - | -1 | -5 | - | -1 | -5 | - | -1 | -5 | V |
| Transition Times | V$_{IN}$=0.6V V$_{OUT}$=Max TR=TF<1nS | 4 | - | 4.2 | 6.0 | - | 3.8 | 5.5 | - | 2.9 | 4.0 | - | 6.5 | 10 | nS |
| Linearity Error ② | V$_{GAIN}$=4V V$_{OFF}$=1V V$_{CM}$=0.5V | - | - | - | ±2 | - | - | ±2 | - | - | ±2 | - | - | ±2 | %GS |
| Gain Linearity ② | V$_{OFF}$=1V V$_{IN}$=0.2V V$_{CM}$=0.5V | - | - | - | ±2 | - | - | ±2 | - | - | ±2 | - | - | ±2 | % |
| Thermal Distortion ② | | - | - | - | ±2 | - | - | ±2 | - | - | ±2 | - | - | ±2 | %GS |

## NOTES:

① +V$_{CC}$ = +20V, -V$_{EE}$ = -10.5V, V$_{BLANK}$=0.4V V$_{GAIN}$ = V$_{OFF}$ = ±V$_{IN}$ = 0V, C$_L$=10pF, V$_{HV}$=typical value and T$_C$=25°C unless otherwise specified.

② Guaranteed by design but not tested. Typical parameters are representative of actual device performance but are for reference only.

③ R$_P$=Internal R$_P$ except MSK 1903-0. External value = 400Ω unless otherwise specified for the MSK 1903-0.

④ Industrial grade and "E" suffix devices shall be tested to subgroups 1 and 4 unless otherwise specified.

⑤ Military grade devices ("B" suffix) shall be 100% tested to subgroups 1,2,3 and 4.

⑥ Subgroups 5 and 6 testing available upon request.

⑦ Subgroup 1,4 T$_A$=T$_C$= +25°C
   2,5 T$_A$=T$_C$= +125°C
   3,6 T$_A$=T$_C$=-55°C

⑧ Does not include output current referenced to +V$_{CC}$.

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## POWER SUPPLIES

The input stage of the MSK 1903 requires power supplies of +20V and -10.5V for optimum performance. The negative power supply can be increased to -12V if -10.5V is not available, but additional power dissipation will cause the internal temperature to rise. Both low voltage power supplies should be effectively decoupled with tantalum capacitors (at least 4.7$\mu$F) connected as close to the amplifier's pins as possible. The MSK 1903 has internal 0.01$\mu$F capacitors that also improve high frequency performance. In any case, it is also recommended to put 0.1$\mu$F decoupling capacitors on the +20V and -10.5V supplies as well.

The high voltage power supply (-V$_{HV}$) is connected to the amplifier's output stage and must be kept as stable as possible. The internal or external Rp is connected to -V$_{HV}$ and as such, the amplifier's DC output is directly related to the high voltage value. The -V$_{HV}$ pins of the hybrid should be decoupled to ground with as large a capacitor as possible to improve output stability.

## SUPPLY SEQUENCING

The power supply sequence is -V$_{HV}$, V$_{CC}$, V$_{EE}$ followed by the other DC control inputs. If power supply sequencing is not possible, the time difference between each supply should be less than five milliseconds. If the DC control signals are being generated from a low impedance source other than the V$_{REF}$ output, reverse biased diodes should be connected from each input (V$_{GAIN}$, V$_{OFF}$) to the +V$_{CC}$ pin. This will protect the inputs until +V$_{CC}$ is turned on.

## VIDEO OUTPUT

When power is first applied and V$_{IN}$ = V$_{GAIN}$ = V$_{OFF}$ = 0V, the output will be practically at the -V$_{HV}$ rail voltage. The output voltage is a function of the value of Rp and also the V$_{GAIN}$ and V$_{OFF}$ DC inputs. The maximum output voltage swing for any of the MSK 1903 variants is determined by Vpp = (250mA) x (Rp). The bandwidth of the amplifier largely depends on both Rp and Lp.

Hybrid pins 16 and 17 are directly connected to Rp. Additional external resistance can be added to reduce power dissipation, but slower transition times will result. If an additional resistor is used, it must be low capacitive and the layout should minimize capacitive coupling to ground (ie: no ground plane under Rp).

