TRIPATH

OUTPUT MOSFET SELECTION GUIDE FOR TRIPATH TA3020 AND TA010XA POWER AMPLIFIER DRIVERS

Application Note – AN16 Rev 1.0 – May 2001

INTRODUCTION

Tripath Technology has an established line of audio power amplifier drivers that require high quality, switching grade MOSFETs for proper device operation and maximum performance. Tripath application note, AN10, provides issues to be considered when choosing MOSFETs to mate with Tripath amplifier drivers. In addition, the individual amplifier driver data sheets refer to specific MOSFETs that were used during device development and evaluation board designs. This application note is intended to summarize MOSFETs that Tripath has used either successfully, or not so successfully, in conjunction with their amplifier drivers. In addition, a list of MOSFETs, with promising specifications, is also provided.

GENERAL COMMENTS

There are multiple companies that focus on producing medium and high voltage, switching grade, MOSFETs. The names include ST Microelectronics, Fairchild Semiconductor, International Rectifier Corporation, Intersil, and Mitsubishi Corporation. At this time, MOSFETs from ST Microelectronics, Fairchild Semiconductor, and International Rectifier have been proven applicable through Tripath amplifier driver development work. As a general rule, the latest generation devices work best, as they have a low gate charge to $R_{DS(on)}$ ratio, while possessing sufficient voltage ratings (usually BV_{DSS} >150V) to be applicable. Currently, ST Microelectronics and Fairchild Semiconductor have the widest range of suitable MOSFETs. Additional devices are being released every month from these companies. Thus, the available pool of applicable MOSFETs is continuing to increase.

RECOMMENDED MOSFETs

The following devices are capable of achieving full performance, both in terms of distortion and efficiency, for the specified load impedance and voltage range.

Device Information – Recommended MOSFETs

Part Number	Manufacturer	BV_{DSS} (V)	I_D (A)	Q_g (nC)	$R_{DS(on)}$ (W)	P_D (W)	Package
STW50NB20	ST Microelectronics	200	50	84	0.047	280	TO247
IRFB41N15D	International Rectifier	150	41	72	0.045 (max.)	200	TO220
STW38NB20	ST Microelectronics	200	38	70	0.052	180	TO247
STU36NB20	ST Microelectronics	200	36	70	0.052	160	MAX220
STW34NB20	ST Microelectronics	200	34	60	0.062	180	TO247
FQA34N20	Fairchild Semiconductor	200	34	60	0.06	210	TO247
FQP34N20	Fairchild Semiconductor	200	31	60	0.06	180	TO220
IRFB31N20D	International Rectifier	200	31	70	0.082 (max.)	200	TO220
STP19NB20	ST Microelectronics	200	19	29	0.15	125	TO220
STP16NB25	ST Microelectronics	250	16	29	0.22	125	TO220

Note: The devices are listed in descending current capability.

The following information represents qualitative data from system development using the Tripath Amplifier Drivers and the associated MOSFETs. Recommendations such as maximum supply voltages, and gate resistor values, are dependent on the PCB layout, including board parasitics, as well as associated components like bypass capacitor type and location.

Application Information – Recommended MOSFETs

Part Number	Recommended Maximum Supply Voltage	Typical Load at Maximum Supply	Recommended Gate Resistor	Comments
STW50NB20	+/-90V	4 ohms	3.9 ohms	High power applications
IRFB41N15D	+/-60V	4 ohms	10 ohms	Good for “lower” voltage operation
STW38NB20	+/-85V	4 ohms	5.6 ohms	Original EB-TA010xA part, may be difficult to source
STU36NB20	+/-75V	4 ohms	5.6 ohms	Same die as STW38NB20 but with “clip” type package
STW34NB20	+/-80V	4 ohms	5.6 ohms	MOSFET used on most Tripath Evaluation Boards
FQA34N20	+/-80V	4 ohms	5.6 ohms	Similar to STW34NB20
FQP34N20	+/-70V	4 ohms	5.6 ohms	Same die as FQP34N20 but with TO220 type package
IRFB31N20D	+/-70V	4 ohms	10 ohms	Power limited at high ambient temperatures due to package
STP19NB20	+/-70V +/-50V	8 ohms 4 ohms	10 ohms	Low cost, easily paralleled to increase power dissipation
STP16NB25	+/-70V +/-90V (if paralleled)	8 ohms 4 ohms	10 ohms	High voltage, easily paralleled to increase power dissipation

OTHER MOSFETs

The following MOSFETs do not perform as well as those listed in the Recommended MOSFETs Section. Thus, peak efficiency numbers may be lower, THD+N numbers may be higher, or the system robustness could suffer due to lower voltage ratings. However, they are lower cost and may be more widely available than the preferred alternatives, and will perform acceptably in some applications.

Device Information – Other MOSFETs

Part Number	Manufacturer	BV_{DSS} (V)	I_D (A)	Q_g (nC)	$R_{DS(on)}$ (Ω)	P_D (W)	Package
IRF640N	International Rectifier	200	18	67	0.15 (max.)	150	TO220
IRF530N	International Rectifier	100	17	44 (max.)	0.11 (max.)	79	TO220

Application Information – Other MOSFETs

Part Number	Recommended Maximum Supply Voltage	Typical Load at Maximum Supply	Recommended Gate Resistor	Comments
IRF640N	+/-60V	4 ohms	5.6 ohms	Less efficient than newer generation MOSFETs
IRF530N	+/-40V	8 ohms	15 ohms	Similar to STP19NB20 but only 100V rating

MOSFETs UNDER EVALUATION

The following MOSFETs appear from the data sheets to be suitable for use with Tripath drivers, and we are waiting for samples to evaluate. Most of these devices come from the same “family” or generation, as other recommended MOSFETs. However, experience tells us that we cannot recommend any devices until we have received samples and fully tested them. During evaluation, the following list is verified before the MOSFET can be recommended.