The MSK 1903 Series is conservatively specified with low values for Lp which yield about 5% overshoot. Additional peaking can be obtained by using a high self-resonant frequency inductor in series with the Rp pins. Since this value of inductance can be very dependent on circuit layout, it is best to determine its value by experimentation. A good starting point is typically 0.47$\mu$H for the MSK 1903-0 and 0.0047$\mu$H for the remaining devices.

If external resistors or inductors are not used, be sure to connect high frequency bypass capacitors directly from pins 16 and 17 to ground.

## VIDEO INPUTS

The video input signals should be kept below ±2V$_{MAX}$ total, including both common mode offset and signal levels. The input structure of the MSK 1903 was designed for ±0.714Vpp RS343 signals. If either input is not used it should be connected directly to the analog ground or through a 25$\Omega$ resistor to ground if input offset currents are to be minimized.

## OUTPUT PROTECTION

The output pin of the MSK 1903 should be protected from transients by connecting reverse biased ultra-low capacitance diodes from the output pin to both -V$_{HV}$ and ground. The output can also be protected from arc voltages by inserting a small value (50-100$\Omega$) resistor in series with the amplifier. This resistor will reduce system bandwidth along with the load capacitance, but a series inductor can reduce the problem substantially.

## V$_{GAIN}$ CONTROL INPUT

The V$_{GAIN}$ control (contrast) input is designed to allow the user to vary the video gain. By simply applying a DC voltage from 0V to V$_{REF}$, the video gain can be linearly adjusted from 0 to 80V/V. The V$_{GAIN}$ input should be connected to the V$_{REF}$ pin through a 5K$\Omega$ pot to ground. For convenient stable gain adjustment, a 0.1$\mu$F bypass capacitor should be connected near the V$_{GAIN}$ input pin to prevent output instability due to noisy sources. Digital gain control can be accomplished by connecting a D/A converter to the V$_{GAIN}$ pin. However, some temperature tracking performance may be lost when using an external DC voltage source other than V$_{REF}$ for gain adjustment.

The overall video output of the MSK 1903 can be characterized using the following expression:

$$Vpp = V_{HV} - V_{OUT}$$

$$V_{HV} - V_{OUT} = (V_{IN})(V_{GAIN})(0.1)(Rp)(0.9)$$

Here is a sample calculation for the MSK 1903-2:
Given information:

- V$_{IN}$ = 0.7V
- V$_{GAIN}$ = 1VDC
- Rp = 400$\Omega$ (internal)
- V$_{HV}$ = 100VDC

$$V_{HV} - V_{OUT} = (0.7V)(1V)(0.1)(400\Omega)(0.9)$$
$$V_{HV} - V_{OUT} = 25.2V \text{ Nominal}$$

The expected video output would swing from approximately -80V to -54.8V assuming that V$_{OFF}$ = 0V. This calculation should be used as a nominal result because the overall gain may vary as much as ±20% due to internal high speed device variations. Changing ambient conditions can also effect the video gain of the amplifier by as much as 150 PPM/°C. It is wise to connect all video amplifiers to a common heat sink to maximize thermal tracking when multiple amplifiers are used in applications such as RGB systems. Additionally, only one of the V$_{REF}$ outputs should be shared by all three amplifiers. This voltage should be buffered with a suitable low drift op-amp for best tracking performance.

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## V_OFF CONTROL INPUT

The brightness (output offset) can be linearly adjusted by applying a 0 to $V_{REF}$ DC voltage to the $V_{OFF}$ input pin. The output quiescent voltage range is from approximately (5μA) (Rp) to (100mA) (Rp) from -$V_{HV}$. This control voltage is normally generated by connecting the $V_{OFF}$ control pin to a 5K potentiometer between $V_{REF}$ and ground. The $V_{OFF}$ input pin should be bypassed with a 0.1μF capacitor to ground placed as close as possible to the hybrid. This DC voltage can be any stable system source.

Keep hybrid power dissipation in mind when adjusting the output quiescent voltage. Practically all of the voltage is seen across Rp. This power must be taken into account when high Rp currents are used. If the quiescent level is set too close to -$V_{HV}$, the power dissipation will be minimal but the rise time will suffer slightly. If the quiescent level is set too far from -$V_{HV}$, the power dissipation will increase dramatically and the output fall time will be limited. The output black level is obviously dependent on system requirements but a little experimentation will strike the optimum balance between power dissipation and bandwidth. Total current through Rp should be limited to less than 290mA when operating from power supplies greater than 90V. The gain adjust alone can set the AC current to 250mA (ie: 250mApp = 100Vpp/400Ω). This would leave about 40mA left for black level output current.

## BLANK INPUT

The video input can be electrically disconnected from the amplifier by applying a TTL high input to the blank pin. When this occurs, the output will be set to approximately -$V_{HV}$. The $V_{GAIN}$ and $V_{OFF}$ control pins have little or no effect on the output when it is in blank mode.

When the TTL compatible blank input is not used, the pin must be connected to ground to enable the amplifier. The blank input will float high when left disconnected which will disable the video.

## V_REF OUTPUT

The MSK 1903 has an on board buffered DC zener reference output. The $V_{REF}$ output is nominally 5.5V DC and has full temperature test limits of 5.2V to 5.8V DC. This output is provided for gain and offset adjustment and can source up to 4mA of current.

## THERMAL MANAGEMENT

The MSK 1903 package has mounting holes that allow the user to connect the amplifier to a heat sink or chassis. Since the package is electrically isolated from the internal circuitry, mounting insulators are not required or desired for best thermal performance. Use 4 to 6 inch/pounds for mounting the device to the heat sink.

The power dissipation of the amplifier depends mainly on the load requirements, bandwidth, pixel size, black level and the value of Rp. The following table illustrates a few examples:

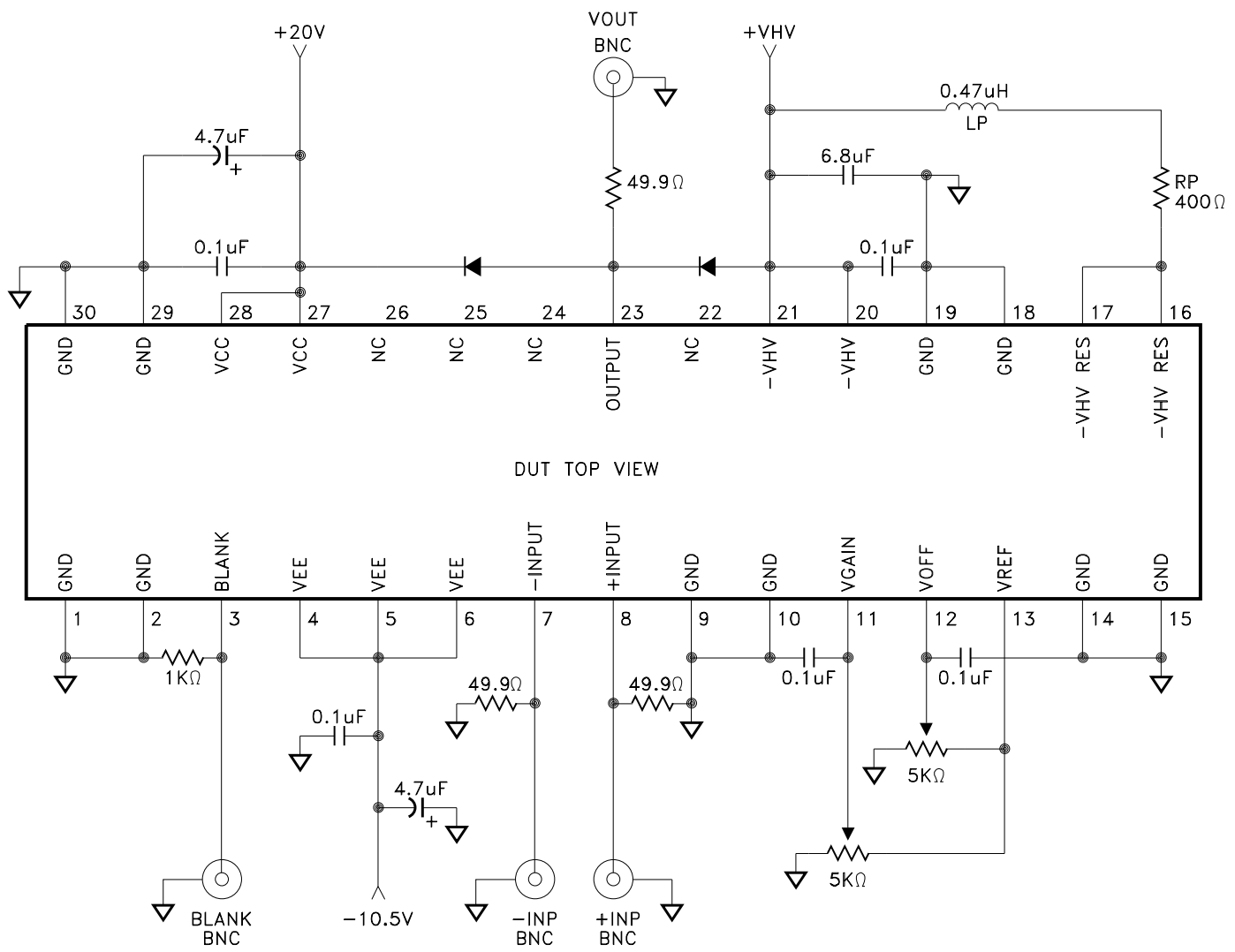| DEVICE TYPE | -VHV | BLACK LEVEL | WHITE LEVEL | OUTPUT VOLTAGE | PERCENT OF SIGNAL | | | OUTPUT AVE. Pd | TOTAL AVE. Pd |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | BLANK | BLACK | WHITE | | |
| 1903-6 | -120V | -110V | -20V | 0V | 100% | 0% | 0% | 0W | 2.5W |
| 1903-6 | -120V | -110V | -20V | -90V | 20% | 40% | 40% | 13.3W | 15.7W |
| 1903-4 | -70V | -65V | -15V | 0V | 100% | 0% | 0% | 0W | 2.5W |
| 1903-4 | -70V | -65V | -15V | -50V | 20% | 40% | 40% | 8.4W | 10.6W |