- The THD+N is close to or equal to the performance shown in the specific Tripath data sheet and meets the application requirement. Tradeoffs can be made like increasing lower power efficiency at the sake of increasing distortion.
- The quiescent output stage current is stable and reaches an equilibrium value once the system ambient temperature has stabilized. In most applications, quiescent current above 125mA (per 4 output devices) is unacceptable. Usually, the output stage current is kept below 100mA at idle. The output stage idle current can be affected by the BBM setting, gate resistor values, and any external RC delay (see Tripath AN-15).
- The idle (no input) switching frequency is above 550kHz-600kHz. The idle switching frequency can be affected by the BBM setting, the gate resistor values, and any external RC delay (see Tripath AN-15).
- There is clean, 50% duty cycle waveform (assuming no input signal) as viewed before the LC filter. A sporadic switching waveform is a sign of amplifier instability and is most likely linked to an output stage that is too slow.
- The driver temperature stabilizes once the system ambient temperature reaches equilibrium. Typically, the heat sink of the driver rises approximately 40-50C above the ambient temperature. If the driver heat sink temperature rises significantly more than this, then the MOSFET gate charge specification may be too large for the Tripath Amplifier Driver.

Device Information – MOSFETs Under Evaluation

Part Number	Manufacturer	BV_{DSS} (V)	I_D (A)	Q_g (nC)	$R_{DS(on)}$ (W)	P_D (W)	Package
FQA27N25	Fairchild Semiconductor	250	27	50	0.083	200	TO247
IRFB42N20D	International Rectifier	200	42	103	0.055 (max.)	300	TO220
FQP19N20	Fairchild Semiconductor	200	19	31	0.12	140	TO220
HUF75842P3	Intersil Corporation	150	43	77	0.035	230	TO220
FQA28N15	Fairchild Semiconductor	150	33	40	0.067	227	TO247
IRFB33N15D	International Rectifier	150	33	60	0.056 (max.)	170	TO220
IRFB23N15D	International Rectifier	150	23	37	0.090 (max.)	136	TO220
FQA33N10	Fairchild Semiconductor	100	36	38	0.04	163	TO247
HUF75623P3	Intersil Corporation	100	22	23	0.054	85	TO220

Note: The devices are listed in descending BV_{DSS} rating.

UNSUITABLE MOSFETs

A popular MOSFET we have tried without success is the IRFP250, available from International Rectifier, and other second sources. The gate charge is too high to operate with the typical switching frequency of a Tripath driver without significant output stage idle power current.

Other MOSFETs that do not work, despite promising specifications, are the PSNM070-200P and the PHW35NQ20T from Philips Semiconductor. The rise and fall times appear to be too slow to switch at 600-700kHz, which results in excessive output stage idle current.

Summary of possible issues with unsuitable MOSFETs, improper external component selection, and/or BBM setting:

- The idle (no input) switching frequency, as viewed before the LC filter, is below 525-550kHz.
- The output stage idle current is greater than 125mA. The 125mA specification refers to the typical application which uses 4 output devices (2 per half-bridge)
- The quiescent output stage current does not reach an equilibrium value once the system ambient temperature has stabilized.
- The Tripath Amplifier Driver does reach equilibrium once the system ambient temperature has stabilized. In this case, a different MOSFET type may be needed. Another solution is to increase the amount of heat sinking or air flow.
- A sporadic switching waveform, as viewed before the LC filter. This is a sign of amplifier instability and is most likely linked to an output stage that is too slow.
- Poor THD+N performance.

PARALLELING MOSFETs

For high power designs, using a Tripath Amplifier driver in bridged mode (or for load impedances less than 4 ohms single ended), it may be necessary to parallel output devices. The “need” to parallel usually arises from output stage power dissipation concerns that are the result of amplifier inefficiencies, as opposed to insufficient MOSFET current capability. It should be noted that the power dissipation numbers quoted in the tables are for case temperatures of 25C. Each MOSFET has a different power dissipation derating factor dependent on package type, die size, and maximum junction temperature. This information must be taken into consideration when choosing the output device type. Paralleling output devices is not a panacea for amplifier designs especially a switching type like Tripath’s due increased switching losses. Thus, the number of output devices should only increased if dictated by an application requirement such as needing to drive low impedance bridge loads.

Designs using 2 x STW34NB20 MOSFETs in parallel have achieved between 1-2kW depending on the supply voltage and load impedance. AN10 recommends a maximum of 100nC though the empirical limit seems to be between 130-150nC. Thus, a design using 3 x STW34NB20 is not recommended.

Paralleling output devices puts additional strain on the Tripath amplifier driver, due to the additional gate charge requirements. This results in an increase (nominally double) in the DC current draw from the VN10 or VN12 supply that powers the Tripath driver. For designs that result in greater than 100nC of gate charge (for the parallel combination), additional cooling of the Tripath driver will be needed. This can take the form of a heat sink heat mounted to the Tripath driver with thermally conductive epoxy or forced cooling with a small fan.

When paralleling 2 mosfets, the gate resistor size should be reduced by a factor of two as compared to the appropriate value for the “single fet” case. Each MOSFET should have a separate gate resistor. In addition, the gate and source routing length should be minimized as much as possible to minimize PCB parasitics. Bypassing at each MOSFET is also highly recommended to minimize output overshoots (and undershoots) during high current events.

Besides the STW34NB20 (2 devices), the most likely candidates for paralleling include the STP19NB20 (2-4 devices), the STP16NB25 (2-4 devices), the FQA27N25 (2 devices) and the FQA28N15 (3 devices).