This table does not include power dissipation due to output switching since this is dependent on individual load requirements. The input stage power dissipation is typically 2.5 watts and is essentially independent of output levels.

### RESOLUTION TABLE FOR A TYPICAL CRT

| Display Resolution | Maximun Pixel Time | Minimum Pixel Clock Frequency | Required Rise Time at CRT | Required System Bandwidth (F-3dB) |
|---|---|---|---|---|
| 320 x 200 | 182nS | 5MHz | 60nS | 6MHz |
| 640 x 350 | 52nS | 19MHz | 17nS | 20MHz |
| 640 x 480 | 38nS | 26MHz | 12.5nS | 28MHz |
| 800 x 560 | 26nS | 38MHz | 8.6nS | 41MHz |
| 1024 x 900 | 12.6nS | 80MHz | 4.2nS | 84MHz |
| 1024 x 1024 | 11nS | 90MHz | 3.7nS | 95MHz |
| 1280 x 1024 | 8.9nS | 112MHz | 2.9nS | 120MHz |
| 1664 x 1200 | 5.8nS | 170MHz | 1.9nS | 180MHz |
| 2048 x 2048 | 2.8nS | 360MHz | 1nS | 380MHz |
| 4096 x 3300 | 860pS | 1.2GHz | 280pS | 1.23GHz |

All data assumes retrace time equal to 30% of frame time and a 60Hz refresh rate.

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## TYPICAL CONNECTION CIRCUIT

+20V  VOUT BNC  +VHV

0.47uH
LP

4.7uF

6.8uF  RP 400Ω

0.1uF  49.9Ω  0.1uF

| 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GND | GND | VCC | VCC | NC | NC | NC | OUTPUT | NC | −VHV | −VHV | GND | GND | −VHV RES | −VHV RES |

DUT TOP VIEW

| GND | GND | BLANK | VEE | VEE | VEE | −INPUT | +INPUT | GND | GND | VGAIN | VOFF | VREF | GND | GND |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |

1KΩ  49.9Ω  49.9Ω  0.1uF  0.1uF

0.1uF  5KΩ

4.7uF  5KΩ

BLANK BNC  −10.5V  −INP BNC  +INP BNC

The connection circuit shown above is for the MSK 1903-0 evaluation board. The Rp and Lp are external components and must not be located near ground planes if possible. A high quality resistor such as Bradford Electronics P/N FP10-400 is required for optimum response times. Use an inductor with a high self-resonant frequency that can withstand the currents required for the application.

When using the other variants of the MSK 1903, place an additional bypass capacitor on pins 16 and 17 if series (Rp and Lp) components are not utilized. The pin should connect to -VHV with a short low impedance path.

For additional applications information, please contact MSK. Evaluation amplifiers with test boards are available upon request.

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ESD TRIANGLE INDICATES PIN 1.
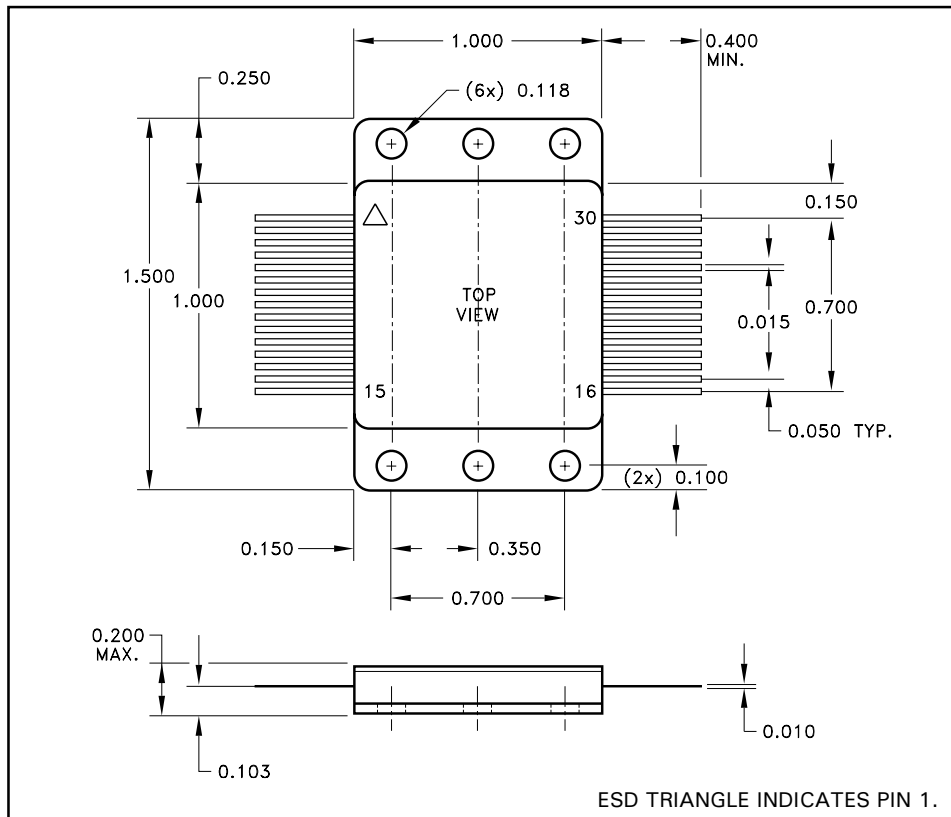
ALL DIMENSIONS ARE ±0.010 INCHES UNLESS OTHERWISE LABELED.

# *ORDERING INFORMATION*

| PART NUMBER | +VHV MAX | INTERNAL RP | TYPICAL RISE TIME | SCREENING LEVEL |
|---|---|---|---|---|
| MSK 1903-0 | 110V | NONE | 4.2nS | Industrial |
| MSK 1903B-0 | 110V | NONE | 4.2nS | Mil-PRF-38534 Class H |
| MSK 1903E-0 | 110V | NONE | 4.2nS | Extended Reliability |
| 5962-9324301HX | 110V | NONE | 4.2nS | DSCC-SMD |
| MSK 1903-2 | 110V | 400Ω | 3.8nS | Industrial |
| MSK 1903B-2 | 110V | 400Ω | 3.8nS | Mil-PRF-38534 Class H |
| MSK1903E-2 | 110V | 400Ω | 3.8nS | Extended Reliability |
| 5962-9324302HX | 110V | 400Ω | 3.8nS | DSCC-SMD |
| MSK 1903-4 | 75V | 200Ω | 2.9nS | Industrial |
| MSK 1903B-4 | 75V | 200Ω | 2.9nS | Mil-PRF-38534 Class H |
| MSK1903E-4 | 75V | 200Ω | 2.9nS | Extended Reliability |
| MSK 1903-6 | 130V | 400Ω | 6.5nS | Industrial |
| MSK 1903B-6 | 130V | 400Ω | 6.5nS | Mil-PRF-38534 Class H |
| MSK1903E-6 | 130V | 400Ω | 6.5nS | Extended Reliability |

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